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Investment in Offshore Wind Energy in Poland and Its Impact on Public Opinion

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Abstract: The availability of energy-bearing resources is a key determinant of the development strategy of the world's energy systems. In the case of Poland, the wind energy potential of the Baltic Sea provides the basis for the development of offshore wind energy in the country. The processes of transforming solutions towards green technologies require appropriate legislation, significant financial outlays, as well as public support for this dimension of activities. The latter strand requires continuous measurement to dynamically model the energy transition strategy. In the author's opinion, the available literature does not sufficiently explain this theme in relation to Polish conditions. Hence, it was considered reasonable to investigate the impact of offshore wind energy development in Poland on public opinion in a selected region of Poland, in order to diagnose the current scale of support for the changes taking place, and to identify the main expectations and fears related to this activity, which was assumed as the main objective of the study. The added value of the survey is the analysis of changes in public opinion over time. The methodology used for the research was a study of the scientific literature, with analysis of the results of own and secondary research conducted in Poland. In terms of in-depth research, statistical survey techniques supported by the PQstat programme were used. The results of the survey confirmed significant public support in the surveyed area for offshore wind energy development in Poland (68%). The overall percentage of support for offshore development increased by 5% y/y. Economic considerations for the support of the activities in question with the potential vision of lowering energy prices in the domestic market were confirmed with a result of 65%. It was further confirmed that a key aspect of support for the offshore development strategy in the surveyed region of Poland is the potential for development of the region in relation to offshore farm investments, with a focus on the labour market, with indications of 53% for both themes. Interestingly, there was no concern in relation to the risk of landscape change in an undesirable direction in 2024.

Keywords: offshore wind; renewable energy technologies; management of renewable sources; Baltic Sea wind potential; economics of RES solutions; public opinion

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1. Introduction

The direction of strengthening energy security derived from renewable sources is becoming more and more pronounced worldwide [1]. Through the orientation towards renewable sources and low-carbon production [2], renewable energy sources are recognised as environmentally friendly [3] and therefore justified and fully desirable in energy system transformation processes [4]. This is another very important argument in favour of the need to take measures to increase the share of energy from renewable sources in countries' energy proportions. The scale and degree of this development characterises the economies of the world to varying degrees and extents [5] and remains a significant challenge for many of them. Constraints in this area may arise against a complex background, including, inter alia, geographical location and conditions created by the natural environment, determining the availability of specific types of natural resources, which, in combination with the dimension of the greening of society resulting from its level of awareness and degree of

orientation towards the direction of changes taking place, shape the current state of affairs. The policy of states creating formal and legal framework for the development of RES solutions, together with the system of economic motivation for the development of this dimension of activity (e.g., subsidies, grants, tax relief or exemptions) is also important.

As global energy demand continues to grow, the world's economies are striving to make the energy transition to renewable energy sources as rapid as possible. The green transformation of the world's energy systems is motivated by social expectations, which combine the aspect of clean and safe energy from renewable sources with the potential of low purchase prices on the local market. The aspect of high electricity prices particularly affects Poland, whose energy system still relies heavily on coal. This is because the high level of caesium per 1 KW of energy is shaped by the high cost of mining the energy-bearing raw material in question, compounded by the volume of greenhouse gas emission charges [1,6]. High energy prices make the topic of the domestic energy market extremely important for the Polish community. Therefore, the process of its transformation is urgent and justified, and the actions taken focus wide attention of the environment and arouse public emotions.

An important aspect of the energy transition is drawing energy from offshore wind. This prospect of strengthening the national energy system also applies to Poland, due to the significant wind energy potential of the Baltic Sea. Offshore wind, by definition, adopts higher speeds than onshore wind [7], but only professional research makes it possible to assess its usefulness for offshore wind energy [8] by determining its energy quality [9]. The strength, intensity and direction of the Baltic Sea wind in studies scores well, with an average speed assessment of about 8–10 m/s [10]. With an appropriate distance of 26 kilometres from the shore of the basin and the availability of a seabed with a low average water depth of 42 m, the Baltic Sea fulfils the key natural conditions of the basin [11], allowing the realisation of offshore wind farm installations. This is an important argument, placing the Baltic Sea among the attractive offshore basins, alongside the North Sea, among others. This is an important source of renewable energy, taken into account in the strategy for the transformation of Poland's national energy system towards RES.

The rate of development of energy systems towards RES is determined by a number of factors. Among the main ones are appropriately structured legislation and capital expenditure. The issue of public support for the planned and ongoing changes is also significant. The aspect of social opinion requires constant measurement; therefore, in response to the diagnosed demand and the noted gap in the literature on the subject, it was deemed justified to investigate the impact of offshore wind energy development in Poland on social opinion, which was adopted as the main objective of the study. The added value of the study is the analysis of changes in social opinion over time, in order to capture trends in its evolution. The adopted direction of the research is justified by the paucity of literature discussing the adopted theme, and the noted gap particularly relates to social opinion on the issue of offshore wind energy development. This paper aims to strengthen knowledge in the area of offshore wind energy in Poland, as well as to draw attention to public opinion regarding investment activities in this direction. The results of the research may serve to create a strategy for offshore wind development in Poland and may also inspire the creation of educational and promotional undertakings for local communities. With the above in mind, the undertaken issues are considered important and worthy of scientific exploration.

The adopted structure of the paper is to ensure substantive findings in the implementation of the research objective.

The layout of the study is built up by the following:

(a) An introduction;
(b) A literature review oriented towards renewable energy issues including the offshore wind thread;
(c) Analysis of the renewable energy market in Poland, including the potential of offshore wind energy;

(d) Analysis of the impact of offshore wind development in Poland on public opinion;
(e) Discussion;
(f) Summary and conclusions.

2. Offshore Wind Energy in Light of RES in the Transformation of Energy Systems of World Economies—Literature Review

The development of urban agglomerations, together with the increase in the use of technology and techniques that are displacing conventional formulas of operation, the computerisation of the world and the development of the field of electric transport all contribute to a constantly high demand for electricity [12]. The high demand for electricity stimulates its market price. In addition, rising fossil fuel prices, obsolete technologies and environmental charges for discharges and toxic emissions [13] all contribute to reinforcing the upward trend of energy prices on the market [14]. The economic theme of high energy prices is one of the reasons for seeking solutions to correct them.

An essential response to contemporary market challenges is sustainable economic development, part of which is the ongoing process of transforming the energy systems of the world's economies towards renewable energy [15]. The rationale for lowering energy prices [16], energy security and environmental safety are aspects that determine the pattern of actions taken in the transformation processes. These are also themes of fundamental interest to the public. This is because the development of the standard of modern life goes hand in hand with a widespread process of greening life, which is now considered an absolute necessity. Increased awareness of the impact of human activity on the environment motivates actions in which environmental protection takes on key significance. It is an activity that grows out of concern for the health of the planet and the safety of future generations. Hence, the economies of the world are promoting the development of renewable energy sources [17,18]. According to IRENA data, already in 2021, renewable energy installations reached a global capacity level of close to 257 GW, representing an increase of more than 9% in the share of RES sources in the world's energy mix [19]. An orientation towards increasing the energy efficiency of the energy sector, while reducing the negative environmental impact of energy production, is promoted in the energy and environmental policies of countries globally [20,21]. A differentiated approach to the issue of sustainable development is evident [22], which is caused by economic conditions or the level of availability of energy sources. However, the path of energy system development is relatively precisely defined [23]—limiting the extraction of energy resources of natural origin (non-renewable sources) and reducing greenhouse gases to halt climate change, while targeting renewable energy sources, which have been given priority in the development of the energy system globally. In the countries of the European Union, this action is subordinated to the aim of developing the potential for the availability of sustainable-cheap and secure electricity, safeguarding the interests of both individual and institutional consumers [24], as well as state institutions. The main priority in this area is to secure competitive electricity prices, which determine the competitiveness of this part of the world, inter alia through investment in smart grids and energy storage, or smart-self-balancing energy buildings and structures, with a real impact on improving energy security.

Renewable energy has many sources. Wind energy is a highly popular source in the sphere of green energy generation, against which context offshore wind power takes on a significant role.

As already signalled within this paper, offshore wind has, in principle, better parameters than inland wind (strength, intensity, and limited turbulence [25]). It should be stressed, however, that in the context of the investment potential of wind farms, the formal and legal framework related to the impact of wind on the environment, which defines the guidelines for the location of wind turbines in relation to buildings, plays an important role. This places offshore wind in first place compared to inland wind, as confirmed by studies [26,27]. In the light of the above, it is natural for countries neighbouring onshore waters to diagnose

the potential of offshore wind and, if its parameters are confirmed, to take steps towards offshore wind energy production. The rationale for these measures is reflected in economic practice. Improved technologies in this area [28] increase the investment justification for these measures. It is worth noting that 93 GW of energy was already generated from wind power in 2021, of which 21 GW was generated by offshore wind farms [19].

In terms of offshore energy development, the Baltic, Black, North, Caspian, Yellow and East China Seas offer significant potential, with countries bordering these basins playing a key role in global offshore development [29].

Poland's coastline with the Baltic Sea creates an attractive potential for the development of renewable energy based on offshore wind farms. It was therefore deemed important to explore this potential, together with a diagnosis and evaluation of the public opinion shaped by the development of this area.

3. Materials and Methods

3.1. Research Concept

The adopted aim of the research determined the structure of the paper and the choice of methodology. The introduction contains content of a conceptual nature. The background of the research and its rationale referred to the existing literature, which is captured in the literature review section. The empirical and analytical part is presented in the following sections of the paper, where a diagnosis of the state of renewable energy, with particular emphasis on offshore wind energy in Poland, is made, followed by a systematisation of development conditions in the field in question. The process of researching the phenomena was conducted according to the rules of economic analysis, which determined the substantive course of inference.

The system of hypotheses constituting the research reference of this paper is as follows:

1. Offshore wind energy investments are an appropriate dimension of Poland's energy system transformation, which is socially supported (H_1);
2. Offshore wind development may significantly strengthen the share of renewable energy in Poland's energy mix (H_2);
3. Offshore wind development may, to a significant extent, strengthen the socially expected effect of the transformation of the Polish energy system (H_3).

3.2. Research Sample, Qualitative Research

The need to monitor the impact of activities in the area of transformation of the country's energy system on public opinion is justified. Consumers of energy—the public—express their needs or expectations regarding the effects of the changes by approving or disapproving the activities. Specialised research in this area can provide opinions or suggestions for the direction of projects. In this respect, the public voice is important. Public consultation procedures, which are regulated by law, have a real impact on the modelling of implemented activities. Citizen involvement can therefore be beneficial in balancing the differing needs of the commercial market and the individual sphere. Therefore, the identification and evaluation of the impact of implemented measures on public opinion is an important activity. It provides a basis for diagnosing the degree to which the activities implemented match the actual needs of the consumer potential. With the above in mind, an in-house survey was carried out in the period 1–3 May 2024 in Ustka—a tourist town in Poland, located on the Baltic Sea (Słupsk County, Pomeranian Voivodeship), in the area of which an offshore wind farm investment project is being implemented [30].

The research being carried out is characterised by a monitoring of the 2023 findings; hence, the survey design from last year was repeated in the area of findings in the area of social assessment of offshore wind development in the study region. The layout of the survey in the area in question adopted a narrow scope—six questions, including four closed and two multiple-choice questions, of an open-ended nature, narrowing the research reference to the essential aspects of the issues explored. The research part specifies in detail the content of the issues constituting the scope of the study, the aim of which was to

diagnose the actual opinion of the surveyed community formed in the studied area. For the validity of the study, a contrasting street survey technique was used, which made it possible to identify a wide spectrum of opinions. To ensure the value of comparability, an analogous place and time of surveying was adopted for the study, and the results of the questionnaires were accepted for analysis in analogous numbers within the three research groups as in the previous year, viz:

- Respondents aged up to 30 years (54.6%);
- Respondents aged 31–60 (37.3%);
- Respondents aged 61 and over (8.1%).

The Pomeranian Voivodeship was represented by 23.7% of the population surveyed, with the remaining 76.3% of respondents representing the other voivodeships of Poland. In this study, the characteristics of the population did not constitute differentiating variables.

It should be noted that the limited nature of the sample creates findings appropriate only for this sample, which means that they should not be transferred to the general population.

For comparability of findings, the choice of research instrumentation was imposed by the survey of the previous year. Its original selection determined the layout of the data and the research questions established. Participation in the survey was open and anonymous. A total of 335 people took part in the survey, with 273 correctly completed questionnaires accepted for analysis in the representation of groups analogous to 2023.

Simple methods were used in the pre-treatment area of the data, and causal research was used in the inference part.

The research sample consisted of Polish respondents who stayed in Ustka during the period covered by the survey. The results obtained apply only to this sample and are therefore not transferable to the general population.

3.3. In-Depth Quantitative Surveys

The in-depth part of the study used a statistical approach (logistic regression model), supported by the PQstat software (version 1.8.4.164). The study was oriented towards the analysis of the degree of probability of the course of the transformation of the Polish energy system taking into account offshore—with the participation of the explored determinants of this process, established in the qualitative research.

For the purposes of the study, the explanatory variables were established, with a scale of 1–3 denoting, respectively:

1. Full support;
2. No opinion on support;
3. No support.

The pattern of classification of variables is specified in Table 1.

Table 1. Characteristics of variables.

Variable Number	Description Variable	Variable designation X_1–X_3; Y_1–Y_3	Type of attribution Dichotomic/Numerical scale (1–3)

The next step of the study involved determining the influence of the explanatory variables (X_1–X_3) and the explanatory variable (Yx) using logit regression in the model, according to the following formula [31]:

$$ln\frac{p_i}{1-p_i} = Z_i = x^J\beta = \beta_0 + \beta^1 + \beta^2 X_i^1 + \beta^2 X_i^2 + \ldots + \beta_k X_{ki} \quad (1)$$

where:

$$ln\frac{p_i}{1-p_i} = logit\ (p_i)$$

The estimated parameters are $\beta_0 \ldots \beta_K$,—components of the vector β.

The next step was to use the odds ratio (OR) in the estimation process. The object of the findings in this regard was to determine whether the odds ratio for a variable (X_{mi}) augmented by a unit magnification would be equal to the odds ratio without the unit magnification, according to the following formula [32]:

$$exp(\beta_m) = \frac{\Omega({x_i}^m, X_{mi} + 1)}{\Omega({x_i}^m, X_{mi})} \quad (2)$$

where:

${x_i}^m$—vector of the variable x_i variable is a vector without the X_{mi} variable, whereby chance is expressed by the following notation:

$$ln\frac{p_\mathrm{i}}{1-p_\mathrm{i}} = exp\left({x_i}^J\beta\right) = exp(\beta_0 + \beta 1X1_i + \beta 2X2_i + \ldots + \beta_k X_{ki}) = \Omega(x_i) \quad (3)$$

A unit increase in the value of the variable X_{mi} with all other parameters held constant is created by a change in the odds ratio of $exp(\beta_m)$—multiples; then, if:

1. $exp(\beta_m) > 0$, then the odds ratio increases;
2. $exp(\beta_m) < 0$, then the odds ratio decreases.

The above indicates the OR shift multiplicity for a binary variable X_m, $exp(\beta_m)$ at „$Y_\mathrm{i} = 1$" for category "1" and variable x_m„ towards OR for the category "0" and variable x_m. It should be emphasised that the results for the logit model $\hat{\beta}_j$ (in terms of the scale of change OR) determine the odds ratio values exp ($\hat{\beta}_j$), whereby the average change OR determines the unit growth of the variable [32]. In this aspect, the degree of probability of the course of the transformation of the Polish energy system including offshore wind energy, with the participation of the determinants of this process, can be captured in the range <0.1>. In this situation, a probability score of $\leq$0.5 indicates that the transformation of the Polish energy system including offshore wind energy is independent of social opinion, while scores of >0.5 define the process in question as dependent on social opinion.

The classification of the results in the area in question, together with the findings in the sphere of the odds ratio > 1, makes it possible to identify and assess measures of a random nature, and also provides a basis for establishing the predicted values in the adopted model [32].

The methodology as a research design can be applied to similar research in emerging markets, subject to the need to tailor the scope of the diagnostic survey to the research needs.

4. Results

4.1. Findings from Literature Research and Industry Reports

4.1.1. The Essence of Wind as an Energy Resource—Outline of Technical Conditions and Investment Challenges in Poland and the World

The movement of air in the Earth's atmosphere, created by the difference in temperature and pressure in its various corners, is the wind. Wind energy is created by converting mechanical wind energy into environmentally friendly alternating current (AC) using a mechanical wind turbine. The use of a converter in the conversion process creates direct current (DC), which, with the use of additional solutions (PMSG inverter), ensures the quality of DC (voltage, frequency), making it possible to feed it into the power grid [33]. The aspect of adaptability to wind speed is a fundamental cost factor in the construction of offshore wind installations. Also important are the investment costs for the establishment of transmission lines and energy banks, which are estimated at an average of EUR 40 per MWh [20].

Wind energy investment in Europe in 2021 reached USD 18.7 billion [34]. Investment in offshore energy is a significant part of this load. It is estimated that investment in the offshore wind dimension in Poland could reach EUR 980 billion by 2040 [35]. The installation preparation process requires a team of in-depth studies and analyses of the available wind potential (actual resource [35]) in order to properly address the parameters

of the installation, ensuring its energy efficiency, captured, e.g., in the appropriate turbine power [36]. At the same time, it is worth noting that, on average, offshore wind blows with greater force and is less turbulent than the onshore wind resource, which means that it is characterised by higher energy and stability and, as a result, higher efficiency, which motivates projects in this area.

Selecting the parameters of an offshore wind installation is a time-consuming and capital-intensive task, involving modelling of the wind speed and distribution and prediction of its density [37] to ensure appropriate assumptions minimising the risk of fluctuations in the operation of the installation and the system (power quality [38]) while limiting the costs of operation and maintenance of the installation. The procedure for the construction of an offshore wind installation is very complex and expensive (seabed foundation—monopiles, gravity truss foundation, tripods or floating foundation of semi-sub, spar, and barge type) [39]. The operating parameters of the turbines also provide the basis for determining the planned power generation performance, giving the basis for ensuring efficient plant operation. This includes the positioning of the turbines in the direction most suitable for the wind, and costly solutions for the management of surplus power generated, including the option of very expensive storage. In this respect, there are a number of methods and techniques for monitoring the plant system, supporting the management of the unit (e.g., fuzzy-logic-based control MPPT, optimum tip speed ratio control—TSR MPPT, hill climb searching control—HCS MPPT, etc. [40–42].

Research into the efficiency of wind installations indicates that optimal siting is at the heart of the work on productivity. In terms of conditions for the availability of a suitable wind resource and conditions related to the investment availability of the offshore wind area (suitable land, adequately low water depth), the North Sea is of high interest for the construction of offshore wind farms, where a significant part of wind installations are located (80% of European wind installations), as well as the Irish Sea (10%) and the Baltic Sea (10%). These areas meet the average conditions for offshore wind turbine installations to date, i.e., they have the required surface availability already mentioned in this paper with an average water installation depth of 42 m, with an average distance from the shore of 26 km [43]. With regard to the forecasts for offshore wind energy development in the world, the Baltic Sea (Poland), as well as the North Sea, the Yellow Sea and the East China Sea, has significant potential, due to the established average wind speed in the offshore wind areas in question of approx. 8–10 m/s [43]. This creates good development conditions for offshore wind and attracts interest in investing in this energy segment. Currently, 12 European countries have 5785 offshore wind installations connected to the power grid. The development of this field is progressing, which is reflected, among other things, in the interest of a number of countries around the world in this field, in particular [43]:

1. On the European continent: Poland, Lithuania, Latvia, Estonia, Spain, Portugal, Greece, Ireland, Romania;
2. On the Asian continent: Turkey, Azerbaijan, Vietnam, Philippines, India, Sri Lanka;
3. On the American continent (Latin America): Costa Rica, Brazil, Mexico, Colombia;
4. On the African continent: South Africa, Namibia, Morocco;
5. Australia.

In most cases, the countries in question are emerging markets in this field of energy, which reinforces the importance of this dimension of energy supply for the energy systems of the countries mentioned.

4.1.2. Offshore Wind Energy in the Polish Energy System—Negotiations

The availability of offshore wind resources gives Poland the opportunity to take this source of energy supply into account in shaping Poland's energy mission potential in future years. This vision is becoming closer and closer, and the year 2024 seems to be a breakthrough in terms of strategic decisions in this regard. The above is supported by the fact that the construction of Poland's first offshore wind farm, Baltic Power, will be launched just in 2024; hence, this investment is considered an important aspect of Poland's

energy system transformation. Baltic Power is to bring together about 100 turbines in an area of 130 km^2 in the Baltic Sea with a connection capacity of 1.2 GW and will ultimately supply more than 1.5 million Polish energy consumers with green electricity [44].

Another important step for the development of the Polish offshore wind dimension is the current fact of obtaining financial support from the European Union for the construction of an offshore wind terminal in the Port of Gdansk, which is to handle the installation of key elements of offshore wind farms with a limiting capacity of 5 GW [45]. The European Union's support in this regard is being realised with the funds of the Instrument for Reconstruction and Increasing Resilience in the amount of EUR 194 million to fuel the development of offshore wind farms in Poland, the inclusion of which in the country's energy system is to create measurable economic, environmental and social benefits [45], being in line with the essence of sustainable development. Importantly, the project in question is to be implemented in 2026, and the total installed capacity is to reach 11 GW by 2040, which is a key step in the implementation of the Polish offshore wind energy development strategy. According to estimates, 5.9 GW of offshore wind energy should be connected to the grid by 2030 [46].

Another important aspect bringing Poland closer to drawing energy from offshore wind is the issuance by the Pomeranian Voivode of a permit for the construction of 'Bałtyk 2'—an offshore wind farm located in the Polish economic zone of the Baltic Sea, which is to comprise 50 innovative wind turbines, along with the development of internal networks—electricity and telecommunications [46]. This permit covers all of the documentation necessary to commence construction, which is expected to be completed between 2026 and 2027 [46]. According to Baltikwind.eu, the ongoing 'Bałtyk 1' project with an estimated connection capacity of 1560 MW, and the planned 'Bałtyk 2' and 'Bałtyk 3' farms with a total capacity of 1440 MW can satisfy the energy demand of 4 million Polish energy consumers [46].

The outlined projects are worth comparing with the assumptions of the Polish Energy Policy, according to which the installed capacity of offshore wind farms is to reach 5.9 GW by 2030 and 11 GW by 2040, although alternative sources determine the expected level of offshore wind capacity by 2040 to be approximately 18 GW [47]. Moreover, according to strategic assumptions, the first offshore wind energy connections to the Polish grid are to take place at the end of 2025. Observing the current progress of settlements in the offshore wind investment sphere, there is a high probability of achieving the established assumptions in this respect.

4.2. Analysis of the Impact of Offshore Wind Energy Development on Public Opinion—Results from a Diagnostic Survey

The investment process requires resources and means for its implementation. In the case of critical activities, which include supplying the country with energy—taking into account broadly understood social security (prism of availability—volume and price of energy available on the market, prism of production—environmental protection), investment activities require general public approval. Hence, the direction of Poland's energy system development towards RES is subject to public consultation. Activities in this area are aimed at obtaining opinions or assessments in the sphere of planned solutions in order to adjust the response to various consumer needs. In this respect, it can be concluded that public opinion influences the scope and pace of investment activities through the prism of the agreement process (in the case of government investments regulated by law). In the outlined context, it is important to diagnose and assess social opinion in the area of investment processes implemented in Poland in the offshore wind sphere. For the purposes of this assessment, a diagnostic survey was carried out between 1 and 3 May 2024 in a tourist town in Poland (Ustka) to investigate the general attitude of the public towards ongoing offshore wind investment projects in the immediate vicinity. The survey adopted an open and anonymous character in order to ensure the highest level of objectivity of the

results, captured in 273 correctly completed questionnaires. The results of the questionnaire survey established the following:

1. With regard to the survey question about the support of implemented offshore wind investments in Poland, 68% of respondents confirmed support, 28% indicated no opinion on this issue and 4% specified no support for such an action (Figure 1).

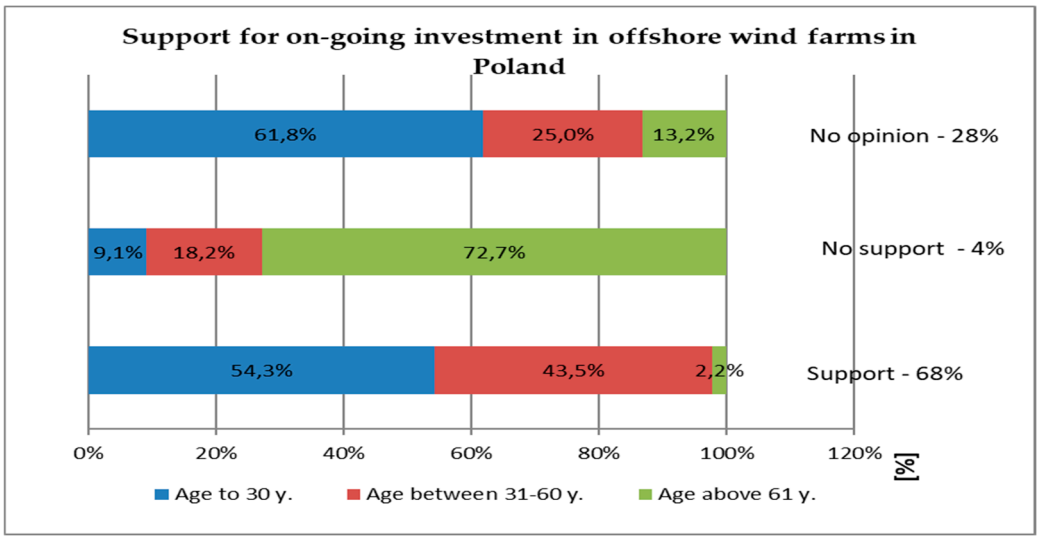

Figure 1. Support for on-going investment in offshore wind farms in Poland—results of a study.

Analysis of trends in changes in public opinion over the period 2023–2024 showed a strengthening of support for the survey question analysed by 5 percentage points.

2. With regard to the survey question about support for further offshore wind development in Poland, 63% of respondents confirmed support, 32% indicated a lack of opinion on this issue, and 5% specified no support for such a measure (Figure 2).

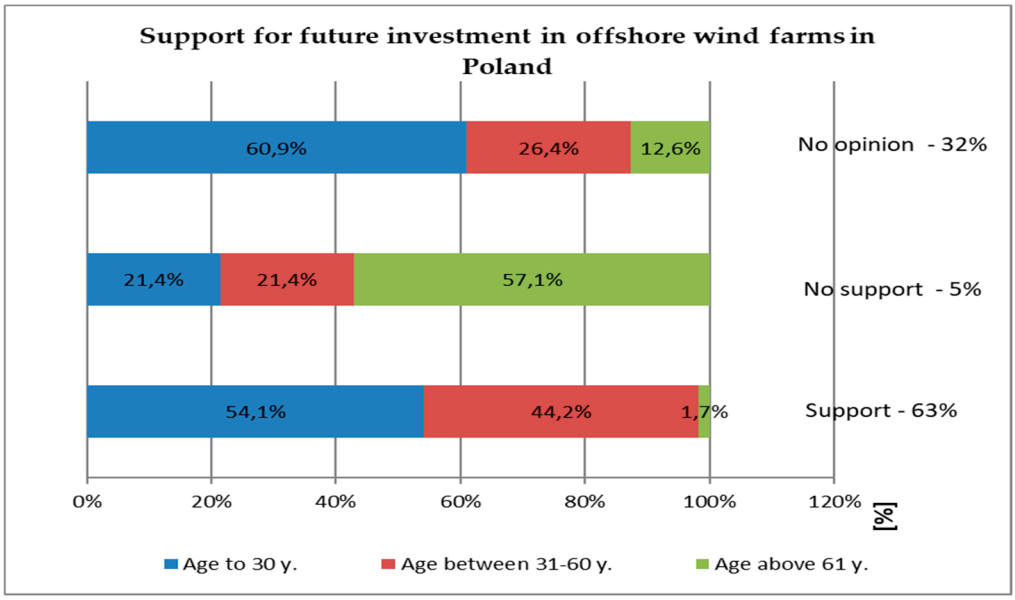

Figure 2. Support for future investment in offshore wind farms in Poland—survey results.

Analysis of trends in changes in public opinion over the period 2023–2024 showed a strengthening of support for the survey question under consideration by 2 percentage points.

3. With regard to the survey question of whether offshore wind development can significantly influence the strengthening of the energy system in Poland, 51% of respondents answered in the affirmative, 32% indicated that they had no opinion on this issue, and 17% described the lack of influence of the activities in question on the strengthening of the energy system in Poland (Figure 3).

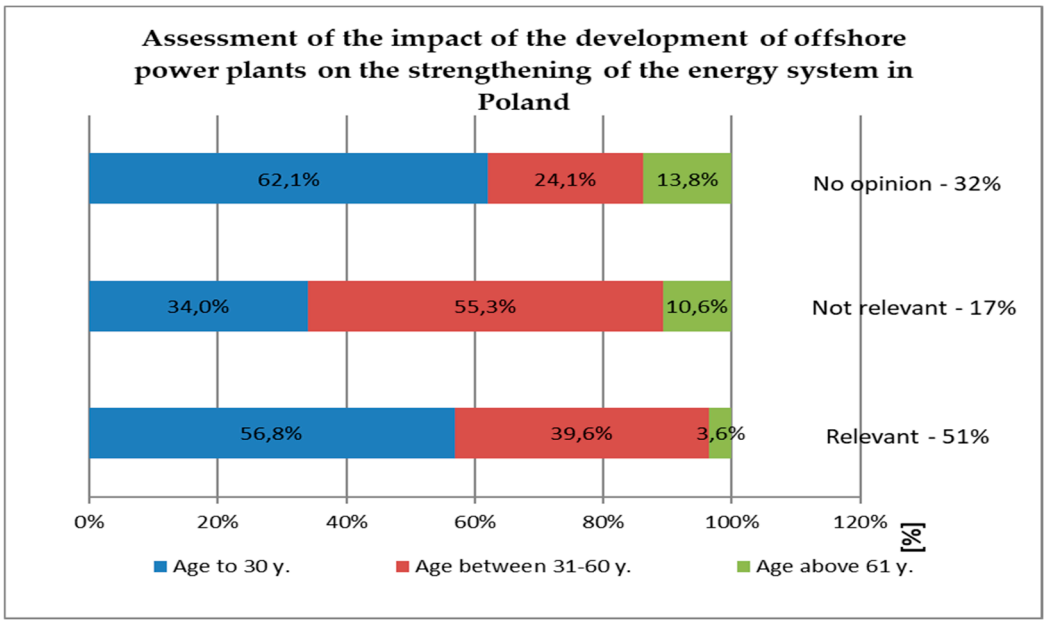

Figure 3. Assessment of the impact of the development of offshore power plants on the strengthening of the energy system in Poland—results of studies.

Analysis of trends in changes in public opinion over the period 2023–2024 showed a strengthening of support for the survey question under consideration by 10 percentage points.

4. With regard to the survey question asking if offshore wind investments will strengthen the transformation of the Polish energy system in the direction socially expected, 63% of respondents indicated yes, 31% indicated no opinion on this issue and 6% indicated that offshore wind development is not that important (Figure 4).

The analysis of trends of changes in social opinion in the period 2023–2024 showed a strengthening of support for the analysed survey question by 4 percentage points.

5. Regarding the survey question asking for (max. three) attributes of offshore wind investment in Poland, respondents indicated the following:

(a) Potential to reduce electricity prices (65%);
(b) Green energy source (58%);
(c) Direction of modernisation of the Polish energy system (73%);
(d) Development of the Pomeranian region—increase in investment potential (53%);
(e) Development of the labour market—new jobs (53%).

6. In terms of the survey question asking for (max. 3) negative sides of offshore wind investments in Poland, respondents indicated the following:

(a) Risk of destruction of onshore and offshore ecosystems due to construction and operation of offshore wind farms (41%);
(b) Risk of disturbing the tourist character of coastal towns in connection with the construction and operation of offshore wind farms (48%);
(c) Risk of negative impact of offshore wind farms on human health (61%).

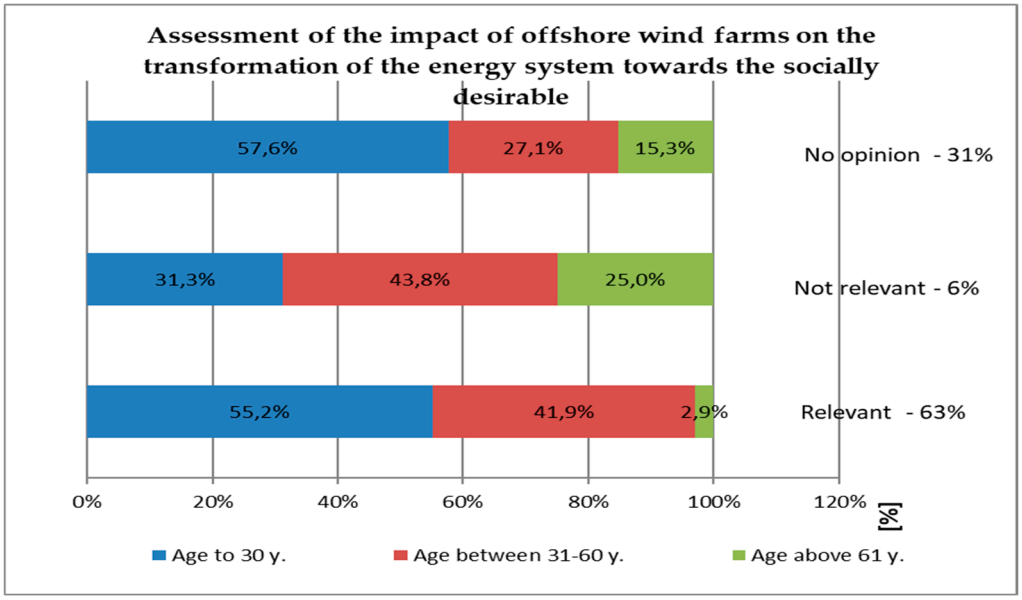

Figure 4. Assessment of the impact of offshore wind farms on the transformation of the energy system towards the socially desirable—results of studies.

The results of the qualitative data processing led to the following findings:

1. The highest level of support for offshore wind investment is shown by respondents aged up to 30 years. This group of respondents also most strongly associates offshore wind development with increasing opportunities for the development and stabilisation of the national energy economy.
2. The lowest level of support for offshore investment is shown by the group of respondents aged over 61. It should be noted, however, that the share of this group in the population of respondents was a low percentage—8.1%.

The results of detailed data processing provide the argumentation required to verify the theses adopted in the research process. Hence, a necessary step of the research is the statistical analysis of the collected data. For the purposes of the study, a logistic regression model was used. In the first step, explanatory variables (determinants of the development of the Polish energy system towards RES) were determined. The results of the survey revealed that the transformation of Poland's energy system towards RES is driven by offshore wind investments; hence, they should be considered as an important determinant of the transformation in question.

With this in mind, three key explanatory variables were identified in the sphere of public support, viz.:

1. The development of offshore wind investments;
2. Increased importance of offshore wind in the Polish energy system;
3. Progress in the transformation of the Polish energy system.

The scale designation 1–3 means, respectively:

1. Full support;
2. No opinion in favour;
3. No support.

The characteristics of the variables in question are specified in Table 2.

Assuming, based on the findings so far, that support for offshore wind development in Poland plays a significant role, further findings will be related to the explanatory variable Y_1, representing full support for the activities explored.

In line with the above, the findings of the descriptive statistics of the variables are specified in Table 2.

Table 2. Summary of variables with their characteristics.

Variable Number	Description Variable	Variable Designation	Type of Attribution
1	development of offshore wind investments	X_1	Dichotomic
2	growth in offshore wind importance in the Polish energy system	X_2	Dichotomic
3	progress in the transformation of the energy system in Poland towards RES	X_3	Dichotomic
4	fully support the measures	Y_1	Numerical (scale 1–3)
5	no opinion in favour of supporting activities	Y_2	Numerical (scale 1–3)
6	no support for action	Y_3	Numerical (scale 1–3)

The results from the area of descriptive variable statistics are presented in Table 3.

Table 3. Results from the area of descriptive statistics.

	Mean	SE	SD	SD^2	Min.	Max.
Y_1	0.5384	0.029	0.487	0.237	0	1
X_1	0.6026	0.058	0.476	0.226	0	1
X_2	0.4033	0.057	0.491	0.241	0	1
X_3	0.5775	0.056	0.489	0.239	0	1

The next steps of the study include the following:

1. Determining the influence of the explanatory variables (X_1–X_3) and the explanatory variable (Y_1) using logit regression in the model;
2. The use of the odds ratio (OR) in the estimation process.

The results of the correlation study of the variables analysed were captured in a matrix of their correlations, as shown in Table 4.

Table 4. Correlation matrix of the variables.

Variable	Y_1	X_1	X_2	X_3
Y_1	1.000			
X_1	1.537	1.000		
X_2	2.221	1.382	1.000	
X_3	1.578	0.946	0.685	1.000

The findings in the area of interdependence of the variables account for their homogeneity. The indications take on a positive character in relation to the strength of the linear relationship. The highest indication from the interdependence sphere obtained a level of 2.221 (Y_1–X_2), indicating a strength of correlation, where collinearity does not play a significant role (findings < 0.5).

The logistic regression results for the Y_1 variable are specified in Table 5. It illustrates the results in the following areas:

(a) Vector β;
(b) Error scale: b;
(c) Confidence interval: CI;
(d) Results of the Wald statistic;
(e) Odds ratio: OR.

Table 5. Logistic regression model for category Y1 (full public support).

	β	Error b	−95% CI	+95% CI	Wald Stat.	OR Odds Ratio
X_1	0.573	0.279	0.018	1.148	3.908	1.684
X_2	1.088	0.286	0.603	1.756	14.531	3.082
X_3	1.197	0.257	0.736	1.773	21.812	3.352
Pseudo R2	0.101					

The unit distribution of the change in the odds ratio is included in Figure 5.

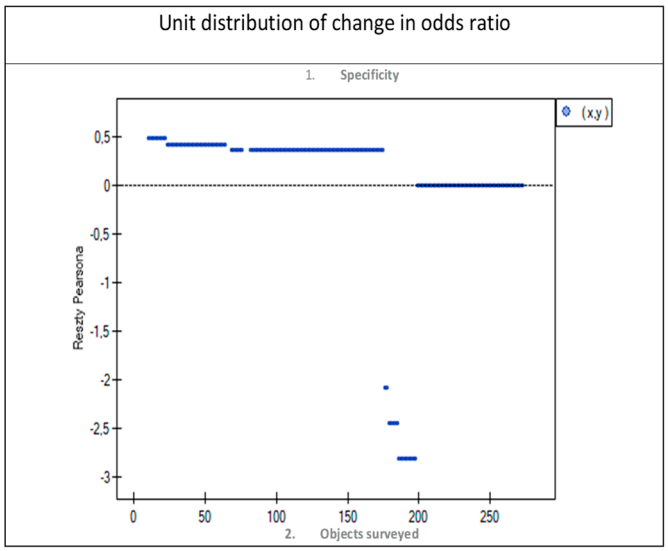

Figure 5. Unit distribution of change in odds ratio.

An in-depth analysis of the data revealed a positive impact of social support on the transformation of the Polish energy system towards RES. Particular support for offshore wind energy development in the surveyed categories is manifested by the young community (respondents under 30 years of age), representing the region directly related to wind energy investments (West Pomeranian voivodeship). This means that social support is stimulated by the direct impact of investment-related processes on the region. On the other hand, this support determines the smooth progress of the process in question, emphasising its socio-economic importance. This confirms the need to monitor public opinion in order to take measures to increase public interest in the projects undertaken through education to elicit the opinions of those who abstain. In doing so, it is important to monitor public opinion with an analysis of trends in its changes.

5. Discussion and Conclusions

The importance of public opinion assumes an important role from the point of view of the undisturbed development of the economy. A critical point in this exercise is the

need to clarify the doubts that the public may raise, as indicated by Čábelková et al. [48] and Buylova in [49]. Comments, opinions, proposals for modifications or additions [50] to ongoing projects are therefore important. Determinations of the degree of support for the implemented measures expressed by the public are made in various forms. Oral or written consultations are undertaken, as well as interviews, surveys or the results of information and education meetings. The diagnostic survey occupies an important place among these forms. Either carried out by those directly involved (the investors' side) or through professional opinion pollsters, process or mechanism researchers, it provides useful knowledge that can be used by decision-makers to tailor actions to the expectations of the parties. In doing so, it is important to emphasise the personal contribution of citizens to the design of responsible change, as pointed out by, among others, the European Commission. Kádár i in. [51], which strengthens the formation of responsible attitudes. This is an important measure, as the level of alignment creates future economic benefits, which strengthens the rationale for investment projects.

The need to court public opinion on the offshore wind dimension [52] is necessary [53], due to the still relatively limited number of studies in this field in comparison to the significant importance of this dimension in the socio-economic sphere due to its development [54,55]. The offshore wind energy direction represents Poland's contemporary investment challenge, offering the potential to strengthen the national energy system towards RES. The offshore wind direction, due to the pace and scope of investment projects already implemented and planned in the future, is considered an important element in the transformation of Poland's energy system. Hence, the identification of the current public opinion created through the prism of investment activities undertaken in Poland in the area of RES—which is the subject of this paper—is important and fully justified.

The study of the impact of sustainability measures on public opinion is intended to provide up-to-date knowledge on the characteristics of adopted developments. Narrowing down to the field of offshore wind energy, it is to help in assessing the impact of offshore wind investments on the public opinion on this issue and to estimate the public perception in assessing the effects of this process. Hence, an important aspect of the findings in this dimension is to identify the assessment of the impact of offshore wind farm investments on the development of the country or region. It is also important to assess the aspects of energy security—the market availability of electricity (volume of supply, market price of electricity [56], which is signalled by, among others, the German Ministry of Energy. Friman et al. [57])—as well as reference to aspects of the capacity and efficiency of supply chains [58], which translate into the aforementioned security aspect.

Measuring public opinion can also touch upon the theme of a sustainable approach to society captured in a social partnership. This dimension is related to the evaluation of offshore wind energy development and the associated strengthening of the labour market. The socially expressed evaluation in the development of the RES field in the region is an excellent driving force for pro-environmental consumer activities. The importance of research in this regard is emphasised by Lucas et al. [59], pointing out the need to strengthen public education in order to promote [60] and explain the directions of the ongoing energy transition of economies and to strengthen acceptance of the current of the changes taking place (public awareness [24]). In this regard, Broska et al. [61] point out that public participation strengthens the effect of the implemented measures and can contribute to the formation of energy communities—not insignificant in the process of transformation of national energy systems; hence, education and social inclusion [62] are justified in this regard.

Investments in RES at the level of individual energy buyers [32], to an important extent, can strengthen the interest of the environment in this dimension of activities. A sustainable society is in fact a responsible society, the behavioural models of which may strengthen the activities aimed at stabilising the dimension of supply of clean energy to the market of its consumers.

Another important issue of measuring public opinion is the recognition of environmental protection activities in connection with investment activities in innovative directions of sustainable development, such as in Poland in the offshore wind energy sphere. The main field of interest focuses on aspects of broadly understood safety [63,64], including the safe use of natural energy-bearing raw materials and sustainable economic activities—aimed at reducing the carbon footprint, the importance of which is emphasised, among others, by Wójcik-Jurkiewicz et al. pointing to the continuous need for education in this area [65]. In doing so, it is important to respect the local community and nature [66].

The results of the research presented in this paper indicate an increase in public support for the investment processes undertaken in the area of sustainable development in Poland, with particular emphasis on the development of offshore wind farms. The crucial importance of research on this subject is confirmed by legal regulations obliging to carry out public consultations in the field of common investments.

The findings of the results of the research presented in this paper at a detailed level revealed a causal relationship between the age of the respondents and their position on the assessment of the development of the offshore wind energy direction. Bearing in mind the nature of social opinion monitoring, an analogous representation of Pomeranian voivodeship (in relation to a group of other voivodeships in Poland) in the population of respondents was adopted for data processing. The findings in 2024 confirm the significant support recorded in 2023 for measures aimed at the green transformation of the national energy system—with a particular focus on offshore wind energy development in this area. This year, as last year, the respondent's place of residence plays an important role in shaping public opinion on the issue. Invariably, representatives of the Pomeranian Voivodeship most strongly expect the rapid development of offshore wind energy, linking it to tangible future benefits, which they see in the following:

(a) The development of the region (57%);
(b) The strengthening of the attractiveness of the labour market (55%);
(c) The potential for reducing the market price of energy (84%).

The survey results revealed a 4% lack of support for the implemented measures in general and a 28% lack of opinion on the issue. Compared to 2023, there was a weakening of the negative stance towards offshore wind energy development by 1 percentage point, as well as a lack of opinion by 4 percentage points. The group surveyed identified a set of risks associated with the projects in question in the study region in the form of the following:

1. Destruction or disturbance of marine and terrestrial ecosystems due to the construction and operation of offshore wind farms (58%);
2. Disturbance of the tourist character of coastal resorts in connection with wind energy installations and energy business development (40%);
3. Negative impact of offshore wind farms on human health (22%).

Concerns about disturbance to the landscape in connection with offshore wind energy installations identified in 2023 in a relatively high percentage (41%) were not noted.

The findings of the diagnostic survey to a strong extent reveal public expectations of the potential for improved functioning of the region due to offshore wine energy development, which should be perceived positively. In the sphere of threats, no negative impacts on people were recorded for wind farms located at such a crucial distance (26 km from the shore); hence, comments in this regard should be considered pointless. In other respects, i.e., the potential for negative environmental impact of wind farms, it is important to undertake research and activities to reduce the risk of negative effects of their erection and ultimate operation. Public education on actions taken to prevent negative environmental impacts should be communicated. The promotion of this knowledge should be particularly widely carried out for the community functioning in the direct vicinity of the investments in question.

Invariably, since 2023, public opinion has focused on the development of the region. Indeed, offshore wind investments represent intensive economic development, entailing

the development of the labour market, which should be followed by an increase in social well-being [30]. Emphasising these arguments should result in a broader openness to offshore wind, although, as research shows, support for the investments in question is increasing. This is a good direction, indicating a social openness to RES. This direction should reinforce responsible behaviour towards sustainability, reinforcing a new trend in energy [67], while creating a new dimension of value [68]. These are important issues of creating public awareness, fixing the basis for the creation of socio-economic benefits on the ground, important for both energy producers and consumers.

Summarising the findings, it is clear that public support for offshore wind energy development is strengthening. This confirms the growing importance of this energy dimension in the country's energy system. Invariably, the strongest support for the implemented measures is shown by the young generation (respondents aged up to 30 years). Detailed research into the findings of the odds quotient in this area confirmed the above trend in the minor dimension—(3.082). A similar odds ratio result was determined for the issue of progress in the transformation of Poland's energy system (3.382). The research limitations created by the adopted sample are important; therefore, with certain reservations, only generalisations can be made in the assessment of public opinion on offshore wind energy development in Poland.

The presented research results are a theoretical enrichment of the existing literature on the area, scope and mode of findings of measurement and analysis of offshore social opinion in a selected region of Poland. Particularly valuable is the analysis of the trend of social opinion changes over time (y/y). The above may inspire analogous research challenges in other regions of the country (e.g., Western Pomerania). The findings may furthermore be of value to other developing countries, in terms of analysing the potential for challenges in the social sphere that are needed to be addressed in relation to the design of offshore development-oriented work. The practical contribution of the findings, in turn, is the confirmation of the appropriateness of the adopted energy system transformation strategy in the studied region of Poland, as well as the indication of the effectiveness of education and social promotion of these activities. The above may constitute an argument for strengthening offshore wind energy development policy in other maritime areas in Poland, providing a source of knowledge on the practical approach to the development of this trend in Poland. Indeed, public support for offshore development in Poland is undeniable. At the same time, it is worth emphasising that the strongest effect of re-evaluation of public opinion in favour of offshore may occur with the integration of the first offshore wind farms into the grid, which will allow the potential benefits in social and economic terms to become a reality, as confirmed by the practice of countries benefiting from offshore energy. This step should positively verify doubts and fears signalled by the community in Poland, justifying the validity of the approach pursued, which has proven itself in the world. The fundamental justification for investment processes is the economic aspect. In this case, the economic strand goes hand in hand with the social and environmental strand, dimensioning a sustainable approach in modelling Poland's energy system. These are important findings, confirming the correct and effective direction of the implemented changes. They may confirm the validity of the direction of European Union investment support for strengthening Poland's energy system towards offshore wind energy, thereby increasing the ability to achieve Poland's and Europe's sustainable development goals.

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