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Poland's energy policy: main problems and forecasts

Abstract: The objective scope of this analysis is focused on selected problems of the Polish energy policy. The text addresses three groups of issues connected with Polish energy policy: (1) institutional and legal matters, (2) forecasting, and (3) problems. In the first case, attention is given to the statutory solutions with regard to the goals, tasks, the model and the elements of the energy policy, as well as to the responsibility of different entities for its implementation. In the second case, scenarios for the development of the energy policy are presented; they are also subjected to a brief comparative analysis. In the third case, attention is given to the presentation of the following issues: (1) energy dependence, (2) energy monoculture, (3) the level of development of renewable energy sources, (4) emissions performance, and (5) energy efficiency. In order for the research problem to be elaborated, the text features the following research questions: (1) to what extent do institutional and legal solutions affect the effectiveness of the energy policy pursued in Poland?; (2) which scenario for the development of Polish energy policy should be deemed most likely?; (3) which problem issues singled out in the analysis should be regarded as the greatest challenge to the Polish energy policy?

Key words: energy policy, energy forecasts, energy security, energy production structure, energy dependence, renewable energy sources, energy sector emission performance, energy efficiency

Introduction

The object of analysis in the present text is concerned with the Polish energy policy from the institutional-legal, forecast and problem aspect. In the first case, the analysis will focus on the statutory solutions related to the goals, tasks, the elements as well as the model of energy policy, also within the compass of the entities pursuing the energy policy in Poland. In the second case, scenarios for the development of an energy policy and their comparative analysis will be presented. In the third case, a selection of the Polish energy policy as well as challenges to the entities responsible for their implementation will be presented. The chief problem issues have been recognised as: (1) energy dependence, (2) energy monoculture, (3) a development level of renewable energy sources, including low-emission ones, (4) emission performance, and (5) energy efficiency. The individual issues, that is the selected diagnostic features of the energy policy, have been illustrated with the analyses of the index values. The following indexes have been considered crucial: (1) the energy dependence index, (2) the Stirling index, (3) the index of renewable energy use, (4) the emission performance indexes, and (5) the energy efficiency indexes.

The main goal of the analysis is to present the crucial issues and challenges that the Polish energy policy is facing. In order that the research problem can be elaborated, the text features the following research questions: (1) *To what extent do institutional and legal solutions affect the effectiveness of the energy policy pursued in Poland?*, (2) *Which one of the scenarios for the development of the Polish energy policy should be deemed most likely?*, (3) *Which ones of the problem issues singled out in the analysis should be regarded as the greatest challenge to the Polish energy policy?*

The analysis included in the text is of an informative character, and hence the conducted research will consist in elaboration of and a synthetic approach to secondary data. It is, however, to be noted that the collected quantitative and qualitative secondary data will be supplemented with the author's own conclusions and opinions. In the case of the analysis of the quantitative secondary data, where the Stirling index is used, the author's own calculations will be performed. In the case of the description of the term of energy policy and the subjective scope of energy policy, the legal-institutional approach has been adopted. In the case of the description of the forecasting aspects of Poland's energy policy, a comparative analysis will be performed for the three exploratory scenarios contained in the draft energy policy of 2015.

1. Description of legal and institutional aspects of energy policy

1.1. Concept of energy policy

While analysing energy policy in the institutional and legal approach, attention should be given to political activities of an instrumental character. In the case of Poland, the instrumentalism is of a negative character, and one of its effects is a low level of statutory law established by the legislator. The bad quality of the statutory law above all concerns such issues as its clarity, systematicity and lack of stability (cf. Rosicki, 2015a, pp. 51–62).

The lack of reasonable and long-term strategic plans in the energy sector – despite the existence of many “policies” and “strategies” concerned with energy issues – is a crucial problem. The lack of real accountability for non-performance of the guidelines contained, among others, in the document specified in the *Energy Law Act* (Chapter III, Art. 13–15, UPE), which gives rise to the lack of rationality in the investment and planning process.

Another one of the problems related to the legal aspects of energy policy is the one concerned with its character within the structure of administrative and constitutional law. The document on energy policy is drawn up by the *Minister of Energy*, and then it is approved by way of resolution by the *Council of Ministers*. It must, however, be stressed that the resolutions of the *Council of Ministers* are of an internal character and are only applicable to organisational units subordinate to the body issuing such acts (Art. 93 of the *Constitution of the Republic of Poland*). In addition, the effect of the resolution is the acceptance of the document of a “planning” character, which is of no binding force in the sense that non-implementation does not result in any legal consequences, e.g. accountability on the part of the *Council of Ministers* or the *Minister of Energy* (cf. Czarnecka, Ogłódek, 2007, pp. 331–334; Elżanowski, 2008, pp. 77–80; Waligórski, 2008, pp. 69–74). The consequence of such a solution is a document of a blanket character, which in turn gives rise to a question about credibility and stability of the energy policy pursued by the executive in Poland.

The main instruments of energy policy have been defined in the third chapter of the *Energy Law Act*. Analysing the particular articles in the above-mentioned chapter of the act, one can distinguish various understandings of the concept and term of “energy policy”: (1) defining the goals of energy policy (Art. 13 UPE), (2) defining the tasks and the action model (Art. 12 UPE), (3) describing the elements of the “energy policy” document (Art. 14–15 UPE), (4) pointing at the bodies responsible for “energy policy” (Art. 12 and 12a UPE) (cf. Czarnecka, Ogłódek, 2007, pp. 325–363; Pawełczyk, Pikiewicz, 2012, pp. 430–482).

As one attempts to divide the content of the articles in the third chapter, one can distinguish the following issues concerned with “energy policy”:

(1) an energy policy strategy (Art. 12 UPE), (2) a specific document on energy policy (Art. 13–15a UPE), (3) energy security monitoring (Art. 15b UPE), (4) the competitive energy market (Art. 15c and 15f UPE), (5) requirements for energy companies (Art. 16–16b UPE), (6) a local energy policy (Art. 17–20 UPE).

The obligatory objective scope of the planning document, referred to as the “national energy policy,” encompasses the following issues: (1) a country’s fuel-energy balance; (2) generation capacity of the domestic fuel and energy sources; (3) transmission capacity, including cross-border connections; (4) energy efficiency of the economy; (5) environmental conservation activities; (6) development of the renewable energy source installation use; (7) quantities and kinds of fuel reserves; (8) directions of restructuring and ownership changes in the fuel and energy sector; (9) directions of scientific and research work; (10) international cooperation (Art. 14 UPE). Despite precisely pointing to the main items in the content of the planning document, the literature levels accusations of the quality of the issues under preparation, e.g. attention is drawn to the inadequate elaboration of Poland’s fuel-energy balance, which may result from the lack of statutory regulation of its content (cf. Zawiska, 2016, pp. 58–64).

1.2. Subjective scope of energy policy

For quite some time it has been proposed that the energy policy be formulated by a specially separated ministry (cf. Rewizorski, Rosicki, Ostant, 2013, pp. 311–314; Rosicki, 2015a, pp. 51–62). *The Ministry of Energy* was established by virtue of the Act of 19 November 2015 *to amend the Act on government administration departments and some other Acts* (as amended on 11 February 2016) (Journal of Laws 2015, item 1960). Until that time the tasks and authority assigned to the *Ministry of Energy* were executed by the *Ministry of Economy*, so the energy industry was assigned to the economy sector. It appears that the new solution may, in principle, be assessed positively, for the Polish energy industry will necessitate more effective action, also in the institutional dimension. Besides, specialisation is a natural process of contemporary administration development, including the central government level (cf. Swora, 2012, p. 105 onwards). Even though some arguments are put forward, whereby such institutional fragmentation will be less rational in some scopes. For instance, M. Swora and M. Stefaniuk claim that the former solution offered more possibility for reconciling various interests in one government department (Swora, Stefaniuk, 2016, pp. 39–40). While analysing the changes, another demand may be made – it concerns the need to consolidate at least selected environmental conservation departments and energy generation, and thus to extend the formula of the *Ministry of Energy* activity.

The tasks of the *Ministry of Energy* are laid down in Art. 12, Para 2 of the *Energy Law Act* (UPE), where the following is pointed to: (1) drafting the national energy policy and coordination of its implementation; (2) defining detailed conditions of planning and functioning of the systems for fuel and energy supply, in the mode and scope specified in the act; (3) supervision of the security of gaseous fuel and electrical energy supply as well as supervision of the operation of the domestic energy systems in the scope specified by the act; (4) cooperation with province governors and local authorities in planning and implementation of fuel and energy supply systems; (5) coordination of cooperation with international government organisations in the scope specified in the act.

Despite the changes, and given the appointment of the *Minister of Energy*, the deliberations concerned with his role as the body supervising the energy policy are still topical. His position results from the separation of the function to create energy policy in the strategic and systemic dimension from the regulatory function on the energy market. Hence, this can serve as an example supporting the claim that the supervision of energy policy is situated at the political (ministerial) level and the level of central administration institutions. Consequently, there is the necessity to point to other entities connected with the sphere of energy policy, e.g. *the President of the Energy Regulatory Office, or the Government Plenipotentiary for Strategic Energy Infrastructure.*

2. Description of forecast aspects of energy policy

2.1. Scenarios of energy policy

The premises of the Polish energy policy provide for three main scenarios, that is (1) *a balanced scenario*, (2) *a nuclear scenario*, and

(3) *a scenario based on the development of the RES sector and the gas sector* (gas + RES). Distinguishing individual scenarios was a result of the adopted goals which should actuate the Polish energy policy, among others: (1) the necessity to limit the negative impact of the energy sector on the natural environment, (2) the necessity to effectuate the assumptions of the energy policy of the European Union, (3) the necessity to verify the costs of hard and lignite coal mining, (4) the necessity to consider the reasonableness of the development of the nuclear energy industry, (5) the necessity to precisely define the potential of conventional and unconventional gas, (6) the necessity to precisely define the potential of unconventional energy sources (*Projekt Polityki energetycznej Polski do 2050 roku*, 2015).

The first scenario, that is the *balanced scenario*, provides for a lack of particularly revolutionary changes to Poland's energy structure. This scenario points to the need to continue the former trends and assumptions in the domestic energy policy. The forecast assumptions in this variant involve a lesser risk of possible costs should erroneous decisions be made with regard to the energy sector. It is noteworthy that the period 2035–2050 is projected to be characterised by a certain degree of stability, which means that Poland's energy balance would not undergo major changes. Still, it must be stressed that the renewable energy sources and gas would be gaining more and more significance in the energy structure, while coal and oil would preserve their substantial – and yet limited compared to the current state – role (Ciechanowska, 2014, pp. 839–842; *Projekt Polityki energetycznej Polski do 2050 roku*, 2015).

In the case of the *balanced scenario* an increase in the energy balance share for the renewable source energy is expected (as a result of the realisations following from the EU regulations concerned with the obligations to ensure a RES share of at least 10% in transport fuels, and of 15% in the primary energy balance and goals concerned with emission reduction). Besides, given the necessity to build a uniform energy market in the European Union and to strengthen the old transmission infrastructure, there will be a need to increase the investment outlays on the development of (smart) transmission and distribution grids, including the extension of inter-system connections with a view to increasing the transmission capacity. Maintaining a steady rise of gas share in the electrical energy generation structure (three-and-a-half-fold increase compared to 2015) will require a proper engineering and technical staff (*Wnioski z analiz prognostycznych...*, 2014; *Projekt Polityki energetycznej Polski do 2050 roku*, 2015).

The second one of the proposed scenarios is a *nuclear scenario*, which does not appear to be the most real one. It must be pointed out that the outlays on the realisation of this undertaking would be the greatest, which is connected with substantial investment costs, as well as the costs concerned with the development of human resources. Still, it is noteworthy that in the future the investment costs might be offset by relatively low costs of fuel acquisition (cf. Badyda, Kuźniewski, 2015, pp. 695–700; Bartnik, Hnydiuk-Stefan, 2016, pp. 257–263).

It is worth pointing out that the development of the nuclear sector might bring positive results in the scope of: (1) energy security (understood as security of energy supply and diversification within the energy structure), (2) reduction of the energy sector emission performance, (3) energy efficiency (understood as losses in the energy transformation processes) (cf. Kubowski, 2016). Hence, increasing the energy security would consist in reducing the threat of power outages, enhancing the stability of electrical energy production, while diversifying the structure of electrical energy generation. Threats resulting from mechanisms for ensuring access to nuclear fuel can be regarded as a risk in the energy supply chain.

The third one of the proposed scenarios is the *gas + RES scenario*, which appears to be feasible, particularly when we take into consideration the development of transmission grids and the plans to create a gas hub in Poland. In this scenario, the share of the two main carriers, that is gas and RES, in the energy balance would amount to 50–55%. The realisation of the scenario assumptions will result in: (1) a substantial elimination of the emissions in the Polish energy sector, (2) a substantial diversification of the energy structure. Preserving the sources of great installed power capacity allows for an effective use of distributed and less stable renewable sources in the situation of problems with electrical grid balancing (Bukowski, Śniegocki, 2011; *Projekt Polityki energetycznej Polski do 2050 roku*, 2015).

The gas + RES scenario will require continual outlays on the gas transmission and distribution infrastructure, but above all on gas-fired power plants. The realisation of this scenario will also require a development of gas storage infrastructure so as to eliminate threats to gas supply security. Besides, it seems that the heralded extensive mining of unconventional gas in Poland will take place on account of the geological, but above all economic conditions. Hence, the activities geared towards development of the transnational gas transmission infrastructure should be intensified (cf. Pronińska, 2013, pp. 42–67; Rosicki, 2015b, pp. 133–148).

2.2. Evaluation of the energy policy scenarios

While comparing the scenarios of the energy industry development, it must be assumed that all long-term forecasts and long-term scenario methods are fraught with a strong possibility of error. This does not mean that the main advantages of the individual energy policy scenarios cannot be pointed out. In the case of the *balanced scenario*, which can be deemed most probable – even though political factors might affect this – it must be stated that it is the least problematic one for the country’s current economic structure. However, maintaining a considerable share of solid fuels in the country’s energy structure for a long time would be its disadvantage. Furthermore, compared to the other scenarios, the realisation of this one will involve the least reduction in greenhouse gas emissions.

In the case of the *gas-RES scenario, compared to the others*, we would witness a substantial reduction in greenhouse gas emissions, and by extension an improvement of air quality in Poland. In order to realise this scenario, activities aimed at the development of transmission and distribution grids would have to be intensified, both for gas and electrical energy. Besides, activities aimed at the liberalisation of the energy markets would have to be undertaken, with a view to facilitating economic development and creating the most favourable conditions for consumers as well as a prosumer-friendly market.

The assessment of the *nuclear scenario* and of the development of the nuclear program itself ought to be negative, not because of the reasonableness or non-reasonableness of the creation of this type of energy industry, but because of the unclear and hardly decisive political action in this respect. It must be pointed out that the realisation of the program of a nuclear power plant construction is rather unlikely in the nearest future. The content of the *Poland’s Energy Policy Until 2050* draft included the stages of the investment realisation, which already at the moment of their announcement were unfeasible. It was expected that the change of government in Poland in 2015 would bring more commitment to the development of the nuclear energy industry; such an expectation might have been premised on the emphasis laid on the issues of energy supply diversification and security by the new government. Till now these premises have not come to fruition in the form of any game-changing decisions or political action, since no coherent vision on operating plans in this respect has been presented. Furthermore, the economic plans presented after 2015 feature a variety of ways in which to develop the energy industry. On the one hand, the announcements of the development of the nuclear energy industry with a pre-defined installed capacity (6000MW) are continued, but on the other hand innovative projects on Gen IV nuclear reactors, that is ones concerned with the development of HTR (*High Temperature Reactor*) and SMR (*Small Modular Reactor*) technologies are presented (cf. *Program polskiej energetyki jądrowej*, 2014; *Uchwała nr 15/2014...*, 2014; *Uchwała nr 14/2016...*, 2016; *Plan na rzecz Odpowiedzialnego Rozwoju...*, 2016; *Obwieszczenie Ministra Energii...*, 2017).

Taking into account the above-mentioned remarks, it must be admitted that one should not expect commissioning of commercial nuclear reactors with the announced installed capacity before 2030 (and maybe even before 2035). The development of innovative programs of HTR and SMR technologies is to be deemed more probable. Still, these assumptions will have to be verified on account of political factors: (1) political divisions (intergovernmental, inter-party and interparliamentary), (2) interest group activity (including energy sector interest groups).

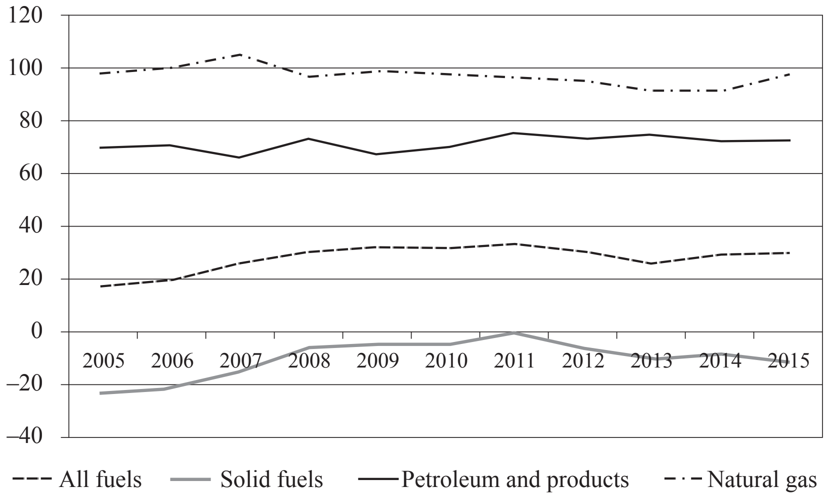
It is worthwhile to stress that as a result of political factors any radical solutions based on enterprising decisions aimed at changing the Polish energy industry may be treated as less probable. Given the analysis of the political and legislative activity between 2004 and 2017, it can be concluded that Poland’s international obligations are the decisive factor affecting the Polish energy policy – both in the regional and global aspect. In the former aspect, Poland’s membership of the European Union is of the greatest importance, which involves the necessity to fulfil the requirements concerned with the natural environment protection and energy generation; the requirements were laid down among the EU states. The solutions worked out in the European Union compete against the internal policy and the economic situation of Poland. Hence, the energy policy directions will be deeply affected by election results. One can assume that liberal, left-wing and “pro-EU” parties are more inclined to make decisions changing the main directions of the energy policy. More conservative and “EU-sceptical” parties prefer decisions favourable to the traditional energy policy, preserving the significance of conventional carriers (hard and lignite coal), while showing a bias against radical solution, as well as a minimalist implementation of the energy policy guidelines laid down on the European Union level (cf. *Bezpieczeństwo energetyczne...*, 2015; Księżopolski, 2015).

3. Description of main energy policy problems

In the present analysis the following items have been regarded as the main problems to the Polish energy policy: (1) energy dependence, (2) energy monoculture, (3) a development level of renewable energy sources (and/or low-emission sources), (4) emission performance, and (5) energy efficiency. The individual problems have been linked with indexes allowing for a synthetic description of the enumerated problems. Among these indexes reckoned are: (1) the import dependence index, (2) the Stirling index, (3) the index of renewable energy use, (4) the indexes of emission performance, (5) the indexes of energy efficiency.

The import dependence index is frequently identified with the index that is supposed to describe the level of energy security. The link between this index and security results from the fact that energy security is construed as the security of raw material and electrical energy supply (cf. Chester, 2010, pp. 887–895; Pronińska, 2012, pp. 21–61; Rosicki, 2012, pp. 35–66; Winzer, 2012, pp. 36–48; Soroka, 2015, pp. 13–38). The analysis presented in the text features both the overall index of import dependence for all the main carriers and the indexes for individual carriers, that is gas, petroleum and its products, and coal (see Figure 1).

Figure 1. Index of Poland’s import dependence in 2005–2015 (in %)



Source: Own study based on Eurostat and IEA data.

The index of import dependence with regard to all the carriers amounted to almost 30% in 2015, which means that it was 25% better than the EU mean for all the member states at the same time. The countries with indexes better than the one in Poland were Estonia (7.4%), Denmark (13.1%) and Romania (17.1%), whereas in Sweden (30.1%), the Czech Republic (31.9%) and Bulgaria (35.4%) the index value was close the Polish one. It is interesting to note that two decades earlier the index value for all the carriers in Poland amounted to –1.2%, which was indicative of a high level of energy self-sufficiency (cf. Figure 1).

Poland’s distinguishing feature was the high level of self-sufficiency with solid fuels, that is hard and lignite coal, which results from Poland being in possession of sizeable reserves and the Polish energy industry relying on them. Despite the fact that Poland has its own reserves, the change in the index value of solid fuel dependence is noteworthy. In 2005–2015 the index fluctuated, which resulted from the global and domestic economic situation, as well as from structural changes in the Polish mining industry. The import dependence index for solid fuels registered –30.2% in 1995, 23.9% in 2005, whereas 2011 witnessed a substantial deterioration in import dependence, which came to be expressed in the index value reaching –1.1%. In 2015 the index value for all the solid fuels registered –11.6%, but it must be emphasised that for hard coal the index value was 1.0% in 2014. The situation on global markets and on the Polish market, structural changes and an accumulation of problems concerned with the lack of effective political decisions caused the import dependence index value for hard coal to reach –31.7% in 1995, –21.3% in 2005, 3.7% in 2010, and five years later it amounted to about 1.0% (cf. Figure 1).

Poland shows a high level of import dependence on petroleum and petroleum products; one might say that since 1995 this index has not registered much change. This is the outcome of a lack of own substantial petroleum reserves and the resulting necessity to heavily rely on import. Diversification of petroleum import sources and directions remains a problem, since the eastern direction prevails.

Another one of the carriers on which Poland is heavily dependent is gas, but the value of this index is not as high as the one of petroleum, which amounted to more than 72% in 2015. The value of this index was slightly higher compared to 2005, but it increased by 2.5%, while compared to 1995 it increased by 7.6%. Greater import dependence was to be observed with gas liquids (NGL), whereby the import dependence index registered 97.1% in 1995, 97.3% in 2005, and 96.5% in 2014 (cf. *EU energy in figures...*, 2016, pp. 69–71).

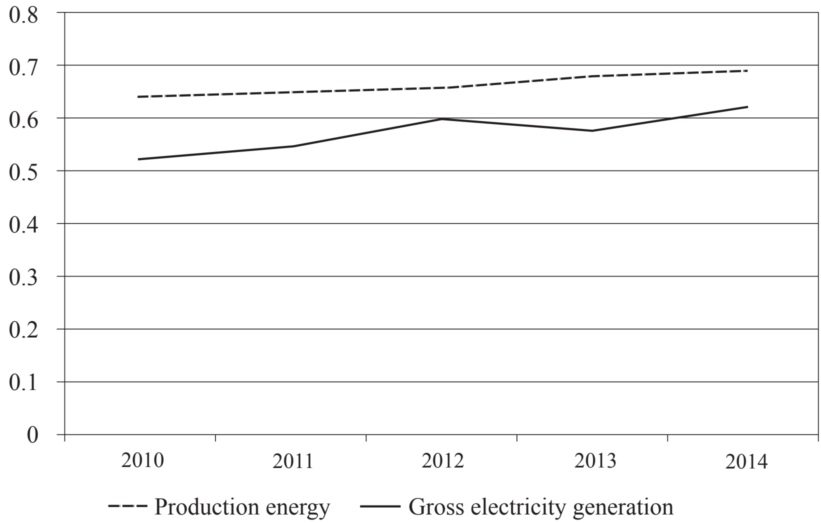
While analysing another problem that might be linked with the energy generation sector and Poland's energy policy, attention can be drawn to the energy structure diversification. To illustrate Poland's special situation, the Stirling index will be used. It must be pointed out that with the aid of this index, a diversification of various energy structures can be analysed, e.g. the primary energy generation structure, the electrical energy generation structure, as well as the energy consumption structure. In the case of the presented analysis, the Stirling index was used to calculate the diversification level of the energy generation and electrical energy generation (Kaliski, Staśko, 2003, p. 4; Kaliski, Staśko, 2007, pp. 11–12; Kałążna, Rosicki, 2010, pp. 69–73; Leszczyński, 2012, p. 4).

The analysis featured trends in the value changes of the Stirling index for "energy generation" and gross electricity generation in 2010–2014. In the first case, following the Eurostat methodology, "energy generation" was construed to encompass primary energy generation along with the products obtained otherwise. The main elements of this kind of generation include: (1) indigenous production, (2) primary product receipts, (3) receipts from other sources include supplies of energy commodities, the production of which has already been covered in other fuel balances, (4) recycled products (*Energy Statistics of the European Union...*, 2015). In the second case, gross electricity generation embraces a total electricity quantity that is generated as a result of converting other energy forms, e.g. nuclear or wind energy. It also embraces electricity used by auxiliary generators and transformer losses, that is energy used for purposes of energy conversion (*Electricity gross generation...*, 2017).

The structure of electricity generation and consumption in Poland is not balanced, and the same applies to primary energy generation, which directly results from heavy reliance of the Polish energy industry on solid fuels (hard and lignite coal). From the perspective of energy security assessment, the low value of the Stirling index alone does not have to be viewed negatively. For instance, if we make a theoretical assumption that Poland would not be obliged to make any changes as to low-emission performance, and the domestic solid fuel reserves were sizeable, and the import dependence index was adequately high, then the threat to the energy security would be rather negligible. Still, the necessity to make changes as to the low-emission performance, and to develop the renewable energy industry enforces a broader context for the analysis of energy diversification. Besides, given the depleted reserves (including the deposits of the so-called recoverable coal), diversification of the country’s energy structure should be one of the main tasks.

The years 2010–2014 brought a visible slight uptrend in the value of the Stirling index for energy generation. In this period the value of the index was in Poland much lower than the value of the index for all the European Union member states. For instance, in 2010 the Stirling index value in Poland registered 0.639, in Germany – 1.381, and in the 27 EU member states – 1.576. For comparison, in 2014 the value of the index in Poland was 0.689, in Germany – 1.397, whereas in the 28 EU member states – 1.549 (see Figure 2). Interestingly enough, if scenarios for the development of the size and structure of the domestic demand for primary energy, according to the same fuels in 2030 and 2050 were taken into account, then Poland’s situation would considerably improve, for in the first case the Stirling index would register 1.435, while in the second case it would register 1.556.

Figure 2. The Stirling index value for Poland 2010–2014



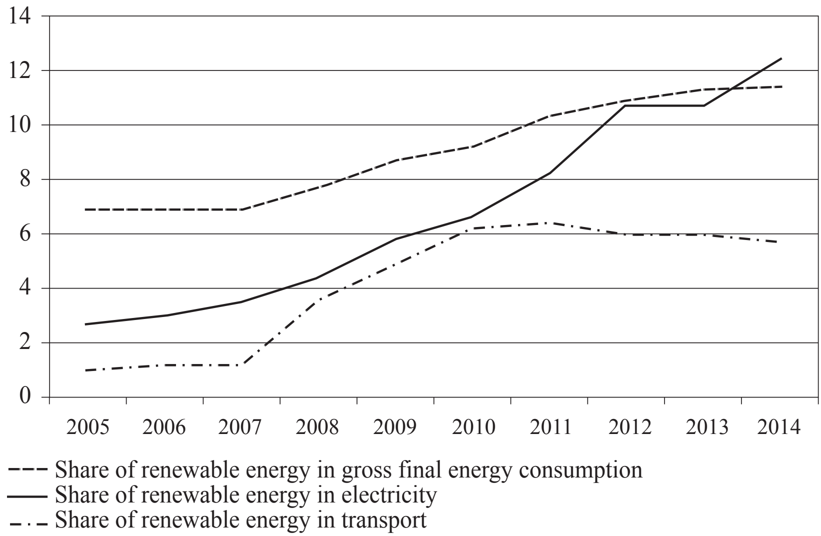
* The calculation of the Stirlinga Index was performed for the main five carriers n=5 (solid fuels, nuclear fuels, gaseous fuels, petroleum and petroleum sub products, renewable energy sources along with waste). Hence, the optimal value for the balanced distribution for n=5 amounts to 1.6.

Source: Own study and calculations based on Eurostat and IEA secondary data.

As for the gross electricity generation in 2010–2014 there is also an observable slight uptrend in the Stirling index value. Similarly, like in the previous case, the index value for Poland was much lower than the index value for all the EU member states. While in Poland the Stirling index value for gross electricity generation in 2010 was 0.521, in Germany it was 1.360, and in the 27 EU member states it was 1.467. For comparison, in 2014 the index value for Poland was 0.619, for Germany – 1.299, while for all the 28 EU member states – 1.424 (see Figure 2).

The following are selected to form a group of indexes illustrating the use of renewable sources: (1) a share of the renewable energy sources in the final gross energy consumption; (2) a degree of electricity generation based on renewable sources; (3) a share of renewable sources in transport fuel consumption. Adoption of these indexes makes it possible to describe the share of renewable energy sources after energy transition in the case of the use of energy by end users, as well as to describe the share of renewable energy sources in electricity generation, and the share of renewable energy sources in the consumption of fuels in the transport sector (see Figure 3).

Figure 3. Share of energy from renewable energy sources in Poland 2005–2014 (in percentage points)



Source: Own study based on Eurostat data.

As for the increase in the share of renewable energy sources, of great importance are the EU requirements and the necessity to implement the resolutions concerned with the *climate and energy package*. The homogeneous structure of final and electrical energy production brings the share of renewable energy sources down to a small quantity, although there is a visible rise in the share of both final energy consumption and of electrical energy production. As for the index of share of renewable energy sources in transport, there is an observable downswing in 2012–2014. It is also noteworthy that in 2014 a considerable share of the electricity produced from renewable energy sources was in the sector of heat generation – it amounted to 67% (cf. *Sprawozdanie z działalności...*, 2016, pp. 39–41).

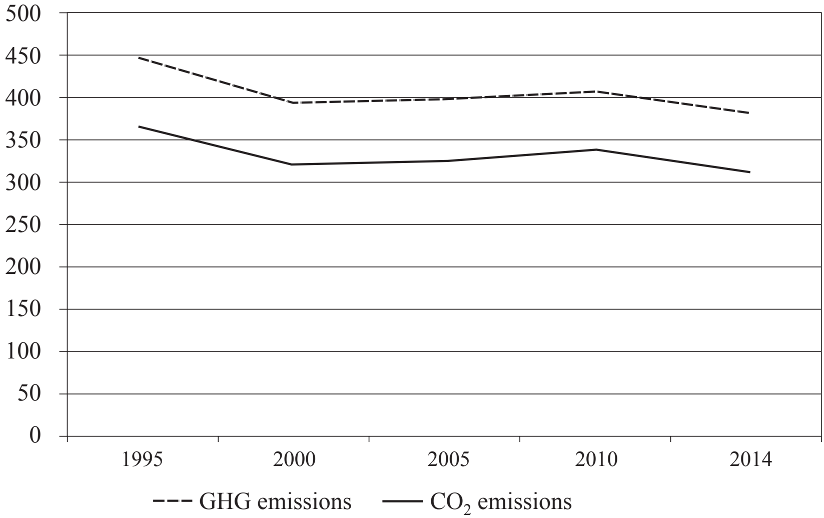
In 2014 the share of renewable energy sources in the final gross energy consumption in Poland was 11.4%. With this share Poland ranked ninth in this respect among the 28 EU member states, whereas the lower share was in: Hungary (9.5%), Cyprus (9.0%), Ireland (8.6%), Belgium (8.0%), UK (7.0%), the Netherlands (6.0%), Malta (4.7%) and Luxembourg (4.5%). At the same time the share of renewable energy sources in the produced electricity amounted to 12.4%. The lower share was in: the Netherlands (10.0%), Cyprus (7.4%), Hungary (7.3%), Luxembourg (5.9%) and Malta (3.3%). The share of renewable energy sources in 2005–2014 consistently rose in Poland, though at the same time there were changes to the structure of the share of individual carriers in electricity generation. Considerable dynamics was observed in wind energy generation, while production of energy from solid biofuels remained constant and at a high level. In 2015 the share of wind energy generation as part of RES generation of electricity amounted to almost 48%, while the share of solid biofuels amounted to almost 40% (*EU energy in figures...*, 2015; *EU energy in figures...*, 2016; *Energia ze źródeł odnawialnych...*, 2016, pp. 31–40).

The share of renewable energy sources in the use of transport fuels in Poland registered 5.7% in 2014, which – despite negative assessments – is a value slightly below the mean for the 28 EU member states. Still, it must be stressed that in the same period seventeen EU member states registered a lower index share of renewable energy sources than Poland. For instance, this group included, among others, Spain (0.5%), Greece (1.4%), Portugal (3.4%), Italy (4.5%), Belgium (4.9%), UK (4.9%), Ireland (5.2%) and Luxembourg (5.2%) (*EU energy in figures...*, 2016; *Energia ze źródeł odnawialnych*, 2016, p. 51). Remarkably enough, the development of the sector of renewable energy sources in transport may become one of the factors enhancing the dynamics of the country's economic development, even though the lack of clear and stable legal solutions makes such prospects impossible. A major role in the lack of stability in this fuel sector is played by ill-considered political decisions, often caused by ad-hoc interests of the fiscal and parliamentary policies.

It is worthwhile pointing out that the growth rate of the RES share in Poland will be affected by political and institutional factors. For instance, from the viewpoint of investors, Poland is characterised by: (1) an untransparent legislative process, (2) a poor quality of the established laws, (3) a lack of predictable directions in the legislative solutions concerned with the support of renewable energy sources and the operation of their market. The lack of clear legislative and energy policy planning may, in the future, result in a slowdown in the growth of RES share, and in Poland's minimalist commitment to the implementation of more ambitious solutions at the EU level, and – depending on the political stand taken by a government currently in power – also in obstruction thereof. At the same time, attention should be given to the fact that Poland does not fulfil its potential concerned with the development of renewable energy sources, which might positively affect the economic growth.

The greenhouse gas emissions in Poland amounted to 382 Mt (CO_2 equiv.) in 2014, while the emission of CO_2 alone amounted to 312.5 Mt (Million ton CO_2). Both the first case and the second one registered a downtrend in emissions in 1995–2014 despite a momentary rise (see Figure 4). With the data concerned with the value of the GHG emission index it is possible to point out that the emission performance of Poland in 2014 was reduced by more than 14% compared to 1995, and by more than 6% compared to 2010. In the case of the GHG emissions, in 2014 the countries with higher emissions were only Germany (924.8 Mt), UK (556.7 Mt), France (475.4 Mt) and Italy (428 Mt). The emission performance of Spain, whose population outnumbers Poland by more than 6 million, was in the neighbourhood of that of Poland (342.7 Mt). This means that Poland, despite its heavy reliance on coal for energy generation purposes, was not the largest GHG emitter in the European Union; for instance, in 2014 Germany emitted 142% more GHG than Poland. As for the emission of CO_2 alone, the order is adequate to the GHG emission, that is Germany – 817.2 Mt, UK – 464.6 Mt, France – 352.6 Mt, Italy – 352.2 Mt (cf. *EU energy in figures...*, 2015; *EU energy in figures...*, 2016).

Figure 4. GHG and CO_2 emissions in Poland, 1995–2015 (million ton CO_2 equiv. and million ton CO_2)



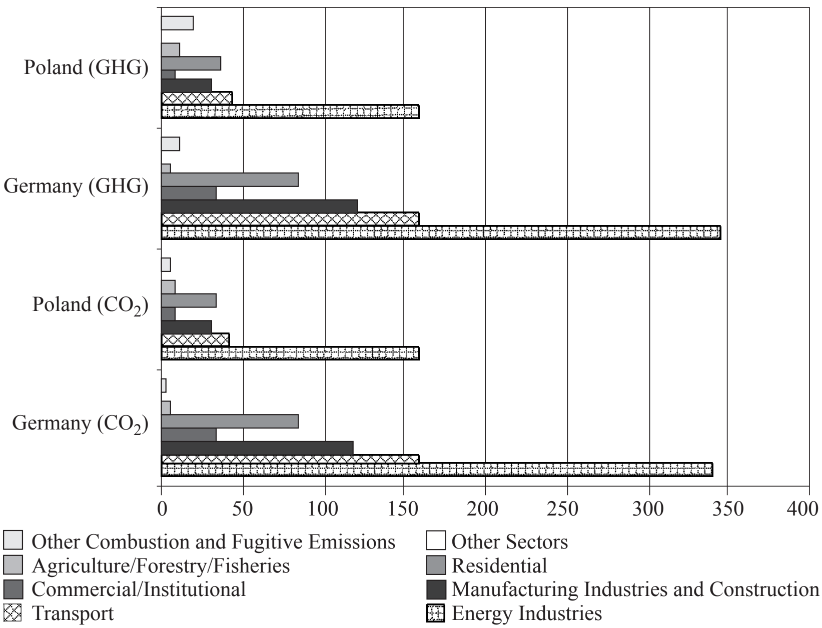
Source: Own study based on Eurostat data.

The conclusion that can be drawn from the above analysis is that Poland is among the countries leading the way in the development of low-emission energy generation; moreover, Poland is not the largest GHG emitter among the 28 EU member states despite the fact that such an image of Poland is projected in the mass media. Still, this analysis should take into account the level of overall energy production, efficiency and emission indexes, given the ratio of the number of inhabitants and/or Gross Domestic Product of a given country. For instance, the Carbon Intensity index (when converted to kg CO_2/toe) for Poland registered 3314 in 2014. In the same period, the highest index value was in Cyprus (3442) and Greece (3375), whereas in Germany, the largest GHG emitter among the 28 EU member states, the index was lower than in Poland – 2611 (cf. *EU energy in figures...*, 2016).

Besides the analysis of the Carbon Intensity index, also the values of the CO_2 emission *per capita* index (kg CO_2/cap) and the Carbon GDP Intensity index (ton CO_2/M€’10) are to be compared. In the first case the value of the index in Poland was 8221.1, but – like with the GHG and CO_2 emissions alone – there was no longer the usual set of main countries, i.e. Germany, UK, France and Italy. The greatest values of the CO_2 emission *per capita* index among the 28 EU member states were in Luxembourg (the index value was twice as big as in Poland), Estonia, Germany, the Netherlands, the Czech Republic, Finland and Cyprus. In the case of the Carbon GDP Intensity index, the value in Poland was 774.6, while in Germany it was 298.6. It is worth paying attention to the considerable downtrend in the value of this index in Poland, for it amounted to 1910.7 in 1995. For instance, in the same period a similar index value in Estonia dropped by almost 52% (cf. Budzianowski, 2012, pp. 575–581; *Trends in global CO_2 emissions...*, 2014; *EU energy in figures...*, 2016).

The problem of Poland’s emission performance should also be considered in the context of the emission performance of the energy sector itself and the transport sector as part of the GHG and CO_2 emission, which is connected with fuel combustion. In the case of Poland, the energy generation sector (160.4 Mt), the transport sector (44.2 Mt) and households (37.2 Mt) have the greatest shares in the emission of this kind for GHG. There is also an adequate value ratio, as to the order of emissions, in the case of CO_2 alone (see Figure 5).

Figure 5. GHGs emissions and CO_2 emissions from fuel combustion activities in 2014 (million ton CO_2 equiv. and million ton CO_2)



Source: Author’s own study based on Eurostat, IEA data.

It is necessary to note that showing Poland as the chief GHG emitter among the 28 EU member states does not necessarily adequately depict the situation in the European Union. For instance, Germany is the largest GHG emitter among the 28 EU member states, and the largest GHG emitter in the energy generation sector, as well as in the transport sector. This fact should be emphasised, for Germany – in the debate on the directions of energy policy – is presented as an example for others to follow as regards the low-emission energy industry. Germany emits more than twice GHGs in the energy sector and approximately three and a half times more in the transport sector than Poland (cf. *Environmental Trends in Germany...*, 2015). For instance, to present the scale of differences in the emission performance, one might point to the fact that the Polish energy sector emits as much CO_2 as the German transport sector alone does. Still, the thing that typifies Poland is the considerable – in comparison to Germany – quantities of the so-called fugitive emissions concerned with human activity (see Figure 5).

While analysing the emission of greenhouse gases within the energy sector in the 28 EU member states, which is connected with all the processes of fuel combustion, it must be pointed out that Germany is responsible for 10.4% of the emission, Poland – 4.8%, and UK – 4.5%. In the analysis of the emission performance itself of the energy sector in the 28 EU member states, then Germany is responsible for as much as 28% of greenhouse gas emissions, Poland – almost 13%, and the UK – more than 12% (cf. *EU energy in figures...*, 2016).

In 2017 the European Commission presented the “EU Environmental Implementation Review” (*The EU Environmental Implementation Review...*, 2017), in which it invoked earlier results of the analyses by the European Environment Agency (EEA), regarding air pollution. According to the EEA in the years 1990–2014 Poland effected major reductions in many kinds of air pollution. For instance, the emission of sulphur was forced down by 72%, emission of nitrogen oxide by 33%, emission of ammonia oxide by 36%. At the same time the emission of volatile organic compounds increased by 11%.

Following the Environmental Protection Inspectorate, the Supreme Audit Office quoted data, which indicated that in the period 2005–2013 the biggest problem concerned with the air quality was the so-called supernormative concentrations of particulates and the concentration of one of the organic compounds from the group of benzopyrenes, i.e. *bezno(a) pyrene* – B(a)P. The gravity of the situation can be illustrated with the fact that in the years 2011–2013 in 91% of the zones in which air quality is measured, the quality norms were exceeded. Besides, at the same time, the number of zones in which the standard values for atmospheric particulates (particulate matter – PM2.5) were exceeded, was rising. Still, it should be acknowledged that the number of zones with exceeded acceptable concentrations of particulate matter PM10 has dwindled (in: *Ochrona powietrza...*, 2014, pp. 21–24).

However, it is worth noting that in the years 2009–2012 the significance of many factors affecting the emission of PM10 decreased, which comes to be expressed in the fact that an increasingly important role is being played by the so-called low emissions, and a minor role is being played by the transport- and industry-related pollution. This trend is depicted with the aid of the data from 2007–2012, in which a progressive rise in the emission of B(a)Ps concerned with individual building heating systems is to be observed – a rise from 45.8% to 96% (*Ochrona powietrza...*, 2014, pp. 21–24).

As regards the atmospheric particulate matter (PM2.5), when compared to the other 28 EU member states, the influence of the communal sector, that is the low emission, is significant in Poland, but lower than the EU average value. At the same time, one can observe in Poland an impact of factors concerned with energy conversion, that is the energy and transport sector (coal burning, biomass co-firing, transport fuel burning), whereby the emission performance of atmospheric particulate matter (PM2.5) is higher than the EU-28 average (*Sytuacja zdrowotna ludności Polski...*, 2016, pp. 289–300).

According to the EEA the air quality in Poland, given the concentration of fine mode aerosols, may have caused more than 48,000 premature deaths, where the concentration of O_3 may have caused more than 1,000 deaths, and the concentration of NO_2 may have caused more than 1,600 deaths (*Air quality in Europe...*, 2016, pp. 60–61). According to the data of the National Institute of Public Health-National Institute of Hygiene, in 2013 in Poland cardiovascular disease accounted for around 70% of the adverse health effects resulting from the emission of PM2.5. Moreover, according to the same data, the air quality also affects the uptrend in the overall balance of premature mortality causes related to malignant tumours (*Sytuacja zdrowotna ludności Polski...*, 2016, pp. 289–300).

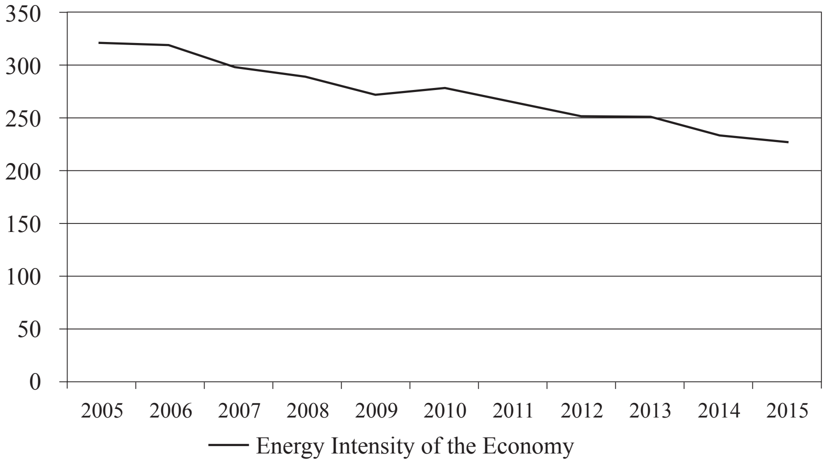
Another group of indexes comprises energy efficiency indexes that may be concerned with energy conversion itself, as well as with the ratio of energy conversion to, say, GDP or GHG emissions. Hence, the energy efficiency as a general concept can be characterised through such indexes as: (1) the Energy Intensity of Economy index, (2) the Carbon Intensity index, (3) the Gross Inland Consumption of Energy *per capita* index, (4) the Final Electricity Consumption *per capita* index, (5) the Primary Energy Intensity index (cf. Forsström et. al., 2011, pp. 12–31; *Energy Efficiency Indicators*..., 2014; *EU energy in figures*..., 2016).

In the analysis the attention was focused on the economy efficiency, that is the Energy Intensity of Economy index, which is a ratio of gross energy use and gross domestic product. This index is supposed to illustrate the amount of energy needed to generate one unit of gross domestic product (see Figure 6). The index defines the use of energy in the production process in individual sectors of the state’s economy. The differences in the level of energy intensity may point to a level of economic development, an economic structure, technological advancement and the kind of carriers used in the production of primary energy. In the case of a low value of energy intensity, conclusions can be drawn as to a greater efficiency in the process of fuel management. Still, it should be pointed out that low energy intensity may characterise countries with low economic growth with the proviso that they feature low energy use in general (cf. Pach-Gurgul, 2012, pp. 166–167; *Energy glossary*..., 2016; Rosicki, 2016, p. 232).

As regards Poland, on the basis of the data concerned with the economic efficiency index, it can be pointed out that Poland’s energy intensity in 2015 decreased by more than 56% compared to 1995, by almost 37% compared to 2000, and by more than 29% compared to 2005. According to the comparative analysis, it must be concluded that Poland is among the 28 EU countries with the highest value of the energy intensity index, which typifies the countries in Central and Eastern Europe (cf. Rosicki, 2016, pp. 225–236). In 2015 among the 28 EU countries with a higher index value of energy intensity of the economy reckoned were only the Czech Republic, Estonia and Bulgaria, whereas the energy intensity of the Bulgarian economy was nearly twice as high. The countries with an energy intensity index similar to Poland included Slovakia, Hungary and Romania.

In the period 2004–2014 we witnessed a steady growth of GDP, which in 2014 reached a value 45% bigger than in 2004. The greatest growth rate was registered in the industrial sector, which at the same time was characterised by a considerable energy intensity (*Efektywność*..., 2016, p. 11). For instance, the Polish processing industry is dominated by three

Figure 6. Energy Intensity of the Economy Index for Poland 2005–2015



* The index defines the quantity of energy (*gross inland energy consumption*) used to generate one GDP unit (kg of oil equivalent per 1,000 EUR).

Source: Own study based on Eurostat data.

energy-intensive industries – the smelting, the chemical and the mineral industry, which in 2014 in total accounted for 55% of energy use, while a decade earlier they accounted for 60% (*Efektywność...*, 2016, p. 18; Komorowska, Mirowski, 2016, pp. 297–305; Skoczkowski, Bielecki, 2016a, pp. 5–18). The changes in the index values illustrate the processes taking place in the Polish economy, as well as the energy transition processes themselves (Szczerbowski, 2013, pp. 35–46).

It is noteworthy that the greatest dynamics with regard to the improvement of energy efficiency was in the engineering, textile and smelting industries. At the same time, some slow changes as to the improvement of energy intensity took place in the timber, chemical and other industries. As for the paper industry there was an observable rise in energy intensity (*Efektywność...*, 2016, p. 20).

R. Szczerbowski points out that the power generation industry, including the electric power industry, may as well be subjected to activities aimed at improving energy efficiency. This follows from the fact that considerable attention is frequently focused on the energy user, while it stands to reason that losses can be contained by way of focusing on electrical energy production, transmission and distribution processes. For instance, according to

R. Szczerbowski the average efficiency of solid fuel exploitation amounts to about 35%, while in the energy transmission and distribution processes, losses are estimated at 9%. Another problem is the conversion technology itself, since it is estimated that the efficiency of electrical energy production in gas-fired systems amounts to 50%, while in the case of coal-fired power stations, the average efficiency amounts to 35% (Szczerbowski, 2013, pp. 35–46; Gollinger-Tarajko, Zaręba, 2015). As regards Poland, improvement of the quality of infrastructure in the generation, transmission and distribution sector will be of great significance; also, attention should be paid to new technologies in the combustion systems, combined heat and power generation and *smart grid* (cf. Marecki, 2005; Davoli et. al., 2012; Skoczkowski, Bielecki, 2016b, pp. 9–14).

It is worthwhile to spotlight the necessity to increase the installed capacity of the power plants and to modernise the currently operational infrastructure. In the first case, a lack of outlays may result in a power shortage, which may directly impact the energy supply security. In the second case, it must be pointed out that the hard coal- and lignite coal-fired commercial power plants account for 75% of the installed capacity. In addition, the condition of generating units in Poland must be taken into consideration, because 58.64% of these are more than 30 years old, and 13.88% are 26–30 years old. Similar statistics apply to boilers in thermal power stations, where 63.38% of these have been operating for more than 30 years (*Sprawozdanie z wyników...*, 2015; *Zapewnienie mocy...*, 2015; *Sprawozdanie z działalności...*, 2016, pp. 39–144).

Summary and conclusions

The object of analysis in the text comprises selected problems of Poland’s energy policy, and hence the analysis is not of an overall character. Thus, there is a necessity for in-depth studies on the presented issues. In order to elaborate the objective scope of the research problem, the following research questions have been included in the text: (1) *To what extent do the institutional and legal solutions affect the efficiency of the energy policy pursued in Poland?*, (2) *Which of the scenarios for the development of the Polish energy policy should be considered most likely?*, (3) *Which of the problem issues isolated in the analysis should be considered the greatest challenge to the Polish energy policy?* The individual questions have been related to the following conclusions:

(1) Conclusions

It must be pointed out that the institutional and legal solutions with regard to the formulation of the Polish energy policy are inadequate. The main problems related to this include: (1) the legal status of the approved "planning documents" of the energy policy, (2) a lack of real responsibility for the lack of the implementation of the approved "planning document" on the energy policy, (3) a lack of stable solutions in respect of the energy policy directions, (4) a lack of strategic solutions in respect of future challenges facing the energy policy. Besides, it must be pointed out that the consolidation of individual areas of issues concerned with the energy industry in one *Ministry* (*the Minister of Energy*) is appropriate, but there must follow more changes that would encompass selected issues concerned with the environmental protection and corporate governance of state-owned companies operating in this field.

(2) Conclusions

The *Poland's Energy Policy Until 2050* draft features three scenarios – *a balanced one, a nuclear one and gas + RES one*. It must be pointed out that the choice of strategic directions of the Polish energy policy is affected by the two main political factors – the internal and the external one. In the first case, of great significance is the question of who currently exercises legislative and executive power. One can assume that liberal, left-wing and "pro-EU" parties would be more willing to make decisions resulting in the change of the main energy policy directions, which are still connected with the maintenance of something that can be termed a "coal culture." Still, it should be pointed out that despite the political stand, political decisions about the energy industry will be affected by interest groups connected with the coal sector and the traditional (conventional) energy generation. In the second case, Poland's membership of the European Union is of the greatest significance, which involves the necessity to fulfil the requirements collectively laid down by the member states and concerned with the protection of the natural environment and the energy industry. Poland's participation in the European Union structures enforces more progressive solutions concerned with the energy sector, and hence it must be admitted that the policy processes as part of the individual community policies, and the integration processes have a considerable influence on the decision processes on the national level. It is worth adding that new work on the energy policy directions is necessary, whereby a more profound and wide-ranging transformation of the Polish energy industry as well as a selection of key technologies would be effected.

(3) Conclusions

The text features an analysis of the main problem issues – the following challenges facing the Polish energy policy: (1) energy dependence, (2) energy monoculture, (3) a development level of renewable energy sources (and/or low-emission sources), (4) emission performance, and (5) energy efficiency. It should be pointed out that the greatest challenge facing the Polish energy policy is the necessity to conduct the transformation of the energy sector, which is still and to a significant degree based on coal. The action undertaken in this respect by the authorities appears to be inadequate, particularly if we take into account the fact that the recoverable hard coal reserves recognised till this day will last for about 30–40 years. Given the fact that Norway is staging an energy revolution, and Germany is to stage one in the forthcoming decades, it is quite likely that Poland will run up against a technological gap and thus remain on the economic periphery. Besides, it should be emphasised that changes to the energy structure might to a considerable degree affect other problems, e.g. emission performance, energy efficiency. For the changes to the energy sector to be effected, the conclusions presented above as part of the summary should be taken into consideration.

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Polityka energetyczna Polski: główne problemy i prognozy

Streszczenie

Zakres przedmiotowy analizy zawartej w tekście skupia się na wybranych problemach polityki energetycznej Polski. W tekście poruszono trzy zagadnienia związane z polityką energetyczną Polski: (1) instytucjonalno-prawne, (2) prognostyczne i (3) problemowe. W pierwszym przypadku, zwrócono uwagę na ustawowe rozwiązania w zakresie celów, zadań, modelu i elementów polityki energetycznej oraz na odpowiedzialność podmiotów za jej realizację. W drugim przypadku zaprezentowano scenariusze rozwoju polityki energetycznej, poddano je również krótkiej analizie porównawczej. Natomiast w trzecim przypadku, uwagę skupiono na prezentacji następujących kwestii: (1) zależności energetycznej, (2) monokultury energetycznej, (3) poziomu rozwoju odnawialnych źródeł energii, (4) emisyjności oraz (5) efektywności energetycznej.

W celu uszczegółowienia problemu badawczego w tekście zaprezentowane zostały następujące pytania badawcze: (1) *W jakim stopniu rozwiązania instytucjonalno-prawne wpływają na efektywność prowadzonej polityki energetycznej w Polsce?*, (2) *Który ze scenariuszy rozwoju polskiej polityki energetycznej należy uznać za najbardziej prawdopodobny?*, (3) *Które z wyodrębnionych w analizie zagadnień problematycznych należy uznać za największe wyzwanie dla polskiej polityki energetycznej?*

Słowa kluczowe: polityka energetyczna, prognozy energetyczne, bezpieczeństwo energetyczne, struktura produkcji energii, zależność energetyczna, odnawialne źródła energii, emisyjność sektora energetycznego, efektywność energetyczna