Scientific quarterly journal ISNN 2083-1587; e-ISNN 2449-5999

Agricultural Engineering

2015: 4(156):129-138

Homepage: http://ir.ptir.org

DOI: http://dx.medra.org/10.14654/ir.2015.156.159

THE APPLICATION OF THE SWOT AND AHP METHODS FOR THE ASSESSMENT OF REGION`S STRATEGIC POSITION IN THE ASPECT OF WIND ENERGY

Aldona K.Wota[a*], Andrzej Woźniak[b]

[a] Technical Institute, State Higher Vocational School in Nowy Sącz
[b] Department of Regional Economy, Cracow University of Economics
[*]*Contact details: ul. Staszica, 33-300 Nowy Sącz; e-mail:aldonawota@gmail.com*

ARTICLE INFO

Article history:
Received: June 2015
Received in the revised form:
August 2015
Accepted: Septembet 2015

Key words:
SWOT
AHP
strategic position
wind energy

ABSTRACT

The paper suggests a method for diagnosis of a region's strategic position with the use of two decision tools: SWOT analysis (strong, weak points, opportunities and threats) and a multiple criteria method AHP. The integration of the methods constitutes a complex approach, which may be useful at the assessment and forecast of the development strategies of regions for particular types of renewable energy sources. The AHP method enabled structuring of the decisive problem and quantification of the significance of SWOT factors, both quantity and quality ones, being at the same time a very comfortable mathematical apparatus. The paper presents a theoretical aspect of methodology, and in the practical perspective, an approach to establishing a strategic position of Małopolskie Voivodeship in the aspect of using wind energy was suggested. There is a development trend in the voivodeship based on the defensive strategy, namely on the unfavourable arrangement of factors - more weak points than the strong ones and more threats than opportunities.

Introduction

Development of renewable energy sources (RES) is one of six fundamental trends in the energy policy set forth in the Energy policy of Poland to 2030, a key document for the energy sector signed by the Council of Ministers in November 2009. According to this document, a participation of renewable energy sources in the final consumption of gross energy is going to rise up to 15% and 20% in 2030. The highest increase of energy production is expected in the wind energy, biogas production and solid biomass and in transport biofuels.

The power of the installed wind energy in Poland has been dynamically and systematically growing since 2005. In 2013 there were 835 wind installations with the total power of 3,389 MW and the electric energy production of 5,888 GWh. Moreover, the increase in the wind energy participation in the total electric energy production has been reported. In 2013 it was the highest and it was approx 29%. Water energy was 20% and co-firing technolo-

gies were 20.3% (URE, 2014). Despite the unquestionable acceleration in the realization of investment in the wind energy, Poland takes the 20th position in the EU - a relatively distant place – when calculating the power installed per a citizen (Biuletyn..., 2014).

It should be mentioned that the wind energy has a great unused potential and the lowest carbon dioxide emission among all renewable energy sources (Piaskowska, 2009). According to the Polish Association of Wind Energy, the wind energy in Poland develops below its capabilities. Installation of approximately 13 GW and achieving electric energy production from the wind installation on the level of 33 TWh annually is a possible, safe and real level of its development to 2020 (Wizja..., 2009).

Many advantages but also many restrictions are related to the perspective of using a big potential of wind energy in Poland. Environmental reasons (reduction of carbon dioxide emission), guarantee of energy stability, development or activation of regions are for the use of wind energy. In the presented context, the possibility of using wind energy constitutes a significant strategic issue not only in the domestic perspective; this problem should also be of interest for the authorities of regions (voivodeships).

Objective of the paper

The paper presents a procedure that aims at evaluation of the region's strategic position on account of the development possibilities of the so-called wind energy (wind turbines above 1 MW). The paper constitutes an attempt to apply the combined SWOT analysis (evaluation of strong and weak points as well as opportunities and threats to the region) and a multiply criteria decision making method – (*Analytic Hierarchy Process – AHP)*. Małopolskie Voivodeship was selected as an area of research, for which no strategy of development of wind energy has been prepared yet.

Research methodology

The accepted methodology plays a significant role in determination of the development strategy of an enterprise, region or investment. The SWOT analysis may be included into one of the most important methods (Gierszewska and Romanowska, 2003). Analysis of strong and weak points as well as opportunities and threats constitutes the basis of methodology *(Strenghts (S), Weaknesses (W), Opportunities (O), Threats (T) Analysis)*. Weak and strong points are considered with reference to outside factors, and opportunities and threats to external factors. The SWOT analysis requires identification of all key factors. When applied properly it is a good foundation for determination of a present and perspective position of the SWOT assessment object and for the forecast of the procedure strategy. Selection of the strategy depends on the strength of relations between the groups of factors. There are 4 normative strategies of operation in this method (Weihrich, 1982):

Aggressive strategy SO (maxi-maxi) – concerns the situation when strong points prevail inside and opportunities outside. The strategy is related to a strong expansion and a diversified development.

Competitive strategy WO (mini-maxi) – it has more weak than strong points and the arrangement of external conditions works for its favour. The strategy should consist in the use of opportunities at the simultaneous decrease or improvement of internal shortcomings.

Conservative strategy ST (maxi-mini) – uses the prevailing strong points over weak ones at the unfavourable arrangement of external conditions. The activities which are carried out should be oriented at the decrease of the impact of those threats and more effective use of opportunities.

Defensive strategy WT (mini-mini) is related to the situation, when weak points and threats related thereto prevail. There are no decisive strong points, which would oppose the threats. This strategy has to ensure that the object of analysis will survive thanks to actions against negative preconditions.

Assessment of factors is one of the most problematic issues of the SWOT analysis. In practice, majority of strategies, e.g. development of communes or voivodeships ends at identification of developmental factors. The issue of quantification of particular elements and resultant strategies may be solved by including the multiple criteria decision making method of taking up the AHP decisions. Except for a comfortable mathematical model, AHP also plays a significant role in the problem structuring, presenting it in the hierarchical form (Saaty, 1980; Wota and Woźniak, 2008).

The first examples of the use of the SWOT and AHP methods combination are related to the works concerning forest resources management (Kurttila et al., 2000; Pesonen et al., 2001). In literature, in particular the world one, integration of the SWOT-AHP methods is a solution which is more frequently applied. The SWOT-AHP technique is applied in various fields, e.g. agriculture and forestry (Shrestha et al., 2004; Duchelle et al., 2012), tourism sector (Kajanus et al., 2004), project management (Stewart et al., 2002), water resources management (Gallego-Ayala and Juizob, 2011), selection of a container terminal in the East Asia (Chang and Huang, 2006) or in determination of potential for development of the market based on the energy biomass production (Catron et al., 2013).

According to the authors' knowledge, an attempt to apply the SWOT and AHP methods for assessment of the strategic position of the selected region (regions) in the context of applying wind energy is an innovative idea. A procedure that covers subsequent few stages was suggested as an attempt to solve a decision problem:

Stage 1. SWOT factors identification – concerns diagnosis of key factors as a part of four main groups S, W, O and T which affect a strategic position of the assessed region on account of the possibilities of development of wind energy.

Stage 2. Construction of the decision making model – in this stage, key factors S, W, O and T will serve for construction of a model under the AHP principles. As a part of the method a structuring of the decision problem is carried out in the form of hierarchical structure - goal, main criteria, their expansion. On each level of hierarchy, elements which are compared to each other are placed and their number must not be exceeded, namely 9 elements (Saaty, 1980).

Stage 3. Calculation of priorities (weights) of the model elements – a developed model constitutes a basis for analytical calculation, namely for assessment of components according to the AHP method. Significance assessments are expressed in the form of local priorities (weights). This stage consists in the matrix A construction (with dimensions n x n, where n – the amount of elements on a certain level) of assessment of factors of a certain level separated in pairs towards a higher level. In the matrix $n(n\text{-}1)/2$ pairwise comparisons are carried out.

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \tag{1}$$

Words located over the diagonal $a_{ij} = \frac{w_i}{w_j}$ (assessment of the advantage of the significance of *i*- element over the *j*- element) are experts' assessments assumed based on the 9-degree assessment scale of a pairwise comparison. Words located on the diagonal $a_{ij} = 1$, on the other hand words below the diagonal are the opposite to words located over the diagonal $a_{ji} = 1/a_{ij}$. After the construction of the assessment matrix, which images the problem, for each matrix the maximum eigenvalue $\lambda_{\max}$ and the eigenvector value *w* is determined (Saaty, 1980).

A consistency index CI is used in the assessment of errors made or inconsistencies in experts' opinions

$$CI = \frac{\lambda_{\max} - n}{n-1} \leq 0{,}10 \tag{2}$$

where:

n – matrix dimension,

$\lambda_{\max}$ – maximum eigenvalue of the matrix.

In case, $CI > 0{,}1$ an assessment in the matrix should be repeated.

Then, for each factor of the SWOT-AHP hierarchy model factor, local and global weights will be calculated. A local weight is related to a given level, whereas a global one results from multiplying a local weight of a given level by a global weight of the higher level element.

Stage 4. Determination of the strategic position of the region (variant) – a point in the coordinate system which allows determination in which quarter of the system the evaluated region is located, constitutes a strategic position. Particular quarters of the system correspond to one out of four basic strategic positions: competitive strategy WO, aggressive strategy SO, defensive strategy WT, conservative strategy ST. The position is determined after coordinative internal factors are computed (x-axis: the sum of global priorities from the impact scale $(S)_j$ i $(W)_j$) and external factors (axis of ordinates: the sum of global factors priorities $(O)_j$ i $(T)_j$) (Qingzhe et al., 2012). Point *P*, which reflects a strategic solution, is determined as:

$$x = \sum (S)_j - \sum (W)_j / 4 \tag{3}$$

$$y = \sum (O)_j - \sum (T)_j / 4 \tag{4}$$

Global priorities for the impact scale are calculated by multiplying a global weight of the factor *j* by a local weight of each element of the impact scale related with the factor *j* (Wota and Woźniak, 2008).

Case study

The suggested methodology was implemented for assessment of the strategic position of Małopolskie Voivodeship in the context of wind energy development possibilities. Firstly, key factors related to the condition of resources and preconditions of the surrounding were selected, i.e. within four main groups: strong and weak points, opportunities and threats (table 1). The basis for classification of the recommended factors were information included in the papers by (Wizja…, 2009; Wiśniewski, 2011; Wpływ energetyki…, 2012).

Table 1
Key factors SWOT

Strong points (S)	**Opportunities (O)**
(S1) Wind conditions (S2) Attractiveness for investors (S3) Renewable Energy Cluster	(O1) Incomes for communes from real property taxes (O2) Interest of other investors in the possibility to invest within RES (O3) Advantageous impact on the labour market and economic activity (O4) Development of the borderland areas and improvement of international contacts
Weak points (W)	**Threats (T)**
(W1) Areas covered by legal protection (nature reserves, landscape parks, Natura 2000 areas etc.,) which limit investments (W2) Areas with high landscape and cultural values, observation points (W3) Transmission infrastructure (W4) No changes in spatial planning (W5) Urbanization of land, distributed ownership of land	(T1) Development of lands included in NATURA 2000 (T2) Uncertain legal regulations concerning e.g. granting and dismissing certificates of origin (T3) Fear that the plots located near turbines will lose their values (citizens' reluctance) (T4) Fear of losing tourists (tourist and health resort properties)

The listed most significant factors constituted the basis for construction of the SWOT-AHP model (fig. 1). A decisive aim was located in the first level, control criteria on the second one, the third level consists of four main groups of the SWOT analysis, whereas the fourth level is represented by a key criteria related to specific groups. The fifth level includes an extension of each of key criteria according to their intensity of influence on the assessed voivodeship.

Thus constructed SWOT-AHP hierarchy model constituted the basis for assessment of all its elements. Assessment was carried out by the authors. For assessment of significance of particular S, W, O and T groups, the use of the so-called strategic criteria was suggested and with reference to them their meaning was assessed. In the analysed case, the assumed criteria (a) environmental, (b) social and (c) political (domestic regulations) were compared pairwise on account of the decision goal. Each of the strategic criteria determined on

account of S, W, O and T at the use of Saaty's (1980) verbal scale, where: weight (0.42) corresponds to very high intensity, (0.26) to high, (0.16) to average, (0.10) to low and (0.06) to very low. For example, to assess the group of threats, 3 questions should have been answered – referring to subsequently all strategic criteria -e.g. how significant will be a threat related to the development of the best strategy for wind energy development in Małopolskie Voivodeship on account of the first strategic criterion namely environmental preconditions? By applying this method of calculation, the normalized weights were obtained subsequently for: S=0.17, W=0.28, O=0.20 and T=0.35.

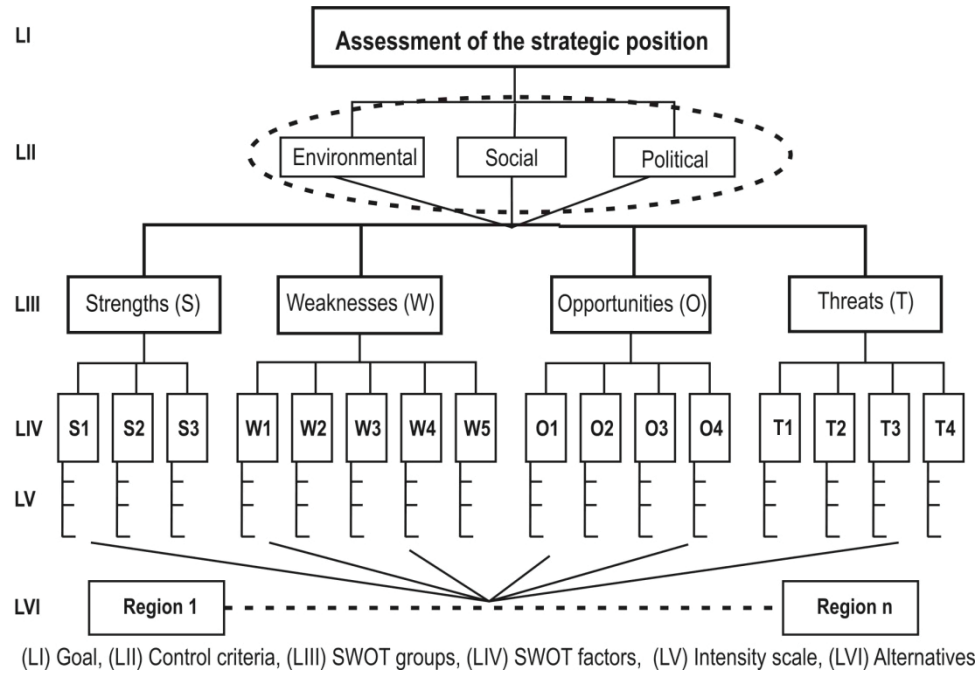

Figure 1. SWOT-AHP hierarchy model

Then, on the 4th level of hierarchy, where 4 groups of factors, which are an extension of S, W, O and T groups are located, 4 matrices $M_1IV(S), M_2IV(W), M_3IV(O), M_4IV(T)$ with dimensions (3x3), (5x5), (4x4), (4x4) were solved. The matrix $M_1IV(S1)$ is an assessment of factors on account of the higher level element. $n(n-1/2)$ pairwise comparisons were carried out in the matrix and responded to the question: which one of the compared factors is more significant and to what degree at determination of the best strategy on account of strong points? The matrix $M_1IV(S)$ has the following form:

$$M_1 IV(S) = \begin{bmatrix} S1/S1 & S1/S2 & S1/S3 \\ S2/S1 & S2/S2 & S2/S3 \\ S3/S1 & S3/S2 & S3/S3 \end{bmatrix}$$

where:

S1 – wind conditions,
S2 – attractiveness for investments,
S3 – renewable energy cluster.

After calculating the matrix weight $M_1 IV(S)$, local weights vector for the assessed elements was obtained, where: (S1=0.70), (S2=0.20) and (S3=0.10). The components of the vector show that on account of the assessed chief assets (strong points), wind conditions are the most significant criterion which influences the strategic position of the energy development. Assessment was carried out for all groups of level IV (table 2). When analysing particular global priorities for the level IV from the point of view of development opportunities, it was reported that except for wind conditions (0.119), threats related to uncertain legal regulations (0.146), environmentally valuable areas, which decisively limit, even exclude the opportunity to carry out investments (0.134) or citizens' reluctance (0.131) have the biggest impact. On the other hand, incomes for communes may constitute a considerable incentive for development of wind energy (0.110).

Each SWOT factor was assessed according to the intensity of their impact on the strategic position of Małopolskie Voivodeship. After multiplication of global weights of IV level and local weights from the impact scale, global weights for the assessed Małopolskie Voivodeship were obtained (table 2).

Table 2
Matrix for the strategic assessment of the SWOT-AHP analysis

SWOT group	Weight	SWOT factor	Local weight	Global weight of IV level	Local weight from the impact scale	Global weight for the assessed Małopolskie Voivodeship
Strong points (S)	0.17	(S1)	0.70	0.119	0.16	0.119
		(S2)	0.20	0.034	0.10	0.034
		(S3)	0.10	0.017	0.10	0.017
Weak points (W)	0.28	(W1)	0.48	0.134	0.42	0.134
		(W2)	0.15	0.042	0.26	0.042
		(W3)	0.05	0.014	0.26	0.014
		(W4)	0.06	0.017	0.26	0.017
		(W5)	0.26	0.073	0.26	0.073
Opportunities (O)	0.20	(O1)	0.56	0.110	0.10	0.110
		(O2)	0.12	0.032	0.16	0.032
		(O3)	0.26	0.044	0.16	0.044
		(O4)	0.07	0.014	0.16	0.014
Threats (T)	0.35	(T1)	0.06	0.020	0.16	0.020
		(T2)	0.42	0.146	0.26	0.146
		(T3)	0.38	0.131	0.26	0.131
		(T4)	0.15	0.052	0.26	0.052

The final response concerning the agreement on the strategic situation of the voivodeship was obtained after calculation of internal and external factors, where:

$$x = \sum(S)_j - \sum(W)_j / 4 = (-0{,}0175)$$

$$y = \sum(O)_j - \sum(T)_j / 4 = (-0{,}0159)$$

The obtained results where graphically reflected on a plane, where particular quarters of the coordinate system correspond to developmental strategies types (fig. 2).

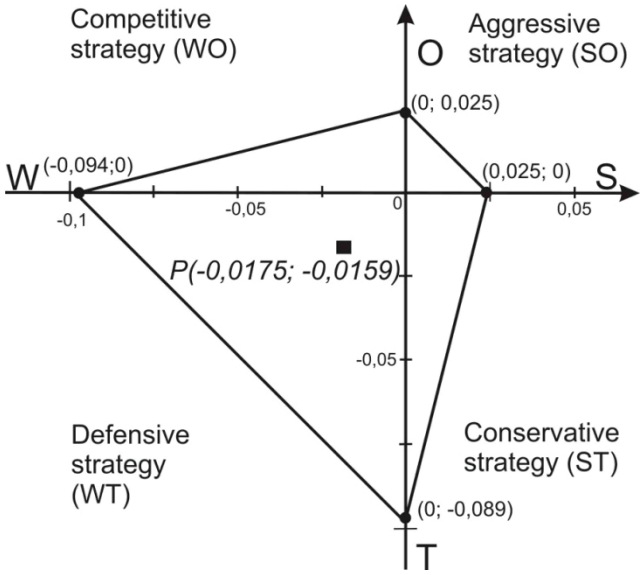

Figure 2. Graphical interpretation of results of development strategy assessment

In Małopolskie Voivodeship on account of wind energy development possibilities a development trend has been shaped based on the defensive strategy. The voivodeship has an unfavourable system of factors. Weak points prevail over strong ones and threats over opportunities. Weak points emerged mainly within the scope of areas which are valuable on account of environmental protection (parks, nature reserves, landscape parks, Natura 2000). The above forms cover 52.1% of the voivodeship area, thus limiting, even excluding opportunities of investment development. Landscape and cultural values constitute the next problem. Weak points also concern urbanization of the area or distribution of lands' ownership. These elements decisively influence difficulties in participation in the construction of investment, as well as cause conflicts due to closeness of the investment. The system of external factors is also unfavourable; threats constitute uncertain legal regulations related to functioning of the support system for the investment and threats from citizens' reluctance to install wind turbines.

Conclusions

Wind energy has become in Poland even more dynamic element of power energy. Many advantages but also many restrictions are related to the possibility of using a big potential of wind energy. The suggested procedure based on the integration of the SWOT analysis and multiple criteria decision making method AHP enables assessment of the significance of the analysed factors of internal conditions (weak and strong points) and external (opportunities and threats). In the context of assumed factors it also allowed recognition of the strategic position of Małopolskie Voivodeship. The developed SWOT-AHP model with the impact scale may be used for assessment and ranking of other voivodeships. New elements, as well as experts' opinions may be included in the model. The suggested approach undoubtedly prevails over a classical SWOT analysis, which usually is carried out in an intuitive, descriptive manner.

Based on the accepted assumptions, it was determined that Małopolskie Voivodeship is characterised by a defensive strategy. Weak points and threats related thereto prevail. In such a system of factors, Małopolskie Voivodeship has greater opportunities for development of great-scale wind energy. In the presented system of factors, one should consider another trend in the wind energy development, e.g. small power generation.

References

Biuletyn Energii Odnawialnej – Energetyka Wiatrowa. Eurobserv`er. (2014). Obtained from: http://www.energies-renouvelables.org/observ-er/stat_baro/observ/baro-jde14_po.pdf.

Catron, J., Stainback, G.A., Dwivedi, P., Lhotka, M. (2013). Bioenergy development in Kentucky: A SWOT-ANP analysis. *Forest Policy and Economics, 28*, 38-43.

Chang, H-H., Huang, W-H. (2006). Application of a quantification SWOT analytical method. *Mathematical and Computer Modelling, 43*, 158-169.

Duchelle, A.E., Guariguata, M.R., Less, G., Albornoz, M.A., Chavez, A., Melo, T. (2012). Evaluating the opportunities and limitations to multiple use of Brazil nuts and timber in Western Amazonia. *Forest Ecology and Management, 268*, 39-48

Gallego-Ayala, J., Juizob D. (2011). Strategic implementation of integrated water resources management in Mozambique: An A'WOT analysis. *Physics and Chemistry of the Earth, 36*, 1103-1111.

Gierszewska, G., Romanowska, M. (2003). *Analiza strategiczna przedsiębiorstwa*. Polskie Wydawnictwo Ekonomiczne, Warszawa, ISBN 83-208-1389-1.

Kajanus, M., Kangas, J., Kurttila, M. (2004). The use of value focused thinking and the A'WOT hybrid method in tourism management. *Tourism Manage, 25*, 499-506.

Kurttila, M., Pesonen, M., Kangas, J., Kajanus, M. (2000). Utilizing the analytical hierarchy process (AHP) in SWOT analysis – A hybrid method and its application to a forest-certification case. *Forest Policy and Economics, 1*, 41-52.

Pesonen, M., Kurttila, M., Kangas, J., Kajanus, M., Heinonen, P. (2001). Assessing the priorities using A'WOT among resource management strategies at the Finnish forest and park service. *Forest Science, 47*(4), 534-541.

Piaskowska, M. (2009). Potencjał techniczny i opłacalność wykorzystania energii wiatru w Polsce. *Polityka Energetyczna 12*, Zeszyt 2/2, 465-474.

Qingzhe, J., Yanming, Xu., Wenju, Xin., Zhaozheng S., Qianqian S., Ming K. (2012). SWOT-AHP hybrid model for vehicle lubricants from CNPCLC, *China Petroleum Science, 9*(4), 558-564.

Polityka energetyczna Polski do 2030 roku. Ministerstwo Gospodarki. Załącznik do uchwały nr 202/2009 Rady Ministrów z dnia 10 listopada 2009r.

Saaty, T.L. (1980). *The analytic hierarchic process*. Mc Graw Hill. New York.
Shrestha, R.K., Alavalapti, J.R.R., Kalmbacher, R.S. (2004). Exploring the potential for silvopasture adoption in south-central Florida: an application of SWOT-AHP method. *Agricultural Systems 81*(3), 185-199.
Stewart, R.A., Mohamed, S., Daet, R. (2002). Strategic implementation of IT/IS projects in construction: a case study. *Automation in Construction, 11*, 681-694.
URE – Sprawozdanie z Działalności Prezesa Urzędu Regulacji Energetyki w 2013. Warszawa, kwiecień 2014. Obtained from http://www.ure.gov.pl/.
Weihrich, H. (1982). The TOWS matrix – a tool for situational analysis. *Journal of Long Range Planning, 15*(2), 54-66.
Wiśniewski, G. (red.). (2011). *Określenie potencjału energetycznego regionów Polski w zakresie odnawialnych źródeł energii – wnioski dla Regionalnych Programów Operacyjnych na okres programowania 2014-2020*. Warszawa, MRR, ISBN 978-83-7610-352-5.
Wizja Rozwoju Energetyki Wiatrowej w Polsce do 2020 r. Raport wykonany na zlecenie Polskiego Stowarzyszenia Energetyki Wiatrowej przez Instytut Energii Odnawialnej, Warszawa, listopad 2009.
Wota A., Woźniak A. (2008). Metodyka wyboru lokalizacji składowisk odpadów komunalnych. *Infrastruktura i Ekologia Terenów Wiejskich, 8*, 101-103.
Wpływ energetyki wiatrowej na wzrost gospodarczy Polski. Raport przygotowany przez Ernst&Young,2012. Obtained from: http://www.domrel.pl/_publikacje/raport_psew_2012.pdf

ZASTOSOWANIE METODY SWOT I AHP DO OCENY POZYCJI STRATEGICZNEJ REGIONU W ASPEKCIE MOŻLIWOŚCI ROZWOJU ENERGETYKI WIATROWEJ

Streszczenie. W pracy zaproponowano metodykę diagnozującą pozycję strategiczną regionu z zastosowaniem dwóch narzędzi decyzyjnych: analizy SWOT (mocnych, słabych stron, szans i zagrożeń) i wielokryterialnej metody AHP. Połączenie metod stanowi kompleksowe podejście, które może być pomocne przy ocenie i prognozowaniu strategii rozwojowych regionów dla poszczególnych rodzajów odnawialnych źródeł energii. Metoda AHP umożliwiła strukturalizację problemu decyzyjnego oraz skwantyfikowanie istotności czynników SWOT, zarówno ilościowych, jak i jakościowych, stanowiąc tym samym bardzo wygodny aparat matematyczny. W pracy przedstawiono teoretyczny aspekt metodyki, natomiast w ujęciu praktycznym zaproponowano podejście do ustalenia pozycji strategicznej województwa małopolskiego w aspekcie możliwości wykorzystania energetyki wiatrowej. W województwie nakreślił się kierunek rozwoju oparty na strategii defensywnej, czyli sytuacji o niekorzystnym układzie czynników - przewadze słabych stron nad silnymi oraz zagrożeń na szansami.

Słowa kluczowe: SWOT, AHP, pozycja strategiczna, energia wiatru