

Dr inż. Marzena Ogórek
Politechnika Częstochowska
ORCID: 0000-0003-1627-1422
e-mail: marzena.ogorek@pcz.pl

Dr Agnieszka Bala-Litwiniak
Politechnika Częstochowska
ORCID: 0000-0003-2859-849X
e-mail: a.bala-litwiniak@pcz.pl

Green-strategic analysis of the use of pellets from selected wood and waste materials for heating purposes

Ekologiczno-strategiczna analiza wykorzystania pelletów z wybranych materiałów drzewnych i odpadowych na cele grzewcze

Abstract

The paper presents the possibilities of using wood, waste and energy plant biomass as a material for the production of fuels in the form of pellets. Pine sawdust, energy willow chips, sunflower husk and corn straw were analysed. The materials were pelletized. Selected physicochemical properties and elemental composition were determined. It has been shown that the best alternative to replace wood pellets can be pellets made from both energy willow and sunflower husks. Sunflower husk pellets were selected as the most promising fuel and subjected to a strategic analysis using the SWOT/TOWS method. Based on the analyses, it was shown that sunflower husk pellets, due to their competitive price, appropriate physicochemical parameters and wide availability, can be successfully used as a fuel in boilers adapted to burn wood pellets and more.

Keywords:

biomass pellets, waste, alternative fuels, energy plants, SWOT/TOWS analysis

Streszczenie

W pracy przedstawiono możliwości wykorzystania biomasy drzewnej, odpadowej i pochodzącej z upraw energetycznych jako materiału do produkcji paliw w formie pelletów. Analizie poddano trociny sosnowe, zrębki wierzby energetycznej, łuskę słonecznika i słomę kukurydzianą. Materiały poddano procesowi pelletyzacji. Określono ich wybrane właściwości fizykochemiczne i skład elementarny. Wykazano, że najlepszą alternatywą dla pelletu z drewna mogą być pellety zarówno wytworzone z wierzby energetycznej, jak i łuski słonecznika. Jako najlepiej rokujące paliwo wytypowano pellet z łuski słonecznika i poddano go analizie strategicznej z wykorzystaniem metody SWOT/TOWS. Wykazano, że pellet z łuski słonecznika ze względu na konkurencyjną cenę, odpowiednie parametry fizykochemiczne i szeroką dostępność może być z powodzeniem stosowany jako paliwo w kotłach przystosowanych do spalania pelletów drzewnych i nie tylko.

Słowa kluczowe:

pellety z biomasy, odpady, paliwo odnawialne, analiza SWOT/TOWS

JEL: Q16, Q44, Q55

Introduction

Thermal energy is obtained from fossil fuels in most countries of the European Union. The combustion of fuels such as coal, oil and natural gas causes significant emissions, including CO₂, which

requires constant restrictions due to increasingly higher environmental standards (IPCC, 2018; Mateus et al., 2023; Sulaiman et al., 2020; M. Wang et al., 2015). According to the European Commission's Energy Strategy for 2020–2030, the priority is to reduce greenhouse gas emissions by 40%, increase the share of renewable energy

sources to at least 27%, continuously increase energy efficiency and ensure competitive, affordable and secure energy. The use of biomass is one of the key solutions proposed by the European Commission in order to reduce dependence on imported oil and petroleum products and, thus, improve security of energy supply in the long term (European Biofuels Technology Platform, 2008).

The main advantage of biomass is its production in the process of photosynthesis, in which carbohydrates necessary for growth are obtained from CO₂ and H₂O. In this way, the CO₂ obtained during combustion is equivalent to the amount necessary to produce biomass, resulting in net zero CO₂ emissions (Cherubini et al., 2011; Possell et al., 2005). Replacing fossil fuels with biomass is therefore one of the best solutions to reduce greenhouse gas emissions, as well as SO₂ and NO_x (Obaidullah et al., 2012; Ozgen et al., 2021; L. Wang et al., 2012). Compared to fossil fuels, biomass is widely available, cheap and easier to prepare for direct use as a fuel (Bala-Litwiniak, 2020; Sulaiman et al., 2020; Variny et al., 2021). Biomass becomes biofuel as a result of mechanical, thermal or chemical processing. The properties of biomass are variable and have a significant impact on the biofuels produced from it. Therefore, the physicochemical properties of biofuels depend to a large extent on the chemical composition of biomass, i.e. both the content of combustible and mineral parts, as well as the content of volatile matter and ash and its composition. The origin of biomass is very diverse, ranging from field crop production, through biomass of animal origin, to that of municipal origin. Biomass can also come from wood waste in forestry, wood and pulp and paper industries (Amjith & Bavanish, 2022; Bilgili et al., 2017). Industries such as food and agriculture can also generate large amounts of waste which, if properly prepared, could be used for heating purposes (Bala-Litwiniak & Musiał, 2022; Kougioumtzis et al., 2021; Theerarattananoon et al., 2011). We also should not forget about plants grown typically for energy purposes. Such plants are characterized by high calorific value, high dry matter gain during the growing season and, at the same time, low soil and climatic requirements. Intensive research has been carried out on the selection of this type of plants for many years (Baker et al., 2022; Mckendry, 2002; Von Cossel et al., 2022). The group of energy crops suitable for the production of heat energy by combustion includes, among others, flagelliform willow, Pennsylvania mallow, Chinese grass, tuberous sunflower and common reed (Borkowska & Molas, 2012; Bridgeman et al., 2008; Long et al., 2016; Stolarski et al., 2019).

Therefore, biomass can be divided into three groups by origin: wood biomass, waste biomass and biomass from energy crops. The VAT rate in Poland is 23% for wood fuels, 8% for non-wood pellets and 7% for pellets from energy crops. Therefore, the production of pellets from raw materials other than wood seems to be the best economical solution. A reasonable solution may be to produce pellets from agricultural waste, however, the chemical composition and physicochemical properties of this type of waste may have an adverse effect on the composition of flue gases, as well as on the operation and maintenance of the boiler (Bala-Litwiniak & Zajemska, 2020; Hardy et al., 2012; Pawlak-Kruczek et al., 2020).

The aim of the study was to analyse the suitability of selected wood and waste raw materials for the production of pellets for heating purposes as an alternative to fossil fuels. Therefore, an green-strategic analysis was carried out for pellets produced from wood, waste and energy biomass. One type of wood biomass material (pine) and energy crop material (energy willow) as well as two materials from waste biomass (corn straw, sunflower husk) were selected as materials representative for each group. Pellets were produced from the studied raw materials. Their selected physicochemical properties were determined in terms of their usefulness as a fuel, and an analysis of the composition of flue gases was carried out. Based on the results of this research, a strategic analysis was carried out for the most promising fuel, using the SWOT/TOWS method.

Materials and methods

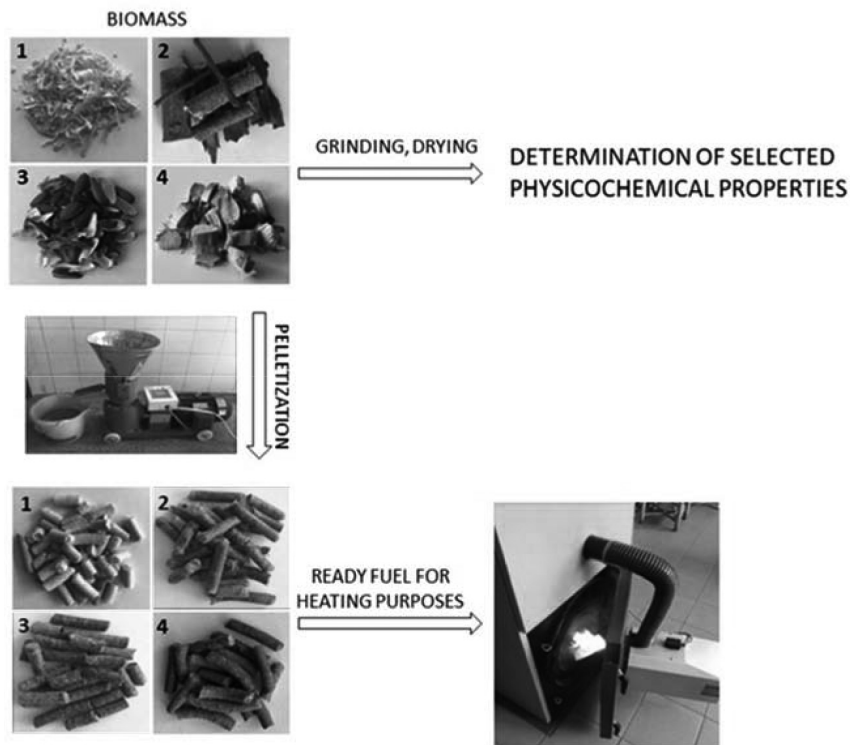
Four types of biomass were tested: pine sawdust, energy willow chips, sunflower husk and corn straw. Pre-dried, cleaned and shredded materials were pelletized. The method of management of the analysed types of biomass is shown in Figure 1.

Pellets were produced using a KL.ZLSP pellet mill with a power of 7.5 kW, production efficiency of 140–300 kg/h and die rotation speed of 200–300 rpm. In order to determine the selected physicochemical properties (moisture content, ash content, calorific value, CHN), the pellets were crushed in a blade mill using a sieve matrix with mesh size of up to 1 mm.

The moisture content was determined based on the loss in mass of 1.00 g of the sample after drying at 105 ± 5°C to a constant weight in accordance with EN ISO 18134–3:2015. The ash contents were determined by burning 1 g of each tested biomass fuel in a muffle furnace at 250 ± 10°C for 50 minutes, and then at 550 ± 10°C for 4 hours, in accordance with EN ISO 18122:2015. The calorific value of the tested pellets was determined using the KL-12Mn

Figure 1

Diagram of the processing of selected types of biomass into heating fuel in the form of pellets, where: 1 – pine, 2 – energy willow, 3 – sunflower husk, 4 – corn straw



Source: own elaboration.

calorimeter (PRECISION-BIT, Poland) in accordance with EN 14918:2009.

The content of C, H, N for all the four types of pellets was determined using an elemental analyser (Truspec CHN628 LECO, USA).

SWOT analysis

The SWOT analysis is defined as a comprehensive method used to study the organization's environment and analyse its interior. The name SWOT comes from the first letters of the words: strengths, weaknesses, opportunities and threats. The concept of force field analysis, developed by Lewin in the 1950s was the scientific and methodological inspiration for the development of the assumptions of the SWOT analysis (Almutairi et al., 2021). Today, it can undoubtedly be considered one of the best-known and most frequently used strategic planning tools (Helms & Nixon, 2010). Some authors, however, refuse to allow the SWOT analysis the status of the method, treating it as a kind of analytical procedure combining various ways of collecting research material, which organizes their application and

enables transparent presentation of their results. A characteristic feature of this procedure is heterogeneity expressed in the existence of many mutations existing in theory and practice. They differ in the operationalization approach, but in all cases the idea has been unchanged for years. The SWOT procedure consists in a detailed identification and, then, classification of all phenomena and states of economic categories affecting the development of a given organization. Two criteria apply. The first is the type of actual effect or potential impact of a given factor on the organization, while the second is the broadly understood location of the factor in relation to the organization (Namugenyi et al., 2019). The use of these two criteria allows to distinguish four groups of factors: strengths, weaknesses, opportunities and threats. It is assumed that the identification of strengths and weaknesses concerns the situation within the organization. On the other hand, the search for opportunities and threats is an analysis of external factors. The results of research based on this method are most often summarized in a table in which the first row contains strengths and weaknesses, and in the second – opportunities and threats (Yamagishi et al., 2021).

Results

Selected physicochemical properties and elemental composition of the tested pellets are presented in Table 1.

Pellets made from all the four raw materials meet the EN-ISO-17225-2:2014 standard in terms of bulk dimensions and moisture content. When it comes to pellets made from waste biomass, too high ash content and low bulk density and calorific value for pellets made from corn straw can be observed. Pellets made from sunflower husk have much better parameters and, together with energy willow pellets, meet the standard for each of the analysed parameters. Although pine pellets have the highest calorific value (17.55 MJ/kg), they contain the most nitrogen compared to all the four types of biofuels, so it does not meet the standard. Sunflower husk pellets have a slightly lower calorific value (17.35 MJ/kg). Based on the literature (Demirbas, 2004; Vassilev et al., 2010), it was observed that the sulphur content in all the four types of biomass does not exceed 0.1%. The same applies to the chlorine content: up to 0.03% in willow and pine and up to 0.1% for sunflower husk. Corn straw has the highest chlorine content (0.64%). In addition, in earlier articles, attempts were made to burn the analysed pellets in a boiler adapted to biomass combustion (Bala-Litwiniak & Musiał, 2022; Bala-Litwiniak & Zajemska, 2020). The research carried out in these articles shows that, due to the too low calorific value of corn straw pellets, it is not possible to burn them directly in this type of boilers. Burning sunflower husk pellets is no different from burning pine pellets and even contributes to lower NO_x emissions.

In view of the above, it can therefore be concluded that pellets made from sunflower husk can be a cheap alternative to commonly used wood fuels, while meeting the EN ISO-17225-2:2014 standard and emitting less NO_x during combustion. In the further part of the article, a SWOT/TOWS analysis was carried out for sunflower husk pellets.

In order to carry out the SWOT/TOWS analysis for sunflower husk pellets, the most important features of strategic importance were selected. Key areas were identified and adapted to external factors (opportunities, threats) and internal factors (strengths and weaknesses). Each of these four characteristics was given a weight according to which the assessment was made. The sum of the weights within each category must be equal to 1.0 (Table 2).

The next stage of the SWOT/TOWS analysis was the formulation of the key questions:

- 1) Will the strengths allow to take advantage of the opportunities?
- 2) Will the strengths overcome the threats?
- 3) Will the weaknesses not allow the opportunity to be seized?
- 4) Will the weaknesses strengthen the impact of the threats?
- 5) Will the opportunities increase the strengths?
- 6) Will threats weaken the strengths?
- 7) Will the opportunities overcome the weaknesses?
- 8) Will the threats exacerbate the weaknesses?

In order to answer the above questions, eight cross-tables were drawn up, containing specific features, their weights, the number of interactions and the Product of W&I. If there is

Table 1

Comparison of the selected physicochemical properties and the elemental composition for pellets made of pine, willow, sunflower husk and corn straw

Parameter	Pine	Energy willow	Sunflower husk	Corn straw	EN ISO-17225-2:2014
Moisture [%]	4.65	5.35	5.42	5.45	≤10
Ash [%]	0.56	1.25	2.45	6.93	≤3
Calorific val. [MJ/kg]	17.55	16.85	17.35	15.38	≥16.5
Bulk density [kg/m ³]	640	620	635	525	≥600
Length [mm]	5–20	5–20	5–20	5–20	3.15–40.00
Diameter [mm]	6	6	6	6	6
C [%]	46.2	48.3	48.1	46.3	–
H [%]	6.3	6.0	6.5	6.2	–
N [%]	3.5	0.8	0.7	0.9	≤1
O (bal.) [%]	38.79	38.3	36.83	34.22	–

Source: own elaboration.

a dependency, the value is "1", if not – "0". The number of interactions means the sum of the instances of dependencies, while the Product of

W&I means multiplying these variables and entering the result in the appropriate place in the table (Tables 3–10).

Table 2
List of weights for the opportunities, threats, strengths and weaknesses

External factors			Internal factors		
	Sum of weights: 1.0	Opportunities		Sum of weights: 1.0	Strengths
O1	0.2	Possibility of selling pellets for Polish energy producers	S1	0.1	Natural, clean, green fuel from biomass
O2	0.3	Subsidizing electricity produced from renewable sources	S2	0.3	Freely available raw material
O3	0.2	Constantly growing pellet market in Europe	S3	0.2	Constantly growing demand for green fuels in industry and individual customers
O4	0.3	Growing market for pellet-fired boilers	S4	0.4	Low price of raw material
	Sum of weights: 1.0	Threats		Sum of weights: 1.0	Weaknesses
T1	0.3	Insufficient amount of raw material	W1	0.2	Poor knowledge of the product
T2	0.2	Possibility of increasing competition	W2	0.4	Poor public awareness of the benefits of using biomass
T3	0.2	Development of research on the possibilities of using other types of waste	W3	0.3	Production line building costs
T4	0.3	Rapidly growing market for renewable energy sources	W4	0.1	Acquisition of qualified staff

Source: own elaboration.

Table 3
Cross table: Will the strengths allow to take advantage of the opportunities?

Strengths/opportunities	O1	O2	O3	O4	Weight	# of interactions	Product of W&I
S1	1	0	1	1	0.1	3	0.3
S2	1	0	1	0	0.3	2	0.6
S3	1	1	1	1	0.2	4	0.8
S4	1	0	1	1	0.4	3	1.2
Weight	0.2	0.3	0.2	0.3			
# of interactions	4	1	4	3		x	
Product of W&I	0.8	0.3	0.8	0.9			
Sum of interactions					24/2		
Sum of products					5.7		

Source: own elaboration.

Table 4

Cross table: Will the strengths overcome the threats?

Strengths/threats	T1	T2	T3	T4	Weight	# of interactions	Product of W&I	
S1	0	0	1	1	0.1	2	0.2	
S2	1	1	1	1	0.3	4	1.2	
S3	1	1	1	1	0.2	4	0.8	
S4	0	1	0	1	0.4	2	0.8	
Weight	0.3	0.2	0.2	0.3				
# of interactions	2	3	3	4	x			
Product of W&I	0.6	0.6	0.6	1.2				
Sum of interactions					24/2			
Sum of products					4.0			

Source: own elaboration.

Table 5

Cross table: Will the weaknesses not allow the opportunity to be seized?

Strengths/opportunities	O1	O2	O3	O4	Weight	# of interactions	Product of W&I	
W1	1	1	0	1	0.2	3	0.6	
W2	0	0	0	0	0.4	0	0.0	
W3	0	1	0	0	0.3	1	0.3	
W4	0	0	0	0	0.1	0	0.0	
Weight	0.2	0.3	0.2	0.3				
# of interactions	1	2	0	1	x			
Product of W&I	0.2	0.6	0.0	0.3				
Sum of interactions					8/2			
Sum of products					2.0			

Source: own elaboration.

Table 6

Cross table: Will the weaknesses strengthen the impact of the threats?

Weaknesses/threats	T1	T2	T3	T4	Weight	# of interactions	Product of W&I	
W1	1	0	1	0	0.2	2	0.4	
W2	1	0	0	0	0.4	1	0.4	
W3	1	1	0	0	0.3	2	0.6	
W4	0	0	1	1	0.1	2	0.2	
WWeight	0.3	0.2	0.2	0.3				
# of interactions	3	1	2	1	x			
Product of W & I	0.9	0.2	0.4	0.3				
Sum of interactions					14/2			
Sum of products					3.4			

Source: own elaboration.

Table 7
Cross table: Will the opportunities increase the strengths?

Opportunities/strengths	S1	S2	S3	S4	Weight	# of interactions	Product of W&I	
O1	1	1	1	1	0.2	4	0.8	
O2	1	0	1	0	0.3	2	0.6	
O3	1	1	1	1	0.2	4	0.8	
O4	1	1	0	1	0.3	3	0.9	
Weight	0.1	0.3	0.2	0.4	x			
# of interactions	4	3	3	3				
Product of W&I	0.4	0.9	0.6	1.2				
Sum of interactions					26/2			
Sum of products					6.2			

Source: own elaboration.

Table 8
Cross table: Will threats weaken the strengths?

Opportunities/strengths	S1	S2	S3	S4	Weight	# of interactions	Product of W&I	
T1	1	1	1	0	0.3	3	0.9	
T 2	0	0	1	0	0.2	1	0.2	
T 3	1	1	1	0	0.2	3	0.6	
T 4	1	0	1	1	0.3	3	0.9	
Weight	0.1	0.3	0.2	0.4	x			
# of interactions	3	2	4	1				
Product of W&I	0.3	0.6	0.8	0.4				
Sum of interactions					20/2			
Sum of products					4.7			

Source: own elaboration.

Table 9
Cross table: Will the opportunities overcome the weaknesses?

Opportunities/weaknesses	W1	W2	W3	W4	Weight	# of interactions	Product of W&I	
O1	1	0	0	0	0.2	1	0.2	
O2	1	1	1	1	0.3	4	1.2	
O3	1	1	0	0	0.2	2	0.4	
O4	1	0	0	0	0.3	1	0.3	
Weight	0.2	0.4	0.3	0.1	x			
# of interactions	4	2	1	1				
Product of W&I	0.8	0.8	0.3	0.1				
Sum of interactions					16/2			
Sum of products					4.1			

Source: own elaboration.

Table 10
Cross table: Will the threats exacerbate the weaknesses?

Opportunities/weaknesses	W1	W2	W3	W4	Weight	# of interactions	Product of W&I
T1	1	1	0	1	0.3	3	0.9
T2	0	0	0	0	0.2	0	0.0
T3	0	0	0	1	0.2	1	0.2
T4	1	1	0	1	0.3	3	0.9
Weight	0.2	0.4	0.3	0.1			
# of interactions	2	2	0	3	x		
Product of W&I	0.4	0.8	0.0	0.3			
Sum of interactions	14/2						
Sum of products	3.5						

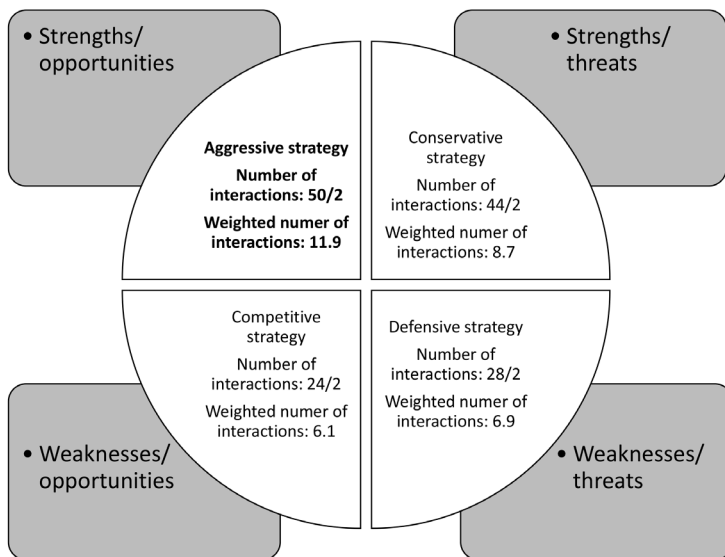
Source: own elaboration.

Table 11
Summary of the SWOT/TOWS analysis

Combination	SWOT results		TOWS results		SWOT/TOWS results	
	Sum of interactions	Sum of products	Sum of interactions	Sum of products	Sum of interactions	Sum of products
Strengths/opportunities	24/2	5.7	26/2	6.2	50/2	11.9
Strengths/threats	24/2	4.0	20/2	4.7	44/2	8.7
Weaknesses/opportunities	8/2	2.0	16/2	4.1	24/2	6.1
Weaknesses/threats	14/2	3.4	14/2	3.5	28/2	6.9

Source: own elaboration.

Figure 2
Strategy matrix for the sunflower pellet sector



Źródło: own elaboration based on: Redlich et al., 2019, s. 2.

Based on the data contained in Tables 2–10, a summary of the results obtained was made (Table 11), as well as a strategy matrix was created (Figure 2).

Analysing Table 3, it can be seen that among the opportunities and strengths for the use of sunflower husk pellets as fuel, there are such aspects as: low price, high demand, easy access and ecology. The weaknesses and threats, in turn, are insufficient knowledge of this type of product and the benefits of its use.

Based on the SWOT/TOWS analysis (Tables 3–11), it was noted that the highest number of interactions and the highest weighted number of interactions indicated the strategy that should be chosen for the promotion and dissemination of sunflower husk pellets. It can be concluded from the matrix of strategies that aggressive strategy will be the most beneficial: max-max (Figure 2). This strategy concerns a situation in which strengths and opportunities offered by the environment prevail, i.e. the possibility of using opportunities through strengths.

The strategic analysis carried out confirms the legitimacy of introducing this type of fuel to the energy market.

Statements and conclusions

Pellets made of pine, energy willow, sunflower husks and corn straw comply with EN-ISO-17225-2:2014 in terms of bulk density, dimensions and moisture content. Straw pellets deviate from the norm in terms of calorific value and ash content. In turn, pellets obtained from sunflower husk and energy willow meet the standard in every respect. Due to the comparable calorific value and lower NO_x emissions, compared to commonly used wood pellets, sunflower husk pellets were identified as the most promising alternative fuel.

This is also confirmed by the strategic analysis. The SWOT/TOWS analysis allows to conclude that the most beneficial for the further development of the analysed product will be the maxi-maxi aggressive strategy, in which the strengths and opportunities offered by the environment prevail. This strategy assumes a high demand for this type of products. Therefore, it should be expected that, in a short time, fuels made of biomass, especially waste, will become more beneficial not only in terms of lower emission of harmful compounds into the atmosphere, but will also be one of the competitively priced materials used to generate heat.

References/Bibliografia

- Almutairi, K., Hosseini Dehshiri, S. J., Hosseini Dehshiri, S. S., Mostafaeipour, A., Hoa, A. X., & Techato, K. (2021). Determination of optimal renewable energy growth strategies using SWOT analysis, hybrid MCDM methods, and game theory: A case study. *International Journal of Energy Research*, 46(5), 6766–6789. <https://doi.org/10.1002/er.7620>
- Amjith, L. R., & Bavanish, B. (2022). A review on biomass and wind as renewable energy for sustainable environment. *Chemosphere*, 293, 133579. <https://doi.org/10.1016/J.CHEMOSPHERE.2022.133579>
- Baker, P., Charlton, A., Johnston, C., Leahy, J. J., Lindegaard, K., Pisano, I., Prendergast, J., Preskett, D., & Skinner, C. (2022). A review of Willow (*Salix* spp.) as an integrated biorefinery feedstock. *Industrial Crops and Products*, 189, 115823. <https://doi.org/10.1016/J.INDCROP.2022.115823>
- Bala-Litwiniak, A. (2019). Possibilities of using selected types of biomass for energy purposes. *Material Economy and Logistics Journal*, (11), 49–54. <https://doi.org/10.33226/1231-2037.2019.11.8>
- Bala-Litwiniak, A. (2021). Environmental and economic aspects of combustion of biomass pellets containing a waste glycerol. *Combustion Science and Technology*, 193(11), 1998–2008. <https://doi.org/10.1080/00102202.2020.1746774>
- Bala-Litwiniak, A., & Kamieniak, K. (2014). Corrosion resistance of the boiler-and chimney steels in the exhaust fume condensates coming from burning of cellulose-waste glycerin based compositions. *Ochrona Przed Korozją*, (5), 179–183.
- Bala-Litwiniak, A., & Musiał, D. (2022). Computational and experimental studies of selected types of biomass combustion in a domestic boiler. *Materials*, 15(14). <https://doi.org/10.3390/ma15144826>
- Bala-Litwiniak, A., & Radomiak, H. (2019). Possibility of the utilization of waste glycerol as an addition to wood pellets. *Waste and Biomass Valorization*, 10(8), 2193–2199. <https://doi.org/10.1007/s12649-018-0260-7>
- Bala-Litwiniak, A., & Zajemska, M. (2020). Computational and experimental study of pine and sunflower husk pellet combustion and co-combustion with oats in domestic boiler. *Renewable Energy*, 162, 151–159. <https://doi.org/10.1016/j.renene.2020.07.139>
- Bilgili, F., Koçak, E., Bulut, Ü., & Kuşkaya, S. (2017). Can biomass energy be an efficient policy tool for sustainable development? *Renewable and Sustainable Energy Reviews*, 71, 830–845. <https://doi.org/10.1016/J.RSER.2016.12.109>
- Borkowska, H., & Molas, R. (2012). Two extremely different crops, *Salix* and *Sida*, as sources of renewable bioenergy. *Biomass and Bioenergy*, 36, 234–240. <https://doi.org/10.1016/J.BIOMBIOE.2011.10.025>
- Bridgeman, T. G., Jones, J. M., Shield, I., & Williams, P. T. (2008). Torrefaction of reed canary grass, wheat straw and willow to enhance solid fuel qualities and combustion properties. *Fuel*, 87(6), 844–856. <https://doi.org/10.1016/j.fuel.2007.05.041>
- Cherubini, F., Peters, G. P., Bernsten, T., Stromman, A. H., & Hertwich, E. (2011). CO₂ emissions from biomass combustion for bioenergy: Atmospheric decay and contribution to global warming. *GCB Bioenergy*, 3(5), 413–426. <https://doi.org/10.1111/j.1757-1707.2011.01102.x>

- European Biofuels Technology Platform. (2008). *Strategic Research Agenda & Strategy Deployment Document*, (January).
- Grudziński, Z. (2013). Koszty środowiskowe wynikające z użytkowania węgla kamiennego w energetyce zawodowej. *Rocznik Ochrona Środowiska*, 15(1), 2249–2266.
- Hardy, T., Musialik-Piotrowska, A., Ciolek, J., Mościcki, K., & Kordylewski, W. (2012). Negative effects of biomass combustion and co-combustion in boilers. *Environment Protection Engineering*, 38(1), 25–33.
- Helms, M. M., & Nixon, J. (2010). Exploring SWOT analysis – where are we now? A review of academic research from the last decade. *Journal of Strategy and Management*, 3(3). <https://doi.org/10.1108/17554251011064837>
- IPCC. (2018). *Global Warming of 1.5 °C. An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change*. <https://www.ipcc.ch/sr15/>
- Kougioumtzis, M. A., Kanaveli, I. P., Karampinis, E., Grammelis, P., & Kakaras, E. (2021). Combustion of olive tree pruning pellets versus sunflower husk pellets at industrial boiler. Monitoring of emissions and combustion efficiency. *Renewable Energy*, 171, 516–525. <https://doi.org/10.1016/J.RENENE.2021.02.118>
- Long, X. H., Shao, H. B., Liu, L., Liu, L. P., & Liu, Z. P. (2016). Jerusalem artichoke: A sustainable biomass feedstock for biorefinery. *Renewable and Sustainable Energy Reviews*, 54, 1382–1388. <https://doi.org/10.1016/J.RSER.2015.10.063>
- Mateus, M. M., Neuparth, T., & Cecílio, D. M. (2023). Modern kiln burner technology in the current energy climate: Pushing the limits of alternative fuel substitution. *Fire*, 6(2). <https://doi.org/10.3390/fire6020074>
- Mckendry, P. (2002). Energy production from biomass (part 1): Overview of biomass. *Bioresource Technology*, 83(July), 37–46. [https://doi.org/10.1016/S0960-8524\(01\)00118-3](https://doi.org/10.1016/S0960-8524(01)00118-3)
- Namugenyi, C., Nimmagadda, S. L., & Reiners, T. (2019). Design of a SWOT analysis model and its evaluation in diverse digital business ecosystem contexts. *Procedia Computer Science*, 159, 1145–1154. <https://doi.org/10.1016/j.procs.2019.09.283>
- Obaidullah, M., Bram, S., Verma, V. K., & De Ruyck, J. (2012). A review on particle emissions from small scale biomass combustion. *International Journal of Renewable Energy Research*, 2(1), 147–159.
- Ozgen, S., Cernuschi, S., & Caserini, S. (2021). An overview of nitrogen oxides emissions from biomass combustion for domestic heat production. *Renewable and Sustainable Energy Reviews*, 135, 110113. <https://doi.org/10.1016/j.rser.2020.110113>
- Pawlak-Kruczek, H., Arora, A., Mościcki, K., Krochmalny, K., Sharma, S., & Niedzwiecki, L. (2020). A transition of a domestic boiler from coal to biomass – Emissions from combustion of raw and torrefied Palm Kernel shells (PKS). *Fuel*, 263. <https://doi.org/10.1016/j.fuel.2019.116718>
- Possell, M., Hewitt, C. N., & Beerling, D. J. (2005). The effects of glacial atmospheric CO₂ concentrations and climate on isoprene emissions by vascular plants. *Global Change Biology*, 11(1), 60–69. <https://doi.org/10.1111/j.1365-2486.2004.00889.x>
- Rimár, M., & Kuna, Š. (2013). Design of methodology for wood chips moisture evaluation. *Applied Mechanics and Materials*, 308, 141–146. <https://doi.org/10.4028/www.scientific.net/AMM.308.141>
- Stolarski, M. J., Niksa, D., Krzyżaniak Michałand Tworowski, J., & Szczukowski, S. (2019). Willow productivity from small- and large-scale experimental plantations in Poland from 2000 to 2017. *Renewable and Sustainable Energy Reviews*, 101, 461–475. <https://doi.org/10.1016/j.rser.2018.11.034>
- Sulaiman, C., Abdul-Rahim, A. S., & Ofozor, C. A. (2020). Does wood biomass energy use reduce CO₂ emissions in European Union member countries? Evidence from 27 members. *Journal of Cleaner Production*, 253, 119996. <https://doi.org/10.1016/J.JCLEPRO.2020.119996>
- Theerarattananon, K., Xu, F., Wilson, J., Ballard, R., Mckinney, L., Staggenborg, S., Vadlani, P., Pei, Z. J., & Wang, D. (2011). Physical properties of pellets made from sorghum stalk, corn stover, wheat straw, and big bluestem. *Industrial Crops and Products*, 33(2), 325–332. <https://doi.org/10.1016/J.INDCROP.2010.11.014>
- Variny, M., Varga, A., Rimár, M., Janošovský, J., Kizek, J., Lukáè, L., Jablonský, G., & Mierka, O. (2021). Advances in biomass co-combustion with fossil fuels in the European context: A review. *Processes*, 9(1), 1–34. <https://doi.org/10.3390/pr9010100>
- Vassilev, S. V., Baxter, D., Andersen, L. K., & Vassileva, C. G. (2010). An overview of the chemical composition of biomass. *Fuel*, 89(5), 913–933. <https://doi.org/10.1016/j.fuel.2009.10.022>
- Von Cossel, M., Lebedig, F., Müller, M., Hieber, C., Iqbal, Y., Cohnen, J., & Jablonowski, N. D. (2022). Improving combustion quality of Miscanthus by adding biomass from perennial flower-rich wild plant species. *Renewable and Sustainable Energy Reviews*, 168, 112814. <https://doi.org/10.1016/J.RSER.2022.112814>
- Wang, L., Hustad, J. E., Skreiberg, O., Skjevrak, G., & Gronli, M. (2012). A critical review on additives to reduce ash related operation problems in biomass combustion applications. *Energy Procedia*, 20, 20–29. <https://doi.org/10.1016/j.egypro.2012.03.004>
- Wang, M., Joel, A. S., Ramshaw, C., Eimer, D., & Musa, N. M. (2015). Process intensification for post-combustion CO₂ capture with chemical absorption: A critical review. *Applied Energy*, 158, 275–291. <https://doi.org/10.1016/j.apenergy.2015.08.083>
- Yamagishi, K., Sanosa, A. R., de Ocampo, M., & Ocampo, L. (2021). Strategic marketing initiatives for small co-operative enterprises generated from SWOT-TOWS analysis and evaluated with PROMETHEE-GAIA. *Journal of Co-Operative Organization and Management*, 9(2), 100149. <https://doi.org/10.1016/J.JCOM.2021.100149>

Dr inż. Marzena Ogórek

Assistant professor at the Department of Production Management at the Faculty of Production Engineering and Materials Technology at the Częstochowa University of Technology. She carries out scientific activities in two disciplines: materials engineering and management and quality sciences. Her scientific interests focus on issues related to the efficiency of production processes, strategic management and personnel management.

Dr Agnieszka Bala-Litwiniak

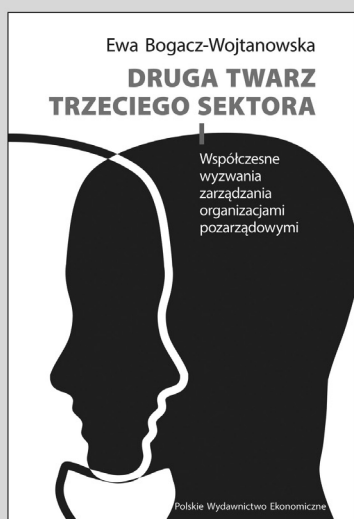
Assistant professor at the Department of Production Management at the Faculty of Production Engineering and Materials Technology at the Częstochowa University of Technology. Her scientific interests focus on broadly understood environmental protection, in particular air protection. The subject of research conducted by dr Bala-Litwiniak focuses mainly on issues related to low-emission combustion and co-combustion of fuels, biofuels, fuels and waste.

Dr inż. Marzena Ogórek

Adiunkt w Katedrze Zarządzania Produkcją Wydziału Inżynierii Produkcji i Technologii Materiałów Politechniki Częstochowskiej. Działalność naukową realizuje w dwóch dyscyplinach: inżynierii materiałowej oraz naukach o zarządzaniu i jakości. Koncentruje się na problematyce z zakresu efektywności procesów produkcyjnych, zarządzania strategicznego oraz zarządzania personelem.

Dr Agnieszka Bala-Litwiniak

Adiunkt w Katedrze Zarządzania Produkcją na Wydziale Inżynierii Produkcji i Technologii Materiałów Politechniki Częstochowskiej. Jej zainteresowania naukowe skupiają się wokół ochrony środowiska, szczególnie ochrony powietrza. Tematyka badań prowadzonych przez dr Bałę-Litwiniak koncentruje się głównie wokół zagadnień związanych z niskoemisyjnym spalaniem i współspalaniem paliw, biopaliw i odpadów.



Ewa Bogacz-Wojtanowska

**DRUGA TWARZ TRZECIEGO SEKTORA.
WSPÓŁCZESNE WYZWANIA ZARZĄDZANIA
ORGANIZACJAMI POZARZĄDOWYMI**

ZAPOWIEDŹ

Książka składa się z pięciu rozdziałów. W każdym, oprócz osadzenia w różnorodnych ramach koncepcyjnych i teoretycznych, autorka pokazuje wyniki badań zarówno światowych, jak i polskich badaczy, a także próbuje dokonać pewnych podsumowań. Tam, gdzie polski trzeci sektor jest nieco odmienny, pokazuje w szczególności owe różnice, jak również wyjaśnia ich przyczyny. W każdym rozdziale Czytelnik znajdzie także różne konkretne przykłady zachodzących procesów i zjawisk w organizacjach pozarządowych lub w ich otoczeniu, które przybliżają omawiane zagadnienia. W pierwszym rozdziale omówiono zmiany, jakie zaszły w ostatnich trzydziestu latach w rozumieniu,

czym są organizacje pozarządowe, oraz przedstawiono dowody ich stopniowej hybrydyzacji. W drugim rozdziale omówiono światowe megatrendy, które wpływają na funkcjonowanie organizacji pozarządowych i transformują je. Dużo uwagi poświęcono także procesom upodabniania się organizacji pozarządowych do przedsiębiorstw. Trzeci rozdział dotyczy przede wszystkim tradycyjnych funkcji pełnionych przez organizacje pozarządowe. Prezentuje także zmiany w realizacji tych funkcji. Rozdział czwarty poświęcono w całości dysfunkcjom i nieprawidłowościom zarządzania organizacjami pozarządowymi. Rozdział piąty dotyczy zmagania się organizacji z paradoksami. Na koniec rozdziału autorka przybliży dwa dominujące w literaturze przedmiotu modele radzenia sobie z paradoksami w zarządzaniu organizacjami pozarządowymi.

Monografia jest opracowaniem skierowanym przede wszystkim do badaczy trzeciego sektora, jego liderów, ale także wszystkich tych, którym nie jest obca troska o rozwój i powodzenie społeczeństwa obywatelskiego w Polsce i na świecie.

Więcej informacji na stronie www.pwe.com.pl