

Analysis of Information Needs for the Establishment of a Supply Management System for Waste Groups in Poland

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Abstract

Aim: The aim of the research is to accurately present the current and future status of the availability of municipal waste for thermal conversion with energy recovery, and to determine the balance of the level of supply of this waste (alternative fuels) in the RP market in relation to the level of its processing in installations in Poland.

Methodology: To conduct the study, the desk research method was used, which involves an evaluation of the records of available data sources, particularly their compilation, peer review and processing. Four publicly available, up-to-date documents and studies were used for this purpose.

Results: The research fulfilled the goal of presenting the state of availability of municipal waste for thermal conversion and the balance of its supply and processing in Poland. In 2022, the volume of municipal waste amounted to 13,420 thousand tons, and forecasts indicate a further increase until 2030. The analysis showed that in 2021 the stream of alternative fuels (RDF) exceeded the capacity for processing, suggesting the need for new investments. Efficient thermal conversion of waste is being implemented in Podlaskie, Zachodniopomorskie i Małopolskie provinces, and the cement industry is replacing coal with alternative fuels, exceeding the EU average by more than 60%.

Implications and recommendations: The work indicates the need for further monitoring and analysis of the municipal waste market for thermal conversion in Poland. It also recommends the development and modernization of existing waste processing facilities to effectively use available alternative fuels for energy production. Further studies should also consider more spatial information, such as housing characteristics, the average income of households, environmental values, the psychological factors that influence the behaviour of the inhabitants, and the location of a municipality regarding metropolises and regional peripheries.

Originality/value: The research is distinguished by its comprehensive approach to analysing the market for municipal waste for thermal conversion in Poland. The value of the work lies in the use of up-to-date, publicly available data sources and a detailed analysis of the balance of waste supply and processing, which provides valuable information for further research and activities in this area.

Keywords: municipal waste, thermal conversion, alternative fuels, supply balance, waste market

1. Introduction

Recent decades have seen a rapid increase in the amount of human-generated waste. Solid waste management has become a critical issue to the environment (Dong & Lee, 2009; Tisserant et al., 2017). Municipal waste and the threats related to it are also becoming an increasing problem in Poland (Iwaszko et al., 2021; Kotlińska & Żukowska, 2023, p. 180). In 2022, 13,420 thousand tons of waste were collected in Poland. This information was obtained from national documents, articles and studies: *Market Research of Municipal Waste Management Services in Installations in 2014-2019* by Office of Competition and Consumer Protection (UOKiK, 2019), *National Waste Management Plan 2028* by the Council of Ministers (Uchwała Rady Ministrów z dnia 12 czerwca 2023...), *Environmental Protection 2023* by Central Statistical Office (GUS, 2024) and *Rynek paliwa alternatywnego [The alternative fuel market]* by Bień (2023), presenting data on municipal waste generated and collected for thermal conversion with energy recovery, providing support for this publication.

“The instability of the geopolitical situation of European Union countries and the disruption of the stability of energy raw materials supplies have led to a reorientation of strategic actions in the field of energy security. In 2022, the European Union introduced the REPowerEU plan, whose main premise is the diversification of supplies and acceleration of the green transformation process to increase energy security” (Manowska et al., 2024, p.2). Poland, as a member of the Union, is also obliged to meet Community objectives such as included in REPowerEU.

With these data in mind, the authors of this article aim to accurately present the current and future state of availability of municipal waste for thermal conversion with energy recovery, as well as to determine the balance of the level of supply of municipal waste for thermal conversion (alternative fuels) in the RP market to the level of processing of this waste in installations in the RP (use as fuel or other means of energy production). To achieve this goal, the authors used a methodological approach including literature analysis, document analysis, and the desk research method. The structure of the article is adapted to the formulated purpose of the work. Accordingly, the following section is devoted to the description of methods. The third section presents the results of the analysis of the current and future state of supply for the listed waste. At the end of the article there is a discussion of the results and a summary.

2. Literature Review

The first definition of sustainable development was given by The World Commission on Environment and Development (Chomiak-Orsa, 2016). As a result of the Commission’s work, a framework for development was set: it should take place in a sustainable manner and be based on three pillars – environmental, social and economic (Laconte, 2012). Sustainable development is also expressed in the concept of the 17 UN Sustainable Development Goals (SDGs), which set out a common vision for the future and a roadmap for governments, industry, NGOs and all citizens for a better world (Chomiak-

Orsa et al., 2023, p. 2184). Sustainable development goals are the basis for taking action to reduce environmental degradation by human activity (Barbier & Burgess, 2017; Lyle, 1996). The term 'sustainable development' has become a key element of the political, economic and social agenda, and its importance continues to grow in the face of increasingly obvious challenges related to environment and climate degradation (Tomaszewski & Sekściński, 2020, p. 10). Energy management, including renewable energy sources (RES), is one of the directions of investment worldwide, and Poland is part of this global trend (Elsaid & Aghezzaf, 2015; Zaleski & Chawla, 2020). Modern companies that want to meet customer demands are pursuing sustainable goals through investments, including waste management, which is crucial in the context of the problem of global littering of the planet (Bednarowska, 2015; Wolff et al., 2017). Municipal waste management and investment in RDF (Refuse Derived Fuel) processing plants are therefore among the developments in the area of sustainable development.

The results of currently available studies on municipal waste processing in Poland indicate significant variations in the level of supply of waste for thermal processing. In 2022, the highest share of such waste in total waste generated was observed in the following provinces: Podlaskie (46.3%), Zachodniopomorskie (33.2%), Małopolskie (31.5%), Kujawsko-pomorskie (29.9%) and Lubelskie (28.5%). The largest volume of waste for thermal conversion at the national level was in the following provinces: Wielkopolskie (414,000 t), Małopolskie (365,000 t) and Mazowieckie (245,000 t) (GUS, 2024).

The aim of our article is to thoroughly investigate the current and future status of the supply of municipal waste for thermal treatment with energy recovery on the Polish market. Current studies provide valuable information that confirms that the amount of municipal waste in Poland has increased to 13,420,000 t in 2022, which is an important basis for further analysis. With regard to the purpose of our article, the collected data indicate a growing demand for RDF waste treatment facilities, which is in line with our hypotheses regarding the increasing potential of using waste as an alternative fuel.

In addition, our research questions focus on the forecasts for the waste market in Poland and the balance of municipal waste supply to the level of treatment in installations. Current studies, such as those conducted by UOKiK (2019) and Bień (2023), indicate that the cement industry plays a key role in RDF processing, confirming the high efficiency of waste use as an alternative fuel, exceeding the EU average by 60%.

3. Methodology

The aim of this study is to examine in detail the current and future status of the supply of municipal waste for thermal treatment with energy recovery. In order to achieve this objective, the following research questions were formulated:

1. What is the level of supply of municipal waste for thermal treatment with energy recovery in the RP market?
2. What are the expert forecasts for the waste market in Poland?
3. What is the balance between the level of supply of municipal waste for thermal treatment (alternative fuels) in the RP market and the level of treatment of this waste in installations in RP (use as fuel or other means of energy production)?

The study was based on three publicly available, up-to-date documents and an article:

- *National Waste Management Plan 2028* (Uchwała Rady Ministrów z dnia 12 czerwca 2023...),
- *Environmental Protection 2023* (GUS, 2024),
- *Market Research for Municipal Waste Management Services in Installations 2014-2019* (UOKiK, 2019),
- The article entitled *Rynek paliwa alternatywnego [The alternative fuel market]* by Bień (2023).

When analysing the above sources, data on municipal waste generated and collected for thermal treatment with energy recovery was taken into account.

4. Results

National Waste Management Plan 2028

Any market analysis, in order to be well formulated, must have identified external factors affecting the development of a given market. The *National Waste Management Plan 2028* passed by the Council of Ministers lists these factors as follows (Uchwała Rady Ministrów z dnia 12 czerwca 2023...):

- type of area (urban, rural) where they are produced,
- social trends (changes in people's lifestyles, increasing level of prosperity, growing environmental awareness),
- legal tendencies of the changes,
- regulations regarding the restriction or elimination of certain products (e.g. single-use plastic items),
- population density,
- type of development (single-family, multi-family),
- number of tourists,
- presence of public facilities,
- presence, type, size, and number of retail and small industry or service establishments.

The projection for 2022-2040 of municipal waste generation was made on the basis of the mass of municipal waste generated in 2013-2020 in the country and of the correlation of waste generation with GDP. The values of the unit indicator of waste generation were correlated with the growth rate of Poland's GDP in 2013-2020, and the indicator was extrapolated based on forecasts of the growth rate of Poland' GDP value. Thanks to the above, it was possible to carry out a forecast for 2019-2030 to 2040, assuming that the population of Poland will steadily decrease throughout the forecast period (see Table 1).

Table 1. Projected masses of waste streams in Poland (thousand Mg/year)

Waste \ Year	2020	2022	2025	2030	2035	2040
Fraction < 10 mm	944.4	969.7	939.7	734.3	519.9	273.9
Fraction 10-20 mm	577.1	605.0	629.0	598.3	516.3	418.5
Bio-waste food (kitchen)	1 726.3	1 827.8	1 963	2013.3	1 900.6	1 752.2
Bio-waste from green spaces	2 037.2	2 157.0	2 316.6	2375.9	2 383.1	2363.1
Wood	63.0	67.3	74.6	81.6	86.7	91.3
Paper and cardboard	1 414	1 512.4	1 675	1 832.4	1946.1	2 050.4
Plastics	1 389.1	1 470.8	1 579.7	1 620.1	1 625.0	1 611.4
Glass	1 349.7	1 443.6	1 598.9	1 749.1	1857.6	1 957.2
Textiles	223.0	233.7	253.5	260.1	260.9	258.6
Metals other than aluminium	127.2	136.1	150.7	164.9	175.1	184.5
Aluminium	179.7	192.2	212.9	232.9	247.3	260.6
Multi-material waste	115.4	123.5	136.7	149.6	158.9	167.4
Mineral waste	928.7	983.4	1 078.1	1 155.4	1 188.6	1 211.9
Hazardous waste	38.0	40.7	45.1	49.3	52.4	55.2
Hygiene waste, pampers	721.4	771.6	854.6	934.9	992.9	1 046.1
Bulky waste	924.7	979.2	1 062.5	1 102.5	1 120	1 139.8
Rubber, leather	285.9	305.8	338.7	370.6	393.6	414.6

Source: (Ministerstwo Klimatu i Środowiska, 2023).

The data presented above clearly indicate that the supply of waste in the Polish market will maintain an upward trend at least until 2030. However, the most adequate analysis of the supply of raw material is presented by Bień (2023).

Environmental Protection 2023

The most important information provided in the report by the Central Statistical Office (GUS, 2024) is the separation by province of the methods of municipal waste management, shaped as shown in Tab. 2.

Table 2. Municipal waste generated in 2022 according to the mode of management and provinces (thousand tonnes)

Province	Intended for				
	total	recycling	composting or fermentation	thermal transformation	storage
Dolnośląskie	1220	418	157	131	514
Kujawsko-pomorskie	717	154	112	215	237
Lubelskie	519	126	78	148	167
Lubuskie	391	72	58	62	198
łódzkie	849	224	130	162	333
Małopolskie	1 156	285	168	365	338
Mazowieckie	1 974	529	256	245	944
Opolskie	361	102	59	47	153
Podkarpackie	505	118	41	115	230
Podlaskie	339	93	47	157	42
Pomorskie	904	233	151	198	322
Śląskie	1 713	498	269	182	764
Świętokrzyskie	325	89	18	42	177
Warmińsko-mazurskie	438	154	50	89	146
Wielkopolskie	1 331	323	216	414	378
Zachodniopomorskie	677	166	89	225	167

Source: own elaboration based on (GUS, 2024).

In 2022, the share of waste for thermal conversion in total waste generated reached the highest value in the following provinces: Podlaskie (46.3%), Zachodniopomorskie (33.2%), Małopolskie (31.5%), Kujawsko-pomorskie (29.9%), Lubelskie (28.5%). The largest amount of waste for thermal conversion nationwide occurred in the provinces: Wielkopolskie (414 000 t), Małopolskie (365 000 t), and Mazowieckie (245 000 t). These provinces have the greatest potential for thermal waste processing.

Market Research of Municipal Waste Management Services in Installations in 2014-2019

The first of the two most important conclusions of the Office of Competition and Consumer Protection (UOKiK, 2019) study is the conclusion of the thesis that plants engaged in the thermal conversion of RDF-type waste generated from the combustible fraction of pre-RDF have a complementary role to MBP plants (i.e. plants engaged in mechanical-biological processing of waste). Only installations that thermally transform non-segregated municipal waste play a substitute role (Bień, 2021). To illustrate the share of individual types of installations their distribution according to the online waste database operating under the provisions of the Act on open data and reuse of public sector information (Ustawa z dnia 11 sierpnia 2021...) is presented in Figure 1.

The second key finding of the study is that the cement industry processes the largest part of its waste in the form of segregated RDF. At present, cement works are the only receivers of RDF in Poland (Bień, 2023). This is due to the fees that municipal utilities pay to cement plants for the collection and thermal conversion of this waste. The consequence of this is a very high rate of coal substitution with alternative fuels, which reached 70% in 2019, exceeding the EU average of 44% by 60%.

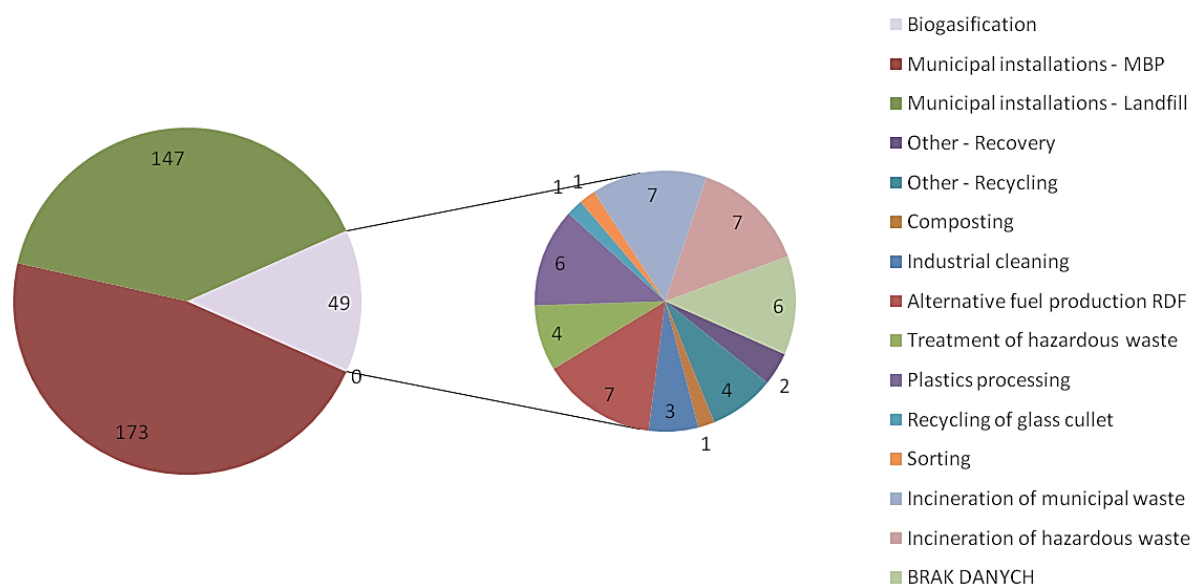


Fig. 1. Share of installation types in Poland for waste treatment

Source: own elaboration based on (BDO, 2025).

The Alternative Fuel Market

The first data Bień (2023) provides in his article is the supply of RDF feedstock from 2016 to 2021 (Fig. 2).

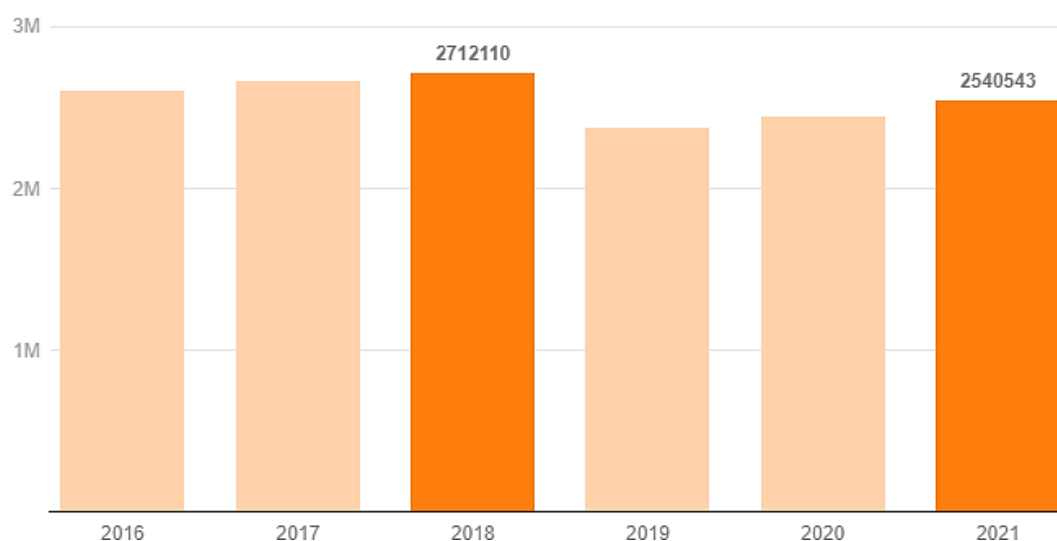


Fig. 2. Amount of alternative fuel 191210 produced in 2016-2021

Source: (Bień, 2023).

The supply of RDF fuel for 2021 aggregated in all provinces was 2,540,843 t (see Table 3).

Table 3. The amount of alternative fuel 191210 produced in each province from 2016 to 2021 (in t)

Province	Year					
	2016	2017	2018	2019	2020	2021
Dolnośląskie	136 246	205 290	208 208	213 059	144 878	185 804
Kujawsko-pomorskie	188 629	209 882	255 032	259 221	327 700	299 302
Lubelskie	231 241	247 509	229 535	229 447	208 184	232 328
Lubuskie	64 880	15 137	184 845	100 482	58 532	66 675
łódzkie	42 624	60 552	67 123	53 876	130 164	144 198

Province	Year					
	2016	2017	2018	2019	2020	2021
Małopolskie	166 869	88 572	96 930	104 409	134 262	110 883
Mazowieckie	697 032	664 364	559 436	301 203	341 330	297 154
Opolskie	42 825	46 616	51 198	70 947	66 534	65 009
Podkarpackie	90 905	94 216	76 569	46 013	38 931	92 240
Podlaskie	16 518	15 781	19 031	26 171	8 941	10 263
Pomorskie	22 189	23 798	28 321	22 686	25 508	10 851
Śląskie	304 120	426 910	455 248	465 437	412 835	470 916
Świętokrzyskie	81 454	96 386	118 388	156 557	167 994	191 155
Warmińsko-mazurskie	154 627	134 885	119 056	128 572	126 409	118 412
Wielkopolskie	216 267	183 340	180 002	140 900	13 076	153 305
Zachodniopomorskie	151 329	145 640	63 187	59 800	112 396	92 348

Source: own elaboration based on (Bień, 2023).

A potential process for the use of waste with the listed codes is the recovery of alternative fuel through the so-called R1 process. The amount of alternative fuel processed thermally is increasing year by year. In the analysed period, i.e. 2016-2021, the amount increased from 1.22 million t to 1.73 million t, which would indicate growing interest and investment in the area of this type of processing, as shown in Fig. 4.

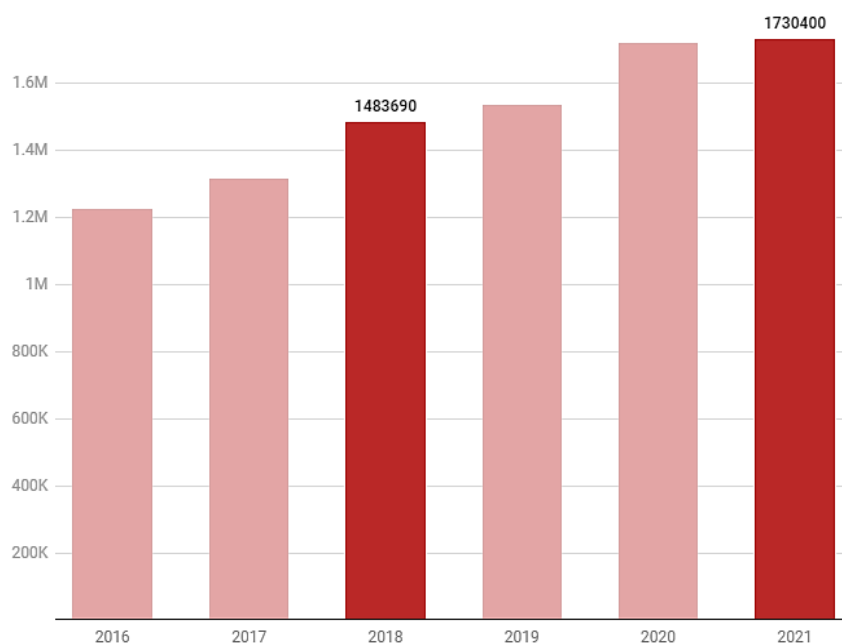


Fig. 4. Recovery of alternative fuel 191210 in the R1 process

Source: (BDO, 2025).

The analysis shows that the stream of alternative fuels produced for 2021 is still greater than the possibility of its energetic management in the R1 process in Poland – the amount of fuel produced is 2,540,543 t and the amount of recovery – 1,730,400 t.

5. Discussion and Conclusions

This article provides an in-depth analysis of the availability of waste groups in the Polish market, using a wide range of data from a variety of sources, including national documents, industry reports and scientific studies, and presents data on the potential of facilities for the thermal conversion of RDF waste generated from the combustible fraction of pre-RDF.

The authors focused on answering the following research questions:

- What is the level of supply of municipal waste for thermal conversion with energy recovery in the RP market?
- What are the expert forecasts for the waste market in Poland?
- What is the balance of the level of supply of municipal waste for thermal conversion (alternative fuels) in the RP market to the level of processing of this waste in installations in RP (use as fuel or other means of energy production)?

Below the authors presents the answers for this research questions.

Based on the information gathered, the amount of municipal waste in Poland in 2022 was an impressive 13,420 thousand t, indicating the significant scale of the waste management challenge. The above information can be a starting point for considering the scale of the problem and alternative uses for other waste sections. In addition, an analysis of future forecasts suggests that the upward trend in waste production will continue until at least 2030, requiring effective waste management strategies. Thermal conversion of waste seems to be particularly popular in Podlaskie, Zachodniopomorskie and Małopolskie provinces, which accounts for the favourable effects of the waste reuse method. In light of these data, it becomes clear that effective waste management in Poland requires diverse approaches and strategies. One of the aspects addressed in the article is the analysis of the supply of RDF (Refuse Derived Fuel) feedstock. It turns out that the cement industry plays an important role in processing waste, especially RDF, as confirmed by the high degree of substitution of coal by alternative fuels, exceeding the EU average by more than 60%. It is necessary to continue research on alternative waste processing methods, as well as to promote measures to reduce the amount of waste generated through public education and the use of more efficient waste management practices. The study also shows that the stream of alternative fuels produced for 2021 (2,540,543 t) is still larger than the possibility of its energetic management in the R1 process in Poland – the amount of recovery being 1,730,400 t. This creates the potential for further investments in thermal processing facilities in Poland. The work indicates the need for further monitoring and analysis of the municipal waste market for thermal conversion in Poland. It also recommends the development and modernization of existing waste processing facilities to effectively use available alternative fuels for energy production. Further studies should also consider more spatial information, such as housing characteristics, the average income of households, environmental values, the psychological factors that influence the behaviour of the inhabitants, and the location of a municipality regarding metropolises and regional peripheries (Antczak, 2019).

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Identyfikacja potencjału podaży grup odpadów w Polsce

Streszczenie

Cel: Celem badań jest precyzyjne przedstawienie obecnego i przyszłego stanu dostępności odpadów komunalnych przeznaczonych do przekształcania termicznego z odzyskiem energii oraz określenie bilansu poziomu podaży tych odpadów (paliw alternatywnych) na rynku RP w stosunku do poziomu ich przetwarzania w instalacjach na terenie Polski.

Metodyka: Do przeprowadzenia badania wykorzystano metodę *desk research*, która sprowadza się do oceny zapisów dostępnych źródeł danych, obejmując w szczególności ich kompilację, wzajemną weryfikację i przetwarzanie. Zostały w tym celu wykorzystane cztery ogólnodostępne, aktualne dokumenty i badania.

Wyniki: Wyniki badań pokazują szczegółową analizę podaży odpadów komunalnych przeznaczonych do przekształcania termicznego w Polsce. Analiza wykazała, że ilość odpadów komunalnych w 2022 r. wyniosła 13 420 tys. t i pozwoliła na stworzenie kompleksowego bilansu podaży i przetwarzania tych odpadów.

Implikacje i rekomendacje: Praca wskazuje konieczność dalszego monitorowania i analizy rynku odpadów komunalnych przeznaczonych do przekształcania termicznego w Polsce. Zaleca się również rozwój i modernizację istniejących instalacji do przetwarzania odpadów, aby skutecznie wykorzystywać dostępne paliwa alternatywne do produkcji energii.

Oryginalność/wartość: Badania wyróżniają się kompleksowym podejściem do analizy rynku odpadów komunalnych przeznaczonych do przekształcania termicznego w Polsce. Wartość pracy polega na wykorzystaniu aktualnych, ogólnodostępnych źródeł danych oraz na szczegółowej analizie bilansu podaży i przetwarzania odpadów, co dostarcza cennych informacji dla dalszych badań i działań w tym obszarze.

Słowa kluczowe: odpady komunalne, przekształcanie termiczne, paliwa alternatywne, bilans podaży, rynek odpadów
