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Ryszard WASIELEWSKI<sup>1</sup>, Martyna NOWAK<sup>2</sup>

## Alternative fuel market in Poland

**ABSTRACT:** The article discusses issues related to the generation, use, and transboundary movement of waste labeled with the code 191210 according to the waste catalogue regardless of its origin (municipal, industrial or mixed). Data contained in voivodship reports related to waste management and information about transboundary shipments shared by the Chief Inspectorate of Environmental Protection were also used in the article. The imbalance in the amount of produced and energetically used alternative fuels in Poland in the years 2015 to 2017 has been confirmed. This affects the economy of the waste management sector involved in the production of alternative fuels. The oversupply causes the prices of alternative fuels to fall and increases the need for subsidies in the case of the recovery or disposal of alternative fuels of lower quality. In the near future one should expect a stabilization of the supply of combustible waste to the cement industry, which is now beginning to achieve its technological potential; this is due to a high degree of replacement of fossil fuels. One should also expect an increase in the demand for alternative fuels from the commercial power sector and heating sector. It has been shown that much more alternative fuel is imported than exported from Poland. The amount of imported alternative fuel in the market is relatively low compared to the amount of fuel produced in the country. This oversupply affects, although not significantly, the possibility of using domestic waste for energy recovery. The export of the alternative fuel produced in the country is a favorable phenomenon when there is no possibility of sale on the domestic market. It seems rational, especially in the case of exports from installations producing fuels in border provinces.

**KEYWORDS:** alternative fuels, waste fuels, energy recovery, market

<sup>1</sup> The Institute for Chemical Processing of Coal, Zabrze (IChPW); e-mail: [rwasielewski@ichpw.pl](mailto:rwasielewski@ichpw.pl)

<sup>2</sup> The Institute for Chemical Processing of Coal, Zabrze (IChPW); e-mail: [mnowak@ichpw.pl](mailto:mnowak@ichpw.pl)

## Introduction

The modern waste management system should include energy recovery, without which the development balance of many waste groups cannot be closed (Brunner and Rechtechberger 2015; Żygadło 2018; Rada 2016; Wasielewski and Sobolewski 2009). This is also important from an economic point of view. A large part of waste generated in the production and consumption processes has energy values that can be used to produce electricity and/or heat (Lombardi et al. 2015). The heterogeneity of the composition and the instability of physicochemical properties are, however, a serious obstacle in the direct use of unprocessed waste as fuel. Difficulties include both technical and operational problems, as well as ecological hazards related to the emission of pollutants into the air (Wasielewski and Tora 2008; Wasielewski and Hrabak 2013; Skawińska et al. 2017). A solution to this problem may be the pre-treatment of waste aimed at obtaining so-called qualified alternative fuels, for which specific quality requirements can be set (Beckmann et al. 2012). The production and use of waste fuels in energy-intensive industries, such as cement production or the pulp and paper industry has been widely used in European Union countries for many years (EC-DGE 2003; Fyffe et al. 2016; Mokrzycki and Uliasz-Bocheńczyk 2002; Duczowska-Kądziel and Duda 2014). It is also possible to use these wastes in the power industry and heating (Mokrzycki and Uliasz-Bocheńczyk 2005; Hilber et al. 2007; del Zotto et al. 2015). The use of waste fuels saves fossil fuel resources and contributes to reducing greenhouse gas emissions. Waste fuel can also be a renewable energy carrier because it often contains biodegradable fractions (Wasielewski and others 2007; Wasielewski and Bałazińska 2017). The development of such activities, which allowed for the development of a clear commercial market, has also been observed in Poland (Wandrasz and Wandrasz 2006; Nowak and Szul 2016; Sobolewski et al. 2007; Wasielewski and Sobolewski 2015).

The aim of the article is to present the phenomena occurring in the domestic alternative fuels market, including both generators and customers, as well as their cross-border movement.

Data on the amount of waste generated and processed come from voivodship reports on waste management for the years 2015–2017. These reports are available on the websites of provincial self-governments or after submitting a request (EIA Act 2008). The data provided by the Chief Inspectorate of Environmental Protection, and obtained from direct contacts with producers and recipients of alternative fuels were also used.

## 1. Alternative fuels

Alternative fuels are non-hazardous waste labeled with the code 191210 (Catalog of waste 2014). They are produced from non-hazardous waste and carry the same code regardless of the

origin of the raw material (municipal, industrial, or mixed waste). Alternative fuel producers are mainly specialized producers processing various types of combustible waste from external suppliers, including waste labelled with the code 191210, in order to produce an energy carrier with a high calorific value meeting the quality requirements of the final recipient.

Alternative fuels are also produced in many Municipal Waste Processing Facilities. Municipal Waste Processing Facilities use energy fractions, derived from mechanical and biological processing of mixed municipal waste, which are not suitable for recycling. The introduction of a legislative ban on the storage of selected types of combustible waste in 2016, including waste labelled with the code 191212, which are generated in Municipal Waste Processing Facilities ([Regulation 2015](#)), played an important role in the development of the production of municipal waste fuels.

The presented article discusses waste labelled with the code 191210, regardless of the origin of the raw material and the producer.

## 2. The domestic production potential of alternative fuels

According to data published in voivodship reports – the production of alternative fuels in Poland in the years 2015–2017 exceeded 2 million Mg and was subject to minor changes ([Voivodship reports 2015–2017](#)) as presented in Table 1. In 2015, about 2.37 million Mg of alternative fuel was produced; in the following year this amount increased to 2.61 million Mg, while in 2017 it slightly decreased to the level of about 2.36 million Mg. The largest amount of waste is produced in the following provinces: Masovian (over 600,000 Mg), Silesian (over 300,000 Mg), Kuyavian-Pomeranian, and Lublin Provinces (around 200,000 Mg). The smallest number of alternative fuels is produced in the Podlasie Province (about 25,000 Mg in 2015, with no alternative fuels produced in 2017) and the Pomeranian Province (over 10,000 Mg).

Figure 1 shows the number of installations producing alternative fuels in individual provinces of Poland in 2017. In total, there were 166 producers of alternative fuel with the waste code 191210 in 2017 ([Voivodship reports 2015–2017](#)). The domestic alternative fuel producers market is strongly dispersed. Production installations are unevenly distributed throughout the country. Most of them are located in the Silesian, Greater Poland, and Masovian Provinces, while the least of them could be found in the Podlasie and Lubusz Provinces. The number of generation units is correlated with the economic potential of individual provinces and the amount of waste available for processing. In Figure 1, provinces are marked in accordance with symbols in Tables 1 and 2.

Figure 2 shows the volume of alternative fuel production in the years 2015–2017.

Analyzing the size of individual generating installations, it can be noticed that the production capacities of domestic installations producing alternative fuels are highly variable. Half of the production potential is constituted by small installations producing up to 5,000 Mg/year of

TABLE 1. Changes in alternative fuel production in Poland by provinces in the years 2015–2017 [Mg]

TABELA 1. Zmiany ilości wytwarzanych paliw alternatywnych w Polsce w latach 2015–2017 [Mg]

| Province            | Symbol | Year         |              |              |
|---------------------|--------|--------------|--------------|--------------|
|                     |        | 2015         | 2016         | 2017         |
| Lower Silesian      | LS     | 93,686.49    | 136,123.08   | 73,828.49    |
| Kuyavian-Pomeranian | KP     | 193,760.12   | 188,606.43   | 209,880.14   |
| Lublin              | LB     | 223,384.23   | 230,418.84   | 248,576.88   |
| Lubusz              | L      | 69,874.98    | 64,880.29    | 15,137.48    |
| Łódź                | ŁD     | 56,585.01    | 44,018.62    | 56,026.78    |
| Lesser Poland       | LP     | 119,215.78   | 166,869.45   | 88,571.52    |
| Mazovian            | MZ     | 736,459.10   | 696,983.42   | 643,156.25   |
| Opole               | OP     | 17,342.33    | 42,824.51    | 46,616.14    |
| Subcarpathian       | SC     | 110,844.23   | 90,883.44    | 34,369.23    |
| Podlaskie           | PL     | 25,124.19    | 16,518.30    | 0.00         |
| Pomeranian          | PM     | 11,118.59    | 12,976.26    | 14,121.24    |
| Silesian            | SL     | 304,721.93   | 319,249.73   | 384,736.10   |
| Świętokrzyskie      | ŚK     | 73,828.49    | 81,453.59    | 94,298.36    |
| Warmian-Masurian    | WM     | 98,750.29    | 154,616.51   | 134,885.30   |
| Greater Poland      | GP     | 141,386.79   | 216,251.57   | 174,164.09   |
| West Pomeranian     | WP     | 102,630.54   | 151,328.95   | 145,640.42   |
| TOTAL               |        | 2,378,308.23 | 2,614,002.99 | 2,363,008.40 |

Source: own source based on (Voivodship reports 2015–2017).

alternative fuel. Large production installations producing more than 80,000 Mg/year constitute only 2–3% of all the operating installations. This distribution in the analyzed time period (2015–2017) did not undergo any major changes.

The changes in the production of alternative fuels by the largest domestic producers in the years 2016–2017 are presented in Figure 3.

The biggest producers of alternative fuels are the following companies: NOVAGO Sp. z o.o., (around 190,000 Mg), Municipal Cleaning Company in Warsaw (about 160,000 Mg), PPUH Lekaro in Wola Ducka (around 130,000 Mg) and Ekopaliwa Chełm Sp. z o. o. (approximately 95,000 Mg). Each of these producers can produce more than 150,000 Mg of alternative fuels per year. Meanwhile, it should be noted that according to data obtained directly, the production capabilities of many installations are significantly, at least 20%, bigger and depend only on the possibility of obtaining the raw material and orders of potential recipients.

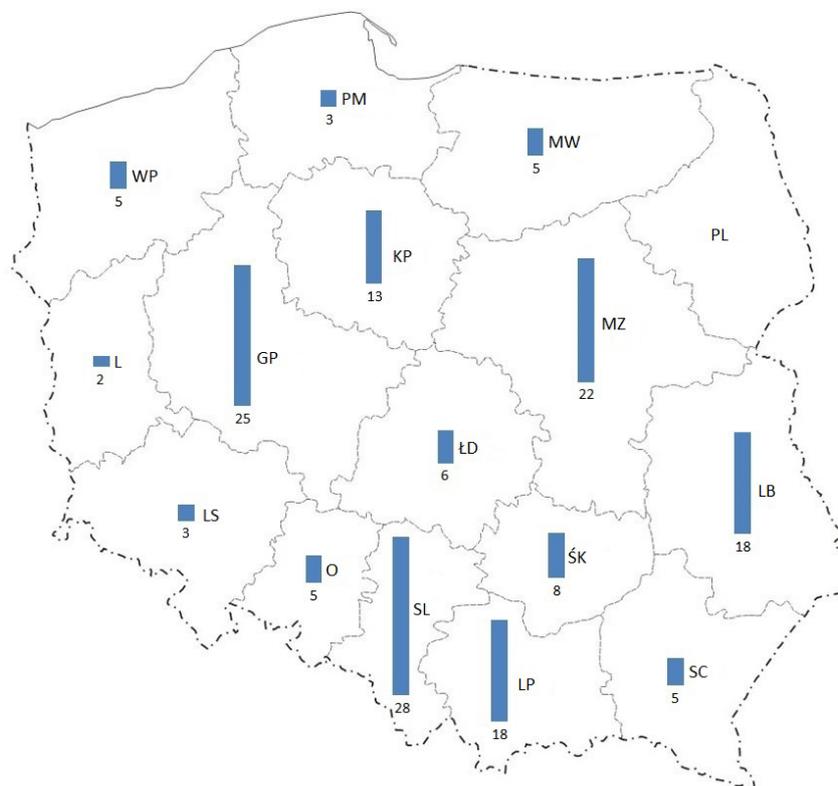


Fig. 1. The number of installations producing alternative fuels in Poland by provinces in 2017.

Source: own source based on (Voivodship reports 2015–2017)

Rys. 1. Liczba instalacji wytwarzających paliwa alternatywne na terenie poszczególnych województw w 2017 r.

### 3. The use of alternative fuels in Poland

There are two main recovery processes of alternative fuels:

- ◆ R1 – used principally as a fuel or other means to generate energy,
- ◆ R12 – exchange of waste for submission to any of the operations numbered R1 to R11 (The Act on Waste 2012).

Figure 4 compares the amount of waste fuels with the code 191210 and waste produced and recovered using R1 and R12 processes in Poland in the years 2015–2017. The amount of alternative fuels subjected to thermal treatment during the R1 recovery operation in the analyzed period was at the level of 1.15 million Mg in 2015 and 1.32 million Mg in 2017, and was slightly increasing annually. Meanwhile, the amount of processed fuels in the R12 process was in the range of

TABLE 2. The amount of waste fuels recovered using R12 process in the years 2015–2017 in Poland by provinces [Mg]

TABELA 2. Ilość paliw alternatywnych poddanych procesowi odzysku R12 w latach 2015–2017 w Polsce, w podziale na województwa [Mg]

| Province            | Symbol | Year       |            |            |
|---------------------|--------|------------|------------|------------|
|                     |        | 2015       | 2016       | 2017       |
| Lower Silesian      | LS     | 17,178.29  | 32,533.28  | 3,506.35   |
| Kuyavian-Pomeranian | KP     | 97,484.82  | 106,368.76 | 85,401.10  |
| Lublin              | LB     | 88,676.60  | 65,094.73  | 82,221.48  |
| Lubusz              | L      | 10,278.88  | 6,555.22   | 0.00       |
| Łódź                | ŁD     | 13,528.90  | 0.00       | 13.00      |
| Lesser Poland       | LP     | 29,578.50  | 35,405.40  | 26,129.90  |
| Mazovian            | MZ     | 155,152.29 | 203,351.25 | 218,665.06 |
| Opole               | OP     | 1075.39    | 8,494.84   | 11,985.86  |
| Subcarpathian       | SC     | 42,698.87  | 16,696.20  | 0.00       |
| Podlaskie           | PL     | 5,838.40   | 9,154.04   | 0.00       |
| Pomeranian          | PM     | 496.66     | 2,920.72   | 583.10     |
| Silesian            | SL     | 37,464.63  | 29,824.42  | 66,245.49  |
| Świętokrzyskie      | ŚK     | 9,016.91   | 6,131.91   | 11,488.71  |
| Warmian-Masurian    | WM     | 79,437.54  | 19,157.20  | 31,459.12  |
| Greater Poland      | GP     | 7,731.00   | 10,336.34  | 4,031.18   |
| West Pomeranian     | WP     | 0.00       | 833.70     | 1,218.60   |
| TOTAL               |        | 595,637.68 | 552,858.02 | 542,948.95 |

Source: own source based on (Voivodship reports 2015–2017).

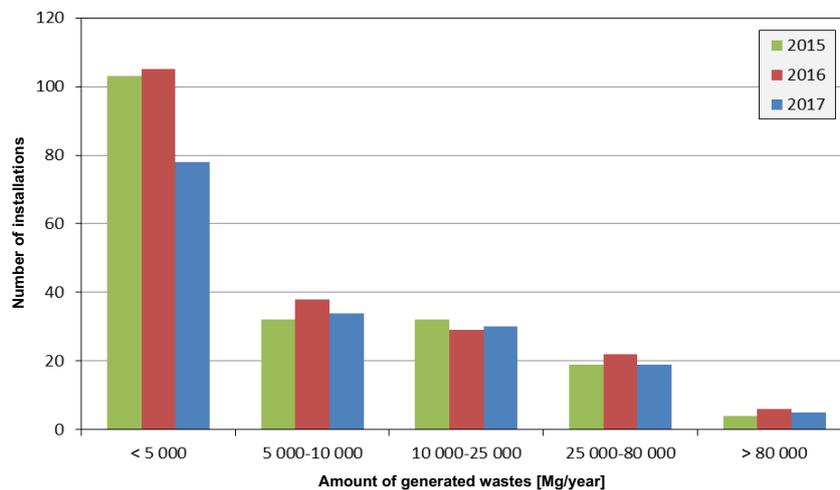


Fig. 2. The changes in the size of installations producing alternative fuels in the years 2015–2017

Source: own source based on (Voivodship reports 2015–2017)

Rys. 2. Zmiany wielkości instalacji wytwarzających paliwa alternatywne w latach 2015–2017

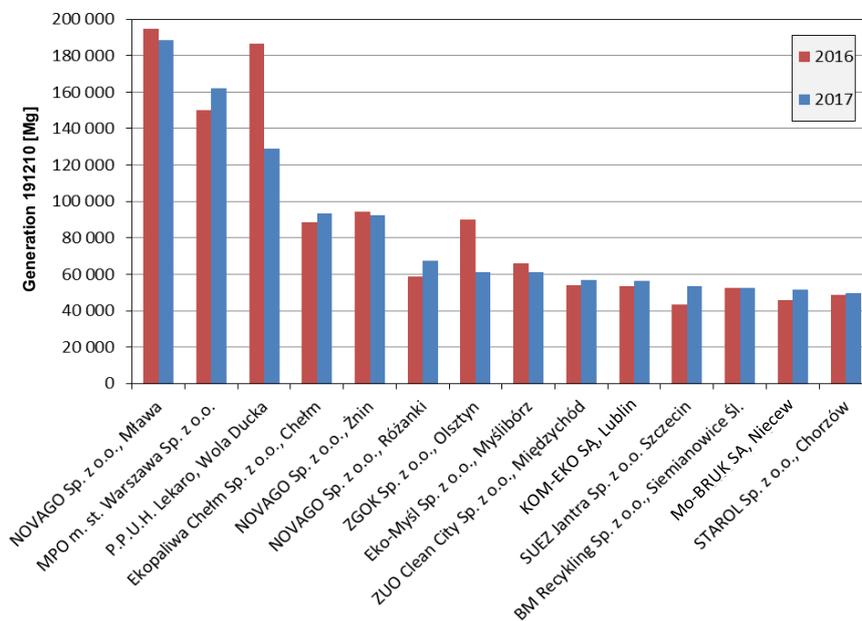


Fig. 3. The largest producers of alternative fuel in the years 2016–2017

Source: own source based on (Voivodship reports 2015–2017)

Rys. 3. Najwięksi wytwórcy paliwa alternatywnego w latach 2016–2017

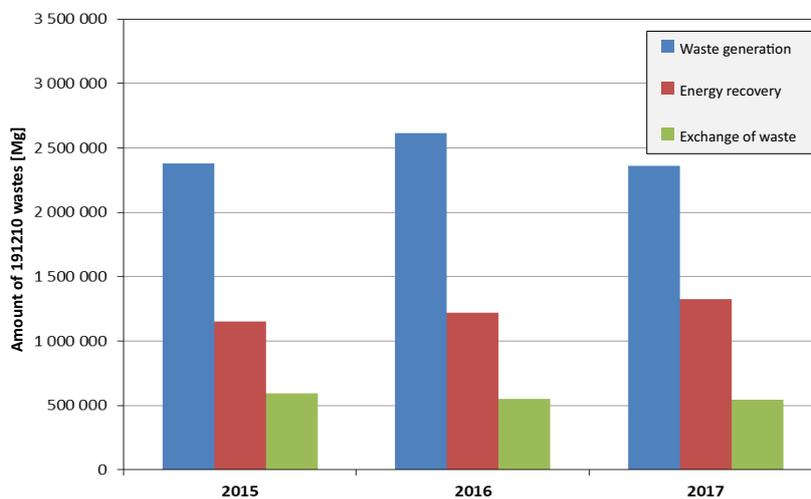


Fig. 4. The comparison of waste fuels produced and recovered using R1 and R12 processes in the years 2015–2017

Source: own source based on (Voivodship reports 2015–2017)

Rys. 4. Porównanie ilości wytworzonych oraz przetworzonych w procesach R1 i R12 paliw alternatywnych w latach 2015–2017

PLN 540–590,000 Mg/year in the analyzed period. The stream of alternative fuels produced in Poland in 2015–2017 was much larger than the stream of their development; this applies both to the R1 and R12 processes in domestic installations.

Although the processing capacities recorded in the integrated permits for individual installations are much larger, none of them has reached this level. It seems that these provisions should be treated as purely theoretical but not realizable.

It should be noted that the reprocessing of already evidenced and reported alternative fuels may cause inaccuracies in the estimation of the total amount of produced alternative fuels in individual periods. In the presented article, due to the need for detailed consideration of each such case, these relations were not taken into account.

### 3.1. The R12 recovery process

Alternative fuels are used by specialized producers in the R12 recovery process ([Voivodship reports 2015–2017](#)), which is aimed at improving the quality parameters of the mentioned fuels. In the R12 process, the net calorific value of an alternative fuel is increased mainly due to drying or mixing with other high-calorific waste streams. Some of these producers also use imported alternative fuels. It should be noted that the R12 process does not end the waste treatment chain and is only an intermediate link before the final use of an alternative fuel in the R1 process.

The number of entities dealing with waste treatment is around 30. In 2015, 36 entities recovered alternative fuels using the R12 process; in 2016 – 39 entities, while in 2017 – 33 entities. In 2017, the largest amount of waste was processed in the NOVAGO Mława (over 200,000 Mg), NOVAGO Żnin (over 85,000 Mg) and Ekopaliwa Chełm (nearly 70,000 Mg) installations ([Voivodship reports 2015–2017](#)).

Table 2 presents the quantities of waste with the waste code 191210 used in installations carrying out R12 process in the years 2015–2017. The amounts of processed waste range from approximately 453,000 Mg to almost 600,000 Mg. In 2017, the largest amount of waste was processed in the following provinces: Masovian (around 200,000 Mg), Kuyavian-Pomeranian (around 85,000 Mg) and Lublin Province (around 82,000 Mg). In 2017, in the Lubusz, Subcarpathian and Podlasie Provinces, no alternative fuels processing using the R12 process has been confirmed.

### 3.2. The R1 recovery process

The energy use of alternative fuels is classified as the R1 recovery process – assuming the used as a fuel or other means of energy generation ([The Act on Waste 2012](#)). This process completes the waste processing chain and only needs to be supplemented with the management of solid by-products.

In Poland, installations recovering energy using alternative fuels are far less common than facilities producing alternative fuels. In the analyzed period of 2015–2017, only 20 industrial installations in Poland have officially confirmed, as shown in documentary evidence, the use of waste with the code 191210 for the R1 energy recovery process. The cement industry plays a decisive role among them. The largest recipients of alternative fuels in the years 2016–17 are presented in Figure 5.

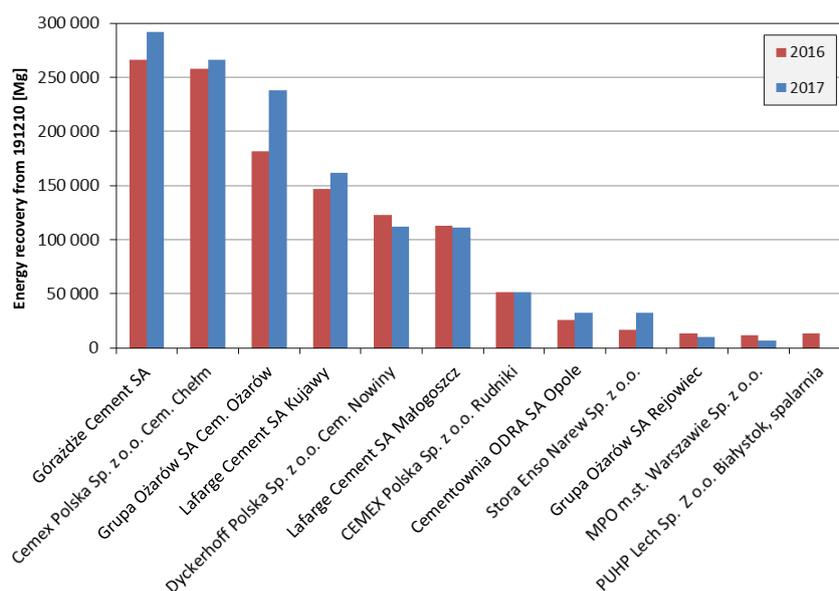


Fig. 5. The largest recipients of alternative fuels in the years 2016–2017

Source: own source based on (Voivodship reports 2015–2017)

Rys. 5. Najwięksi odbiorcy paliwa alternatywnego w latach 2016–2017

The presented data confirms that the cement industry, in particular installations for the production of clinker, has been the most important recipient of alternative fuels in Poland for many years. The demand for alternative fuels in individual cement plants depends on the production of clinker, as well as on the degree of the replacement of fossil fuels, mainly hard coal. The maximum processing capacity of the cement industry with respect to alternative fuels is estimated (2018) at the level of 1.85 million Mg/year (Środa 2018). In 2017, cement plants carried out energy recovery for 97% of the stream of all alternative fuels subjected to thermal treatment in Poland (Środa 2018). The largest recipients of alternative fuels in 2017 were the following cement plants: Górażdże SA (around 292,000 Mg), Chełm (around 266,000 Mg), and Ożarów (around 238,000 Mg).

A limited, but likely to increase in the near future, demand for alternative fuels in other branches of the economy than the cement industry has also been recorded. Special attention should be

paid to the multi-fuel combined heat and power (CHP) plant in Zabrze (opened on 20 September 2018) and the Stora Enso Ostrołęka Mill, and municipal waste incineration plants (Municipal Cleaning Company in Warsaw, PUHP Lech Białystok), which started to receive small amounts of alternative fuels. In the near future, the start operation of the Thermal Processing and Energy Recovery Installation at PGE GiEK SA in Rzeszów is also planned.

#### 4. Cross-border transport of alternative fuels

Procedures for the supervision and control of international waste disposal adopted in European Union countries are regulated by law (Regulation... 2006). Wastes with code 191210 is not included in the green and amber lists, which are annexed to this regulation. Their cross-border movement is covered by the procedure of prior written notification and consent of competent administrative authorities. In Poland, permits are issued by the Chief Inspector of Environmental Protection (CIEP).

Combustible waste (alternative fuel) with the code 191210 is imported to Poland and used in cement plants as a substitute for hard coal. The main recipients of waste are cement factories and plants processing this waste in the R12 process, which produce alternative fuels with a high calorific value for cement plants. The largest amount of alternative fuels was used by the Ożarów cement plant. The next largest importers of alternative fuel are: the Góraźdze cement plant and cement plants of the CEMEX SA group.

According to information specifying the terms and conditions for importing waste into Poland in the form of an alternative fuel, issued by CIEP, this waste must meet a number of requirements. The imported alternative fuel can only be used in the R1 process or the preceding R12 process. All waste processed in the R12 process must be used in the R1 process. The imported fuel must have a net calorific value above 15 MJ/kg, ash content below 20%, moisture content below 25%, and sulfur content below 0.5%.

The quantities of imported and exported waste with the code 191210 in the years 2016–2017 are presented in Figure 6 (CIEP 2016–2017). It should be noted that much more alternative fuel is imported than exported from Poland. In 2016 and 2017, waste imports amounted to around 20,000 and 75,000 Mg, respectively. In turn, waste exports in 2016 and 2017 amounted to around 5,000 Mg.

The amount of imported alternative fuel on the market is relatively low compared to the amount of fuel produced in the country (approximately 0.8% in 2016 and, 3.2% in 2017). However, although not important, it limits the possibility of using the national stream of this waste energetically. The export of the alternative fuel produced in the country is a favorable phenomenon when there is no possibility of selling on the domestic market. It seems rational, especially in the case of exports from installations producing fuels in border provinces.

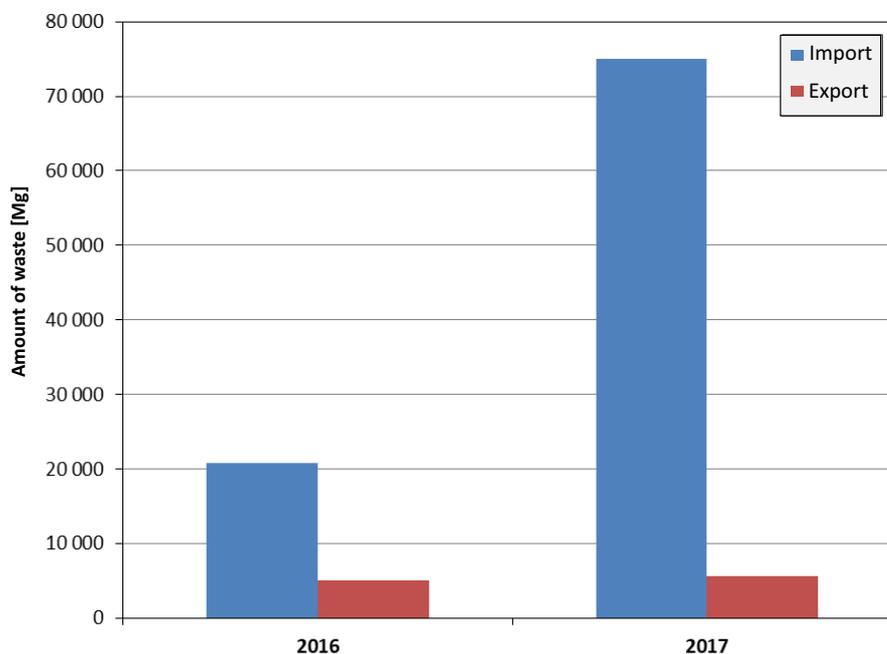


Fig. 6. The quantities of imported and exported waste fuels from Poland in the years 2016–2017

Source: own source based on (CIEP 2016–2017)

Rys. 6. Ilości importowanych i eksportowanych paliw alternatywnych do Polski w latach 2016–2017

## Conclusions

Alternative fuels produced in Poland constitute a major energy source. The amount of alternative fuels produced in Poland can be estimated at 2.4 million Mg/year. Assuming the average net calorific value of an alternative fuel at the level of 12–16 MJ/kg it gives from 28.8 to 38.4 million GJ of energy annually.

Alternative fuels are produced by over 160 domestic producers. The distribution of both generating and receiving capacities in the country is uneven. The largest recipient of alternative fuels is the cement industry, for which alternative fuels account for over 70% of the stream of all energetically used waste.

The stream of alternative fuels produced in Poland in the analyzed period (2015–2017) was much larger than their energetic use in domestic installations. Although the processing capacities recorded in the integrated permits for individual installations are much larger, none of them has reached this level.

Some of the alternative fuels are used by more than 30 domestic specialized producers of alternative fuels in the R12 process, which is aimed at improving the quality parameters of the mentioned fuels.

An analysis of the data provided by CIEP shows that much more alternative fuel is imported than exported from Poland. Both the import and export of alternative fuels is subject to quantitative fluctuations. In the near future, the import of alternative fuels can only apply to waste with high calorific value. However, for other alternative fuels, the lack of possibility to fully use them by domestic consumers, and thus the problem of profitability of their import / export, will continue to be observed.

The presented conclusions point to the imbalance in the amount of produced and energetically used alternative fuels in Poland, observed in the years 2015 to 2017. These changes affect the economy of the waste management sector involved in the production of alternative fuels. The oversupply causes the prices of alternative fuels to fall, and even increases the need for subsidies when it comes to the recovery or disposal of alternative fuels of lower quality.

Subsidies for the recovery of alternative fuels stimulate the development and widening of the range of potential recipients of this waste. The first symptoms of this phenomenon can be observed on the example of the growing interest in alternative fuels from the commercial power sector and heating sector. This is especially advantageous in the case of alternative fuels with a calorific value of 12–18 MJ/kg. The method is currently at an early stage of development, but it will develop, not only because of the costs of obtaining fuel, but also the increasing costs of CO<sub>2</sub> emissions from the combustion of fossil fuels. In contrast, municipal waste incineration plants will rather manage waste fractions with the code 191212, obtained from sorting mixed municipal waste, and reach for significant amounts of municipal sewage sludge.

It has been shown that much more alternative fuel is imported than exported from Poland. The import of alternative fuels, although not significant, limits the possibility of using the domestic waste for energy recovery.

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Ryszard WASIELEWSKI, Martyna NOWAK

## Rynek paliw alternatywnych w Polsce

### Streszczenie

W artykule przedstawiono zagadnienia związane z wytwarzaniem, wykorzystaniem oraz transgranicznym przemieszczaniem wszystkich odpadów o kodzie 191210, przypisanym w katalogu odpadów do paliwa alternatywnego, bez względu na jego pochodzenie (komunalne, przemysłowe lub mieszane). Wykorzystano dane zawarte w raportach wojewódzkich dotyczących gospodarki odpadami oraz informacje dotyczące transgranicznego przemieszczania odpadów udostępnione przez Główny Inspektorat Ochrony Środowiska. Stwierdzono brak równowagi w zakresie ilości wytwarzanych i energetycznie wykorzystywanych paliw alternatywnych w Polsce, obserwowanej na przestrzeni lat 2015–2017. Zmiany te wpływają na ekonomię sektora gospodarki odpadami zajmującego się wytwarzaniem paliw alternatywnych. Sytuacja

nadpodaży wymusza spadek cen paliwa alternatywnego, a nawet konieczność dopłat za jego przyjmowanie do odzysku lub unieszkodliwiania, w przypadku paliw alternatywnych o niższej jakości. W najbliższym czasie należy liczyć się ze stabilizacją poziomu odbioru paliw alternatywnych przez przemysł cementowy, który zaczyna osiągać kres możliwości technologicznych ze względu na już bardzo wysoki stopień zastąpienia paliw kopalnych. Należy także spodziewać się wzrostu zapotrzebowania na paliwa alternatywne przez inne rodzaje instalacji, w tym przede wszystkim w energetyce zawodowej i ciepłownictwie. Stwierdzono również, że do Polski trafia znacznie więcej importowanego paliwa alternatywnego, niż jest z niej wywożone w ramach eksportu. Ilość importowanego paliwa alternatywnego na rynku stanowi stosunkowo niewielką część w stosunku do ilości paliwa wytworzonego w kraju. Wpływa to, chociaż w sposób mało istotny, na zwiększenie luki w zakresie możliwości energetycznego wykorzystania krajowego strumienia tych odpadów. Eksport wytworzonego w kraju paliwa alternatywnego jest zjawiskiem korzystnym w sytuacji braku możliwości zbytu na krajowym rynku. Wydaje się to racjonalne, szczególnie w przypadku eksportu z instalacji wytwarzających paliwa w województwach przygranicznych.

**SŁOWA KLUCZOWE:** paliwa alternatywne, paliwa z odpadów, odzysk energii, rynek

