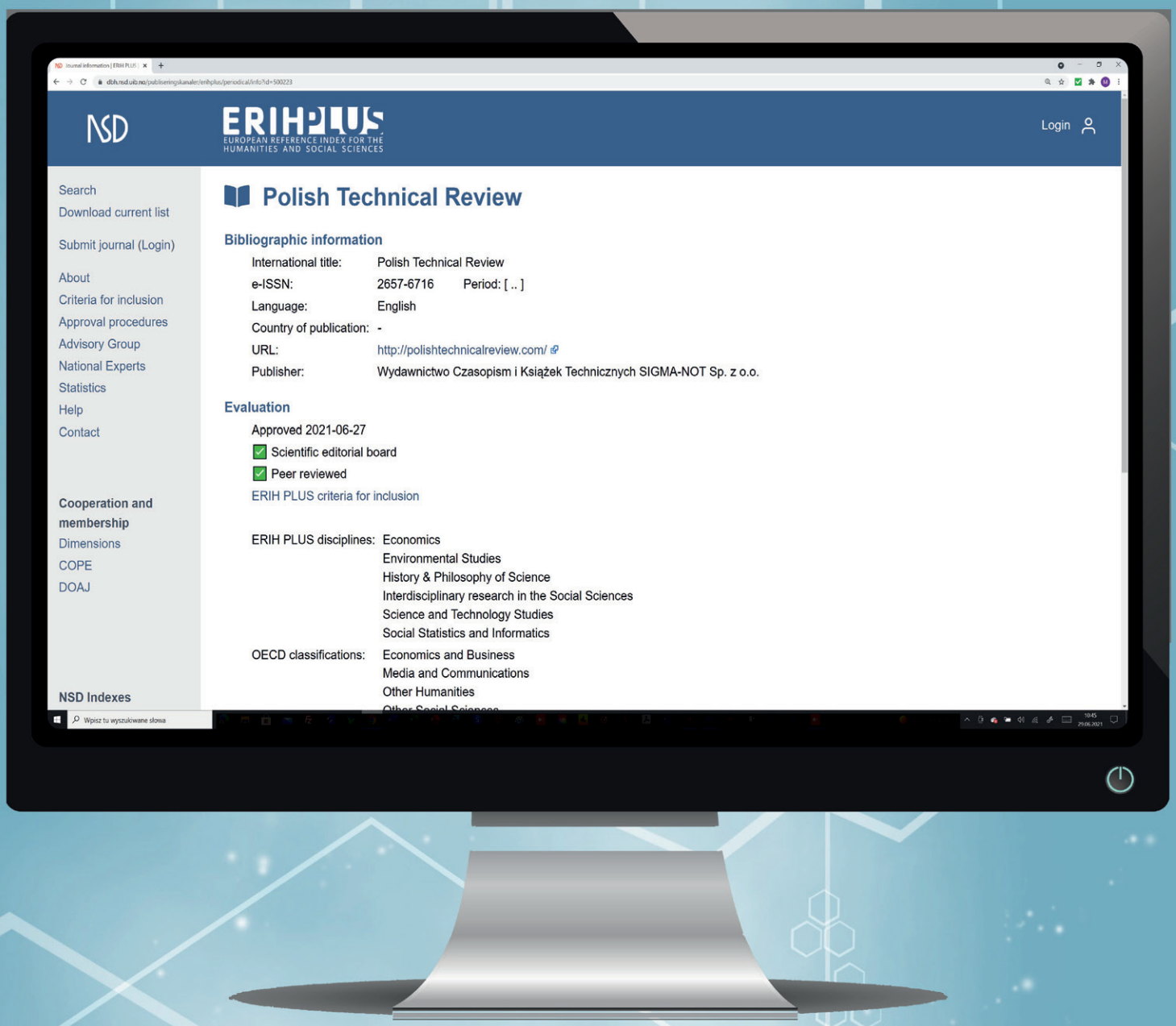
WYDAWNICTWO SIGMA-NOT

POLISH TECHNICAL REVIEW

2/2021

SCIENCE AND INDUSTRY IN A COUNTRY OF CHANGES

Open Access www.polishtechnicalreview.com e-ISSN 2657-6716 www.sigma-not.pl since 1964



THE JOURNAL "POLISH TECHNICAL REVIEW"

HAS BEEN APPROVED FOR INCLUSION IN ERIH PLUS

Polish Technical Review awarded in the NUMERUS PRIMUS INTER PARES Competition

The Laureates of the 34th edition of the Competition NUMERUS PRIMUS INTER PARES

The purpose of the competition *Numerus Primus inter Pares*, organized for the 34th time by the Society of Culture and History of Engineering is to select the best number of technical and popular-technical periodical in respect of popularization of engineering knowledge and culture, dating back to the previous calendar year. The editorial offices themselves choose the number of the suggested periodical and they apply it for the participation in the discussed Competition.

This year's edition was attended by 7 publishers who submitted 19 titles in total.

The Jury of the Competition *Numerus Primus*, as acting under the guidance of Prof. dr hab. Czesław Waszkiewicz, Eng., appreciated highly the professional and graphic level and editorial shape of all sent journals. The Jury awarded the titles of Laureates, i.e. *Numerus Primus inter Pares* to the following publications:

- In the group of the periodicals, popularizing science and technique, the title of Laureate goes to number **3/2020** of the **CONSTRUCTION REVIEW** (Polish: Przegląd Budowlany), the publisher: Chief Board of Polish Association of Construction Engineers and Technicians (PZITB)
- In the group of specialized periodicals, the title of the Laureate goes to number **9/2020** of **ELECTRIC ENGINEERING NEWS**, publisher: SIGMA-NOT

The Jury distinguished also two publications:

- **PETROL AND MINING NEWS, no 7/2020**, Publisher: Scientific-Technical Association of Engineers and Technicians of Petrol and Gas Industry (SITPNiG)
- **POLISH TECHNICAL REVIEW, No 3/2020**, publisher: SIGMA-NOT – for innovative form of on-line publication

Summing up of the 34th Competition: *Numerus Primus inter Pares* and handing over the diplomas will be held after loosening of all restrictions, resulting from Covid-19 pandemic at a later date.

Developed by
Janusz M. Kowalski
Secretary of the Jury of the Competition

POLISH TECHNICAL REVIEW

SCIENCE AND INDUSTRY IN A COUNTRY OF CHANGES

TITLE OWNER/WŁAŚCICIEL TYTUŁU:
National Council of Federation of Engineering Associations NOT
Federacja Stowarzyszeń Naukowo-Technicznych Naczelna Organizacja Techniczna
Czackiego Street 3/5, 00-043 Warsaw
phone: +48 22 336 12 51
www.enot.pl, e-mail: sekretariat-prezes@not.org.pl

PUBLISHER/WYDAWCA:

WYDAWNICTWO *SIGMA-NOT*

SIGMA-NOT Publishing House Ltd.
Wydawnictwo Czasopism i Książek Technicznych
SIGMA-NOT Spółka z o.o.
Ratuszowa Street 11, 03-450 Warsaw
phone: +48 22 818 09 18, +48 22 818 98 32
www.sigma-not.pl
e-mail: sekretariat@sigma-not.pl

EDITOR'S ADDRESS/ADRES REDAKCJI:
Ratuszowa Street 11, 03-450 Warsaw
phone: +48 22 818 09 18, +48 22 818 98 32
www.polishtechnicalreview.com,
e-mail: polishtechnical@sigma-not.pl

ADVERTISING AND MARKETING DEPARTMENT/ DZIAŁ REKLAMY I MARKETINGU:
phone: +48 22 827 43 65, fax +48 22 619 21 87
e-mail: reklama@sigma-not.pl

DTP COMPOSITION/SKŁAD I ŁAMANIE:
SIGMA-NOT Publishing House Ltd.
Wydawnictwo Czasopism i Książek Technicznych
SIGMA-NOT Spółka z o.o.
Ratuszowa Street 11, VII p., 03-450 Warsaw
phone: +48 22 818 09 18, +48 22 818 98 32
www.sigma-not.pl
e-mail: sekretariat@sigma-not.pl

OPEN ACCESS QUARTERLY e-ISSN 2657-6716 SINCE 1964

CONTENTS/ SPIS TREŚCI:

Index Copernicus International Journals Master List
Polish Technical Review database for 2019 ICV 2019 = 61.36

Jerzy KOZŁOWSKI, Dr, Eng.[1)], Marta LEWANDOWSKA, MSc. Eng.[1)], Dawid SOJKA MSc., Eng.[1)]

DOI: 10.15199/180.2021.2.1

[1)] The Łukasiewicz Research Network – Institute of Non-Ferrous Metals in Gliwice
5, General Józef Sowiński str., 44-121 Gliwice
e-mail: jerzyk@imn.gliwice.pl

WASTE MANAGEMENT IN POLAND AND IN OTHER EU COUNTRIES

GOSPODARKA ODPADAMI W POLSCE I INNYCH KRAJACH UNII EUROPEJSKIEJ

***Summary**: The subject of publication includes basic information on the waste management in Poland as compared to other EU countries and on the selected post-consumer waste, occurring in Poland. In the paper, the problems of the waste accumulation on the landfills in Poland and in the EU and the threats, connected with this problem, have been presented. The factors, enabling the effective recycling process have been indicated. Frequent technological changes of the manufactured products and the increasing demand on the mentioned products requires a special approach to the process of their recycling in accordance with the requirement of the natural environment.*

***Keywords**: waste management, recycling, WEEE, waste import, post-consumer waste, batteries, cells, packages, recycling of vehicles*

***Streszczenie**: Tematyka publikacji obejmuje podstawowe informacje o gospodarce odpadami w Polsce w porównaniu z krajami UE oraz wybranych odpadach pouzytkowych występujące w Polsce. W artykule przedstawiono problem gromadzenia odpadów na składowiskach w Polsce i UE oraz niebezpieczeństwa z tym związane. Wskazano czynniki umożliwiające prowadzenie efektywnego procesu recyklingu. Częste zmiany technologiczne wytwarzanych produktów oraz zwiększający się na nie popyt wymaga szczególnego podejścia do procesu ich recyklingu, zgodnie z wymogami środowiska naturalnego.*

***Słowa kluczowe**: gospodarka odpadami, recykling, WSEE, import odpadów, odpady pouzytkowe, akumulatory, baterie, opakowania, recykling pojazdów*

Introduction

Protection of natural environment is a priority target of Circular Economy (in Polish: GOZ). The mentioned aim may be reached by maximum limitation of harmful effect of dangerous materials and substances in the soil, air and human body. The success of the mentioned target is determined by development of waste-free production technologies of goods which limit generation of after-production waste and decrease the effect of harmful substances on natural environment. In the nineties of the 20th century, a sudden economic growth was recorded what was reflected in the increase of the mass of the generated waste. Frequent technological changes of the manufactured products and the increasing demand on these products requires a special approach to their recycling process, in accordance with the requirement of natural environment. Ensuring the appropriate organisation of the waste collection and their processing at the territory of the country is a factor which enables running the effective recycling process. Separation and sale of semi-products, coming from recycling is presently a dominating model of recycling in Poland. Currently, the repeated use of the equipment with the profits to the natural environment is the preferred direction of the waste management in the European Union. The subject of the publication includes information on the selected post-consumer waste such as:

- waste electric and electronic equipment
- waste of car wrecks
- multi-material waste
- waste cells and batteries

In the present publication, the problems of accumulation of the waste at the landfills and the related threats have been also discussed. In order to improve the effectiveness of waste collection and processing in the country, we should invest in educational activity, showing the ecological consequences of waste collection or their processing with the harm to natural environment. A lack of waste segregation is often justified by a lack of appropriate technologies for their processing. Such opinions are harmful for the natural environment as within the frames of many research studies, conducted in Poland, there were developed many technologies which could be applied in the process of waste management. The problems of the publication include basic information on the selected waste, containing metals which occur in Poland, their characteristics and their processing technologies. The mean annual world production is equal to

more than 20 billion Mg of industrial waste and ca. 1.5 billion Mg of post-consumer (municipal) waste coming from households. In Poland, more than 12 million Mg of waste, including ca. 10 million Mg of post-consumer waste are produced. The remaining quantity is constituted by industrial waste. The highest mass of waste is generated by mining and extractive industry (53% of the produced waste), processing sector – almost 23% of the waste and energetic industry generates 16% of the produced waste. If we add the post-consumer waste in the quantity of 8%, we may state that in 2019 we generated 12.754 million Mg of the waste in total; it is equal to 336 kg per one inhabitant. The greatest producer of the waste in Poland is mining and extractive industry which generated ca 6.7 million Mg of the waste in 2019. The second producer of the waste in respect of mass is processing sector which generated more than 2.8 million Mg of the waste in the mentioned above years. At the same time, energetic industry produced almost 1.5 million Mg of the waste. The mentioned three industrial sectors in Poland produced more than 11 million Mg of the waste in 2019. Diagram in Fig. 1 illustrates the producers of the waste in Poland who generated more than 12 million Mg waste in 2019.

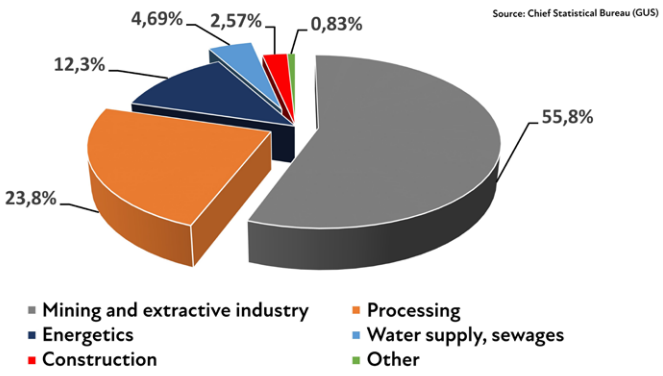


Fig. 1. Producers of the waste in Poland in 2019 (different classification)

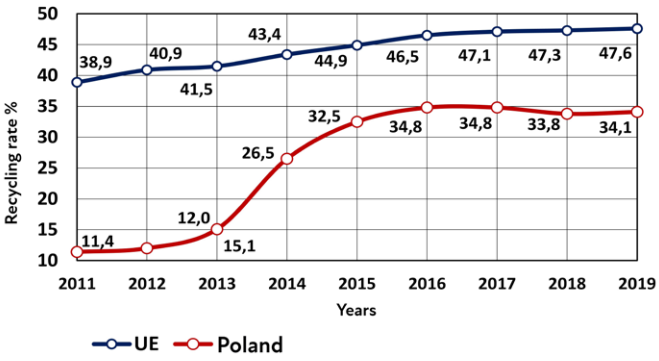


Fig. 2. Indices of waste recycling in the EU and in Poland in 2011–2019

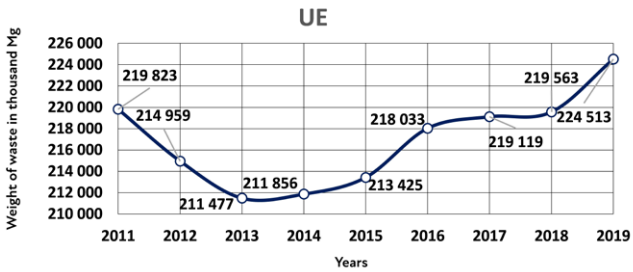


Fig. 3. Weight of the waste generated in the EU in the period of 2011–2019

Fig. 4. Weight of the waste produced in Poland in 2011–2019

POST-CONSUMER WASTE

The situation in respect of waste management in the European Union and in Poland

According to Eurostat data [1], the mean index of waste recycling in the European Union in 2019 amounted to 47.6% whereas in Poland – 34.1%. The comparison of recycling index in the EU and in Poland in 2019 is illustrated in Diagram in Fig. 2.

As it can be seen from the above diagram, since 2013, the 75-% increase in the waste recycling index in Poland has been observed; it increased successively in the next years. A small slowing down of the mentioned tendency was recorded in 2018 but since 2019, the rise in the recycling index has been stated. We are still behind the European Union which showed index of recycling at the level of 47.6% in 2019 what was by 13.5% more as and calculated into waste weight, was equal to 1721.6 thousand Mg of the waste. In Poland, the collection of municipal (post-consumer) waste shows the increasing tendency and in 2019, it amounted to more than 12.75 million Mg what is the participation of 5.68 % in the whole European Union (27 countries).

Fig. 3 and Fig. 4 illustrate the curves of the way of the generated municipal waste in the period of 2011–2019 in the European Union and in Poland. As it can be seen in the diagrams, the run of the lines in the diagram is similar, what is an evidence of rapid development of the economy, resulting in the generation of the waste. The examples of it include change of electronic equipment into a better-quality one, increase of the population incomes etc. The tendency of producing the waste by the society is demonstrated by the coefficient of waste weight, as calculated into 1 inhabitant of the country. In 2019, in the EU, the mentioned index was equal to 502 kg whereas in Poland it was 336 kg. Fig. 5 illustrates the discussed coefficient in the EU and Poland in 2011–2019.

When analysing the above diagram (Fig. 5) we may state that a citizen of our country in 2019 produced by 166 kg less (by 33%) waste than the mean in the European Union. Do we really produ-

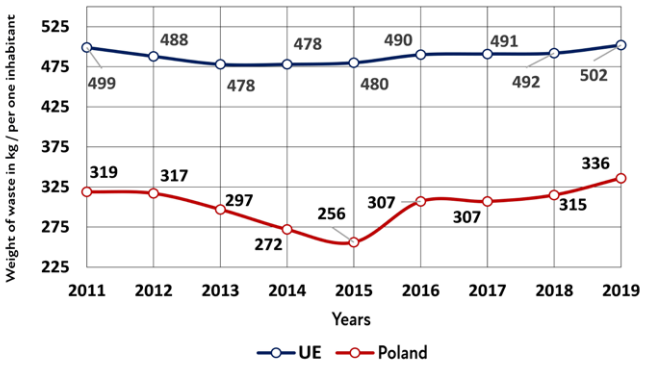


Fig. 5. Weight of municipal waste in the EU and in Poland per one inhabitant in the period of 2011–2019

ce less waste? That's one way of concluding but perhaps there is another reason; we are simply less rich country than a part of the EU countries and we consume less fixed assets. It is not food because we may assume that every person in each of the EU countries consumes in the same way. The mentioned problem requires deeper research analysis. The author encourages the respective competent institutions to perform such activity.

The management of waste may be carried out by 4 following methods:

— accumulation (storage)
— recycling
— thermal processing
— composting

The quantity of the waste gathered or collected selectively for Poland in 2019 amounted to almost 104 kg per one inhabitant, including:

— biodegradable waste – 31 kg per 1 inhabitant (26kg in 2018
— large size waste – 16 kg per 1 inhabitant (14 kg in 2018)
— glass – 15 kg per 1 inhabitant (13 kg in 2018)
— mixed packaging waste – 13 kg per 1 inhabitant (15 kg in 2018)
— plastics – 10 kg per 1 inhabitant (9kg in 2018)
— paper and cardboard – 9 kg per 1 inhabitant (7 kg in 2018).

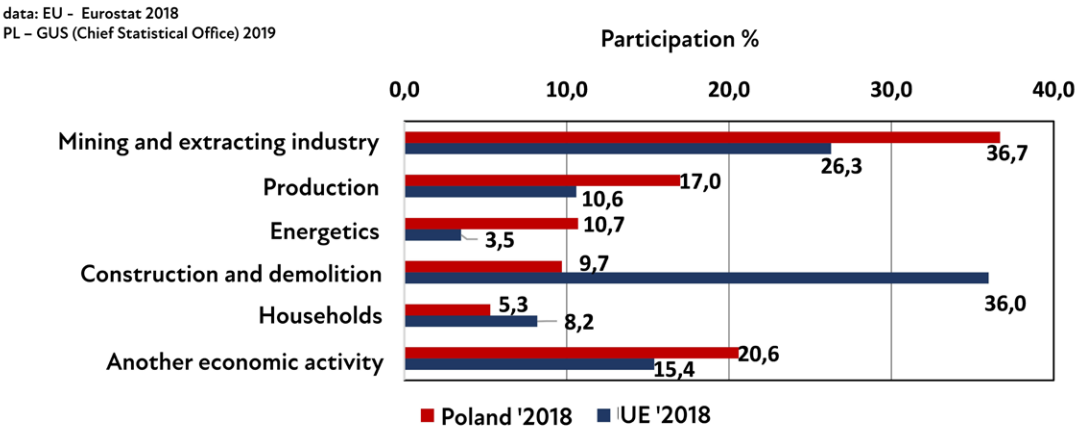


Fig. 6. Waste producers in Poland in 2019 and in the European Union in 2018

Import of waste

Many economic entities, dealing with the waste management are the importers of the waste. It is a profitable business for the entrepreneurs but harmful for the natural environment. Some foreign businessmen are happy to get rid of their waste, especially those poor in metal content or the dangerous ones. It happens especially in the case when the charges for their storage or disposal are high.

In 2019, 405 thousand Mg of waste were imported to Poland; they came mainly from Germany (ca. 68%). The remaining countries include: Great Britain, Sweden, Italy, Austria and Denmark. Due to such high index of waste import, certain media call our country as "garbage dump of Europe". Fig. 7 and Fig. 8 illustrate import of waste from 2015 to 2019. As it is stressed by the Ministry of Climate, Poland cannot forbid import of waste destined for recycling and those ones, present in the so-called green list (e.g. scrap-metal, waste paper) to Poland. Import/export of the mentioned waste is conducted within the frames of the EU on

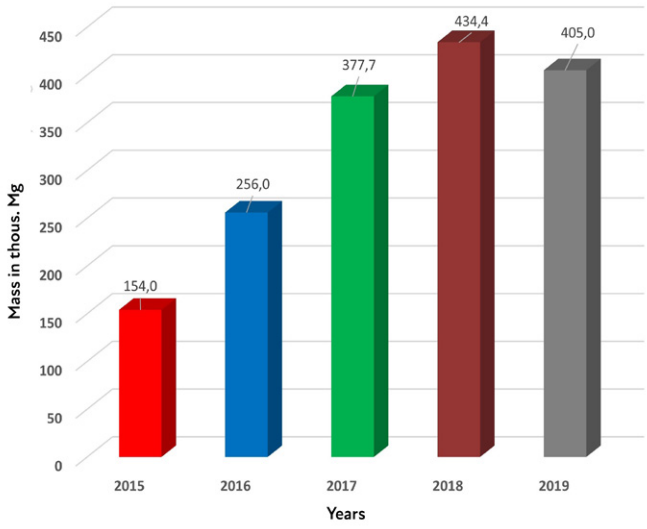


Fig. 7. Waste import to Poland in 2010

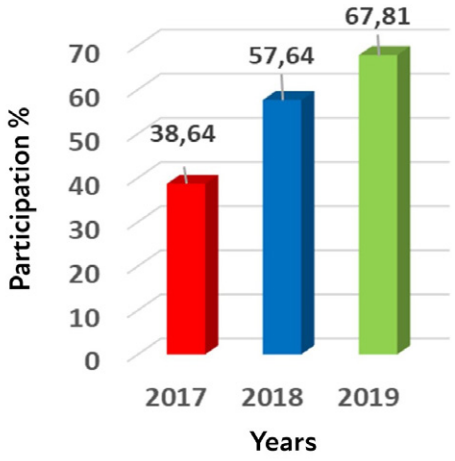


Fig. 8. Waste import to Poland from Germany in 2017–2019

the principles of free flow of goods and the eventual ban would have to refer to the whole European Union.

As the Ministry of Climate informs, Poland cannot forbid import of waste from the so-called green list of waste; the municipal waste – according to the Ministry – is not imported to Poland. As it can be concluded from the above data, presented in the diagram (Fig. 7) import of waste to Poland in the period of 2015–2019 was systematically increasing: from 154 thousand Mg in 2015 to 434 thousand Mg in 2018 and 405 thousand Mg in 2019. In this respect, Germany is dominating as 67.81% of the total weight of the imported waste was imported in 2019 from the mentioned country (Fig. 8).

According to information of the Ministry of Climate [27], "*cross-border movement of waste is a common phenomenon in the whole Europe and Poland participates in it to a small degree. The mass of the imported waste is a marginal quantity in the scale of the whole country, for example: weight of the imported waste in 2017 constitutes 0.33% of the total mass of the waste, generated in Poland in the mentioned year.*

In 2016 (EUROSTAT data), on the grounds of the authorizations of their official authorities, Germany imported almost 6.5 million tonnes of waste from other countries, including Poland (more than 2 million tonnes). The waste intended to be recycled and mentioned in the so-called green list of waste (e.g. scrap-metal, wasted paper) are not "the rubbish"; the raw materials are processed in modern installations which meet the environmental requirements".

The Ministry of Climate informs also that in 2018, there was introduced "*the complete ban on importing – to Poland – all types of waste, destined for disposal and of municipal waste and the waste, resulting from processing of municipal waste, excluding the selectively collected waste, intended for recycling*". The Ministry of Climate informs also that the use of wording "garbage dump of Europe" by certain media in relation to Poland "*is completely untrue, is not reflected by the real state, is a result of failure to know or understand the rules of Polish and EU law, or is simply a pure lie and manipulation*".

Hazards of landfills

Inappropriate storage of waste causes a danger if fire, especially when it is the so-called "wild" landfill, i.e. without the owner. Such landfills may be found on the wastelands or in the forests. At present, the mentioned territories are often monitored, protecting the unlawful waste storage. Fig. 9 illustrates the relationship between the mass of the imported waste and the number of fires in the period of 2015–2018.

We may observe here a certain relationship after 2017. Since 2017, the troubles with the export of the secondary raw materials to China have been commenced. In 2019, there were fires of 243 landfills (Fig. 10) and, as it was given by media, it could be connected with the import of waste to Poland in the discussed period. To confirm the mentioned relationship, we should conduct the appropriate expertises and analyses by the competent institutions.

The mentioned above thesis may be confirmed by the fact that the number of landfill fires in Poland in the period of 2012–2018 increased by ca. 70%. Extinction of the burning landfill is very difficult to be overcome and often impossible in the sites where the combustion gases are harmful to human health and natural environment and increase the so-called "carbon footprint".

Fig. 9. Comparative diagram of the relationship between the amount of landfill fires and the amount of the imported waste in 2015–2018

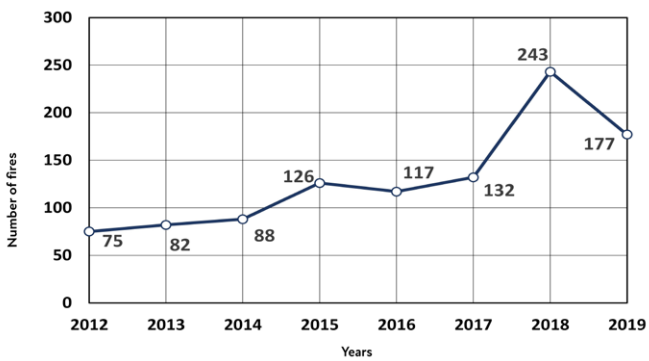


Fig. 10. Landfill fires in Poland in 2012–2018

WASTE ELECTRIC AND ELECTRONIC EQUIPMENT (WEEE)

WEEE waste, being also called "electro-waste" are used, broken-down, defective, inefficient, destroyed, out-of-use or simply unnecessary equipment, the operation of which is dependent on the supply of electric current of electromagnetic fields. There-

fore, all types of the used equipment, operated by power or batteries are "electro-waste".

In 2019, about 53.6 million Mg of WEEE waste were generated all over the world what calculated into 1 person gives 6.9 kg (EU – 16.2 kg/person; Poland – 11.7%) [7]. 82.6% of the above value is processed without documents what gives weight of 44.3 million kg. During the mentioned period, in Europe, there was processed 12 million Mg of WEEE waste, including legally processed 5.1 million Mg, i.e. 42.5%. The participation of Poland in the mentioned weight is 443 thousand Mg i.e. almost 8.7%. The classification of the world collection of waste in 2019 according to the types of the waste is presented in Tab. 1.

During the period of 2009–2019, i.e. 9 years, the weight of the electric and electronic equipment, imported to Poland was increased by ca. 80% whereas the collection of the used equipment during the discussed period was increased by more than 307%.The run of the indicators of the weight of the imported equipment and the collected WEEE waste is shown in diagram (Fig. 11).

Table 1. Weight of WEEE waste collected all over the world in 2019 according to the types of waste

No.	Type of equipment	Million Mg
1	Small household appliance	17.4
2	Big household equipment	13.1
3	Replacement of temperature sensors	10.8
4	IT and internet	6.7
5	Telecommunication	4.7
6	Lamps	0.9
7	**Total**	**53.6**

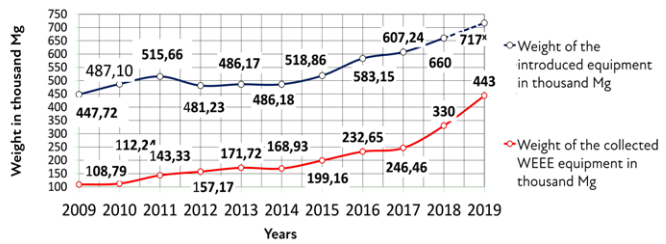


Fig. 11. Weight of WEEE equipment introduced to and collected in Poland in 2009–2018 Remark: x) Due to the lack of the data, the weight of the equipment imported in 2019 was calculated on the grounds of the growth index of 2017/2018

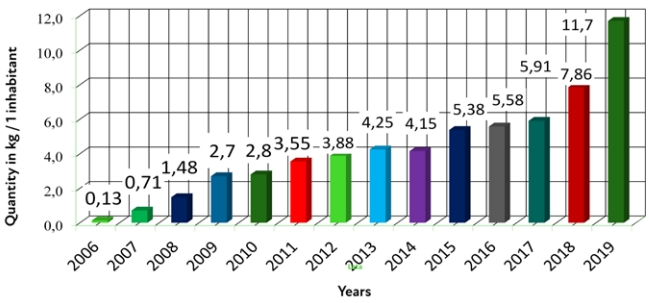


Fig. 12. WEEE equipment collection in Poland in 2019, as calculated into 1 person

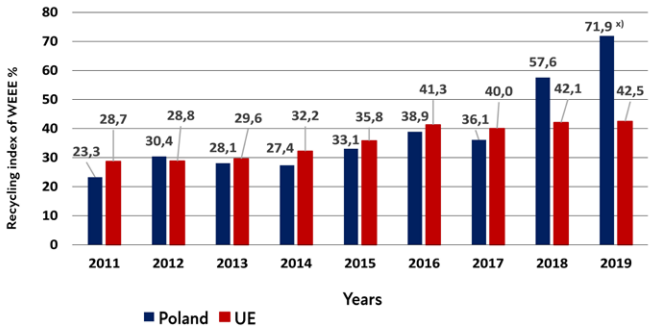


Fig. 13.Index of WEEE equipment recycling in Poland and in EU since 2011

Remark to Fig. 13: x) Index of recycling was calculated from the mean weight of the introduced WEEE equipment from 3 years: 2016-2018 which amounted to 616 thousand Mg and from the weight of the collected WEEE equipment in 2019 what was equal to 443 thousand Mg [7]. As it can be seen from the diagram (Fig. 14), since 2019 WEEE equipment recycling index in Poland was increasing (with certain fluctuations) and in 2018 it reached 57,65% as compared to the European Union (42.1%).

During the period of 2019–2018, the collection of WEEE equipment in Poland increased by more than 34%. The run of the WEEE equipment collection coefficient in Poland in 2006–2018, as calculated into 1 inhabitant is shown in diagram (Fig. 12). On the other hand, Fig. 13 illustrates a recycling index of WEEE since 2011.

Since 2018, GIOŚ (Chief Inspectorate for Environmental Protection) has stopped publishing the report on WEEE equipment management in the country what makes analysis of the state of WEEE equipment management in Poland difficult. All data were collected from Internet pages (publications etc) and from EUROSTAT information. The level of the WEEE equipment recycling index as being calculated above (71.9%) is surprising as during the previous years it varied within the limits of 40–42%. The mentioned value resulted from Eurostat information on the level of WEEE recycling index in Poland at the level of 443 thousand Mg, and GIOŚ information from reports concerning the earlier years. Due to these reasons, it is not possible to verify the calculated recycling index with the real value. The remarks concerning the discussed situation are considered in the final part of the present publication.

In respect of the quantity of the collected WEEE equipment, Poland occupies the seventh place from among the EU countries; the Scandinavian countries are unquestionable leaders. In Sweden, more than 80% of the weight of introduced electronic equipment is collected and subjected to recycling or prepared to the repeated use. High levels of the collection are also recorded in Norway (75 % of the weight of the introduced equipment) and in Switzerland (65%) although the EU regulations are not applied to these countries. The worst situation in respect of electro-waste collection is recorded in such countries as Greece (25%), Rumania (15%) and Cyprus (20%).

The occurrence of multi-componential different types of materials in electric and electronic equipment causes that they are the waste difficult to be processed. WEEE equipment contains metals as well as non-metals being connected in a solid or non-solid way. Metals include steel and non-ferrous metals and non-metals consist mainly of plastics and ceramics. A part

of WEEE equipment contains additionally printed circuit boards (PCBs). The PCB plate wastes are conglomerate of many materials, including precious metals. In manufacture of PCBs, different types of medium are employed, e.g. epoxy resins, reinforced with glass fibre with admixture of the compounds, limiting flammability; they are most frequently bromine derivates. Paper saturated with phenol resins with the admixture of flammability-limiting organic compounds is another universally used laminate. The conducting paths, put on the plates are mainly made of copper but we can meet also conducting elements made of nickel, silver, gold or alloy of tin and lead, or silver solder. The electronic elements, as being assembled on the plates contain a whole series of metals, including non-ferrous metals and their alloys and also, precious metals and REE (Rare Earth Elements). Apart from the metals, there are also ceramic compounds from silicone and aluminium. We may meet also alkaline earth oxides, and mica. However, the basic group of metals which can be found in the PCB plates include non-ferrous metals such as copper, nickel, aluminium and their alloys, iron and tin-lead solder. Depending on the period of time in which the discussed plates were produced, their content of metals is differentiated; for example, copper content may vary from 10-15%, that of aluminium – 5-8%, nickel 1-2%, lead – 1-2% and iron – 5-10% whereas that of precious metals such as silver – up to 1% and gold - several hundred grams per 1 tonne of waste. Besides it, the waste of this type contains also certain amounts of palladium and platinum. The knowledge of the scraped electronic equipment, especially of PCB plates with electronic elements allows choosing the optimum method for processing, enabling maximum utilization of materials (especially non-ferrous metals and precious metals) and on the other side, minimizing the detrimental effect on the environment.

In order to meet the requirements of the Circular Economy, it is necessary to ensure that the electric and electronic equipment (mainly household devices and Radio and TV equipment; in Polish AGD, RTV) is correctly designed and does not cause any problems during the process of its recycling. The Law on the waste electric and electronic equipment, which is obligatory in our country, does not ensure the following requirement; there is a lack of specified safety standards in respect of the re-use of the equipment, there is no list of the types of such equipment and determining which organ would be a supervisor. The producers of the discussed equipment have also doubts concerning the service of such equipment – who would give guaranties?

During the annual conference: "*Recycling of waste electric and electronic equipment*", being held on-line in April, 14, 2021, the perspectives for the duty of collecting WEEE (being introduced into use in 2011–2018) for the years 2021–2023 were presented. It results from the above mentioned prognosis that – for example – in 2021, we should collect 93% of waste from the equipment introduced in 2011, then, in 2022 – 109% and in 2023 – 126% more than it was introduced if we adopt the requirements of the EU '{28]. It is practically impossible if we adopt the s-far existing coefficients, reached during the recent years. It is a great problem if Poland wants to avoid high penalties for failure to fulfil the duties.

WASTE OF PASSENGER CARS

Status of vehicle fleet in Poland

According to the data of IBRM Sambor, in 1928, there were more than 30.7 million pcs of car vehicles registered in Poland. It includes above 23 million pcs of passenger cars. The mean age of car in Poland is 13 years what gives us the 17th place from among 25 European countries (Fig. 14).

As it can be seen from the above diagram (Fig. 15), in 2018 the passenger cars at the age of 10-15 years constituted the highest number of cars moving on domestic roads. The cars below 10 years of age contributed to 28.7% of the whole number of cars, moving on Polish roads.

In 2019, there were 31500 thousand pcs of vehicles, including 24610 thousand pcs (78.1%) of passenger cars. During the coming years, the multi-age vehicles, bought in the country as well as the imported used cars will be subjected to scraping. The age structure of cars in Poland changes from year to year.

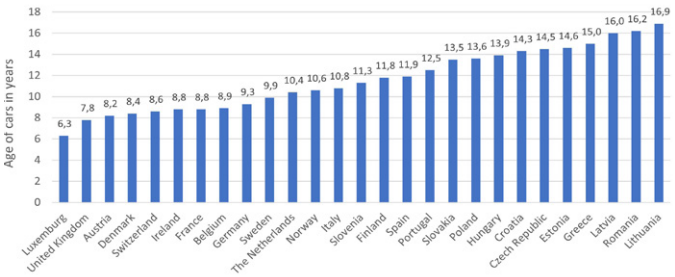


Fig. 14. The mean age of passenger cars in the European countries in 2018

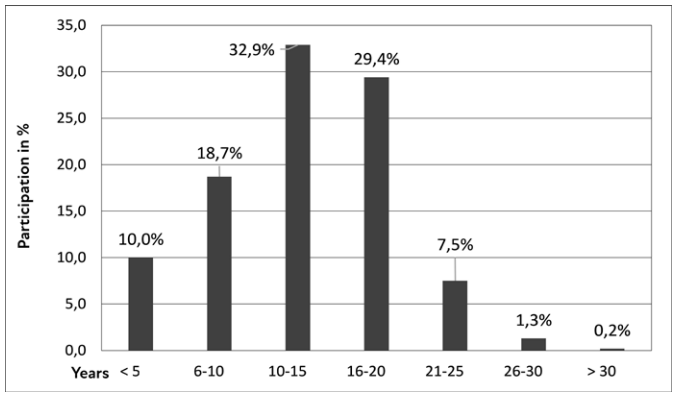


Fig. 15. The age structure of personal cars in Poland in 2018 (Source: The European Association of Car Producers, ACEA)

As it can be seen in Fig. 15 and Tab. 2–3, the number of the registered cars in Poland during the several years has been increasing and in 2019, it reached the level of 31.5 million pcs. Also, the participation of passenger cars was increased whereas the percentage of trucks and tractors decreased from 12.2% in 2018 to 8.9% in 2019. The increasing number of cars causes the generation of greater amount of the waste. Samar Institute, as developing the reports connected with car market in Poland, pays attention to the presence of the registered cars which do

Table 2. The number of registered vehicles in Poland in 2010–2019

Type of vehicle	Years									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
	Number of registered vehicles in thousand pcs									
Passenger	17 240	18 125	18 744	19 389	20 004	20 723	21 675	22 504	23 429	24 610
Trucks and tractors	2 982	3 131	3 178	3 242	3 341	3 429	3 542	3 640	3 759	2 790
Buses	97	100	100	103	106	110	113	116	119	
Motorbikes	1 013	1 069	1 107	1 153	1 190	1 272	1 356	1 427	1 503	4 100
Other	1 706	1 764	1 746	1 796	1 832	1 875	1 915	1 948	1 890	
Total	23 037	4 189	24 876	25 684	26 472	27 409	28 601	29 635	30 701	31 500

Table 2. Percentage participation of the registered vehicles (acc. to the type) in Poland in 2010–2019

Type of vehicle	Years									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
	Participation of registered vehicles according to type, in %									
Passenger	74,8%	74,9%	75,4%	75,5%	75,6%	75,6%	75,80%	75,90%	76,3%	78,1%
Trucks and tractors	12,9%	12,9%	12,8%	12,6%	12,6%	12,5%	12,40%	12,30%	12,2%	8,9%
Buses	0,4%	0,4%	0,4%	0,4%	0,4%	0,4%	0,40%	0,40%	0,4%	
Motorbikes	4,4%	4,4%	4,5%	4,5%	4,5%	4,6%	4,70%	4,80%	4,9%	13,0%
Other	7,4%	7,3%	7,0%	7,0%	6,9%	6,8%	6,70%	6,60%	6,2%	
Total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0	100,0	100,0	100,0

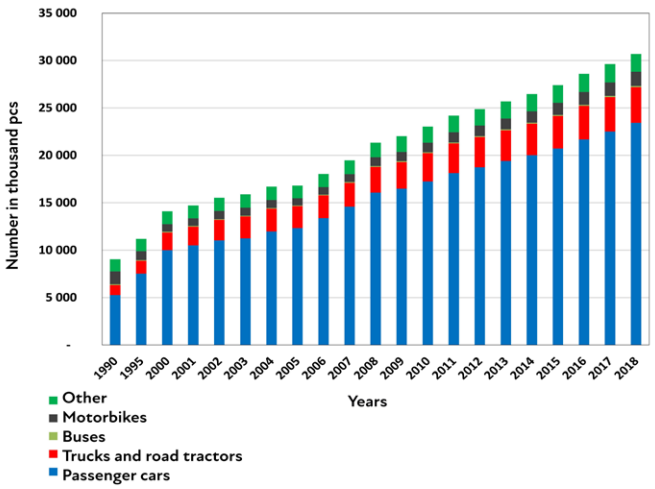


Fig. 16. The number of the registered vehicles in Poland in 1990–2016, with classification into passenger cars, trucks, agricultural tractors, buses and motorbikes

not participate in the movement, i.e. the so-called "dead souls" and which have not been deregistered. It is assumed that the "dead soul" is a vehicle which was registered in Poland 10 years ago and since at least 6 years its data in the car base have not been modified. It is the vehicle which has not been insured for 6 years in respect of third-party liability insurance (in Polish: OC), its owner has not been changed and it has not been subjected to obligatory technical review. According to Samar data, the mentioned difference may constitute even 25% i.e. almost 8 million cars.

Car import

In February 2021, there were 71275 imported passenger cars and delivery (up to 3.5 tonnes) cars in Poland; it is a decline by 13% during the year. In total, during 2 months of the present year, the number of registrations of the imported vehicles was equal to 136817 pcs; it makes by 16.5 % less than in the analogical period of 2020. In January, the mentioned decrease amounted, however, to almost 20%. The anticipated level of import by the end of the years is ca. 850 thousand pcs [11]. The mean age of the cars imported to Poland in 2021 is 12 years. In case of the cars with petrol engines, the mean age of the cars is higher and is equal to more than 13 years. From the mentioned number, one third of the discussed cars are cars dating back to 2006 – 2009. We may observe a systematic decrease of interest in diesel cars. Import of the diesel-driven cars in February of 2021 constituted 41.4% of all imported passenger cars, i.e. by 42.4% less as

compared to 2018. The greatest number of the cars imported in 2021 came from Germany (almost 60% i.e. 80182 pcs) and from France (14155 pcs).

Recycling of road vehicles

According to the announcement of the Marshall of Polish Parliament (the Seym) dated 16 January 2015 on the publication of consolidated text of the Law on "recycling of vehicles, withdrawn from operation" and the Annex to the mentioned Law dated 20 January 2005 on "recycling of vehicles withdrawn from operation", it is considered that a complete vehicle destined for scraping means the vehicle which contains all significant elements and its weight is not lower than 90% of the car weight. Since January, 1, 2015, there have been introduced new, higher levels of recovery and recycling which are equal, respectively, to 95% and 85% of the weight of the cars, accepted to disassembly during the year. Until the end of 2014, the discussed level amounted to 85% and 80%, respectively. In Poland, in 2020, 405204 cars were deregistered on the grounds of certificate from the disassembly station. It is by 13.6% lower number as compared to the previous year, and by 19.6% less than in 2018. The decreasing quantity of the deregistered cars is probably caused by lasting pandemic but also by the existing illegal points of disposal, being called "a grey zone". The cars produced during 1998–2000 were most often directed to disposal (more than 40% of the scraped cars). But as early as in 1999, 15% of all registered cars were subjected to disposal. The cars with petrol engine constituted the highest percentage (71.4%). In 2019, almost 540 thousand cars were deregistered in Poland; 90% of them were found in scrap yard.

The composition of materials used in production of the cars is different, depending on the type of a car. It has an influence on the products, obtained in the recycling process. Tab.5 shows the mean content of materials in passenger car.

From the mean weight subjected to scraping in 2020, it is possible to recover more than 442 thousand Mg of metals including:

— 319.3 thousand Mg of iron;
— 74.2 thousand Mg of cast iron;
— 33.4 thousand Mg of aluminium;

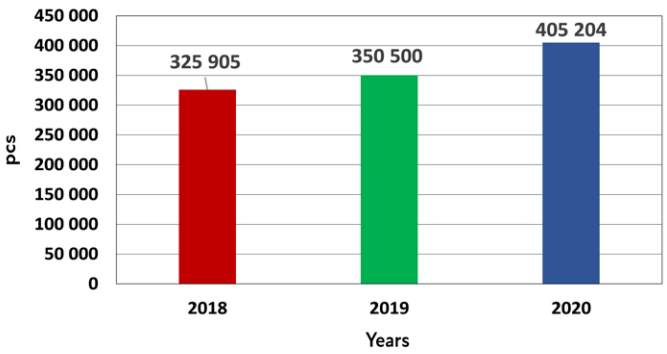


Fig. 17. Number of scraped cars in Poland in 2018–2020

Table 4. The mean content of materials in passenger car

Material	Weight, kg	Participation, %
Metals		
Steel	788,7	60,00
Cast iron	183,1	13,9
Aluminium	82,6	6,3
Copper	19,1	1,5
Zinc	7,3	0,6
Lead	11,3	0,9
Metals in total	**1092,10**	**83,1**
Non-metals		
Tyre	27,3	2,1
Oils	3,6	0,3
Cooling liquids	3,2	0,2
Braking liquids	2,6	0,2
Glass	25,4	1,9
Plastics	7,6	0,6
PU foam	6,3	0,5
Rubber	8,0	0,6
Other	138,7	10,5
Non-metals in total	**222,70**	**16,9**
The whole content in total *)	**1314,8**	**100,0**

*Remark: *) in total weight of the car, we should consider also the content of precious metals, in the weight of ca. 0.0027–0.0050 kg*

— 7.7 thousand Mg of copper;
— 2.9 thousand Mg of zinc;
— 4.6 thousand Mg of lead.

The number of the cars, being directed annually to scraping in Poland is difficult to be specified because in all available information sources, the different data are given. one of them inform that there is 1 million of scraped cars per years and a half of them is done illegally; the other sources inform that about 500 thousand cars are scraped annually in the official way and the doubled quantity is scraped illegally. When taking into account the age structure of the cars, moving on the roads in Poland in 2018, we may adopt that 71.3% are the cars, being more than 10 years old what gives more than 22 million pcs. We may assume that at least 50% of them will be scraped at the age of 20 years. How many of them will be found in illegal scraping points – it is not known. We may suppose that at least 800 thousand cars will be illegally scraped.

WASTE BATTERIES AND CELLS

Market of production of batteries and cells in Poland and in Europe

According to GIOŚ (Chief Inspectorate for Environmental Protection in Poland), the quantity of batteries and cells, imported to Poland in 2018, as compared to 2010, increased from 9866 Mg to 13192 Mg i.e. by more than 33.7%. In respect of the number

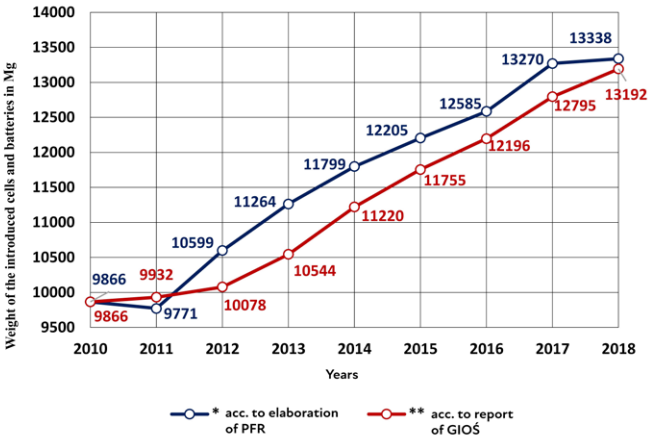


Fig. 18. Weight of the batteries and cells, introduced to the market of Poland in 2010–2018 according to elaboration by PFR [17] and report of GIOŚ ** [18]*
*Data: * acc. to elaboration of PFR – Polish Development Fund, based upon the data of Annual detailed enterprise statistics for industry (NACE Rev.2, B-E) [sbs_na_ind_r2) [17]*

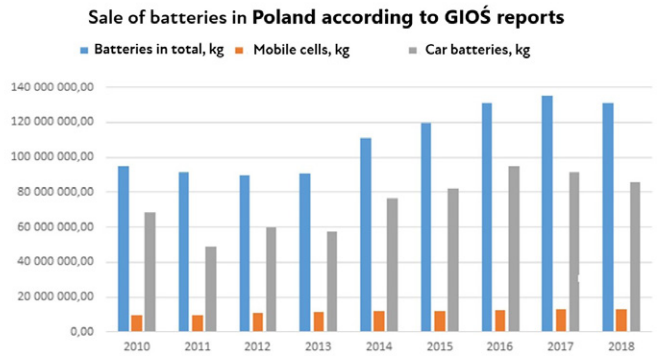


Fig. 20. The sale of cells and batteries in Poland, in kg, in 2010–2018 [18]

of batteries and cells introduced to the market, Poland occupies the fifth place from among the European countries (Fig. 20). According to elaboration of PRF (Polish Development Fund) dating to the same year (2018), we collected 10706 Mg of waste batteries and cells what gives us the 4th place from among the European countries. The weight of batteries and cells introduced to the Polish market is illustrated in Fig. 18. The diagram shows the data coming from 2 sources: publications of PFR and GIOŚ. Polish Development Fund elaboration was based upon the data of Annual detailed enterprise statistics for industry (NACE Rev.2, B-E [sbs_na_ind_r2] – Eurostat [17]. Fig. 19 shows the number of batteries, being introduced to the markets in the European Countries.

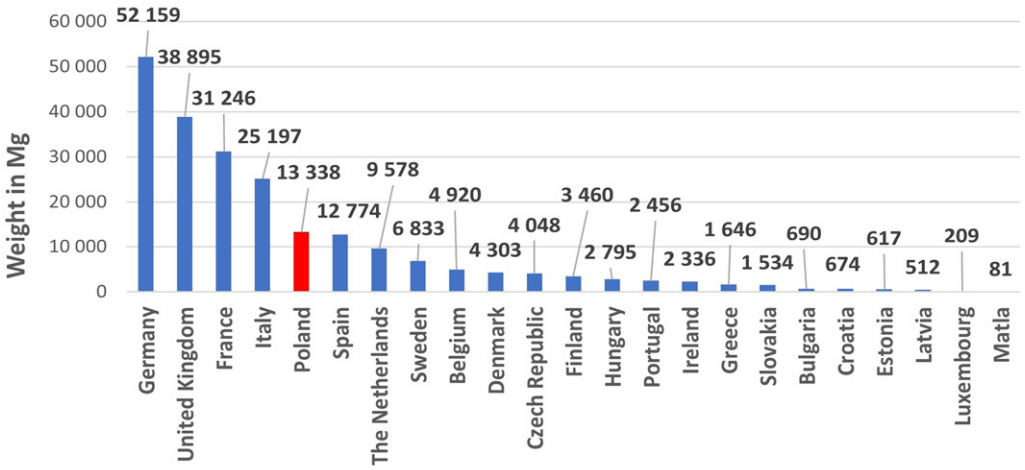


Fig. 19. Weight of batteries and cells, as introduced to the market in the European countries in 2018 acc. to PFR (Polish Development Fund) elaboration on the grounds of the data Annual detailed enterprise statistics for industry (NACE Rev.2, B-E) [sbs_na_ind_r2) [17]

Collection of waste and batteries in Poland and in Europe

According to GIOŚ report (2018), there were 10554 Mg of waste batteries and cells collected in Poland in 2018. In relation to the weight of the introduced batteries and cells to the national market, the recycling index was equal to 80%. It means that Poland has exceeded by 35% the level of collecting the waste batteries and cells, at the required level of 45%. From year to year, the collection of the cells and batteries was increasing; as compared to 2010, it has been by 6 times increased. Fig. 22 shows the collection of waste batteries and cells in Poland in the period of 2010–2018. Their collection in the European countries is illustrated in Fig. 23.

At present, the following chemical power sources are functioning in our country:

- acid-cadmium batteries;
- nickel-cadmium batteries;

- zinc-manganese cells;
- mercury cells;
- lithium-primary cells;
- lithium-ionic batteries;;
- lithium-polymer batteries;
- thionyl cells.

As it can be seen from the diagram in Fig. 21, the data concerning the collection of waste batteries and cells in Poland differ significantly each other. The reason for such differences is unknown. The greatest differences occurred in the years 2015–2016: by more than 45% to above 100% in relation to GIOŚ data. The mentioned difference between the data published in elaborations and reports generates a problem in determination of the state of waste management in Poland. In the discussed years, the enterprises reported to GIOŚ and the reported data were processed by the analysts. At present, there is a different system if reporting on the collection of the data on the waste, i.e. Base of date on Wastes (in Polish: BDO) which assumes unification and tightening os the system for data transfer, and liquidation of differences in the records.

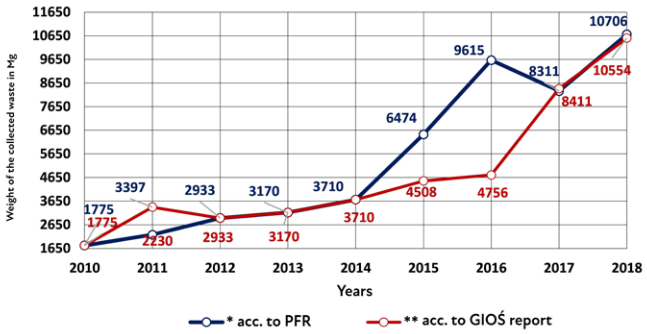


Fig. 21. Weight of waste batteries and cells, collected in Poland in 2010 – 2018 according to elaboration of PFR and GIOŚ report***

*Data: *) according to PFR (Polish Development Fund) elaboration on the grounds of the data Annual detailed enterprise statistics for industry (NACE Rev.2, B-E) [sbs_na_ind_r2) [17], **) according to GIOŚ report*

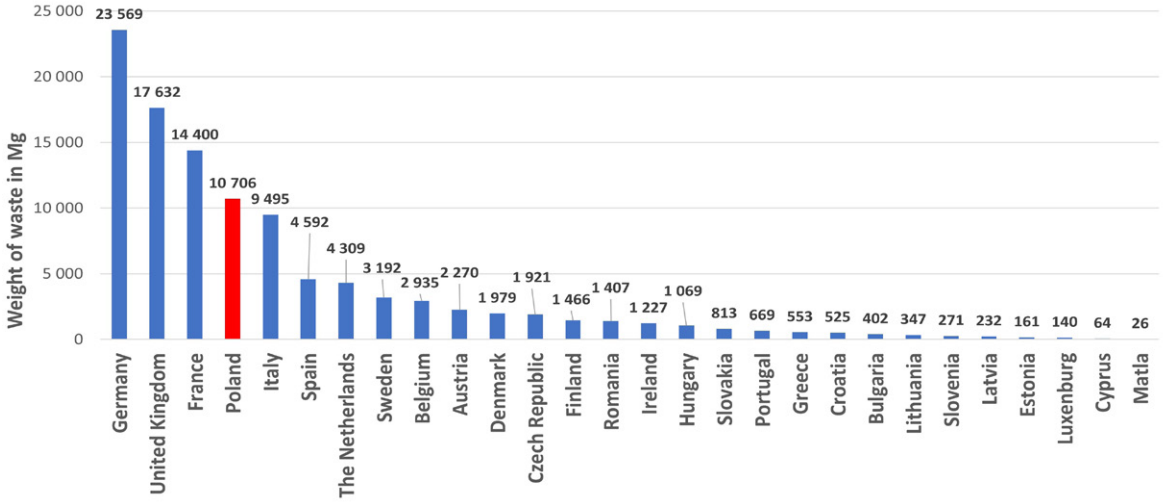


Fig. 22. Weight of waste batteries and cells collected in the European countries in 2018 [17]

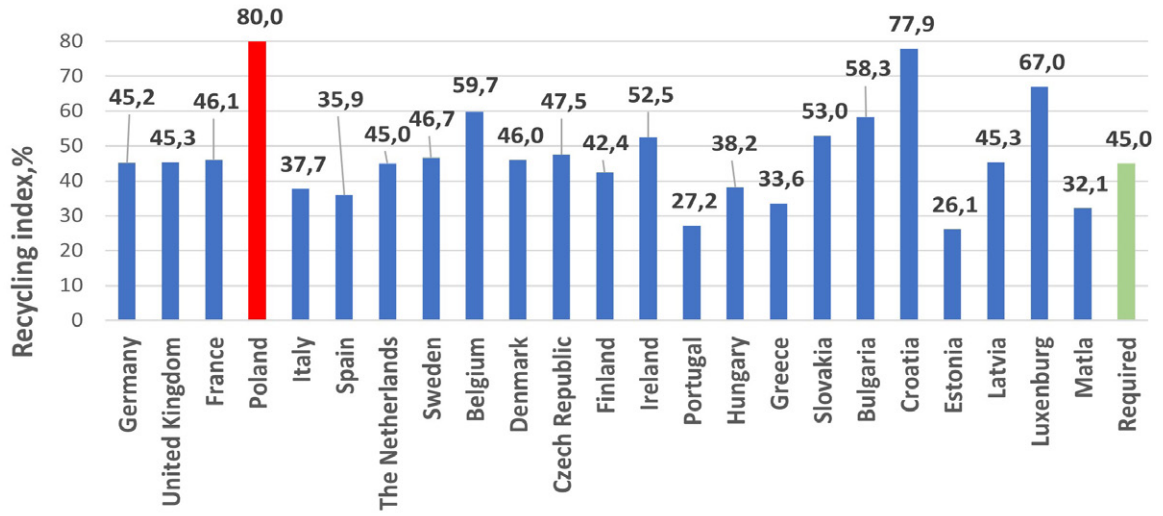


Fig. 23. Index of recycling of waste batteries and cells in the European countries in 2018. Own development based upon the literature data [17].

Recycling of waste batteries and cells

Batteries and cells contain metals and non-metals in different forms which may be utilized in the industry. Waste batteries and cells are hazardous waste and cannot be found in natural environment.

Materials, constituting the composition of batteries and cells:

- Aluminium – in metallic or oxide form,
- Zinc – in metallic or oxide form,
- Cadmium – in metallic or oxide form,
- Cobalt – in metallic or oxide form,
- Lithium – in metallic or oxide form,
- Manganese – in oxide form,
- Copper – in metallic or oxide form,
- Brass – in metallic form,
- Nickel – in metallic or oxide form,
- Lead – in metallic or oxide form,
- Mercury – in oxide form,
- Steel – in metallic form, and
- Plastics and paper for R&D production.

Cells and batteries in Poland are processed by mechanical, thermal and hydrometallurgical methods:

- Mechanic method – disintegration and separation into particular fractions such as:
  - ferromagnetic – steel and other metals;
  - non-magnetic – paper and plastics;
  - paramagnetic – anode-cathode mass, carbon and others.
- Hydrometallurgical methods – it consists in recovery of materials, by the method of salvation in acids or alkalis.
- Thermal method – the recovery of materials is carried out by re-melting in the ovens at temperature of ca. 1400°C what results in obtaining metal or metal oxides.

WASTE PACKAGING

Within a meaning of the Law of 13.06.2013, packaging means "a product, including non-returnable product, made of any materials, intended for storage, protection, transport, delivery or presentation of goods, from raw materials to processed goods". The introducer of the products in packaging is understood as the entrepreneur who performs economic activity in respect of introducing the products in packages to the market.

During the recent years, the increase in the utilization of packaging has been recorded all over the world. It caused the increase of their production. The packages are made of different materials; they have to meet many parameters such as use safety, good quality and aesthetic appearance. Due to their application, the packages are, in many cases, a threat to natural environment. To decrease the mentioned risk, the producers try to use the materials which are the least harmful to the natural environment, and to meet the requirements of Circular Economy.

The waste packagings contain many different materials in their structure such as metals, plastics and paper.

The group of packages includes:

- steel packages (tins and others)
- aluminium (tins and others)
- multi-material packages (tetrapak, sweet packages, packaging of food products and others)
- plastic packages (film, containers and others)
- packages made of wood (boxes, pallets and others).

According to the Act of 13 June 2013 "on management of packaging and waste packaging" (Official Polish Journal of Laws dated 6 August 2013, item 888), there are the obligatory levels of recovery and recycling in Poland. In compliance with the mentioned Act, the level of recovery and recycling of all packages should constitute minimum 61%. The level of recycling which are binding in the country, are shown in Tab. 5.

Tab. 5. Targeted level of recovery and recycling of waste packaging, as specified in Annex 1 to the Law of 13 June 2013 "on management of packaging and waste packaging"

No.	Waste packaging (types)	Level of recovery[1] (%)	Level of recycling[1] (%)
1	Plastics	-	23,5
2	Aluminium	-	51
3	Steel, including steel sheets	-	51
4	Paper and cardboard	-	61
5	Glass	-	61
6	Wood	-	16
7	Multicomponential packaging	-	The level specified respectively in items 1-7 acc. to the type of the material, dominating in a given package
8	Packaging in total[2]	61	56

[1] it does not refer to packages having a direct (immediate) contact with medicinal products, specified in the rules of the Law of 6 September 2001. Pharmaceutical Law. (Official Journal of Laws of 2008, No 45, item 271, with later amendments)
[2] it concerns the sum of all packages, mentioned in items 1-7

The statistics of packaging, in all Polish elaborations as well as in those by Eurostat, includes the data maximum for 2018. It refers to the quantities of the packages introduced to the market as well as those ones collected as waste. In 2018, there were 5470407 Mg of packages introduced to the Polish market, including those subjected to recycling in amount of 3200211 Mg i.e. 58.7%. As compared to the previous year, in 2018 there was less by 4.2% packages introduced to the market. The level of recycling in 2017 was equal to 57.7%. The quantity of the packages introduced to the domestic market is illustrated in diagram (Fig. 24) whereas the obtained levels of recycling are shown in Fig. 25.

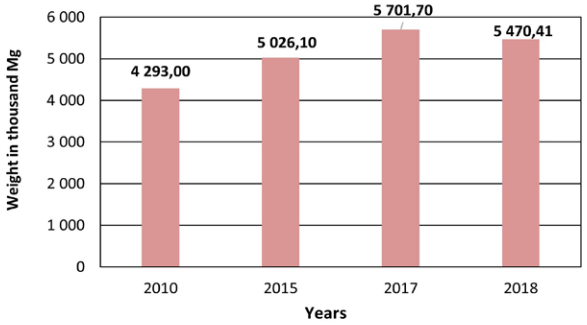


Fig. 24. Weight of the packages introduced to Poland in 2010–2018

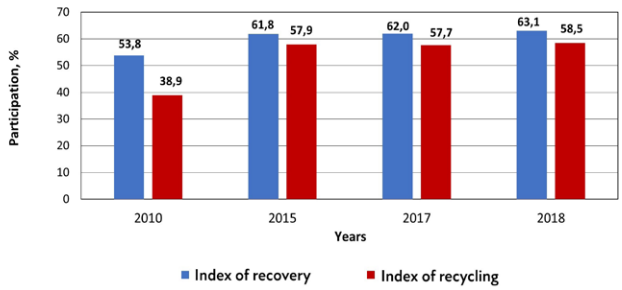


Fig. 25. Levels of recovery and recycling of waste packaging materials in Poland in 2010–2018

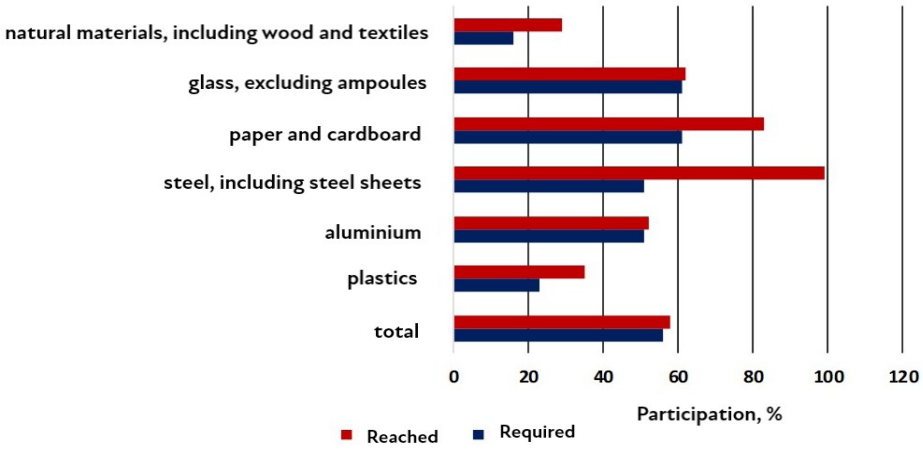


Fig. 26. The obtained (2018) and the required levels of recycling of waste packaging in Poland [23]

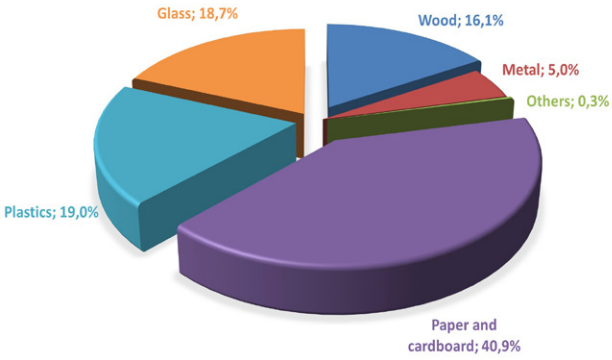


Fig. 27. The percentage of waste packaging according to the collected types in the EU in 2018

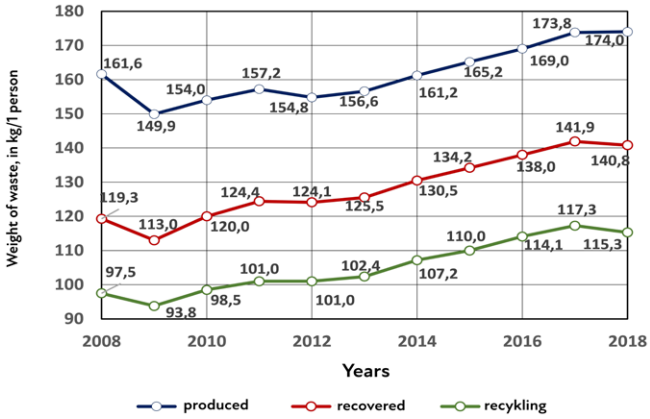


Fig. 28. Weight of the waste packaging, as being produced, collected and recycled in the EU (EU-12) in kg per 1 inhabitant in 2008–2018

When comparing the levels of recovery and recycling of waste packaging, being reached in the recent years, we may observe that the required level of recovery (61%) and recycling (56%) were reached in 2015. The required levels of recovery and recycling in the next years were also reached. The required levels of recycling for the particular fractions of waste packages were reached, as well.

In the countries of the European Union in 2017, 172.8 kg of waste packaging as calculated per 1 inhabitant were produced. Value of the mentioned index for the particular countries varied from 64.0 kg per one inhabitant in Bulgaria to 230.9 kg per 1 inhabitant in Luxembourg. Fr Poland, the mentioned index was equal to 154.0 kg of waste packaging per 1 inhabitant. In the EU countries, the highest quantities of the generated waste were as follows: paper and cardboard (41%), then plastics (19%), glass (19%), wood (16%) and metal (5%).

The obtained and required levels of recycling of waste packaging according to the type, as reached in our country in 2018 are shown in Fig. 26 [23].

The highest mean quantity of packages in the European Union in 2018 was collected in respect of paper and texture; almost 41%, then, plastics in the amount of 19%. The participation of metal was 5.0%. Metal type includes aluminium and steel tin cans. Multi-material waste such as tetrapack and film backed

with paper are considered as the waste paper and cardboard, as the paper is a dominating substance in the mentioned waste. The quantity of the waste generated in the EU countries as calculated per 1 person since 2008 to 2018 increased by 7%. On the other hand, the quantity of the collected and subjected-to-recycling waste in the same period increased by 18% of those recycled ones. The mentioned tendency is an evidence of the progress in the particular EU countries in respect of management of packaging waste and of the choice of the direction assumed in the Circular Economy.

Indices of recovery and recycling of packaging in the European Union countries

The highest index of recovery of waste packaging in Europe was obtained by Finland, as much as 114.6%; it indicates that more was recovered than introduced to the market. The next country, which can boast about the result, is Belgium (index of 99.6%). It means that almost the same quantity was recovered than the amount introduced to the market. Poland has a recovery index equal to 63.4% what gives us the 23rd place from among 12 European countries; we meet the requirements of the law which order obtaining the recovery index at the level of minimum 61%. The lowest recovery index from among EU-27 was reached by Malta (35.6%) and Hungary (55.1%).

As far as the coefficient of recycling is concerned, the highest one was obtained by Belgium (85.3%), then, the Netherlands (78.1%). Poland (58.7%) is found on the 21st place from among 27 EU countries. In the mentioned case, Poland has also met the requirements of the Law which determines obtaining the discussed index at the level of minimum 56%. the lowest recycling index was obtained also by Malta (35.5%) and Hungary (46.1%). the obtained recovery coefficient and index of recycling of waste packaging in 27 EU countries is presented in Tab. 6 and Fig. 29.

Tab. 6. Indices of recovery and recycling of waste packaging in EU-27 and the whole Union and in 4 countries, as obtained in 2018 [24]

No.	Country	Coefficient/index of: (%)		No.	Country	Coefficient/index of: (%)	
		recovery	recycling			recovery	recycling
1	Belgium	99,6	85,3	**17**	Hungary	55,1	46,1
2	Bulgaria	60,5	60,4	**18**	Malta	35,6	35,6
3	The Czech Republic	73,9	69,6	**19**	The Netherlands	95,5	78,1
4	Denmark	88,2	67,7	**20**	Austria	94,4	65,5
5	Germany	96,9	68,5	**21**	**Poland**	**63,4**	**58,7**
6	Estonia	86,5	60,4	**22**	Portugal	66,5	57,6
7	Ireland	90,9	63,9	**23**	Rumania	60,0	57,9
8	Greece	71,6	68,6	**24**	Slovenia	75,3	70,1
9	Spain	74,5	68,8	**25**	Slovakia	69,1	66,6
10	France	76,8	65,7	**26**	Finland	114,6	70,2
11	Croatia	58,4	58,4	**27**	Sweden	70,9	70,1
12	Italy	77,6	68,3	**28**	**European Union**	**80,9**	**66,3**
13	Cyprus	70,1	70,2	**29**	Great Britain	68,2	62,1
14	Latvia	64,3	55,8	**30**	Iceland	63,2	46,8
15	Lithuania	68,4	60,7	**31**	Lichtenstein	92,7	68,0
16	Luxembourg	94,1	70,9	**32**	Norway	94,2	52,9

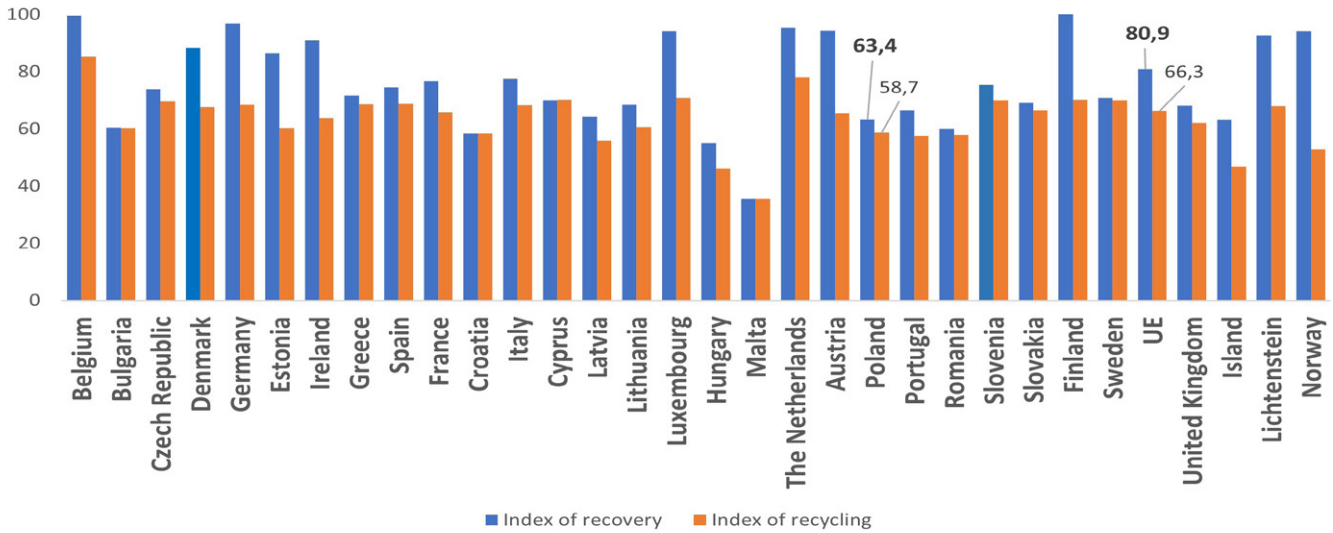


Fig. 26. The obtained (2018) and the required levels of recycling of waste packaging in Poland [23]

Summing up

The problems discussed in the publication include the basic information on waste management in Poland as compared to other EU countries and on the selected post-consumer waste, occurring in Poland.

Natural environment protection is treated as priority all over the world as to pay the attention to the hazardous effect of dangerous materials and substance on the environment and human body. Therefore, few years ago, the conception of Circular Economy was introduced. Its aim was to promote, to maximum degree, the waste-free technologies at manufacture of goods, limiting generation of the waste, harmful to the natural environment. On one hand, technical progress increases welfare of the societies but on the other hand, it is the reason for generation of greater quantity of the post-production as well as post-consumer waste. A dynamic development of industry in Poland, which occurred in the 90-ties of the 20th century, has contributed to increase of the demand on modern electric and electronic equipment; it was the effect of the increase of demand on raw materials. The weight of the waste on the landfills was increased. The Circular Economy assumes the increase of the participation of the recyclables in manufacture of the new products. According to the published data, the mean participation of the recycled metallic materials in the world production of metals is equal to more than 52%; in production of lead, ruthenium and niobium – ca. 50%, aluminium – ca. 36%, copper – ca. 37% and steel – ca. 52%.

Frequent technological changes of the produced goods and the increasing demand on them, requires a special approach to the process of their recycling in accordance with the requirement of the natural environment. Ensuring the appropriate collection of the waste and their processing at the territory of the country and the utilization of the mentioned resources is a factor which enables running the effective recycling process. The adaptation of good legal system and the respective rules in the system of waste management may be helpful in this respect. We should mention here the access to information concerning the waste management which becomes hardly available.

The average citizen, who is interested in problems of waste management, is missing balanced information on the state of waste management in our country. He is lacking information on the Internet pages (all is out-of-date, coming from 2017–2018). The problem of the lack of such information was also discussed during the Conference: Recycling of Waste Electric and Electronic Equipment held on April, 14, 2021 in Warsaw. It was stated that such situation made the functioning of the whole recycling sector difficult. It was also recognized that the published data were the approximate data, differing from the real ones.

When developing the present publication, the author found more available information in foreign materials, such as, *inter alia*, Eurostat, authorial publications as compared to the national sources. The ecological awareness of the citizens cannot be shaped without information on the state of environment.

We may hope that the introduction of BDO system (Base of the Data on Waste) will change the mentioned situation if the data from this system are made available universally for all who are interested in the problems of waste management and who care about the natural environment protection. It means fulfilment of the requirements, contained in the Circular Economy assumptions.

The published information is often out-of-date. There is also a lot of information, differing significantly, e.g. between Eurostat and the data, published in the domestic materials. The recent data date back to 2017, certain concern 2018 and the data of 2019 are unavailable. We have already the second quarter of 2021! Therefore, the attempts should be undertaken with the aim to accelerate the elaboration of the statistical data which help considerably not only the enterprises dealing with waste management but also the state administration institutions which prepare the appropriate regulations.

As we know, in January 2018, there was launched the electronic BOD system which is expected to improve the informational system in this respect. It is fit for not only the units which generate waste but also those transporting, recording and introducing new products to the market (packaging) or those which process the waste. They include companies of various sectors, such as shops, doctor's offices, car workshops, transport and disposal enterprises etc. There are different opinions on the system of introducing the data in BOD, for example, the use of this system brings many troubles, information of moving in the Base are unclear, non-precise and unpractical. The opinion-givers indicate that the system works slowly and is often suspended and waste service and recording consumes a lot of time. The troubles result from the necessity of permanent passage between many folders and many-times-repeated introduction of the same data. It will be possible to assess the effectiveness of the electronic BDO system after few years of its operation, improving meanwhile its defects. Creation of BDO system is a good idea and, after having removed the weak points, it will bring profits to the waste management and meet the requirements of Circular Economy.

At present, in Poland, there is a dominating model of recycling, based upon the separation and exportation of semi-products, resulting from processing of the waste. We should also develop the principle of repeated use of equipment what is successfully effective in other European countries and is supported by the European Union. The aim of improving the effectiveness of the system for collection and processing of after-consumer waste, containing metals, we should invest in educational activity. We should present the ecological consequences of the waste storage, or processing with the hazard to the natural environment. We should, via education, demonstrate that we have the technologies owing to which we may process the waste, generated by the society. Lack of waste segregation is often justified by a lack of appropriate technologies for their processing. It is opinion harmful for the society which, in majority, wishes to run the segregation for the sake of natural environment of Poland.

Apart from Circular Economy (GOZ), the problem of waste management in Poland has been also noticed in the recently developed programmes such as Project of Raw Materials Policy of the State, and Strategy in Favour of Sustainable Development which both assume the minimization of the waste generation and long-term economic policy of policy of Poland. The mentioned strategy is aimed at the country development based on the responsibility and solidarity. Its target includes entrepreneurship, inventiveness and productivity and maximum application of the materials, coming from recycling in manufacture of new products as a substitute of original raw materials. Technological and technical development of Poland and use of more and more devices of common use (e.g. electric cars, mobile telephones, computers etc.) impose the duty to seek for the innovative technical and technological solutions concerning the management of the mentioned equipment after their use period when they become a waste. The participants of the waste management system in Poland which include organizations, enterprises and the research institutes should cooperate closely when developing the innovative solutions for waste processing within the frames of the research projects, in accordance with the requirements of the natural environment and profit to the national economy.

The Łukasiewicz Research Network – Institute of Non-Ferrous Metals has conducted, for many years, the studies on the technologies of waste management in Poland; their solutions have been introduced in many enterprises. In respect of the size, the Łukasiewicz Research Network is found on the 3rd place in Europe. It supplies attractive, complete and competitive technological solutions. It offers the unique system of "challenges" to the business sector owing to which it accepts the business challenge for the period shorter than 15 working days; it submits, free-of-charge, direction of the solution and idea of the research project to the entrepreneur [29]. Within the frames of its activities, the mentioned Institute has developed many publications and monographs and public speeches during national seminars and conferences, supporting the implementation of Circular Economy.

References

[1] Municipal waste by waste management operations – Eurostat 08-02-2021

[2] Eurostat Database.

[3] „Odpady–palący problem czy cenny zasób. Styczeń 2020. Raport Instytutu Jagiellońskiego.

[4] J. Kozłowski, M. Gawliczek „Stan zagospodarowania odpadów w Polsce na tle krajów UE. Rudy i Metale Nieżelazne & recykling, Nr 9-10, Rocznik 2020.

[5] Waste statisticsStatistics ExplainedSource : Statistics Explained. (https://ec.europa.eu/eurostat/statisticsexplained/) - 08/12/2020

[6] Municipal Waste Treatment 2018. https://www.cewep.eu/municipal-waste-treatment-2018.

[7] Vanessa Forti, Cornelis Peter Baldé, Ruediger Kuehr, Garam Bel The Global E-waste Monitor 2020. ISBN Digital: 978-92-808-9114-0

[8] https://www.teraz-srodowisko.pl/aktualnosci/ZSEE-elektroodpady-elektrosmieci-recykling-7847.html

[9] https://www.dw.com/en/un-electronic-waste-gold-silver-platinum/a-54022278

[10] ttps://elemental.biz/en/market-segments/recycling-of-waste-electrical-and-electronic equipment

[11] „Luty 2021 - import znowu rośnie. Powoli..." https://www.samar.pl

[12] https://www.samar.pl/__/3/3.a/111467/Luty-2021-import-znowu-rośnie-Powoli.html?locale=pl_PL

[13] Centralna Ewidencja Pojazdów (CEP) 4.03.2021r.

[14] https://www.wyborkierowcow.pl/wiek-samochodow-w-europie-wiadomosci

[15] M. Brzeziński „Oficjalnie auto w Polsce ma średnio 20 lat - a naprawdę?". https://www.auto-swiat.pl. 22 maja 2020 r.

[16] A. Stefańska „Polscy kierowcy jeżdżą jednymi z najstarszych aut w Europie". 14.09.2020r.rankomat.pl

[16] M. Łubiński „Najczęściej złomowane auta w Polsce w 2020 roku". 26.01.2021 r.

[17] A. Kochman „Producenci baterii i akumulatorów" Biuro Analiz. Polski Fundusz Rozwoju (PFR S.A.). Wrzesień 2020.

[18] Raporty o funkcjonowaniu gospodarki bateriami i akumulatorami oraz zużytymi bateriami i zużytymi akumulatorami za rok 2010 - 2018. GIOŚ.

[19] J. Kończyk, A. Sobianowska-Turek , K. Sobianowska „Odzysk niklu, kadmu i kobaltu ze zużytych baterii". Technika, Informatyka, Inżynieria Bezpieczeństwa 2016, t. IV, s. 233–24. Prace naukowe Akademii im. Jana Długosza w Częstochowie.
[20] https://bdo.mos.gov.pl/web/S
[21] T. Styś, R. Foks „System gospodarowania odpadami opakowaniowymi w Polsce. perspektywa zamknięcia obiegu". Instytut Sobieskiego. 2016 r.
[22] „Ochrona Środowiska 2020. GUS.
[23] Eurostat (env_waspac)
[24] Packaging waste statistics. https://ec.europa.eu/eurostat/statistics
[25] USTAWA z dnia 13 czerwca 2013 r. o gospodarce opakowaniami i odpadami opakowaniowymi. z.U.2020.1114 t.j. Akt obowiązujący Wersja od: 26 czerwca 2020 r. do: 31 grudnia 2021 r.
[26] J. Kozłowski „Recykling odpadów pouzytkowych w Polsce zawierających metale nieżelazne w strategii na rzecz zrównoważonego rozwoju". Wyd. Politechnika Śląska. 2019r. ISBN 978-83-7880-593-9.
[27] M. Rudy „ Minister odpowiada na zarzut, że import odpadów do Polski systematycznie rośnie". Źródło PAP. https://www.bankier.pl/wiadomość. 20-02-26.
[28] G. Skrzypczak „Równowaga popytu i podaży na rynku ZSEE. Perspektywy wzrostu obowiązków zbierania i przetwarzania oraz ich wpływ na koszty gospodarowania ZSEE". Konferencja Recykling Zużytego Sprzętu Elektrycznego i Elektronicznego". Warszawa. 14.04.2021 r.
[29] www.lukasiewicz.gov.pl/biznes.

Article reviewed
Received: 29.04.2021 r. /Accepted: 10.05.2021 r.

Marcin RÓŻEWICZ, MSc ORCID: 0000-0002-3281-5533

DOI: 10.15199/180.2021.2.2

Department of Cereal Crop Production,
Institute of Soil Science and Plant Cultivation – State Research Institute
Czartoryskich 8, 24-100 Puławy
e-mail: mrozewicz@iung.pulawy.pl

PRODUCTION AND SUPPLY OF CEREAL GRAINS IN POLAND AND THEIR IMPORTANCE AND USE IN POLISH ECONOMY

PRODUKCJA ORAZ PODAŻ ZIARNA ZBÓŻ W POLSCE ORAZ JEGO ZNACZENIE I WYKORZYSTANIE

Summary: *Cereals belong to the most important arable crops with 72% of arable land sown. This is due to the great importance of the grains obtained from them, which determines the food security of our country. Grain harvest is the basis for nourishing the country's population both directly through food use, as well as using it for animal feed. A new direction of grain management is the possibility of using surplus supply or grain that does not meet the quality requirements of food and feed processing for energy purposes.*

Keywords: *grain production, supply, food security*

Streszczenie: *Zboża należą do najważniejszych roślin uprawnych, których powierzchnia zasiewów gruntów ornych wynosi 72%. Wynika to z dużego znaczenia pozyskiwanego z nich ziarna, które stanowi o bezpieczeństwie żywnościowym naszego kraju. Zbiory ziarna stanowia podstawę wyżywienia ludności kraju zarówno bezpośrednio poprzez spożywcze wykorzystanie, jak również przeznaczanie go na paszę dla zwierząt. Nowym kierunkiem zagospodarowania ziarna jest możliwość wykorzystania nadwyżek podażowych lub ziarna niespełniającego wymogów jakościowych przetwórstwa spożywczego i paszowego na cele energetyczne.*

Słowa kluczowe: *produkcja ziarna, podaż, bezpieczeństwo żywnościowe*

Introduction

Cereal production in Poland is one of the most important areas of plant production. In the sowing structure, the cereals occupy 72% of the area (Fig. 1). It is due to their great importance in human nutrition, but also in the feeding of farm animals. For the latter, the cereals are the basic raw material for fodder production. A new direction of the use of grains which do not meet quality requirements for food or fodder production, is energy use. The supply of grains determines their price. Price fluctuations in the particular years are caused by unstable grain yields as a result of severe frosts, droughts and floods and flooding. A period of rapid price increases and decreases is usually followed by a period of searching for a new equilibrium level, characterized by short-term, quite violent price fluctuations. Low-cost cereal grains are important for reviving and improving the profitability of meat and milk production. Much will depend on the demand for these products, and thus on the general economic situation. Biofuels and bioenergy may begin to play a more and more important role in stabilizing the Polish cereal market, especially in the conditions of a systematic limitation of all forms of interventionism on the EU cereal market. In Poland the development of this direction of grain management is still at a very early stage

There are six main cereal species grown in Poland. These include wheat, rye, triticale, barley, oats, and maize. Their grains

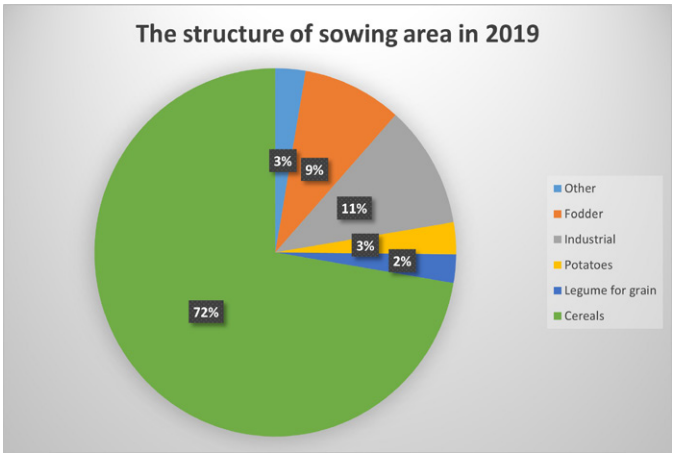
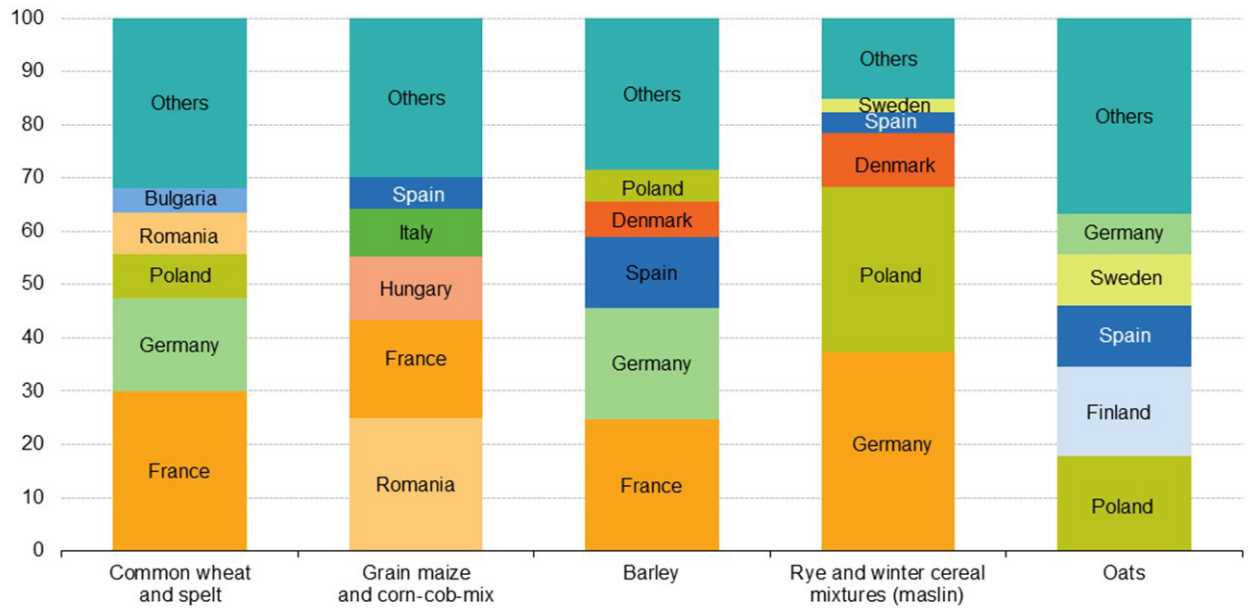


Fig. 1. Percentage of cereals in the sowing structure. Own elaboration based on CSO data [16]

are the basic raw material for food processing and fodder production. Production of grains of particular kinds of cereals depends on soil conditions. In Poland, wheat has the largest cultivation area and grain harvest scale. The grain harvest of this species in 2019 amounted to 11 million tonnes, which was 12% more than in 2018. The second cereal with the largest grain production scale is triticale, 4.5 million tonnes of which was harvested in Poland in 2019, 12% more than in 2018, the same as in the case of wheat. Slightly less, at 3.5 million tonnes of barley

Production of cereals by main producing Member States, 2019
(% share of EU-27 totals)



Source: Eurostat (online data code: apro_cpnh1)

eurostat

grains (10% more than the previous year), and 2.5 million tonnes of rye grains (13% more), were produced. Out of all cereals, Poland produces the least amount of oats, amounting to 1.2 million tonnes, which was more by 5% than a year before. Compared to other European Union countries, Poland is one of the leading grain producers. Production of oats in Poland, despite the fact that it is the smallest among major cereal species, places Poland in the first place in terms of grain production of this cereal in the European Union, with 19% share in the EU total oats production. Poland is second in terms of rye grain production with 30% share in the total grain production of this cereal, just after Germany. Poland ranks third as regards the production of wheat grains with 5% share in their EU total production. As far as the production of barley grains is concerned, Poland is on the fifth place in the European Union with a 4% share in its EU total production [1].

The production of particular cereals in Poland is determined by the demand for them on the market. It results from different allocation of particular species for consumption and fodder purposes. Wheat is considered to be a consumption cereal destined mainly for flour milling and bread baking. Rye is a dual-purpose cereal that is utilized for both human consumption and animal feed. Barley is a dual-purpose cereal used for beer production and animal feed. Oats is considered to be the main feed cereal and to a lesser extent, food cereal

Factors affecting cereal supply

The supply of grains of particular cereal species depends on many factors. These include climatic conditions, including frequent weather anomalies manifested by drought and excess precipitation, as well as periods of low temperatures in winter causing the freezing of winter forms of cereals. Genetic progress and breeding new varieties, which increase their yield, also have a significant impact. Genetic progress in breeding new varieties that yield higher can be noticed since the 1950s. Despite a systematic decrease in the acreage under cereal cultivation, grain yields per hectare and the overall supply of grains, have increased. Despite a decrease in the area of cultivation from the initial 9.5 million ha (100%) in 1950 to 7.4 million (78%), the supply of cereal grains increased in that period by 232%. [2]. The spread of progress in mineral fertilization and significant mechanization of agriculture are also important. Reduction of labour input is a significant incentive to grow cereals. The problem, however, is the changing climate and the occurrence of extreme weather phenomena which significantly reduce the grain yield, and thus its supply. Both heavy rains and droughts are unfavorable. Flooding of cereal crops, especially during the spring snowmelt, causes significant losses. Losses are also caused during the growing season, when excessive precipitation and low air temperatures cause lodging of cereals and increased pressure from fungal diseases. Droughts occurring more and more frequently in the recent years, causing water shortage, also cause significant losses in the cultivation of cereals. Water deficits causing a decrease in grain yields by at least 20%, are being recorded more and more often, both in the cultivation of cereals, and in particular of their spring forms [3]. New solutions to reduce the problem of yield losses, being associated with drought, include increasing water retention through its increased storage in water reservoirs and then irrigating crops during periods of lack of rainfall. Breeding grain varieties with higher

drought tolerance is also a potential solution. Maintaining the growth rate of food production proportional to the increase in the world's population, in a changing climate, is a great task and challenge, especially for cereal breeding. In Poland, the problem of drought affects mainly spring cereals, among which spring triticale has the highest resistance to adverse conditions caused by drought. Other cereal species are much more sensitive to drought periods, but among their varieties, we can distinguish those characterized by higher drought tolerance and those less resistant to drought stress. As one of the indicators of drought tolerance the date of earing is considered, because generally the varieties that earing earlier tolerate drought better, which usually occurs in June-July. Breeding advances aimed to increase yields, at the same time increase drought tolerance, with the benefit of a sufficient and stable supply of grains into the marketplace.

Supply of grains and their price in the era of globalization of trade in agricultural products depends also on harvest in other countries of the European Union and other countries in the world as well as on the stocks in storehouses. International situation related to world grain harvest has a direct influence on the Polish market, prices and supply of grains. This is particularly noticeable against the background of the 2020/2021 season. The mild winter at the turn of 2019 and 2020 had a positive effect on the overwintering of winter forms of cereals. At the same time, there was a short-lived precipitation deficit in April, followed by an offset in May. Cereal grain harvests were at a fairly good level, but already in the autumn of 2020, a systematic upward trend in cereal grain prices was noticed. This is caused by the increase of global grain consumption, which in the season 2020/2021 can amount to 2,76 billion tonnes, i.e. by almost 2% more than in the previous season. The increase in consumption influences the decrease in global grain stocks by 2.2%, mainly due to higher demand, but also due to lower crops compared to the forecast. It is predicted that in the 2020/21 season, about 465 million tons of cereals will be traded internationally, 5.7% more than in the previous season. As a result, a systematic trend of increasing selling prices for cereal grains can be seen on the global cereal markets. The FAO index of cereal prices on the global markets has risen sharply by 7.1% over the past months, primarily due to the high increase in corn prices by 11.2%, which are higher by as much as 42.3% compared to January 2020 prices. The main reason for this increase is the large purchases of maize, mainly U.S. by the Chinese feed industry, which has reduced the world supply of this important feed cereal. China's maize stocks will decrease significantly. This is accompanied by forecasts of a lower maize harvest in the USA, a decrease in global stocks of this cereal and a reduction of maize exports by the authorities in Argentina, one of the most important producers. Analysts of the global cereal market report a progressive increase of cereal prices on the global market. The reasons are smaller areas of grain sowing and lower yields in the 2019/2020 season, as well as recently introduced administrative restrictions on Russian grain exports. In recent months, cereal prices on the Paris MATIF exchange have increased by 7%. A similar price increase was recorded at the CBoT in Chicago. Grain prices in Ukraine have risen by up to 75-80% due to significantly lower yields; because of this, feed prices have risen by 45-50%. In this situation Canada and the EU countries are expecting significant benefits from cereal exports, although under the pressure of higher exports, we can expect an increase in prices on the domestic cereal markets, also in Poland, and thus an increase in feed prices.

At the same time, cereal prices are increasing successively at the global and national exchanges. The increased global demand for cereals is driving up prices on virtually all continents. Some analysts are even talking about a kind of panic among buyers (flour and fodder producers), who fear a further increase in cereal prices in the coming weeks or even months and are hastily concluding contracts for the purchase of cereals in the coming weeks. In order to prevent excessive export of cereals, the Russian authorities have introduced customs duties on wheat exports, announcing a further increase in March, and have also introduced prohibitive customs duties on cereal exports outside of the allocated quota. This also translates into the situation in Poland, where purchase prices for cereals, especially wheat, are rising. The price increase on the Polish cereal market is also fuelled by increasing exports. According to the Grain and Feed Chamber, the total export of cereals in Poland within five months (July-November 2020) increased by almost 58% to 3.68 million tonnes, including wheat export by 33% to 1.2 million tonnes, rye by 230% to 676 thousand tonnes, triticale by 131% to 582 thousand tonnes and barley by 246% to 235 thousand tonnes. The Grain and Feed Board expects that cereal exports in the first quarter of 2021 will also be high, amounting to more than 900 thousand tonnes for wheat, for example (they usually amounted to around 100 thousand tonnes/month). For a long time now, the supply of cereals to the north and west of Poland has been severely depleted due to the very large exports by sea and land to Germany. It would appear that there is also less and less grains in storage in the southeast of Poland, where it is difficult to find larger lots of grain, including wheat. Currently the largest amount of stored grains is still in storage in the center of the country, but even here the market supply of virtually all cereals is severely depleted.

Barley continues to be very difficult to buy and there are not many offers for triticale. There is very little supply of corn, the prices of which have reached the level of wheat. There are indications that there will be a shortage of maize on the Polish market until the new harvest, which will provide strong support to maize prices. The expected record exports of this cereal in the current season, trace imports from southern Europe, and practically no maize imports from Ukraine, will undoubtedly contribute to strong tensions in the balance of this cereal in the later part of the season.

Food use of cereal grains

Cereal grains have always been an important part of the human diet. It is through the use of wheat and the increasingly efficient cultivation and increase in grain yields that it has been possible to feed the ever-increasing world population. The best

example of this is the development of civilization in ancient Egypt, where in the valley of the Fertile Crescent, an efficient production of grain developed, and Egypt as one of the main suppliers of valuable grain developed economically and civilization. For centuries, cereal grains were considered a major trade commodity due to their important role in feeding the growing populations of European countries. Decreases in crop yields and grain shortages caused by unfavourable climatic conditions caused a significant part of the population to starve.

Currently, however, due to the increasing number of people with gluten intolerance, the consumption of cereal products, including bread, is decreasing. In Poland in 2018/2019, the balance consumption of cereal products in flour equivalent was 101 kg per capita, compared to 121 kg in 2001 and 119-120 kg in the mid-1990s. According to the Institute of Agricultural and Food Economics - National Research Institute, consumption of cereal products in flour equivalent in the 2019/2020 season may reach 100 kg per capita. There is a systematic decline in the consumption of bread and cereal products [4]. Consumption of more expensive grain assortments is increasing, as is consumer interest in health-promoting and convenience products. Increasingly, alternatives to cultivation are being sought for pseudo-cereal species with health-promoting effects such as amaranth or quinoa. Cereal grains are used depending on the species. Wheat is the most commonly used for food purposes, and to a much lesser extent, rye. Wheat grains are the most expensive among all grains grown in Poland, therefore it is very popular among growers. It is the main cereal used for food purposes, especially for baking and confectionery, as well as flour production. Rye grains are an important processing raw material, whose considerable supply on the market influences their use mainly for the production of flour and bread baking, but also processing into cereal flakes. The products made of rye grains bring to the human diet many valuable nutrients with a pro-health effect. This is confirmed by the results of scientific research [4, 5]. These are: dietary fiber, minerals, antioxidants, vitamins, phytoestrogens and polyphenols [6]. Rye bread is the most frequently consumed product, which is also the source of these valuable substances [7]. Rye grains contain biologically valuable protein, which includes essential amino acids, mainly lysine. Rye flour, similarly to rye grains, is characterized by a high nutritive value, which depends on the fineness and purification of grains from the fruit and seed coat. Wholemeal rye flour is a source of fiber, outperforming wheat flour in this respect. It is characterized by a higher content of fructo-seed coat and aleurone layer, and also contains more protein, vitamins (especially of the B group), and minerals (iron, phosphorus, and magnesium). Fiber is also considered an important component of the diet. Its content in rye grains depends on the cultivation method [8]. The fiber fraction is dominated by pentosans (arabinoxylans) and betaglucans, which have beneficial effects in human nutrition, as opposed to use in animal nutrition. Rye with high arabinoxylan content and the flour produced from it, contain significant amounts of tocopherols (vitamin E derivatives). Wholemeal rye flour is used for baking wholemeal bread, which contains an increased content of health-promoting substances [9]. Another important criterion for consumers when choosing food products is their calorific value, which is the lowest for rye compared to other cereals. Moreover, the acid fermentation process of rye dough releases more calcium than wheat dough [10]. Rye bread retains its freshness and consumability much longer [11].

Besides the strictly food use, rye grains can be used in the distillery industry. Currently, more than 70% of the spirit produced by domestic distilleries is obtained from rye [12]. Rye grains are characterized by a high carbohydrate content, 60% of which is starch. This makes it possible to achieve high productivity and efficiency in the alcohol production process [13]. Spirits produced on the basis of rye grains are characterized by very good quality, as these grains contain a small amount of undesirable compounds, such as aldehydes (0.07g/dm^3 on average). The final quality of the product, however, depends on the quality of the grains. If the grains are of poor quality, overgrown or infected with moulds, the obtained crude spirit will contain excessive amounts of aldehydes and organic acids [14]. Other cereals, such as barley and oats, are less important for consumption. Oats is used for the production of flakes. A new direction for the use of oat grains is for brewing purposes, to produce beer with health-promoting properties. This is not a new direction of potential processing of oat grain, as it has been practiced by European breweries for many centuries, but nowadays it is somewhat forgotten [15]. Barley in food processing is mainly used for beer production.

Use for fodder

Cereal grains are the basic raw material for the production of feed used in the feeding of various livestock. They constitute from 60 to 80% of the raw material composition of mixed feeds, which depends on the current price and quality. Such a large percentage in the feed is due to the high content of nutrients, especially starch, which is a very good source of energy. Furthermore, cereal grains also contain a certain amount of protein. Apart from the desired nutrients, cereals also contain substances that impair the nutritional value of feeds by reducing the digestibility of nutrients and their absorption in the digestive tract of monogastric animals. Therefore, when formulating compound feeds, the basic criteria for selecting a particular cereal grain include the balance between nutritional value and price. Due to the large percentage of cereals in mixtures, their price is closely related to the final price of feed. According to the CSO data [16], in 2019, the total feed production amounted to 10 499 thousand. A major share, 63%, were feed mixes for poultry, 23% for pigs and 11% for cattle, 3% were mixes for horses, and 1.7 mixes for other animals [16].

The supply of particular grain species is reflected in their price, which has a direct influence on the economics of animal production, ultimately translating into profitability of breeding particular livestock species and the price of products obtained from them. Grains of different cereal species have different nutritional value, which depends on the starch and protein content, as well as the content of components with antinutritional effect. Ultimately, when selecting a particular cereal species for

a compound feed formulation, the feed companies try to achieve the right balance between the market price of the grains and their feed value. Ultimately, these requirements are most often met by triticale, which has a good composition as a feed cereal and is basically only used in animal feed; hence, its price is usually at an optimum level. Other important fodder cereals are barley and oats, which are also readily used for fodder production. The least useful cereal in terms of feed value, but at the same time with the lowest price, is rye.

Grain use for energy

European Union policy imposes on the member states the obligation to use raw materials from renewable sources for energy purposes. In Polish climatic and economic conditions, raw materials of plant origin are becoming more and more important. A new trend currently observed is the use of cereal grain for energy purposes — the production of bioethanol. The expected increase in demand for biofuels will be a factor of further increase in processing of cereals for industrial purposes. Processing of cereals for this purpose may increase from approx. 5-6% to over 10% of the total resources of cereals in Poland [17]. In this context, the rye grains which does not meet quality requirements for milling, baking and fodder processing can be used for energy purposes. This applies to low quality grains, largely infected by fungal diseases and contaminated with mycotoxins. However, these grains are a valuable feedstock for bioethanol production [18]. It is extracted from agricultural renewable feedstocks and then used as a fuel additive. The production of bioethanol from grains entails the benefit of obtaining waste products that can be reused. The bioethanol production process generates by-products - dried distillers grains (DDGS) — that are increasingly used as substitutes for post-extraction soybean meal. Hybrid varieties of winter rye that provide significant amounts of both fresh and dry biomass can be used for biogas production [19]. Biogas from rye is rather not competitive to biogas from winter rapeseed due to higher energy efficiency of the latter cereal — about 43.1 GJ - ha-1 [20].

Straw can be used for energy purposes only when agricultural demand is met, for animal production (fodder and bedding), and for fertilizer purposes to maintain a balanced balance of organic matter in the soil. Dried straw is more valuable from the point of view of energy use. It contains less moisture and chlorine compounds, which adversely affect the durability of the equipment used to burn it. Moreover, the calorific value of dry straw is several MJ higher than that of fresh straw and amounts to approx 14-15 MJ/kg. Dried straw is collected from the field by means of balers with various degrees of crushing. It can be incinerated in batch or automatic boilers.

Oat grains that do not meet quality requirements can also be used for energy purposes. This makes economic sense, especially if the grains are produced on one's own farm using low-input technologies. It also gives environmental benefits as it reduces the consumption of fossil raw materials and reduces the emission of harmful gases and dusts into the atmosphere [21]. Oats has a higher calorific value compared to rye and triticale, which confirms the appropriateness of its use for energy purposes [22]. Compared to hard coal, it has half the energy efficiency. However, its advantage is a smaller amount of ash produced after combustion (2.2%), which can be used as a fertilizer [23].

Other grains are not used for energy production because of their better nutritional and fodder value, and thus higher price, but the exception is contamination of their grains with mycotoxins or other substances that preclude their food or fodder use. Using them for energy production is then justified as an efficient way to utilize the grains.

Summary and conclusions

Cereals are a group of crops of the greatest importance, which is shown by their significant percentage in the sowing structure in Poland. The main direction of grain use is for food and fodder, as well as an alternative use of the excess grains or the grains not meeting quality standards, which is for energy purposes. Climate change, which has a negative impact on grain yields, can result in a lower supply of grain, whose prices can fluctuate wildly. The challenge is, therefore, to breed new, more drought-resistant varieties of cereals in a targeted manner, and to breed varieties that yield more stably under rainfall deficit conditions. Since grain yields of the biggest world grain producers are very important in the era of the global market, it is necessary to create strategic reserves in warehouses in order to ensure the stability of supply and prices in the internal market to maintain the country's food security.

References

[1] Eurostat,2019.https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=File:Production_of_cereals_by_main_producing_Member_States,_2019_(%25_share_of_EU27_totals)_AFF2020.png

[2] Jaśkiewicz B., Sułek A., 2017. Kierunki zmian produkcji zbóż w Polsce. Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu, 19(1), 66-73.

[3] Wójcik I., Doroszewski A., Wróblewska E., Koza P., 2019. Susza rolnicza w uprawie zbóż jarych w Polsce w latach 2006–2017. Woda-Środowisko-Obszary Wiejskie, 19, 77–95.

[4] Stanisławska J. Kurzawa I., 2016. Spożycie pieczywa i produktów zbożowych w gospodarstwach domowych według grup społoczno-ekonomicznych w Polsce. Studia i Prace WNEiZ US, 43, 391-402.

[4] Buksa K., Nowotna A., Gambuś H., 2012. Analiza towaroznawcza i skład chemiczny ziarna wybranych polskich odmian żyta pochodzących z trzech kolejnych lat uprawy. Acta Agrophysica, 19 (2), 265-276.

[5] Nordlund E, Heiniö RL, Viljaen K., 2013. Flavour and stability of rye grain fractions in relation to their chemical composition. Food Rev. Int., 54, 48-56.

[6] Gani A, Wani SM, Masoodi FA i in. (2012) Whole-grain cereal bioactive compounds and their health benefits: A review. J. Food. Proces. Technol. 3: 146-56.

[7] Björk I., Östman E., Kristensen M., 2012. Cereal grains for nutrition and health benefits: Overview of results from in-vitro

animal and human studies in the health grain project. Trends Food Sci. Technol., 25, 87-100.
[8] Łysoń E., Biel W., 2016. Ocena składu chemicznego ziarna wybranych odmian żyta z uprawy ekologicznej i konwencjonalnej. Żywn. Nauka Technol. Jakość, 23(3), 91 – 101.
[9] Szawara-Nowak G., 2013. Bioaktywne składniki pieczywa. Towarozn. Probl. Jakości, 3, 103–115.
[10] Litwinek D., Gambuś H., Sabat R., 2015 Porównanie jakości i wartości odżywczej mąki żytniej, pszennej i orkiszowej z pełnego przemiału. Technologiczne kształtowanie jakości żywności. Red. KM Wójciak, ZJ Dolatowski. Wyd. Nauk. PTTŻ, Kraków, 171-180.
[11] Tomoło J., Dziki D., Różyło R., 2013.Zmiany tekstury pieczywa żytniego podczas przechowywania. Czas. Naukowo-Kulturalne, 2, 143-154.
[12] Pietruszka M., Szopa J., 2014. Agricultural Distillates from Polish Varieties of Rye. Czech J. Food Sci., 32(4), 406–411.
[13] Wang S., Thomas K.C., Ingledew W.M., 1997. Sosulski Rye and triticale as feedstock for fuel ethanol Cereal Chem., 74, 621-625.
[14] Stanisz M., Sapińska E., Pielech-Przybylska K., 2009. Charakterystyka zanieczyszczeń występujących w spirytusach surowych. Zeszyty Naukowe Chemia Spożywcza i Biotechnologia, 1058, 105–121.
[15] Harasym J., Pieciuń T., 2010. Nietypowe słody piwowarskie– przegląd. Nauki Inżynierskie i Technologie, 92, 77-91.
[16] GUS 2020. Rolnictwo w 2019 roku. https://stat.gov.pl/obszary-tematyczne/rolnictwo-lesnictwo/
[17] Urban R., 2006 Stan głównych działów gospodarki żywnościowej po wejściu Polski do Unii Europejskiej Sektor zbożowy, mięsny i napojów. Instytutu Ekonomiki Rolnictwa i Gospodarki Żywnościowej – Państwowy Instytutu Badawczy, 25, 57-66.
[18] Burczyk H., 2011. Przydatność zbóż na potrzeby produkcji energii odnawialnej – w świetle wyników doświadczeń. Problemy Inżynierii Rolniczej, 3, 43-51.
[19] Piechota T., Sawińska Z., Kowalski M., 2017. Plonowanie i zdrowotność wybranych odmian żyta ozimego uprawianego przeznaczeniem na biogaz. Fragm. Agron. 34(2), 67–74.
[20] Bielski S., Jankowski K., Budzyński W., 2014. The energy efficiency of oil seed crops production and their biomass conversion into liquid fuels. Przem. Chem., 93(12) 2270–2273.
[21] Głowacka A., Zych M., Żołnierczuk J., 2016. Środowiskowe i ekonomiczne skutki wykorzystania ziarna owsa na cele energetyczne. Inżynieria Ekologiczna. Vol. 49: 117–123
[22] Piasecka I., Knozowski P., Ropińska P., 2017. Badanie i ocena możliwości wykorzystania na cele energetyczne rozdrobnionych ziaren zbóż wiechlinowatych. Acta Scientiarum Polonorum. Technica Agraria, 16 (1-2), 47–57.
[23] Popczyk J., 2011. Energetyka alternatywna. Wyd. Dolnośl. WSPT, Polkowice.

Article reviewed
Received: 08.04.2021 r./Accepted: 23.04.2021 r.

Jan BARWICKI, PhD, Eng[1, 2], Kinga BOREK, MSc[2]*

DOI: 10.15199/180.2021.2.3

[1] Agency for Restructuring and Modernization of Agriculture, Poleczki 33, 02-822 Warszawa

[2] Institute of Technology and Life Sciences (ITP), Warsaw Branch, Rakowiecka 32, 02-532 Warszawa
*e-mail: k.borek@itp.edu.pl

Jan Barwicki **ORCID: 0000-0002-5437-5284**
Kinga Borek **ORCID: 0000-0002-0171-7498** **Scopus Author ID: 57201670403** **ResearcherID: B-7982-2019**

SLURRY TREATMENT USING ACIDIFICATION TECHNOLOGY TO REDUCE AMMONIA EMMISION

UZDATNIANIE GNOJOWICY Z WYKORZYSTANIEM TECHNOLOGII ZAKWASZANIA W CELU ZMNIEJSZENIA EMISJI AMONIAKU

***Summary**: Most of dairy and beef cattle when being grown in barn with a slotted floor is connected with a high concentration of slurry what creates ammonia emission problems. The article presents some proposals for development of new technologies in this area. Using slurry acidification technology in the barn, in the storage or in the field, we can avoid many environmental problems concerning ammonia emission. Besides that, we can save on overall fertilizers' usage in the farm. The ammonia emissions are a major problem associated with animal slurry management, and solutions to overcome this problem are developed worldwide by farmers and scientists. An obvious way to minimize ammonia emissions from slurry is to decrease slurry pH by addition of acids or other substances acting in a similar way. This solution has been used commonly in Denmark, and its efficiency with regard to the minimization of NH3 emissions has been documented in some studies. Acidification reduced NH3 emission from stored slurry to less than 10% of the emission from untreated slurry, and the NH3 emission from the applied slurry on the field was reduced by 67%.*

***Keywords**: new technology, slurry acidification technology, ammonia emission, environment protection*

***Streszczenie**: Większość bydła mlecznego i mięsnego utrzymywana jest w budynkach inwentarskich wyposażonych w podłogi szczelinowe co powoduje wysoką koncentrację gnojowicy i jest przyczyną emisji dużej ilości amoniaku. W artykule przedstawiono wybrane propozycje dla rozwoju nowoczesnych technologii w tej dziedzinie. Wykorzystanie technologii systemu zakwaszenia gnojowicy w budynkach inwentarskich, zbiornikach lub bezpośrednio na polu pozwala na zmniejszenie emisji amoniaku, co wpływa pozytywnie na ochronę środowiska. Ponadto, możemy zaoszczędzić na ilości nawozów stosowanych w gospodarstwie. Rozwiązaniem tego problemu zajmują się naukowcy, farmerzy na całym świecie. Oczywistym sposobem minimalizacji emisji amoniaku jest zmniejszenie pH gnojowicy poprzez dodawanie kwasów lub innych substancji, działających w podobny sposób. Takie rozwiązania stosowane są w Danii, a jego skuteczność minimalizacji emisji NH3 zostało udokumentowane w pracach naukowych. Zakwaszenie zmniejsza emisje NH3 przechowywanej gnojowicy do 10% w porównaniu z gnojowicą bez zakwaszenia, a emisja NH3 w polu była mniejsza o 63%.*

***Słowa kluczowe**: nowe technologie, zakwaszenie gnojowicy, emisja amoniaku, ochrona środowiska*

Introduction

If we take into consideration the problem of slurry influence on country side environment, it is important to provide some analysis of animal production, what has a substantial influence on manure presence in a close distance to houses and flats.

The size of a herd is either expressed in term of head (number of animals) or Livestock Unit (LSU) where one LSU is the grazing equivalent of one adult dairy cow. According to the data of the Polish Ministry of Agriculture on March 2017 there were in Poland 3 732 616 cows at the age of more than 1 year old. When counting beef cattle of the same age there are 1 024 616 animals. Taking into account pigs, there are 11 824 300 animals of these breed. This number included 1 009 700 sows.

Recently more and more livestock barns, in which animals are kept on a slotted floor, instead of manure as organic fertilizer we gain here liquid manure – a mixture of manure, urine and water. The composition and value of natural fertilizer depend on the breeding technology, feeding and water delivery system. Cow manure and swine manure are different and they show a different effect on the environment. Slurry is usually mixed with some bedding material and some water during management to give the liquid manure with dry matter content in the range from about 1 to 10%. Although potassium is available almost immediately after the application of the manure to the soil, with nitrogen, and especially with phosphorus is not so easy. For phosphorus and a large part of nitrogen, they may be available for plants as nutrients, when a process of mineralization occurs, and generally speaking, must become the activity of soil microflora to provide simple mineral compounds, that can be absorbed by the plant. So the activity of the soil microflora depends on the degree of use of manure as fertilizer [10]. Thus, many studies show that the efficiency of nitrogen supplied in the slurry varies in a very wide range from 30 to 70%. In addition to the mineralization we have to take into account the time – because we want to release the ingredients gradually, along with the course of the growing season. Here, nature favors us, because in the period from April to

the end of August the temperatures are highest, which promotes the development of microflora. To the development of microflora was the most intense, you should provide them with more nutrient components. Slurry as organic fertilizer is used mainly before vegetation. It is important that large doses of manure (especially on light soils) do not precede directly sown plants, as ammonia emitted from the manure can damage and even destroy the root system of rising plants. This assumes that the nutrients and organic matter contained in the slurry should help to increase soil fertility and increase crop yields without the risk of contamination with biogenic compounds of environmental ground water [9].

The use of slurry in an uncontrolled way is a threat to the environment. The European Union legislation allow for the use of natural fertilizers (solid manure, liquid manure, urine) in amount not exceeding 170 kg of nitrogen (N) in pure ingredient per 1 hectare of agricultural land per year [6]. The requirements for agricultural construction sites, utilized for solid manure, slurry and urine storage, are given in the Act of 10 July 2007 concerning fertilizers and fertilization technology. In the case of utilization of liquid manure for many years in doses exceeding the nutritional needs of plants, it can reveal symptoms of the soil fatigue, manifested by the reduced yield of plants. We should, however, take into account the slurry in the fertilization of crops on the farm, as part of the supplementary nutrition. Well-applied manure improves soil physicochemical properties.

The amount of the slurry produced in the EU countries brings all governments to establish special regulations to avoid its harmful influence on the environment in country side surroundings.

Development of new technology for slurry treatment using concentrated sulfuric acid

The international interest for slurry acidification is quite big and current draft BREF (Reference Document for Best Available Techniques) has recognised slurry acidification, which will become a compulsory to Best Available Technic (BAT) in all EU member states. There are three main technologies, namely in-house, tank and in-field acidification. Their effects in reducing ammonia emissions from stables, stores and fields are substantial, and are found in the range of 40 to 64% according to official tests, among other the Verification Statement (VERA) of technology verification programme set up in cooperation between Danish, German and Dutch environmental authorities [2]. Slurry acidification can be explained as equilibrium between the water bound ammonium (NH_4^+) and the volatile ammonia (NH_3) is moved towards ammonium by adding acid to the slurry. Normally, concentrated sulphuric acid is used, and the costs of the acid in many cases outweighed by savings on purchase of S fertiliser.

The nitrogen that is captured via avoided ammonia evaporation is turned into savings on purchase of N fertiliser, or in higher crop yields. Slurry acidification also has a considerable climate effect by increasing the carbon sequestration in soil. Reducing the loss of nitrogen from agriculture is a key to reducing eutrophication of the Baltic Sea. Most of the airborne eutrophication to the Baltic Sea comes from ammonia emissions, and in the Baltic State Region (BSR) almost all ammonia emissions are from livestock manure. Annual deposition of ammonia nitrogen to the Baltic Sea has been increasing during the recent years and it was greater in 2012 than in 1995. While emissions are decreasing slightly in some countries, Baltic Sea Action Plan [4] calls for a reduction of 118,000 tonnes of nitrogen annually to the Baltic Sea, and the Revised Gothenburg Protocol [16] calls for ambitious reductions in ammonia emissions from all Baltic See Region (BSR) countries. Slurry acidification also affects solid/liquid slurry separation efficiency positively; DM is higher, N lower and P higher in the solid fraction. A combined treatment should efficiently prevent gaseous emissions, increase fertilizer value of slurry and reduce transport and energy costs.

Acidification of animal slurry has proved to be an efficient solution to minimize NH_3 emissions in-house, during storage, and after soil application, as well as to increase the fertilizer value of slurry, without negative impacts on other gaseous emissions.

Mobile acidification equipment could be suitable for acidifying the slurry in storage during mixing just before spreading. Such equipment could be invested in by the farmer. Mobile equipment implies that the cost can be shared if the same equipment is used on several farms. The service could also be hired from a contractor, under the conditions that there is a contractor in the neighborhood providing this service.

Just to explain, why ammonia evaporation doesn't exists, it can be explained by drawing the following equilibrium in slurry between ammonium salt and ammonia gas

$$NH_4^+ + OH \leftrightarrow NH_3 + H_2O$$

At pH=6.4 all mineralized N is found as ammonium, and no evaporation takes place [4].

In Denmark, the slurry should after lowering the pH<6 be spread within 24 hours according to rules. As the spreading season lasts for longer time, this could mean a period of several weeks per year. Economical calculations are needed to compare which solution is most profitable for individual farms. When hiring the service of acidification, the technology will be available also for smaller farms. Also, if surplus storage volume is needed because of foaming when adding acid, may make the alternative non-profitable compared to the other two alternatives [15].

Orum Smeden's appeared after in field acidification system as much simpler and cheaper. Using this equipment causes a foam formation in the top of the slurry tank, what means that this part of storage capacity is reduced [8]. Such acidification is usually done a few hours or days before spreading on the field, what makes lower ammonia evaporation when spreading such slurry on crops. So far there are about 40 such installations working in Denmark.

In regards to the type of housing, different systems may be used within the same farm. Therefore, livestock within production having more than one type of housing system are counted once for each housing system used on the farm. However, some housing systems only represent a minor share of the actual production [11]. In order to avoid this double counting, the number of places for each type of housing system is used.

For instance, many farms combine different housing system

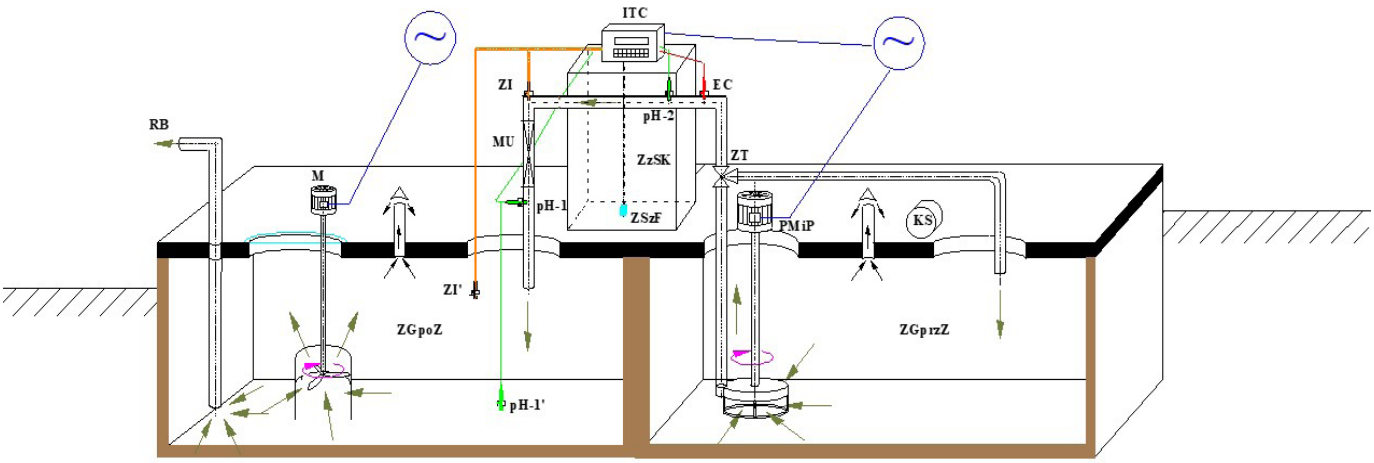


Fig. 1. Experimental pumping of fresh slurry to acidification tank : ITC – dosing pump with pH meter, ZzSK – container with acid, M – mixer, PMiP – pump, ZT – three way valve, ZGprzZ – tank with fresh slurry, ZGpoZ – tank with acidified slurry, RB – discharge pipe

Source: own elaboration

like having slatted floor for the milking cows but solid dung management (deep bed) for the cows about to farrow. Thus, the number of heads on each system changes during the year whereas the number of places is more of an average and represents the actual share of each system [4].

To estimate the potential for each Slurry Acidification Technology (SAT), we should know for each country what are the most represented animal production systems including animal species and what are the most used manure management systems in these most common productions. The manure management systems include the housing types, the storage systems, and the spreading techniques. It is assumed that the SAT is only used for slurry.

The last step of a manure handling system is the spreading stage. There are different techniques for spreading the slurry. Some of them like injection or incorporation have been proven to reduce ammonia emissions [7].

Therefore, Slurry Acidification Technology (SAT) could be seen as an alternative to those techniques. Band-spreading is the technique used in Denmark to apply acidified slurry with as it places the slurry on the soil surface and gives a rather even distribution of the slurry transversal direction.

In the Figure 1, there are presented two slurry tanks, one for fresh slurry and one for acidified slurry. Each one has capacity of 12.5 m^3. It is the experimental system, but it can be utilized for small family farms as stationary acidification system, where preparing acidified slurry just before spreading it in the field.

System contains: slurry pump, slurry mixer, acid pump, pH meter, nozzle, temperature meter, acid tank, electronic steering unit. Slurry from the barn is coming to the right tank and when it is full, pump provides mixing and pumping all its capacity to the left tank, where the acidification process starts.

When slurry gets a proper pH level, then a tractor with tanker is coming and takes all acidified slurry into the field for spreading, using trailing hoses. This type of experimental system will be very helpful when doing field experimentation on the small plots.

In Figure 2, there are presented the components from electronic system, which provides complete automated work, when providing acidification process. The whole system was elaborated with cooperation of FAPO Co. to provide all experiments in SAT Interreg project on the experimental farm in Falenty near Warsaw.

Normal field acidification tests on a bigger scale will be provided with the help of Orum Semeden's acidified system are presented in Figure 3. This system is quite simple in construction, not much automated units, what can be an advantage, when working in very difficult conditions. This system is very mobile and can be moved from farm to farm and preparing slurry to put acid, than mixing with acid and finally pumping to the tanker and spreading on the field using trailing hoses [13].

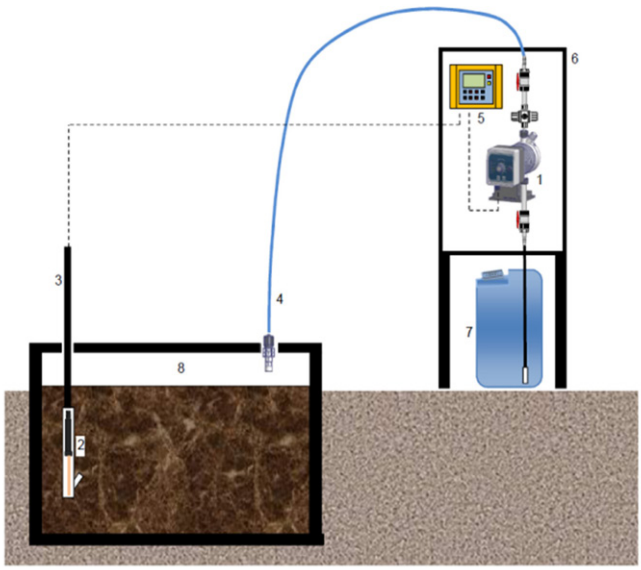


Fig. 2. Fully automated acid delivery system depending on the slurry pH content 1 – acid dosing pump type AMSPLUS, 2 – pH probe type EPHL, 3 – pH probe holder with perfusion system type PECAP-E, 4 – injection line with discharge valve, 5 – control box, 6 – safety cabinet, 7 – container with acid, 8 – slurry tank

Source: FAPO and own elaboration

Fig. 3. Orum Smeden's "in storage" acidification system at work
Source: Orum Semden's marketing material

Orum Smeden's system *www.oerum-smeden.dk* is based on a slurry mixer, equipped in pipes for adding 98% concentrated sulfuric acid. Slurry is pumped directly in the direction of activity of the mixer, what makes easer to obtain slurry mixture uniformity with acid. This is presented in Figure 3.

Acid pipes are located very close to the slurry mixing screw.

Results and discussion

Description of processes when adding sulphur acid to slurry is presented below:

NH_3(ammonia) + H+= NH_4^+(ammonium)

NH_3= gas – may evaporate NH_4^+= salt – does not evaporate)

H_2SO_4 (Sulphur acid) = Hydrogen - Sulphur-Oxygen = Sustainable

Fig.4 Detailed view of acid discharge system of ORUM Co.– construction of "in storage" unit
Source: Orum Semden's marketing material

The concept of reducing slurry pH to get lower nitrogen losses to the air relies on the equilibrium between NH_4 and NH_3 what is presented on Figure 5.

The effect of pig and cattle slurry acidification on equivalent of mineral fertilizer is presented in Figure 6.

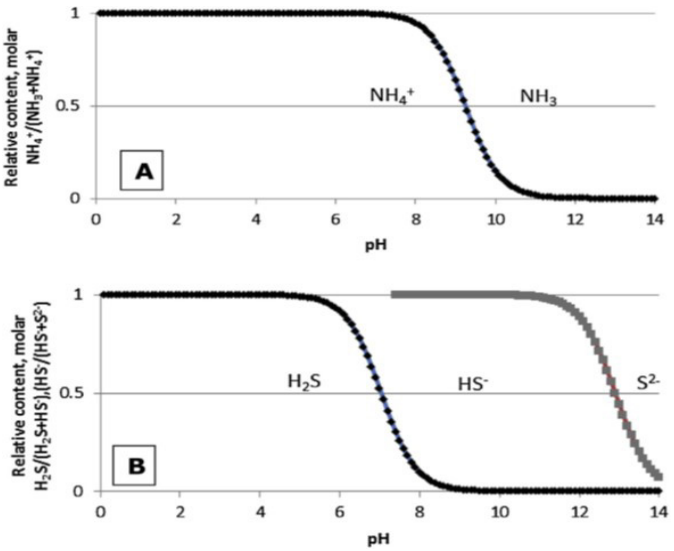


Fig. 5. Effect of slurry pH on its relative content of NH4+ (A) and H2S (B)[13]

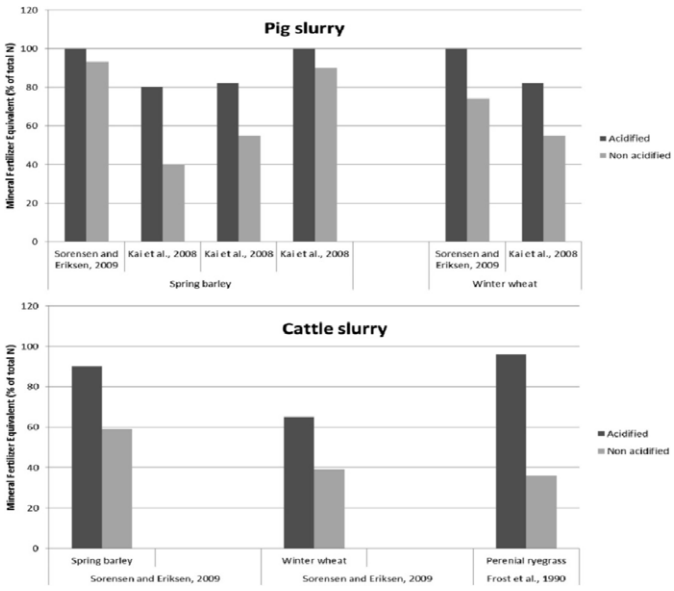


Fig. 6. Effect of pig and cattle slurry acidification on equivalent of mineral fertilizer [4]]

There was a strong relationship between NH_3 emissions and ventilation rate during spring and autumn, but weaker one during the summer period when ventilation rates were generally high. It was concluded that the contribution from floors to NH_3 emissions was <50%. There was some evidence for reduced CH_4 emissions from acidified slurry, but CH_4 emissions were generally low and apparently dominated by enteric fermentation [7]. No effect on N_2O emissions was observed. The effect of acidification on emissions of H_2S differed between the experiments. Implications of slurry acidification on the field state, depends also on N and S availability, and soil pH value [12].

Slurry acidification technology gives many advantages from the point of view of soil fertilization and also the limiting of ammonia emission. Of course, it requires providing safety procedures to avoid a direct contact of farm workers with harmful activity of the acid. But heaving good acidification technology,

which doesn't allow having a direct contact either in the storage area or in the field with the acid, this job is rather safe while fulfilling the procedures.

Conclusions

- Acidification of animal slurry has proved to be an efficient solution to minimize NH_3 emissions in-house, during storage, and after soil application, as well as to increase the fertilizer value of slurry, without negative impacts on other gaseous emissions.
- Furthermore, the acidification impacts positively on other slurry treatments such as solid liquid separation or composting; upon the use of a non-sulphur containing additive, it may also impact positively on biogas production. Nevertheless, acidification of slurry might induce higher losses by leaching, due to solubilisation of mineral elements.
- Alternatives to concentrated acids already exist but more research is still needed to improve both their technical and economic aspects. Moreover, the lack of specific equipment for the acidification of solid manures and the separated solid fraction narrows the possible fields of application of the treatment.
- pH level of 5.5- 6.4 is not very acidic, and no more acidic than rain water, which has a normal pH range from 4.5 to 8.5.
- Corrosion of concrete in stables due to use of slurry acidification has never been an issue in Denmark, as it isn't for an outdoor concrete construction like this exposed to rain.
- Acidification reduces NH_3 emission from pig houses by 70% compared with the standard housing treatment. Little loss was observed from stored slurry, and the NH_3 emission from the applied slurry was reduced by 67%. In consequence, a 43% (S.E. 27%) increase in mineral fertilizer equivalent (MFE) was measured in the field studies. The slurry acidification system is approved by the Best Available Technology (BAT) in Denmark.

References

[1] BalticManure http://www.balticmanure.eu/en/news/acidification_of_slurry_and_biogas_can_go_hand_in_hand.htm (accessed 06.05.2014).

[2] Biocover A/S. (2012). Vera Statement. http://www.veracert.eu/-/media/DS/Files/ Downloads/Artikler/VERA_erklaering_2012_okt_enkeltside.pdf (accessed 07.05.2014).

[3] Fangueiro, D., Surgy, S., Coutinho, J., Vasconcelos, E. (2013). Impact of cattle slurry acidification on carbon and nitrogen dynamics during storage and after soilincorporation. J. Plant Nutr. Soil Sci. 176, 540-550.

[4] Fangueiro, D., Surgy, S., Napier, V., Menaia, J., Vasconcelos, E., Coutinho, J. (2014). Impact of slurry management strategies on potential leaching of nutrients and pathogens in a sandy soil amended with cattle slurry. J. Environ. Manag. 146, 198-205.

[4] HELCOM. (2013). Revised nutrient targets. http://www.helcom.fi/baltic-sea-action-plan/nutrient-reductionscheme/targets (accessed 06.05.2015).

[5] Interreg EU - Baltic Sea Region - Baltic Slurry Acidification Project 2016-2019.

[6] Lyngsø H. F. (2016). Agricultural biogas production in a EU policy context, and ways to enhance effects with slurry acidification technologies. International ITP Conference Monograph, Warsaw, September, 2016.

[7] Moset, V., Cerisuelo, A., Sutaryo, S., Møller, H.B. (2012). Process performance of anaerobic co-digestion of raw and acidified pig slurry. Water Res. 46, 5019-5027.

[8] Nørgaard, J.V., Fernandez, J.A., Sørensen, K.U., Wamberg, S., Poulsen, H.D., Kristensen, N.B. (2010). Urine acidification and mineral metabolism in growing pigs fed diets supplemented with dietary methionine and benzoic acid. Livest. Sci. 134, 116-118.

[9] Nyord, T., Liu, D., Eriksen, J., Adamsen, A.P.S. (2013). Effect of acidification and soil injection of animal slurry on ammonia and odour emission. In: Proceedings from the 15th RAMIRAN Conference, Versailles, France.

[10] Pain, B.F., Misselbrook, T.H., Rees, Y.J. (1994). Effects of nitrification inhibitor and acid naddition to cattle slurry on nitrogen losses and herbage. Grass Forage Sci. 49, 209-215.

[11] Ribeiro, H., Vasconcelos, E., Coutinho, J., Cabral, F. (2009). Treatment by acidification followed by solid-liquid separation affects slurry and slurry fractions composition and their potential of N mineralization. Bioresour. Technol. 100 (20), 4914-4917.

[12] Roboredo, M., Fangueiro, D., Lage, S., Coutiho, J. (2012). Phosphorus dynamics in soils amended with acidified pig slurry and derived solid fraction. Geoderma 189-190, 328-333.

[13] Rotz, C.A. (2004). Management to reduce nitrogen losses in animal production. J. Anim. Sci. (Suppl) 82, 119-137.

[14] Semitela, S., Martins, F., Coutinho, J., Cabral, F., Fangueiro, D. (2013). Ammonia emissions and potential nitrate leaching in soil amended with cattle slurry:effect of slurry pre-treatment by acidification and/or soil application method. In: Proceedings from the 15th RAMIRAN Conference, Versailles, France.

[15] Shi, Y., Parker, D.B., Cole, N.A., Auvermann, B.W., Mehlhorn, J.E. (2001). Surface amendments to minimize ammonia emissions from beef cattle feedlots. Trans.

[16] UNECE. (2012). Parties to UNECE Air Pollution Convention approve new emission reduction commitments for main air pollutants by 2020 (revised Gothenburg Protocol). http://www.unece.org/ (accessed 15.05.2014).

[17] Project implementation contract BIOSTRATEG1/269056/5/NCBR/2015, dated 11.08.2015.

Article reviewed
Received: 27.01.2021 r./Accepted: 05.02.2021 r.

Dr Malwina PILARSKA, Eng* **ORCID: 0000-0002-1140-4161**

DOI: 10.15199/180.2021.2.4

* West Pomeranian University of Technology in Szczecin
Faculty of Maritime Technology and Transport
Department of Air-Conditioning and Refrigerated Transport
Av., Piastów 41, 71-065 Szczecin
e-mail: malwinapilarska@wp.pl

PROJECT OF PRE-INSULATED CENTRAL HEATING NETWORK FOR RESIDENTIAL SETTLEMENT "KOLEJARZ" AND OF BI-FUNCTIONAL HEATING CENTRE FOR ONE OF THE BUILDINGS

SIEĆ CIEPŁOWNICZA PREIZOLOWANA I JEJ PROJEKT DLA OSIEDLA MIESZKANIOWEGO „KOLEJARZ" ORAZ DWUFUNKCYJNEGO WĘZŁA CIEPLNEGO JEDNEGO Z BUDYNKÓW

***Summary**: The publication presents information on the principles of designing the heating network. It also pays attention to the conditions which should be met as well as the elements which should be considered when designing the above mentioned network. The paper contains also the description of the system of nets contained in the plan, the types of the nets according to distribution and, also, the way of conducting the pipelines. Besides it, the attention was paid to the type of material used in construction of the discussed network as it has the influence during its operation. Additionally, the routing of the network was discussed as well as the some respective solutions for heat-supplying network were submitted. It includes the problems of heat power balance, setting of the flows, compensation of elongation and determination of the line pressure and its calculation.*

***Keywords**: routing of network, heating substation, equipment, receiving pipelines, heat power balance.*

***Streszczenie**: Artykuł przedstawia informacje na temat zasad projektowych sieci ciepłowniczej, oraz przedstawia warunki jakie powinny odpowiadać przy projektowaniu sieci i na co należy zwrócić uwagę przy projektowaniu sieci. W pracy została również opisany układ sieci w planie, rodzaj sieci ze względu na dystrybucję, a także rodzaj sieci prowadzenia przewodów. Zwrócono również uwagę na rodzaj materiału z jakiego ma być zbudowana sieć bo to ma duże znaczenie przy eksploatacji. W pracy pojawiło się także kilka słów na temat trasowania sieci, a także przedstawiono stosowne rozwiązania dla sieci ciepłowniczej. Praca posiada metodę obliczeniową sieci ciepłowniczej, która dotyczy zagadnień: bilansu mocy cieplnej, ustalenie przepływów, kompensację wydłużeń, a także ciśnienie linii i jej ustalenie.*

***Słowa kluczowe**: trasowanie sieci, węzeł cieplny, sieć cieplna, urządzenia i przewody odbiorcze, bilans mocy cieplnej*

Introduction

The main source of heating of houses and generation of heat water in Poland is based upon the water as heat transfer medium. It is delivered by the pipeline system which, together with the appropriate fittings, composes the district heating network. The aim of the heating network is to take heat energy in the heat source and then, to transport it to its users.

The assembly of the equipment and receiving pipelines which take and distribute the delivered heat is called a heating substation. It is the site of connection of the heating network and the heating installation. It is found in a separate room, usually underground; it must be centrally situated in relation to heat receivers [1, 2].

The aim of the study was development of the problem of pre-insulated heating network for residential housing area of housing cooperative "Kolejarz" in Koszalin in accordance with the binding standards.

The principles of designing the heating network

When constructing the heating network, we always strive at obtaining the lowest heat losses. A correct transport of heating medium is required to be reliable and characterized by the smallest resistance in flow. In case of the user from industrial sector, water vapour (steam) may be also a heat medium [3].

General condition of designing the heating network is the supply of heat medium under the appropriate pressure to all planned points of receipt, maximum quantity of heat medium, being delivery in a continuous way and reaching of the low costs of construction and operation [2, 4].

Designing of the mentioned network includes designing of the paper project and routing of the network.

The project of the network system in plan

The application of the heating network is the first step considered in its designing. We may distinguish industrial, urban or mixed types of network. When working upon the urban network, we should always check whether it is planned for dwelling settlement which already exists, or for that one which is at the moment of constructing [5, 6, 7].

In the first case, the route of the network is referred to the already existing construction, with a complete infrastructure and also, to the communication road. In the second case of the network development, it should be conducted in parallel to the

plans for development of the streets and infrastructure of a given territory [5, 7].

The type of the network is related to the choice of the heat medium. We may distinguish the following types of the possible heating media: high-temperature water heating (the range above 115oC), low-temperature water heating (temperature of 115°C), high-temperature steam heating (steam pressure is above 0.07 MPa, low-temperature steam heating (the steam has the pressure equal to 0.07 MPa and mixed heating [8].

Types of network according to the way of construction

The network system in plan version consists always in the appropriate choice of the heat medium. We may distinguish the following network types:

- manifold (branched) in a form of truss (Fig. 1) – it is employed in the vase of a very high heat density of the region and for the systems of the streets, crossed at right angle (e.g. in New York); the mentioned solution enables joining of all users with the application of short connections; it is characterized by a high reliability because each of the users receives heat from at least two directions. The basic disadvantage of the branched network is its very high cost; hence, the mentioned solution is employed extremely seldom [9],
- the radial network – the heat is transferred only in a specified direction with the aim to supply big users, or those who are found at greater distance each other [7].

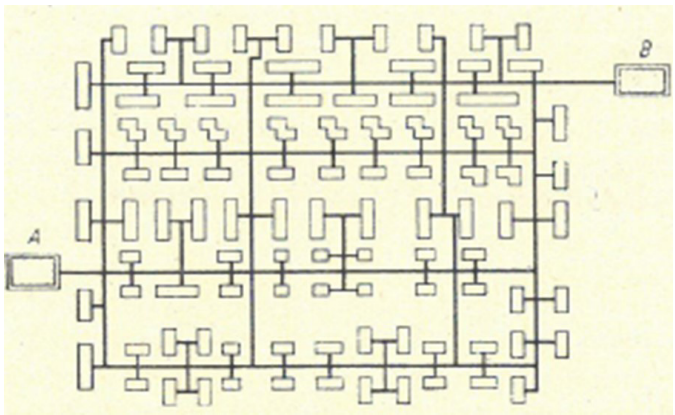


Fig. 1. The branched (manifold) network [12]]

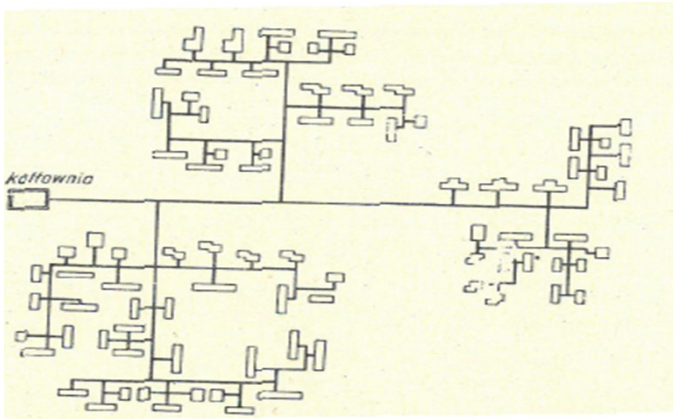


Fig. 2. The ring network [12]]

Types of networks according to the number of pipelines

- A single pipeline network where the cooled water does not return to the source. The return water has a lowered temperature and it is used directly for sanitary purposes via heat network of domestic hot water, i.e. the whole supplied water is directed to sewage system after having passed through heat exchangers what causes lowering of the mentioned above temperature [9, 10]
- Four-pipeline network which consists of two independent pipelines (feeding and returning) which serve only for heating purposes and two independent pipelines which serve for technological purposes [7, 9].

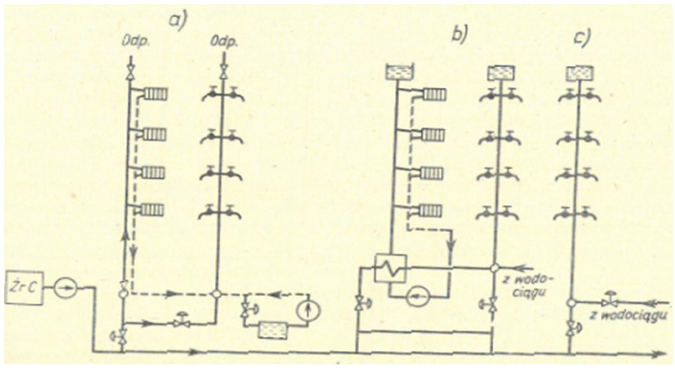


Fig. 3. A single pipeline network: a) connection of central heating and hot tap water installations by the hydro-elevator, b) indirect connection of central heating and hot tap water installations via hest exchanges, c) direct connection of hot water installation [12]]

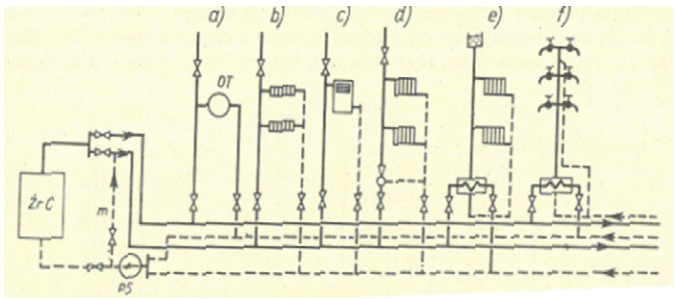


Fig.4. Four-pipeline network: a) direct connection of technological receivers, b) direct connection of central heating, c) direct connection of ventilation heaters, d) direct connection of central heating via hydro-elevator, e) indirect connection of central heating, f) indirect connection of hot tap water installation [12].]]

Types of network according to the way of laying the pipes

We should always choose the appropriate way of laying the pipelines. We can distinguish aboveground and underground networks of pipelines. The heating aboveground network may be employed in the exceptional cases, e.g. in the occurrence of a great number of crosses with railway trails, difference in the level of the area and in the case of wetland with a high level of groundwater [10].

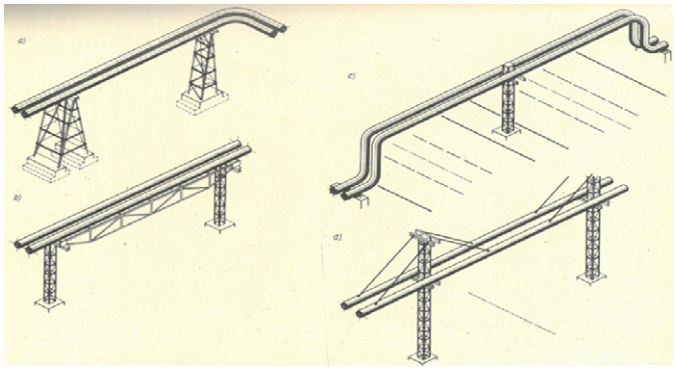


Fig. 5. Laying the pipelines: a) on high steel supports, b) in lattice girder, c) over the two-directional road, d) suspended [12]

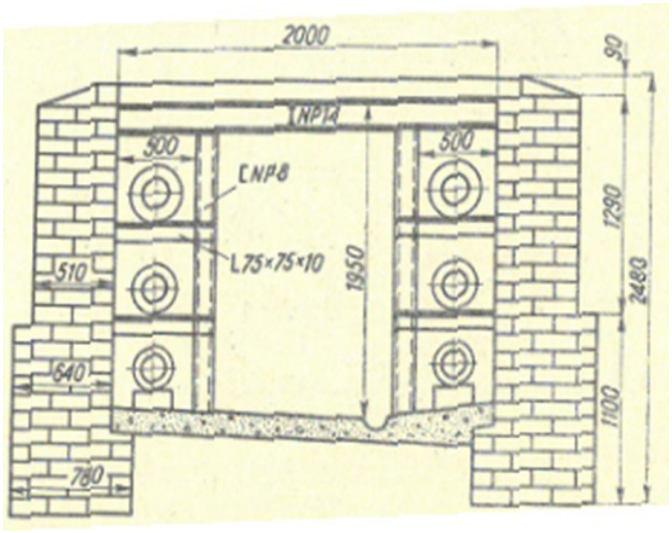


Fig. 6. Pipe network in the front channel [13]]

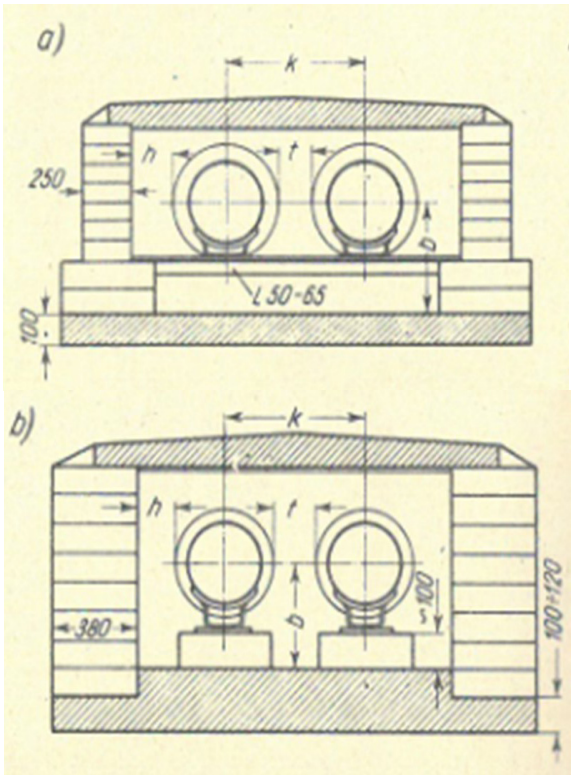


Fig. 7. Pipe network in intransitive channels [13]

The intransitive brick channel for: a) for ϕ 50–100 mm, b) for ϕ 150–600 mm.

Fig. 8. Non-ducted network [14]

Types of the heating pipelines according to the employed material

Choice of the appropriate material is an important aspect of designing the heating networks. We can distinguish the following types of networks:

- Networks made of black steel pipes;
- Networks made of galvanized steel pipes,
- Networks made of plastic pipes,
- Networks made of copper pipes.

Routing of the networks

The routing of the heating networks is connected with the choice of a short route. The mentioned route should have the possibly highest number of users. The arrangement of the network should be found on the developed area, under the pavements and lawns. The network crossing the road and railway rails should be laid in protective pipes. The conducted network of the pipelines should be laid in a distance from the forests and with the protection of the green areas. The mentioned operation should be performed as shallow as possible, with the preservation of the cover, assured by the producer of the pipes. The equipment in the channels should have the ensured ventilation by gravitation [5, 8]:

Significant solutions for heating system

Materials which constitute the heating networks include the pre-insulated pipes. They consist of the conductive insulating pipes and the protective pipelines. The conductive pipes are the most important element of the pipeline. The heating element may be made of black or galvanized steel and also, of copper or plastics (low-parameter pipelines) [4, 6, 7].

The task of the conductive pipe, covered with insulation made of polyurethane foam, is to limit the heat losses and to transfer the thermal elongations onto the protective (external) pipe. On the other hand, the protective pipe is made of polyethylene what prevents corrosion. There is a protective pipe made of galvanized steel band or of corrosion resistant steel. The discussed pipelines are additionally equipped in alarm system which inform about occurrence of humidity of thermal insulation or about a fault [6, 8, 9].

The traditional heating networks, being implemented as intransitive underground channel constructions, are made of prefabricated elements. In contrast to those mentioned above pipes, the pre-insulated pipes are laid on the ground what brings many advantages. The situation of non-ducted pipeline increases its stability, decreases the number of failures and limits the costs of operation. It causes reduction of heat losses, resulting during the transfer of heat medium. A simplified assembly of the pipeline enables its quick laying. We can distinguish the pre-insulated composite pipes and the pre-insulated sliding pipes [6, 7].

The pre-insulated composite pipe is a system of pipes where insulation connects the external protective pipe and internal conducting pipe. The assemblies of pre-insulated pipes have single layer insulation and it is made of polyurethane foam (PIR). The pre-insulated pipelines with the foam PUR are employed in transfer of heating medium, the operating temperature of which is 120–130°C. In the case of foam PIR, its temperature is equal to 160°C [8, 11]:

Fig. 9. The pre-insulated composite pipes

Fig. 10. Pre-insulated sliding pipe [13]

Insulation of pre-insulated sliding pipes consists usually of two layers. The internal insulation is made of mineral wool or fibreglass wool whereas the external layer is made of PUR or PIR foam and insulates from the direct effect of temperature of heating medium. The pre-insulated pipes, intended for construction of pipelines laid directly in the ground with protective polyethylene jacket and for aboveground pipelines with the protective pipe of "spiro" type consist of steel galvanized sheet or corrosion-resistant steel [6, 4].

The pre-insulated pipes and their production

In manufacture of pre-insulated pipes, the popular method of "pipe in pipe" is employed. The mentioned method consists in foam injection into the area between the conducting pipe and protective pipe. The thickness of insulation is determined by the size of diameter of protective pipe. In order to obtain any thickness of insulation, the technology of semi-continuous method is employed [3, 4]. The mentioned method consists in foaming of polyurethane foam in a steel profile which is put on the conducting pipe; when the mentioned form is taken off, the protective HDPE (high density polyethylene) jacket is wound on the insulation.

Conti technology consists in formation of insulation together with anti-diffusion barrier and also, injection of protective jacket into it. The mentioned barrier is found between the PUR foam insulation and the external insulation of the protective pipe. Owing to this fact, the pipes produced by the above discussed method, have slower ageing process during the operation [5, 6, 8]

The calculating methods, employed in relation to district heating network

Routing and designing the network is connected with the following issues:

— ***balance of heat power*** – each user should possess the developed power balance, necessary for designing of the network; it illustrates the demand on the heat power for the following purposes:
  - ventilation Q_w,
  - technology Q_T,
  - central heating Q_{co},
  - hot tap water Q_{cwu},

$$Q = Q_{co} + Q_{cwu} + Q_w + Q_T$$

— ***determination of flow***

Flow is the amount of water, flowing by a defined cross-section of the pipe during a time unit. In the project, the established route of the network should be marked in accordance with the position of the main pipes of the central heating main [6, 7].

— ***Choice of the pipe diameters***

The first step in the choice of the diameter of the pipes is to specify the type of a given pipe and establish the rate of flow of the heating medium [8, 9]. Depending on the above, water in the

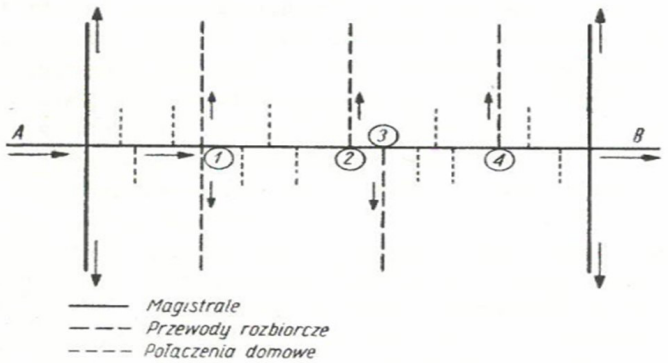


Fig. 11. Scheme of the flow [15]]

heating network may have the rate flow in accordance with its standard:

- 3.0 m/s – the main pipelines;
- 2.0 m/s – the branching from the main pipeline;
- 1.0 m/s – the connection to the buildings

The rate of flow through a given cross-sectional area of the pipe is expressed by the following formula:

$$A = G/V \ [m^3]$$

where:
G – flow rate from the calculations [m^3/s]
V – rate of the heat medium [m/s]

The diameter of the pipe is:

$$d = \sqrt{4 \cdot A/\Pi} \ [m]$$

— *Compensation of elongations*

The increase and lowering of temperature is subjected to phenomenon of thermal expansion. In case of obstruction, the thermal elongation is not possible and a fatigue crack may happen. Such situation happens when the material of the pipes exceeds a standard of mechanical strain. If we want to avoid a risk of destruction of a given part of the material, we have always to consider the possibility of elongation of the pipeline and compensate it [9, 10, 11].

The compensation of the pipelines includes as follows:

- natural compensation with utilization of compensation equipment (housing type compensator)
- application of compensating devices (elastic pre-insulated networks)
- compensation "on cold' (industrial pipes)

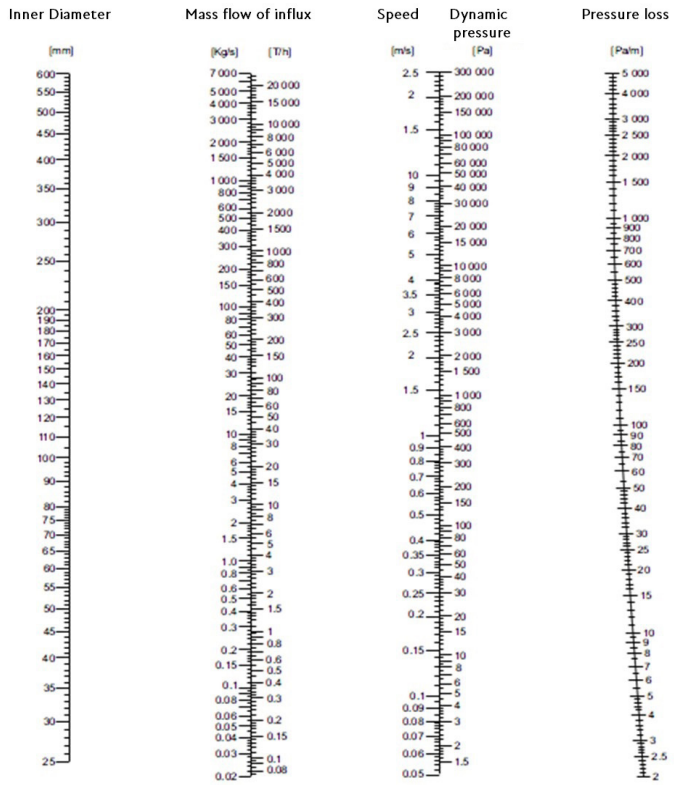
— *Pressure of the heating line and its establishment*

In order to determine the pressure of the heating line, we have to possess a special established nomogram which contains such parameters as pressure loss, dynamic pressure, flow rate, mass flow, flow intensity and dimensions of internal diameter [3, 4].

The determination of the line pressure is obtained by combination of two lower parameters and by prolongation of its segment what gives the readout of the remaining parameters [2].

Tab. 1. Example of choosing the appropriate diameter of the pipe [9]

Seamless service pipe			Casing pipe	Losing strength	Installation length
Dz	g	A	Dzp	F	Lmax
mm	mm	mm^2	Mm	N/m	m
26,9	2,9	219	75	1410	24
33,7	2,9	281	90	1410	31
42,4	2,9	360	110	1723	32
48,3	2,9	414	110	1723	38
60,3	3,2	574	125	1958	46
76,1	3,2	733	140	2193	53
88,9	3,6	965	160	2506	61
114,3	4,0	1386	200	3132	71
139,7	4,0	1705	225	3524	79
168,3	4,5	2316	250	3916	97
219,1	6,3	4212	315	4934	140
273,0	7,1	5931	400	6265	156
323,9	7,1	7066	450	7048	168
355,6	8,0	8736	500	7831	187
406,4	8,8	10992	560	8144	211
457,0	10,0	14043	630	8771	239
508,0	11,0	17175	710	9867	260



Tab. 12. Nomogram for determination of the pressure of heating lines [9]

Summing up

- The underground heating network should be constructed in technology of pre-insulated pipes which are laid directly in the ground. The assumed time of operation of the heating network is 30 years,
- The segments of the pipes should be supplied to the building site in pre-fabricated element of 6.0–12.0 m length. In the case of the pipes delivered in pipe coils, its length should be always given in the material specification,
- The performance of the elements of the pre-insulated pipes' system should be consistent with the standards PN-EN 253-2009 and their later amendments,
- The pipe assembly is a factory made element, consisting of conducting pipe, insulating material and protective sheath, satisfying the requirements of PN-EN 253,
- Heating pre-insulated networks should be so designed and assembled as to meet the requirements of self-compensation, considering the bending of installation in the route of the pipelines,
- It is allowed to lay the routes of heating networks in the territory under the demountable surface of the housing internal roads, driveways and escape routes,
- We should avoid laying the heating pipelines alongside under the road lanes which are charged with big car traffic, excluding the transverse passages on the run of the network; each pipe should be furnished with a warning tape,
- The passage of connections, made of pre-insulated pipes through the outer partitions should be performed in the way, ensuring its waterproofness.

Literature

[1] Szkarowski A., Łatowski L., ,, Sieci centralne i cieplne'', Koszalin 2002, ISBN 83-003-2.
[2] ,,Instalator'', Praktyka budowy rurociągów preizolowanych. Odwodnienie i odpowietrzenie '', Numer 02/2009.
[3] Kamler W., ,,Ciepłownictwo '', Państwowe wydawnictwo Naukowe, Warszawa 1979.
[4] Krygier K., ,,Sieci ciepłownicze '', Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2001.
[5] Krygier K., Klinke T., Seweryniak J., ,, Ogrzewnictwo. Wentylacja. Klimatyzacja'', Wydanie 7, Wydawnictwo Szkolne i Pedagogiczne, Spółka Akcyjna Warszawa.
[6] Petrozilon W., ,, Projektowanie sieci wodociągowych'', Wydawnictwo Arkady 1974.
[7] Poradnik Projektanta, ,,Rury preizolowane'', Finpol Rohr sp.z.o.o.
[8] Rozporządzenie Ministra Infrastruktury w sprawie warunków technicznych jakie powinny odpowiadać budynkom i ich wytwarzaniu, (Dz.U. nr 75 z 2002 r.) z późniejszymi zmianami.
[9] PN-B-02414:1999, ,,Ogrzewnictwo i ciepłownictwo'', Zabezpieczenie instalacji ogrzewań wodnych systemu zamkniętego z naczyniami wybiorczymi przeponowymi.
[10] www.e-instalacje.pl
[11] www.finpol.com.pl
[12] www.radpol.pl
[13] www.poradnikprojektanta.pl
[14] www.podatki.egospodarka.pl
[15] www. thermaflex.co.pl:

Article reviewed
Received: 25.05.2021 r./Accepted: 31.05.2021 r.

Dr Malwina PILARSKA, Eng* **ORCID: 0000-0002-1140-4161**

DOI: 10.15199/180.2021.2.5

* West Pomeranian University of Technology in Szczecin
Faculty of Maritime Technology and Transport
Av., Piastów 41, 71-065 Szczecin
e-mail: malwinapilarska@wp.pl

EFFECT OF THE WIND SPEED AND DIRECTION ON ENERGY BALANCE IN BUILDING

WPŁYW KIERUNKU I PRĘDKOŚCI WIATRU NA BILANS ENERGII W BUDYNKU

***Summary**: In the present paper, the problems connected with the direction and velocities of the wind, having a significant effect on energy balance in a building, have been discussed. The discussed issue concerns the construction object (10-floor skyscraper) being shielded with many obstructions, which is affected by wind activity. The analysis concerns also the balance of heat energy of the discussed building which serves keeping of thermal comfort and by this, it is a summarization of heat profits in the building, obtained from internal heat sources and solar profits, connected with the losses, caused by heat transfer via external construction baffles and ventilation system. The problem connected with the wind and its role in the energy balance has been also presented. Apart from a good thermal insulation of external baffles, the coefficient of heat loss caused by heat transfer plays also a meaningful role. The mentioned building has been subjected to analysis which concerns the impact of the direction and speed of the wind on the heat transfer coefficient. The aim of the study was to determine the influence of the direction and speed of the wind on the value of heat transfer coefficient. As far as the dynamic values of surface heat coefficient are concerned, they have been presented in the Table.*

***Keywords**: wind, direction, speed, energy balance, building, thermal comfort*

***Streszczenie**: W artykule zostały poruszone zagadnienia związane z kierunkiem oraz prędkością wiatru, który ma istotny wpływ na bilans energii w budynku. Została poruszona tutaj kwestia, która dotyczy obiektu budowlanego (10 piętrowego wieżowca) osłoniętego wieloma przeszkodami, na który ma wpływ działanie wiatru. Analiza dotyczy również bilansu energii cieplnej budynku , która służy do utrzymania komfortu cieplnego, a tym samym stanowi sumaryczne zestawienie zysków ciepła w budynku otrzymanego z wewnętrznych źródeł ciepła oraz zysków solarnych związanych ze stratami spowodowanymi przenikaniem przez zewnętrzne przegrody budowalne oraz wentylację. Została również przedstawiona kwestia związana z wiatrem oraz jego rolą w bilansie energii. Oprócz dobrej izolacji termicznej przegród zewnętrznych duże znaczenie ma tutaj współczynnik strat ciepła przez przenikanie. Budynek został poddany analizie, która dotyczy kierunku i prędkości wiatru na współczynnik przenikania ciepła, badanie miało na celu ustalenie jaki wpływ na wartość współczynnika przenikania ciepła ma kierunek i prędkość wiatru. Jeżeli chodzi o wartości dynamiczne przejmowania ciepła na zewnętrznej powierzchni zostały przedstawione w pracy w tabeli.*

***Słowa kluczowe**: wiatr, kierunek, prędkość, bilans energii, budynek, komfort cieplny*

Introduction

Movement of the air, speaking in other words, wind, which is circulating around the surface of the Earth, is generated due to a difference in the existing pressures and also, depending on the relief of the land [9]. The mentioned phenomenon, as being described to a different extent, has the impact on heat transfer via heat loss; the ventilated premises play here a certain role, as well. It is connected with the aired rooms and construction vibrations; it includes also the evaluation of climatic comfort of inhabitant in the internal environment [1].

To obtain the appropriate microclimate in the closed rooms, there are intentionally designed construction baffles; their task is to ensure always the appropriate climatic conditions in the interior, irrespectively of the seasons of the year and varying air temperatures and the velocity and direction of the wind [2]. The quality of the performed external thermal partition affects the thermal sensation which results from the asymmetric radiation which is also significant for obtaining the approximate internal temperature of the surface as compared to the surfaces of other partitions, surrounding the premise.

Each other building object is affected by different effect of the wind what has an influence on its structure. The answer is dependent on many factors: mechanical conditions of the construction object, geometrical shape, direction and speed of the wind and the terrain roughness.

The issues connected with the wind load have the effect on a given building and it is dependent on the situation of the object as well as of its surrounding [2, 3, 4]. The separate buildings are always more sensitive to the wind effect. As far as wind turning point is concerned, it is found at 2/3 of the height for a given building where the segregation of the stream takes place. A part directed to downwards, to the earth, generates a shape of horseshoe; they are the so-called whirling forms which are spreading towards lateral walls, to the windward side of the building [6, 7]. The remaining stream of splitting the parts goes to lateral walls of the building where, as affected by the pressure, it exerts a negative impact on the loss via penetration of thermal bridges which are present in the discussed object. Such part of the mentioned stream begins to move at the leeward side whereas the remaining part of the air streams above 2/3 of the height of the building passes by higher floors and flows around the roof; then, it begins

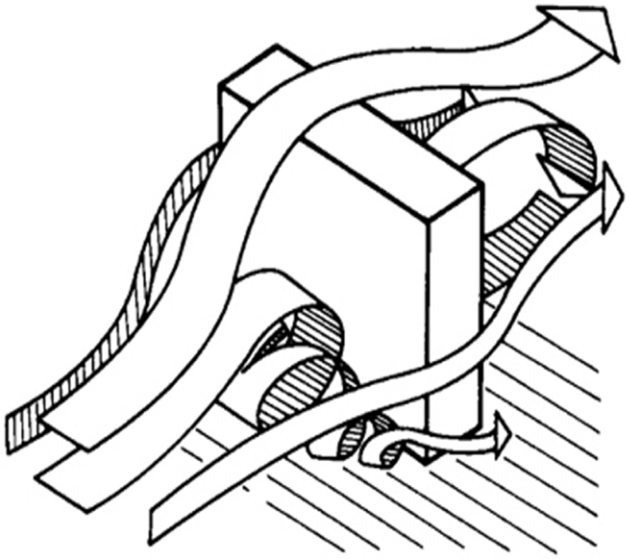


Fig. 1. The impact of the wind on the building [14]

to make a loop on the other side of the object [5, 7, 9]. It has been illustrated in Fig. 1.

As far as more complicated effect of wind is concerned, it is connected with the building which is found in the green surrounding and other construction objects. If the environment has similar geometric dimensions, we deal with the strong influence on the change in the building, caused by the impact of loads. Single buildings, separated due to contact with the stream of wind affect mutually each other. We may conclude that the improper situation of the objects may have a negative influence on the wind. In such case, the velocities of air stream are increased and the whirlwinds are generated; it causes heat losses in the buildings and high operating costs; it decreases also thermal comfort, existing in the building [7].

The aim of the work was to study the effect of the wind impact, its speed and direction which determines value of heat transfer coefficient U; it is the componential of heat loss coefficient via transfer of H_t, determining the demand of the building on heating energy.

Heat energy and its balance in the building

Keeping the comfort of heat energy in the building is consists in the summarized presentation of the heat profit balance in the mentioned building, considering profits and solar losses, caused by transfer of heat via building baffles and by ventilation system. Before designing of such building, or modernization of the existing one, we should strive at decrease of heat losses as to keep the heat comfort for the whole year [5, 8]. To obtain such effect, we have to eliminate heat losses, resulting from a low heat insulation of the discussed building. The unfavourable effect may be also caused by the incorrect position of the building in respect of its geographical situation as well as by the exposure of the discussed building to unfavourable wind influence. The role of the windows' distribution, shape of the building and its ventilation system is also significant from energetic balance viewpoint. The basic energetic balance elements include always profit coming from the sun, equipment, the inhabitants themselves and heat water. We may also mention heat losses which result from ventilation system, internal baffles and ground partitions.

Coefficient of heat transfer via building partition, U

The cause of the effect of the increased value of heat coefficient and its losses on the energy balance in the building includes design and performance errors. Heat losses due to heat transfer are determined by surfaces of partitions and the specified heat transfer coefficient U, characterizing the baffle between the external and internal environment [3, 4]. The role of the effect of other conditions in the building such as shape of the building, urban structure of our object on the losses in energy and the coefficient U are seldom considered. We should also mention the climatic conditions, occurring at a given territory.

To optimize the conditions, we should always analyze the stage of designing a building. When designing the construction of the building, we should pay attention to make it possible simple and compact, with the minimum number of bent parts. The most favourable solution includes a flat roof, or double-pitched (gable) roof with a small slope [7].

The effect of urbanistic structure of Poland on heat losses in building, resulting from a constant air flow to the building and its outflow inside

The post-war tendencies of urbanistic structure in Poland were mainly focused on building the dwelling houses such as multi-storey buildings and skyscrapers which were usually situated on the peripheries of the towns. Such solutions considered mainly the effect of the wind. The constructions inside the residential settlement caused change in the air movement; it was related to the increase in the wind speed inside the urbanistic structure. Additionally, it eliminated the possibility of estimating the heat losses in the building depending on its exposure to the wind. The determination of the wind movement is always important for climatic conditions on the separate territories, occupied

Fig. 2. The Settlement" Zachód" in Stargard [11]

by a group of buildings [7]. We can distinguish three types of exposure to wind: normal, protected (shielded) and the open one to atmospheric conditions and their effect. At the territory of Stargard, the settlement "Osiedle Zachód" is the best example, demonstrating the negative consequences of air stream activities inside the architectural structure (Fig. 2).

When designing the building, the attention was not paid to thermal parameters of building partitions and to the care of performance what resulted in a considerable number of thermal bridges, being the route of the heat escape from the building. It is demonstrated in Fig. 3. The neuralgic point of such building includes the sites of contact of two different constructional components or joining of the elements of different shape [7].

For multi-family houses which were constructed in the eighties of the 20th century, the heat transfer coefficient for the walls is equal to 1.12W/m^2·K and for windows – 2.4 W/m^2·K. The inaccurate connections of the concrete plates with windows and with other concrete plates, what is also the important factor, have been illustrated in Fig. 3. Thermal modernization of the mentioned above buildings before 2013 was not effective as it resulted from the lack of precise analysis of the heat balance and also, due to the lack of the performed energetic audit; it did not meet the requirements of the set standards. After the introduction of the change in the rules, the analysis became more precise [4, 6] but it still did not consider the heat loss which was caused by effect of the wind on the buildings and their construction. The mentioned above analysis concerned the urban nature of the analysed area and climatic conditions at the territory of the country [7].

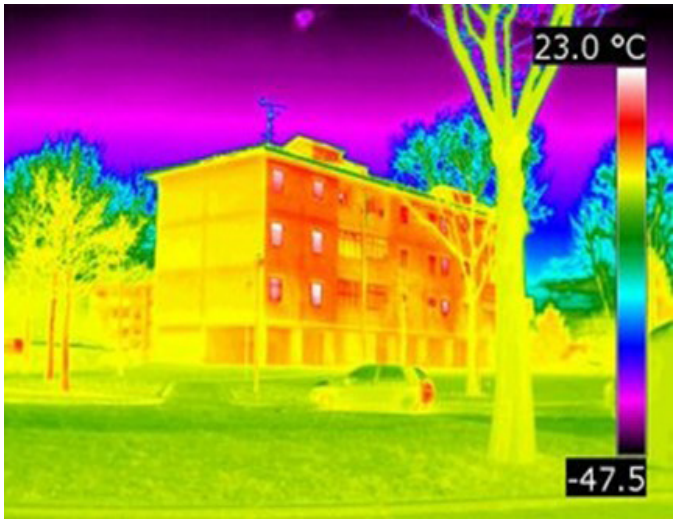


Fig. 3. Photography of the 'building plate', made with the use of thermal imaging camera [12]]

Wind and its role in energy balance

When calculating the energy balance of the building aiming at favourable thermal comfort of the inhabitants, we should also consider, apart from a good insulation, the coefficient concerning heat losses Htr, which includes one-dimensional heat exchange throughout the partitions as well as two-dimensional heat exchange due to the presence of thermal bridges [6]. The direction of the wind has also its effect in the case of a big amount of the heat escaping via thermal bridges. As far as climate in Poland is concerned, the western direction is most unfavourable. If we put direction and speed of the wind together, we will be able, on the grounds of simulation, calculate approximately the shape and height of the air stream, coming to the contact with the building façade [7].

The mentioned simulations may serve for analysis of the air movements and determination of the conditions affecting the turbulence, increase of the speed of the wind what is indispensable at the stage of designing the construction by the architects and urban planners. A high construction for, as dominating at the territory of Poland, has a shape of ring, surrounding the lower buildings; it dates back often to the pre-war period. it is exposed to especially strong effect of air streams during winter what is the reason for a higher pressure of wind on the external walls of the buildings. It causes thermal problems for the residents such

Fig..4. Photography of a single skyscraper of the settlement "Zachód" in Stargard, dating back to the eighties of the 20th century [13]

Fig. 5. Photography of the analysed building object [7]

as e.g. uncontrolled heat losses, penetration of cold air from the outside (windows and doors) as well as thermal bridges at the contact of concrete plates [6, 7].

To illustrate the effect of the wind in relation to the building, 10-storey skyscraper, situated at the settlement Zachód in Stargard, was analysed in the present study. The examined building was shielded with some protection elements such as some trees, bushes and other buildings which allowed a free flow of the wind. The measuring points were situated in the distance of 1 m from the walls of the analysed building. Also, the extreme measuring points were set at the space of 2 m and distance of 3 m from the ground of the examined building and ca. 1.5 m below the line of the roof [7, 8]. After 10-hour observation of the skyscraper, (Fig. 5) it was revealed that the speed of the air varied within the limits of 0.35 m/s; it concerned the central walls. The speed of the coming air stream in the highest corner of the building was equal to 4.12 m/s. It is resulted from our conclusions that the velocity of the wind is always changed together with the dimensions of the building [7, 8]. The initial value of the wind Vo is 4 m/s in the site of 10 m above the ground of the building. The speed of the wind at the level of 3 m above the ground level of the building was analysed for three directions: western, north-western and south-western. If we speak about western direction of the coming wind, it is always perpendicular to the object as the surrounding construction decreases always its speed. It reaches the lowest value in the middle of the building's facade on the windward side. It is illustrated in Fig. 6 [7].

When the wind comes from the north-west direction, the neighbouring object protects, in a certain degree, the analysed wall. The speed of the coming wind is decreased when it approaches the central part of the wall where the collision with the building occurs. The change in the wind direction takes place into the parallel in relation to the building. Together with the decline in the distance from the sharp edges, the air stream becomes separated and its velocity is increased (Fig. 7) [7].

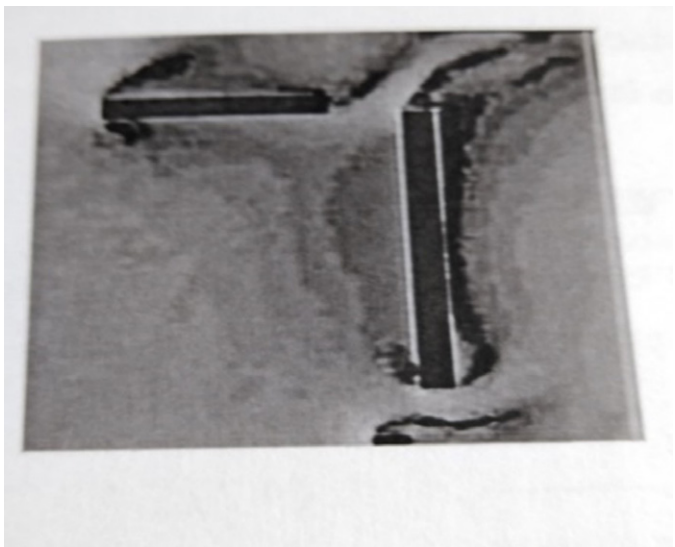


Fig. 6. Western wind [7]

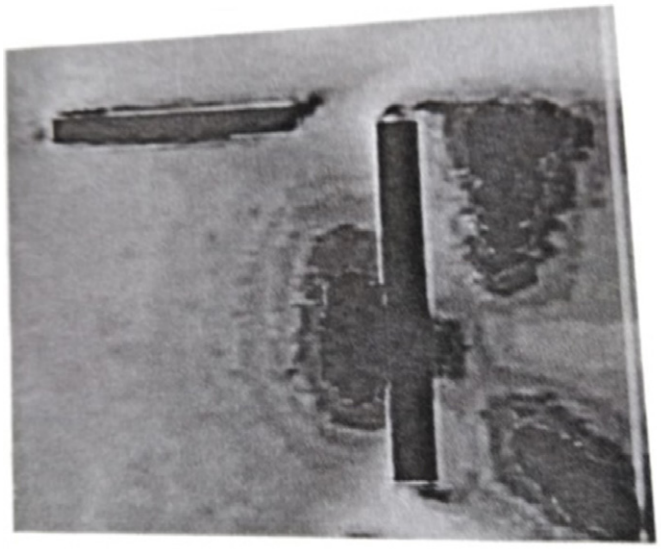


Fig. 7. North-western wind

At the south-west direction, the building is considerable less shielded; due to this fact, a zone of the lowest wind speed is shifted towards the south edge of the skyscraper. The highest speed of the wind flow was found above the corner and in the passage between the neighbouring objects (Fig. 8) [7].

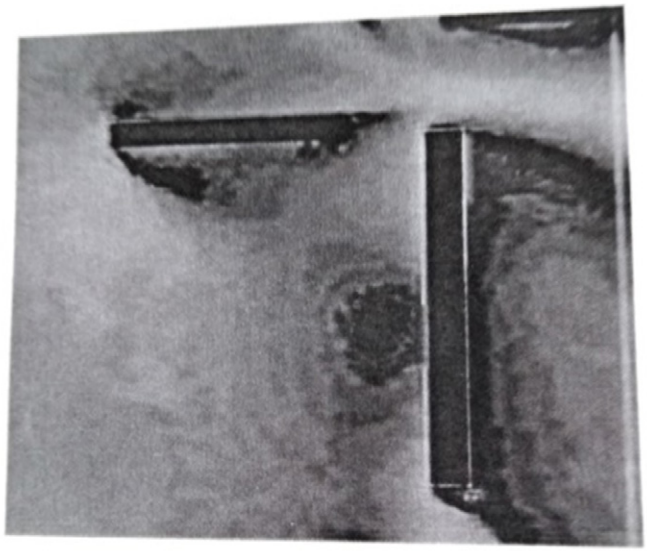


Fig. 8. South-western wind

A significant effect of the speed and direction of the wind on the heat transfer coefficient

The most important calculations concerning the wind effect which had a significant influence on value of heat transfer coefficient were carried out according to the relationships (9.1–9.6). The total thermal resistance begins to change together with the speed of the coming wind; it is related to the building partitions.

Table 1. Resistance to heat transfer on the external side of the surface and heat transfer coefficient

Ambient temperature	Wind speed	Wind direction	Heat flow coefficient due to radiation	Heat flow coefficient via radiuses of back body	Heat flow coefficient on the external side	Ambient temperature	Dynamic resistance of heat flow on the external surface	Heat transfer coefficient
tm [°C]	v[m/s]		$h_T=\varepsilon h_{T\sigma}$	$h_{T\sigma}=4\sigma Tm^3$	$h_\sigma=4+4v$	T_m[K]	$R_{se\ dynam}=1/(h_\sigma+h_T)$ [m²K)/W]	$U_v=1/[1/U)-R_{se}+R_{se\ dynam}]$ [W/(m²K]
2.8	0	0	4.23	4.6	4	275	0.11	1.3380
2.7	0	0	4.23	4.6	4	275	0.11	1.3379
2.5	0	0	4.22	4.5	4	274	0.11	1.3376

In connection with the above, we may distinguish the following formula:

$$U_v = 1/1/U-R_{se} + R_{se\ dynam} \quad (9.2)$$

R_{se} – is thermal resistance of external partition; it is calculated from the following formula: $R_{se\ dynam} = 1/h_\sigma - h_T$ (9.3)

The heat coefficient, being measured at the external side is:

$$h_\sigma = 4 + 4\upsilon \quad (9.4)$$

The heat coefficient, resulting from radiation:
$h_T = \varepsilon h_{T\sigma}$, where the surface of emissivity is $\varepsilon = 0.9$ (9.5)

Black body and the coefficient of its radiation: $h_{T\sigma} = 4\sigma T^3 m$ where: T_m – absolute temperature. Black body and its radiation:

$$5.67 \times 10^{-8}\ W/m^2K4 \quad (9.6).$$

Resistance to heat transfer on the external side of the surface and heat transfer coefficient, which is greatly dependent on such factors as direction and velocity of the wind, have been presented in Table 1.

The velocities and direction of the coming wind have the greatest influence on the heat transfer coefficient, the value of which is U = 0.25 W/m² K. It is greatly dependent on the building, affected by the wind. The coefficient of heat transfer via the building partition has been calculated in accordance with the guidelines, contained in the Polish Standard PN-EN ISO 6946 [8].

Summing up

- Nowadays, in each modern construction sector, we strive at improvement of the external heat building partitions, employing the newer and newer constructional elements as to obtain the lowest heat transfer coefficient for the external partition,
- When designing the external walls, we should choose the most appropriate thickness of the material with the lowest heat transfer coefficient; it has a favourable impact on thermal insulation of the partitions and improvement of thermal comfort in the building,
- Good thermal insulation of the building is specified by basic assumptions of physics of the external walls of the building,
- The conducted analysis in the present study allows concluding that the differences in maximum speed of the wind and in the directions of its flow have the influence on the amount of the lost heat from the inside to the external environment,
- The difference between the external and internal environment, being separated by the discussed partition, is, however, the key aspect of the analysed problem,
- When designing the contemporary buildings with minimum energy use, we should carry out the simulation of the wind effect on the designed object, with the reference to the urban construction in a given area and to the maximum wind speed, occurring at the given area. It would be helpful in designing the external partitions and adaptation of the value of the heat transfer coefficient, being most appropriate for given conditions of the area. It would minimize the effect of wind stream on the heat loss from the inside to the external environment of the building.

Index of determination of the symbols, mentioned in the paper

Tm, K – ambient temperature,
$R_{se\ dyn}$, m² K/W – resistance of heat flow on the external side of the surface,
H_{tr} – heat loss coefficient, resulting from heat transfer,
Uv – heat transfer coefficient for different wind velocities,
v, m/s – wind speed,
t_m, °C – ambient temperature,
h_σ – heat transfer coefficient on the external side,
h_T – heat transfer coefficient, resulting from radiation,
$h_{T\sigma}$ – coefficient of radiation *via* black body,
σ – Stefan Boltzman constant,
ε – surface emission,
V_o – speed of blowing wind,
W – value of heat flow coefficient.

References

[1] Flaga A.: Inżynieria wiatrowa, podstawy i zastosowania, Wydawnictwo Arkady, Warszawa 2008 r.

[2] Heim D., Klemm K.: „ The effect of wind loads on conduction heat looses in high rise building ", The 21 TH Conference on Passive and Low Energy Architecture , Eindhoven , The Netherlands 19-22 September 2004 r.

[3] Maludziński B.: Korekta wskaźnika EP dla lokali mieszkalnych w budynku wielorodzinnym „Czasopismo techniczne "Zeszyt 4 (2-B/2010), Kraków 2010 r.

[4] Neufert E.: Podręcznik projektowania architektoniczno- budowlanego, Wydawnictwo Arkady , Warszawa 2005r.

[5] Panek A., Rucińska J., Ekonomicznie uzasadniona możliwość poprawy wymagań energetycznych budynków w Polsce „ Czasopismo techniczne " Zeszyt 4 (2-B/2010), Kraków 2010r.

[6] Klemm P. Budownictwo ogólne Tom 2, Fizyka Budowli, Wydawnictwo Arkady Warszawa 2010r.

[7] Szczepaniak P., Wesołowska M.: Projektowanie budynku mieszkalnego wielorodzinnego z wymaganą charakterystyką energetyczną. „ Czasopismo techniczne " Zeszyt 4 (2-B/2010), Kraków 2010r.

[8] PN-EN ISO 6946:2008 Komponenty budowlane i elementy budynku . Opór cieplny i współczynnik przenikania ciepła. Metody Obliczenia .

[9] http://pl.wikipedia.pl

[10] htpp://fakt.pl

[11] http://e-stargard/wiadomości/

[13] http://stargard naszemiasto.pl

[14] htpp://inzynieriabudownictwa.pl.

Article reviewed
Received: 10.05.2021 r./Accepted: 18.05.2021 r.

INSTITUTE OF TECHNOLOGY AND LIFE SCIENCES
– STATE RESEARCH INSTITUTE (ITP – PIB)
BRANCH IN WARSAW
02-532 Warszawa, ul. Rakowiecka 32
www.itp.edu.pl

DIRECTOR OF THE INSTITUTE AND THE DEPARTMENT OF RURAL TECHNICAL INFRASTRUCTURE SYSTEMS (ZSIT)

are pleased to invite

to 27th INTERNATIONAL SCIENTIFIC CONFERENCE
under the patronage of the Minister of Agriculture and Rural Development

on "Problems of animal production intensification with regard to environment protection, EU standards and alternative energy production, including biogas"

15 September 2021 (on-line)

CO-ORGANIZERS

Department of Renewable Energy Sources Engineering – West-Pomeranian University of Technology in Szczecin (ZUT Szczecin)
Higher School of Agribusiness in Lomza (WSA Lomza)
Department of Production Engineering, Logistics and Applied Computer Science – University of Agriculture in Krakow
Warsaw University of Life Sciences (SGGW)

Zachodniopomorski Uniwersytet Technologiczny w Szczecinie

Szkoła Główna Gospodarstwa Wiejskiego w Warszawie

WSA Wyższa Szkoła Agrobiznesu w Łomży

MEDIA PARTNERS

TERAZ ŚRODOWISKO .pl
Aktualności i praca w ochronie środowiska

POLISH TECHNICAL REVIEW
SCIENCE AND INDUSTRY IN A COUNTRY OF CHANGES

AURA OCHRONA ŚRODOWISKA

Scientific Board

Prof. Wacław Romaniuk (ITP – PIB)
Prof. Wiesław Dembek (ITP – PIB)
Prof. Andrzej Myczko (ITP – PIB)
Prof. J. Lech Jugowar (ITP – PIB)
Prof. Andrzej Eymontt (ITP – PIB)
Prof. Jan Kamionka (ITP – PIB)
Prof. Maciej Kuboń (UR Kraków)
Prof. Adam Kupczyk (SGGW)
PhD. Adam Koniuszy (ZUT Szczecin)
PhD. Andrzej Karbowy (ZUT Szczecin)
PhD. Andrzej Borusiewicz (WSA Łomża)
Prof. Jacek Dach (UP Poznań)
PhD. Wojciech Czekała (UP Poznań)
Prof. Józef Szlachta (UP Wrocław)
Prof. Andrzej Marczuk (UP Lublin)
Prof. Henryk Juszka (UR Kraków)
PhD. Jan Barwicki (ARiMR Poland)
Prof. Yuri Ivanov (Russian Federation)
Prof. Nikołaj Morozov (Russian Federation)
Prof. Vasilij Sysujev (Russian Federation)
Prof. Petr Savinyh (Russian Federation)
Prof. Vladimir Perednia (Belarus)
Prof. Vladimir Kosolapov (Russian Federation)
Prof. Vitalij Tseyko (Russian Federation)
Prof. Juris Priekulis (Latvia)
Prof. Yuri V. Chigariev (Belarus)
Prof. Nikolay Kapustin (Belarus)

Organizing Committee

Dr. Wacław Roman Strobel – Director of ITP
Dr. Kamila Mazur – Chairman of the Conference
Prof. Wacław Romaniuk – ZSIT, Co-Chair
MSc. Eng. Kinga Borek - secretary, ITP-PIB
Dr. Andrzej Seliga - Warsaw ITP Branch manager
Dr. Adam Brysiewicz – ITP Publishing manager
Dr. Grzegorz Wałowski – ITP Poznań
Dr. Marek Kierończyk – ITP O/Bydgoszcz
Prof. Henryk Sobczuk, Head of Scientific Departments, ITP
Msc. Przemysław Trzosek – Deputy Director, ITP
MSc. Jacek Zamielski – Director's Advisor, ITP
PhD. Jan Barwicki – ARiMR
PhD. Andrzej Karbowy – ZUT Szczecin
PhD. Andrzej Borusiewicz – WSA Łomża
Dr. Krzysztof Wiśniewski – SGGW
MSc. Bogdan Łochowski – ITP
MSc. Renata Kalinowska – ITP
Technician Daniel Mumot – ITP

The XXVII Conference will be held on 15 of September 2021 in on-line mode.
Beginning at 10:00 o'clock. We will provide a link a week before the conference

Principal scientific topics of the Conference:

- technological processes in animal production with the maintenance of animal welfare,
- determination of the future works concerning adaptation of technological standards in animal husbandry and the elements of infrastructure to the EU requirements and environment protection,
- development of the technologies ensuring proper conditions for the animals as well as the work safety for operating personnel,
- improvement of the livestock buildings as an element of infrastructure in modern development for rural area,
- gaining the biogas from natural manure and crop production,
- acidification methods of slurry as an action limiting the emission of ammonia,
- development of the livestock buildings, low-carbon and low-energy.

The conference fee is PLN 400. The charge includes the cost of a monographic materials (including publishing your paper in the form of a chapter monograph), editorial preparation, printing, sending the monograph and ensuring on-line transmission. We encourage you to prepare an article in the form of a monograph chapter (20,000 characters).

Persons who pay the fee by May 28, 2021, can take advantage of a 50% discount on the publication of an article in the Special Issue "Biogas Production Processes from Biomass" in the Processes journal (IF 2.78). If interested, please contact us by e-mail

Detailed information on the terms of publication:
https://www.mdpi.com/journal/processes/special_issues/biogas_production_biomass

For all participants of the Conference, the *Journal Water of Land Development* magazine offers a 20% discount for the publication of the article (https://www.itp.edu.pl/JWLD/index.html)..

Deadlines:
Until 20/08/2021 - application for participation in the Conference, presentation topic, article title, payment.
Until 25/08/2021 - submission of articles for the monograph.

The conference fee should be paid into account:
ALIOR BANK IBAN: PL 40 2490 0005 0000 4530 9244 4533
BIC/SWIFT: ALBPPLPW with the note: "ZSIT Conference" and the name of Participant paying the conference fee.

Persons interested are kindly requested to address the correspondence (notifications) as follows:

Instytut Technologiczno-Przyrodniczy/Institute of Technology and Life Sciences
Oddział Warszawa/ Warsaw Branch
Zakład Systemów Infrastruktury Technicznej Wsi
Departament of Rural Technical Infrastructure Systems
02-532 Warsaw, Rakowiecka 32, Poland

or via email to all 2 addresses
k.borek@itp.edu.pl;
k.mazur@itp.edu.pl;

Contact:
Prof. Wacław Romaniuk, ph. (+48) 694 682 338
email: w.romaniuk@itp.edu.pl

Dr. Kamila Mazur tel. (+48) 694 478 859
e-mail: k.mazur@itp.edu.pl

Msc. Kinga Borek tel. (+48) 694 620 713
e-mail: k.borek@itp.edu.pl

Please send your articles to 2 email addresses:
Msc. K. Borek, Dr. K. Mazur

THE 27TH EDITION OF THE COMPETITION

GOLDEN ENGINEER 2020

27 EDYCJA PLEBISCYTU ZŁOTY INŻYNIER 2020

Source: https://not.org.pl/aktualnosci/inzynierskie-swieto

It is the first time in 27 years when we have been not able to hand over – at the breakdown of February and March – the diplomas and statuettes to the laureates of the plebiscite for a title of **"Golden Engineer of Technical Review 2020"**. We could not somehow imagine our traditional gala in e-formula as we extremely highly appreciate the personal contacts. Perhaps we are somewhat old fashioned but we remember that the idea of organizing associations, societies and unions included, *inter alia*, wish to meet in a friendly society, to stay and act together.

A great value of our plebiscite consists not only in honouring the engineering creators but also meeting of the representatives of engineering society, representing different specialities. We mean here the interdisciplinary approach to civilization development, with its humanistic aspects, possible in the case of personal contacts. We hope we will be successful in reaching this aim because we should, after all, feel practically a positive effect of vaccines, being a great success of science, technology and human creativeness. We cannot, however, forget about the responsibility for our undertakings – not only in relation to ourselves but also our environment as well as about the mutative capabilities of coronavirus. In spite of many threats, we managed to maintain "Technical Review" (Polish: Przegląd Techniczny) on the market and choose (e-voting) laureates of our plebiscite for a title of "Golden Engineer 2020". The chosen persons represent different areas of activity in science, engineering, business and social activity. To emphasize the jubilee of the "Technical Review", we decided to award three titles of "Golden Engineer of the 155th anniversary of TR".

We asked all laureates for a brief interview specifying how their sector, company, university, institute or organization copes with the situation caused by pandemic. It has been revealed that in the case of the possibility of a remote work, the e-system was introduced and it worked well. We all had to pass the accelerated course of digitalization! As a society, we have made a huge civilization jump. Unfortunately, there were also developed the negative consequences, mainly psychic and social ones, which cannot be neglected.

In many companies, where a physical production is necessary, the strict sanitary regimes were employed and – as our laureates say – it gave the positive results. The companies still functioned and the staff did not suffer from pandemic. The mentioned assessment, of course, is based upon only few examples; therefore, we should not generalize the resulting conclusions. The answer to the question: how has the humanity managed with pandemic and what are the conclusions for the future in the light of a new situation requires sociological studies to be carried out. Undoubtedly, much depended and will depend on material and cultural status of the countries and their inhabitants. Science and technology has much to do in this respect. Let's hope the decisions makers will utilize the achievements and knowledge of the specialists even in the case when it is not fully consistent with their expectations. Virus attacks irrespectively of political and religious beliefs and our opinion on its existence.

Fig. 1. The speech of Ewa Mankiewicz-Cudny, the Editor-in-Chief if "Technical Review"

Fig. 2. Minister Andrzej Dera reads out the letter of the President of the Republic of Poland, Mr Andrzej Duda

We express our congratulations to all the Laureates.

Ewa Mankiewicz-Cudny
The Editor-in-Chief of "Technical Review"

Diamond Engineer 2020

Prof. dr hab. Arkadiusz Mężyk, Eng. – Rector of the Silesian University of Technology, the President of the Conference of the Rectors of Polish Academic Schools (KRASP).

Golden Engineers of the 155th anniversary of the "Technical Review"

Prof. dr hab. Andrzej Jakubiak – electronic engineer, lecturer at Warsaw University of Technology (PW) , the President of the Association of Graduates and Friends of PW, activist of SEP (Association of Polish Electric Engineers).

Engineer Sławomir Kasprzak, MSc. – mechanical engineer, director of the Assembly of the Secondary and Technical Schools no. 1 in Warsaw.

Engineer Marek Roszak, PhD, Professor of Silesian University of Technology – scientist, the President of Polish Forum of ISO (International Organization for Standardization), auditor of quality systems.

2020 Golden Engineers

Engineer Jacek Baurski, MSc. – mechanical engineer, specialist in the domain of nuclear energetics, activist of SEP and NOT

Category "Energy"

Engineer Andrzej Czajkowski, MSc. – mechanical engineer, manager in MINE MASTER LTD Company

Category "Structures"

Dr hab. Zdzisław Czaplicki, Eng. – specialist in textile industry, employed at the Institute of Natural Textiles in Poznań

Category "Innovations"

Krzysztof Hnatio, MSc. – mechanical technician, the President of the Board of GAS STORAGE POLAND, company from PGNiG Group

Category "Infrastructure"

Dr Andrzej Konieczny – the forestry engineer (Warsaw University of Life Sciences, SGGW), doctor of economic sciences

Category "Ecology"

Dr Jan Strzałka – electrical engineer, long-term scientific worker of The Staszic University of Science and Technology in Cracow (AGH), activist of the Cracow Department of SEP

Category "Management"

Silver Engineers 2020

Dr Jan Kania – mining engineer, scientist and teacher at Silesian University of Technology

Category "Science"

Eng. Elżbieta Kosydar, MSc. – florist, the President of the Chief Board of the Scientific-Technical Association of Engineers of Gardening, lecturer at Rzeszów School of Engineering and Economics

Category "Ecology"

Eng. Arkadiusz Kukliński – forestry engineer, director of Department of the Office for Forest Management and Forestry Geodesy

Category "Management"

Eng. Paweł Mularczyk, MSc. – mechanical engineer, specialist in machine constructions, co-creator of gas equipment in ZWUG INTERGAS Company

Category "Constructions"

Dr Adam Rylski, Eng. – materials engineer, lecturer at the Łódź University of Technology – Institute of Materials Engineering, promoter of Polish inventors

Category "Innovations"

Kazimierz Wronkowski, MSc – chemist, the founder and president of ETP SA in Katowice

Category "Infrastructure"

The distinguished engineers of 2020

Eng. Miłosława Kujszczyk-Bożentowicz, MSc. – electrical engineer, graduate of Warsaw University of Technology (PW), member of SEP (Association of Polish Electrical Engineers and Technicians)

Category "Association activist"

Prof. dr hab. Kazem M. Kalaji – scientist at Faculty of Plant Physiology of the Institute of Biology (Warsaw University of Life Sciences, SGGW)

Category "Science"

Eng. Henrik Krisch, MSc. – electrical engineer, the founder of PriMac UG company

Category: "Medical engineering"

Master Krzysztof Piotrowski – electrical installation technician, manager in FANEX company

Category "Constructions"

Dr Andrzej Suchecki, Eng. – mechanical engineer, academic teacher, manager of the Laboratory of Working Stand Studies at the BOSMAL Automotive Research and Development Institute

Category "Management"

Young Engineer 2020

Beata Pawlak, MA – stylist and fashion designer, general director at Adika Collection

MSc. Sylwester Skwarczyński – mechanic, deputy head of the Quality Control Department at ASMET

Fig. 3. The speech of the Diamond Engineer 2020, Prof. dr hab. Arkadiusz Mężyk – Rector of the Silesian University of Technology, the President of the Conferences of the Rectors of Polish Academic Schools (KRASP)

Fig. 4. Minister Andrzej Dera (in the middle), Secretary of the State, participated in the final ceremony of the 27th plebiscite "Golden engineer" of the Technical Review being held on 21 June 202 in Warsaw House of Technician

Fig. 5. The guests

Fig. 6. Laureates of the plebiscite: Golden Engineer 2020

17 LAUREATES OF THE 47TH OLYMPIAD OF TECHNICAL KNOWLEDGE

17 LAUREATÓW 47 OLIMPIADY WIEDZY TECHNICZNEJ

In June, 1, 2021, the Chief Committee of Technical Knowledge Olympiads, as debating in on-line mode, awarded 17 Laureates of the 47th Olympiad of Technical Knowledge.

The Laureates were chosen on the grounds of the results of the 3rd degree competitions (central finals) which were carried out on May 22, at the Military University of Technology (Polish: WAT) in Warsaw. The Department of Electronics of the mentioned University was a direct organizer of the event. The finals were attended by 39 pupils; the competitions consisted in solving of one from two suggested tasks and of technical problem from the selected problem group.

Earlier, on 23 October 2020, e-competition of the first degree (school preliminaries) was carried out and on February, 2, the 2nd degree (district) competitions were conducted.

In electric-electronic group, 7 laureates were chosen. Szymon Strzelczyk, the pupil of the secondary Technical School of Modern Technologies in the Jan Paul II Assembly of the Secondary Schools in Kleszczowo occurred to be the best competitor. The Laureate obtained 93 for 100 possible points and he will receive the title of Laureate with number 929; it is the successive number, received by the laureates for 47 years (since the first edition of the Olympiad in 1974). Mr Paweł Kelm is the tutor of the laureate who brought him to the success.

In mechanic-construction group, there were 10 laureates chosen; Korneliusz Obarski, the pupil of the Queen Jadwiga Private Secondary School (Lyceum) in Lublin was the best; he gained 92 points. Mr Piotr Kononowicz is his school tutor.

The Olympiad was established in 1974. Its organizer has been, for many years, Federation of the Scientific-Engineering Associations, Chief Technical Organization (FSNT-NOT). The Olympiad is managed by the Main Committee, presided by Prof. Stanisław Wincenciak from Warsaw University of Technology.

The purpose of the Olympiad is to initiate and develop the interest in engineering, rising of the technical culture, preparation to undertaking further education and independent gaining of knowledge and recognition and stimulation of cognitive activities of the talented young people.

The Competitions of Technical Knowledge Olympiads consists of three stages. School qualifications consisted in solving of the set of tests and several simple tasks. in district competitions, the competitors solved the tasks in the selected problem groups and their content included statistics of construction, kinematics of solid body movement, thermodynamics, rules of physics and structure of matter and, also, circuits of direct and alternating current with passive elements, calculation of electric parameters, basic electronic elements and systems and transformation of digital systems on the level of supplementary requirements in the subjects such as mathematics, physic, chemistry, general mechanics, electrical engineering, electronics and rudiments of electric measuring system.

The content of the subjects is correlated with the core curriculum for secondary schools (their pupils constitute the greatest group of the Olympiad participants) and for technical secondary schools with mechanical, constructional, electrical and electronic profile.

Due to the pandemic situation, the solemn summing up of this year's editionis planned to be held in September 2021.

Developed by
Janusz M. Kowalski
The member of the Main Committee of OWT

INFORMATION FOR AUTHORS

Please submit to the editorial office author's application form with contact details, a title of the proposed article, number of pages, illustrations and tables and a brief abstract. After receiving information about the acceptance of the proposed paper submit the entire text prepared according to the editorial instructions as well as a complete declaration form.

Submitted articles are subjected to editorial assessment and receive a formal editorial identification number used in further stages of the editorial process. Every submitted article is reviewed. Publication is possible after receiving positive reviews (see review procedure).

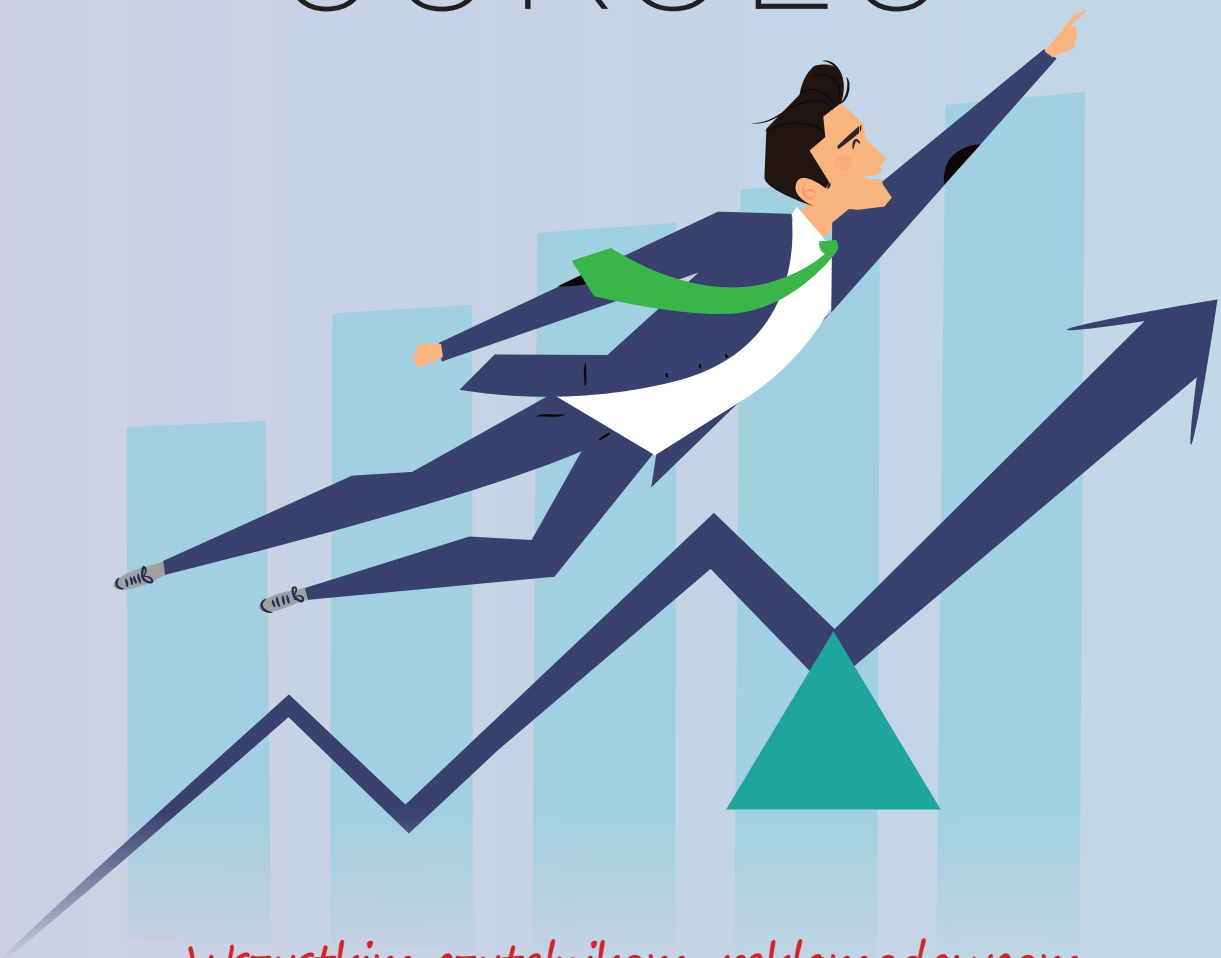
The editorial office does not pay royalties.

GUIDELINES FOR PREPARING PAPERS

- Articles for publication in POLISH TECHNICAL REVIEW should have scientific and research character and deal with current issues of the industry.
- Articles must be original, not previously published (if the article is a part of another work i.e. PhD thesis, Habilitation etc. the information about that should be placed in the reference section) .
- The article should involve a narrow topic but treated thoroughly without repeating general knowledge information included in the widely known literature.
- If the problem is extensive break it into articles for separate publications.
- Articles should be of a clear and logical structure: the material should be divided into parts with titles reflecting its content. The conclusions should be clearly stated at the end of the paper.
- The article should be adequately supplemented with illustrations, photographs, tables etc. however, their number should be limited to absolute necessity.
- The title of the article should be given in Polish and English as well as the abstract and key words.
- The article should not exceed 8 pages (1 page – 1 800 characters).
- The article should include mailing and e-mail addresses of the author(s).
- The article should be electronically submitted in * doc or * docx format. Equations should be written in the editors, with a clear distinction between 0 and O. If the equations exceed the width of column (8 cm) they must be moved, otherwise use double width column (16 cm).
- The editorial staff does not rewrite the texts or prepare illustrations. Apart from doc, * docx formats it is recommended to submit the source files of illustrations (in *.eps, *jpg or * tif format).
- Drawings and graphs must be clear, taking into account the fact that the width of the columns in the magazine is 8 cm, width of the single column – 17 cm, height of the column - 24.5 cm.
- The text on the drawings cut to the size must be legible and not less than 2 mm.
- The authors are required to give at the end of the article a full list of sources used for the paper. The text must include citation references to the position of cited work in the bibliography. The bibliography prepared according to the references in the text must include: books – surname and first letter of the author's name, title, publisher, year and a place of publication (optionally page numbers), magazines – author's name and surname, title of the article, title of the magazine, number, year and optionally page numbers. The bibliography should present the current state of knowledge and take into account publications of world literature.
- The authors guarantee that the contents of the paper and the drawings are originally their property (if not, the source should be indicated). The authors who submit the paper, will receive the following documents from the Publisher SIGMA-NOT to be signed by them:
  - The declaration on granting a licence
  - The licence agreement
  - The Authors' agreement

  on the right of the Publisher to:
  a) Preservation and reproduction of the article, via production of its copies by paper and electronic way,
  b) Turnover of the copies on which the article has been preserved – by introduction to market, lending or lease of the copies,
  c) Making available to the public, including the Internet pages,
  d) Dissemination as a whole or of its parts for advertisement and/or promotional purposes.
- The editorial staff will document all forms of scientific misconduct, especially violations of the rules of ethics applicable in science.

POŁĄCZENIE sił to POCZĄTEK,
POZOSTANIE razem to POSTĘP,
WSPÓLNA praca to
SUKCES



Wszystkim czytelnikom, reklamodawcom
oraz autorom współtworzącym
nasze wydania
DZIĘKUJEMY za to,
że jesteście z NAMI

WYDAWNICTWO *SIGMA-NOT*