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Report

Biogas and biomethane in Poland

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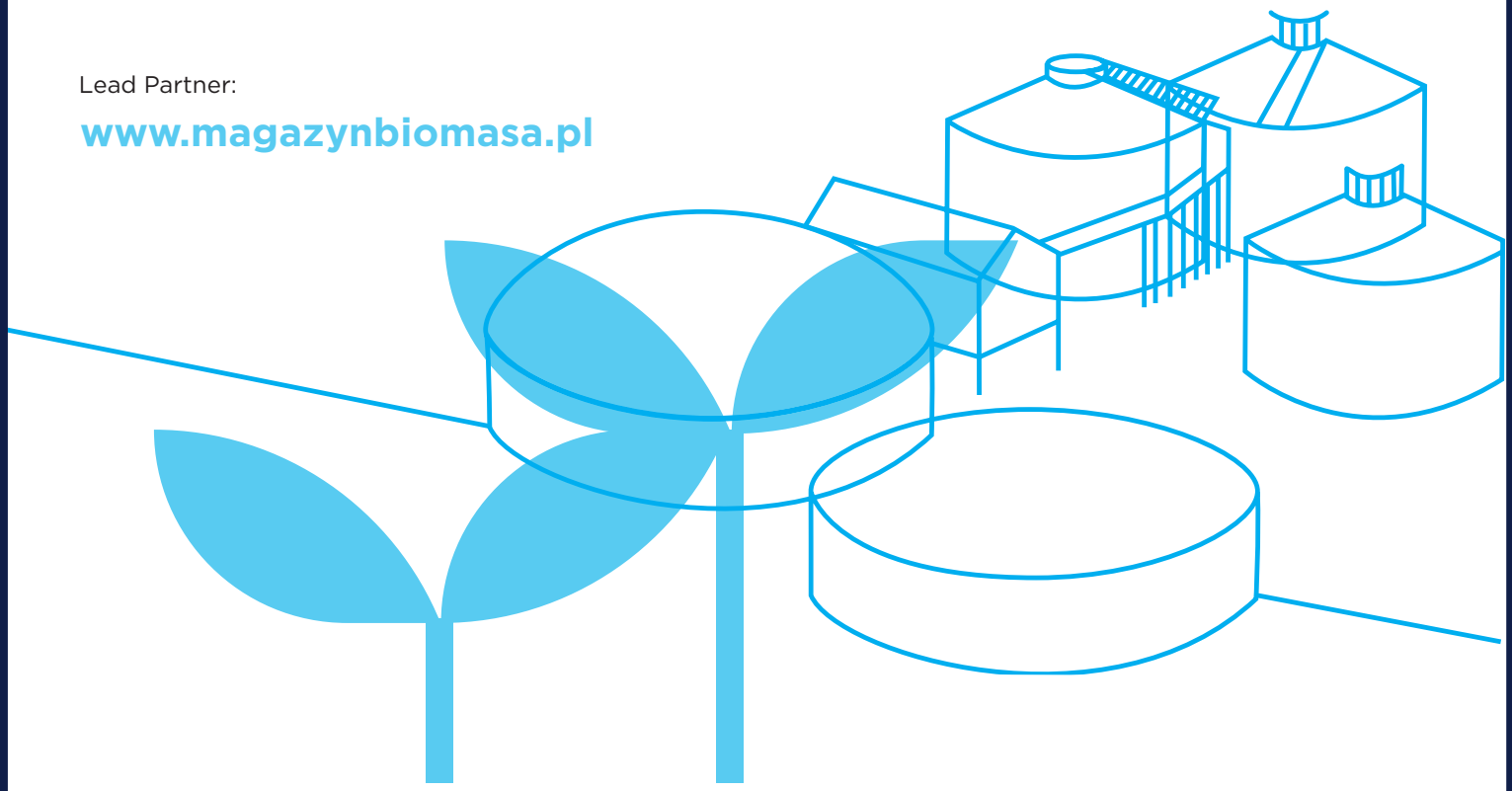

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"Magazyn Biomasa", as the first nationwide publication fully devoted to the biomass industry, has been popularizing topics related to renewable energy since 2014, focusing in particular on the biogas, pellet, and biomass industries. Our publications comprehensively describe the biogas and biomethane sector and contain up-to-date and substantive content aimed at industry professionals – biogas plant owners, investors, farmers, as well as energy and fuel companies. These include: "Rynek biogazu i biometanu" ("Biogas and biomethane market"), "Poradnik inwestora biogazowego" ("Biogas investor's guide"), and the "Biogaz i biometan w Polsce" ("Biogas and biomethane in Poland") report, which is the domestic biogas publication most often chosen by foreign companies.

We are also present online. The portal www.magazynbiomasa.pl is a source of daily information that allows industry representatives to keep their finger on the pulse.

The publishing activity of "Magazyn Biomasa" is complemented by the organization of conferences and workshops. The events focusing on the biogas and biomethane sector include training courses for companies, individuals, as well as communes and local governments, and above all conferences, which have become a permanent fixture on the calendar of major industry events. Organized this year for the sixth time, the Biomethane Congress is gaining increasing national and European prominence, and the Biogas Congress, the eighth edition of which will be held in December 2023, is currently the largest biogas industry conference in Europe.

STRATEGIC PARTNER

Krajowy Ośrodek Wsparcia Rolnictwa

Agro OZE
Energia z rolnictwa

The National Support Center for Agriculture (KOWR) is an executive agency carrying out tasks arising from state policy, particularly in the implementation and application of agricultural support instruments, active agricultural policy, and rural development. The Center is supervised by the minister responsible for rural development.

Its areas of activity include, above all, the creation and improvement of the structure of family farms, development of companies with particular importance for the national economy, implementation of innovation in agriculture and the agri-food industry, stabilization of agricultural markets, and promotion of Polish agri-food products.

In terms of renewable energy sources, the Center, among other things, monitors the production of agricultural biogas and conducts information and promotion activities supporting the development of renewable energy sources in rural areas. These activities are labeled with the "Agro OZE – Energia z rolnictwa" logo.

STRATEGIC PARTNER

The National Center for Research and Development (NCRD) is a government agency connecting the worlds of science and business. It creates appropriate conditions for conducting research and development works. By co-financing R&D processes, it supports entrepreneurs, significantly reducing the business risk associated with the implementation of research projects. The mission of the NCRD is the implementation of tasks serving the social and economic development of Poland and solving specific civilization problems.
The NCRD implements a number of national and international programs, including projects funded from European Funds related to "green" technologies. These include pre-commercial procurements in line with the European Green Deal strategy, such as the "Innovative biogas plant" project. Market consultations are currently underway, preceding the preparation of further pre-commercial procurements for modern biogas and biomethane technologies. For more information, visit: https://www.gov.pl/web/ncbr/1-23-KR-nowoczesne-technologie-dla-sektora-biogazu-i-biometanu

STRATEGIC PARTNER

NATURALNA ENERGIA.plus Sp. z o.o. is a specialized supplier of micro and small biogas plants with a capacity of up to 75 kW. By commissioning and operating more than 55 facilities in Poland, with a total distributed capacity of 2.8 MWe, the company has become a national leader in this sector. Another dozen or so biogas plants are in the production process, and from 2022 we are also implementing investments in Lithuania, Latvia, and Estonia.
The biogas plants we supply are based on two types of digestion: wet and dry percolation. The installations use monosubstrates generated on farms: liquid manure, manure, and green waste, as well as in municipal wastewater treatment plants with a scale of 10 to 50 thousand P.E.
The company is a pillar of the NATURALNA ENERGIA Group, i.e. five specialized entities working in cooperation to provide comprehensive services for investments. We also cooperate with companies that organize financing, including subsidies and FiT.
We can handle your investment in a comprehensive way: from the concept, through audit, design, construction, and commissioning to maintenance, including the use of heat and cold.

PARTNER

KSB is a leading international supplier of pumps, agitators, fittings, and maintenance services. For 150 years, we have been committed to innovation and superior quality.
One of the keys to the success of any biogas plant is effective and energy-efficient mixing of substrates. For this purpose, based on many years of experience, we offer a new generation of HEAVY DUTY submersible agitators designed to operate in the harshest conditions at temperatures up to 60°C.
As a product of our thorough knowledge of the hydraulic behavior of high-viscosity media, the PHANTOM agitators combine industry-leading efficiency (thrust to power input ratio) with maximum service life. This is possible thanks to the use of patented materials and thoughtful solutions, such as blades made of special monolithic plastic, more durable than blades made of stainless steel or fiberglass. Properly selected PHANTOM agitators ensure effective substrate distribution, minimize scum and bottom sediments, and increase the amount of biogas obtained.

PARTNER

NOXON Poland Sp. z o.o. has been distributing the state-of-the-art Swedish NOXON wastewater and municipal sludge dewatering equipment in Poland for 32 years. Our professional approach will also guide you through warranty, post-warranty service, and major overhauls. NOXON works with the pulp and paper, energy, food, metal processing, and petrochemical industries.
NOXON equipment is used wherever the end result counts, with minimal use of polyelectrolyte. The resulting increased dewatering efficiency will provide greater cost savings and reduced environmental impact.
The company also offers: rental of mobile units for dewatering various types of sludge, laboratory equipment for testing methane potential in sludge gases.

PARTNER

Polska Grupa Biogazowa
Spółka Akcyjna

TotalEnergies

Polska Grupa Biogazowa is the leader in the production of electricity from biogas in Poland. The Group started operating in 2007 on the initiative of people with many years of extensive experience in the field of renewable energy. Its main area of activity is the production of electricity and heat from agricultural biogas and the provision of services related to the renewable energy sector. In 2020, we expanded our activity to the production of energy from photovoltaic farms. PGB currently owns and operates 17 operational plants and one newly constructed plant throughout Poland with a total capacity of 18 MW. PGB's portfolio also includes a development line comprising dozens of projects. We also offer the possibility of collecting digestate for fertilizing crops, and most of our installations are equipped with modern and environmentally friendly wood drying systems. Currently this includes 33 drying chambers and 6 belt dryers. In 2023 Polska Grupa Biogazowa became part of the global conglomerate TotalEnergies, a leader in biomethane and biogas production on the European market. The incorporation of PGB will make it possible to implement the company's ambitious plans to rapidly expand its operations and multiply the number of its installations.

PARTNER

SELENA
GREEN INVESTMENTS

Selena Green Investments is a company from the Selena Group, one of the largest producers of construction chemicals in the world. We invest in renewable energy sources and solutions supporting sustainable development, such as biogas, photovoltaic, and wind projects.

We operate in Poland and the region of Central and Eastern Europe. We conclude partnership agreements with developers, production companies, and substrate suppliers, as well as scientific and technological entities. At the same time, we are developing our own team responsible for the development and operation of biogas projects.

Selena Green Investments provides its partners with stable terms of cooperation, long-term contracts for the collection of substrates, as well as cooperation in technology development, education, and social communication. We also work together to improve the technological quality of processes, train teams, and educate on the use of biomass.

Maciej Roik

Publisher
„Magazynu Biomasa"

Since the beginning of 2023, the biogas industry has been eagerly awaiting the introduction of regulations that will ensure its stable development in the coming years and closely following all the related works. The goal is, among other things, to facilitate the investment process when it comes to issuing conditions for connecting biogas plants to the network and structuring the use of digestate. The changes apply to both biogas and biomethane. There are a lot of them and they are to be included in three acts – UC99, UC110, and UD485. Never before has there been so much regulatory activity in the biogas industry. There is one question that arises in this context – what will come of it? The draft laws do not inspire widespread admiration, as evidenced by the number of comments received during consultations. There were hundreds of them. This may affect the legislative process, the pace of further work, and – consequently – the date on which the new regulations enter into force. And time is of the essence. Elections will be held in the fall and remain the focal point for several months. I am concerned that substantive work will then take a back seat to the election campaign. That is why I believe that compromise is so important today – instead of hardening positions and categorically stating what is bad and what is good. Since there have been so many bad things over the past few years, any small step to improve the state of the industry is a positive thing.

For the first time, we can have more than just hope for dynamic and rapid development of the industry. I hope that this time we will not miss this opportunity.

It is encouraging that despite the lack of favorable regulations, the industry continues to grow. According to the National Support Center for Agriculture (KOWR), there were 146 agricultural biogas plants as of March. Biogas and biomethane are becoming more popular every month. This can be seen, for example, in the number of participants at the largest industry events in Poland. The 6th edition of the Biomethane Congress was attended by almost 350 people and dozens of technology companies. This is just one example. Currently, everything related to biogas arouses great interest. One example may be the "Energia dla wsi" ("Energy for the countryside") program, which received 30 applications for funding (separate applications for grants and loans) for 15 biogas plants by the end of March this year, 20 of which are in the advanced stages of submission, and dozens more are underway. Most of them are small-scale installations of up to 0.5 MW, which fits perfectly into the definition of local biomass use.
For the first time, we can have more than just hope for dynamic and rapid development of the industry. I hope that this time we will not miss this opportunity.

dr inż. Waldemar Humięcki

General Director
National Agricultural Support Center

The National Support Center for Agriculture has been consistently supporting the development of renewable energy sources in rural areas for several years. Agricultural biogas plants, which are stable and environmentally friendly sources of electricity and heat, are a very important part of the campaigns implemented by the Center. They are based on renewable, local raw materials and have a positive impact on the natural environment, as they reduce the amount of greenhouse gases emitted into the atmosphere.

Last year, the Center conducted a series of information and promotional activities on agricultural biogas plants, including:

- ✔ production of a series of educational videos presenting the role of an agricultural biogas plant in circular economy, the benefits to local communities associated with the functioning of an agricultural biogas plant, as well as the possibility of managing animal waste in an agricultural micro biogas plant,
- ✔ distribution of the aforementioned videos on nationwide Polish TV channels (they were watched by almost 11 million viewers) as well as on the Internet and social media,
- ✔ conducting workshops on the operation of agricultural micro biogas plants, where farmers could learn about the possibility of using animal waste (liquid pig and cattle manure) to produce electricity and heat in an agricultural micro biogas plant, the conditions for obtaining support under the FIT system, the costs and payback period of the investment, potential sources of financing, and practical aspects of operating the plant,
- ✔ conducting trainings (webinars) on environmental considerations in the construction and operation of biomethane plants, where participants learned about the legal requirements for the construction of biogas and biomethane plants, the principles of operation of these plants, as well as the benefits they provide.

In the plans for 2023, the National Support Center for Agriculture included, among others:

- ✔ continuation of free workshops related to the functioning of agricultural micro biogas plants, agricultural biogas plants, and biomethane production installations (19 workshops in total),
- ✔ production and distribution of additional educational videos about agricultural biogas plants,
- ✔ preparation of a guide constituting a collection of information (e.g. technical and legal) necessary for investors interested in building and operating an agricultural biogas plant, an agricultural micro biogas plant, and a biomethane plant.

I encourage you to check the Center's website for information on upcoming trainings and materials from completed projects.

Wojciech Racięcki

Director of the Innovation Department Program Management Methods National Centre for Research and Development

We live in a time of transformation that requires groundbreaking technologies. Change is driven by objectives related to climate protection and reducing environmental impact. At the same time, business has become an additional driver of change, influenced by disruptions in the energy and raw materials markets. Growing public awareness is also stimulating these changes. Biogas and biomethane are an extremely important, perhaps even irreplaceable element in the process of designing and creating new energy and economic models.

The National Center for Research and Development (NCRD) has been supporting innovations aimed at increasing the competitiveness of the Polish economy for 15 years. The Center's offer includes pre-commercial procurement, using the pull innovation model to procure technologies that meet the needs of society and the economy. There are already 9 very advanced research projects in the area of the European Green Deal strategy, financed by European funds from the Smart Growth Program. One of them is "Innovative biogas plant", within the framework of which three technologies of universal substrate biogas plant were developed and demonstrated last year in the form of an agricultural biogas micro-installation in Brody (Wielkopolska). A full-scale demonstration plant is currently under construction in Brody – the final product of the odorless and energy self-sufficient installation based on waste and residues will be biomethane as well as mineral and organic fertilizers. The developed technology follows the "local content" model very well.

The National Center for Research and Development, as the administrator of over 30% of the entire budget of the European Funds for a Modern Economy program for 2021-2027, plans to support, among others, green technologies that will help strengthen the Polish economy and achieve a higher level of pro-environmental advancement. We are already conducting market consultations preceding the award of several pre-commercial contracts in the area of modern technologies for the biogas and biomethane sector. Together with market partners, we intend to implement projects aimed at developing technologies for upgrading biogas to biomethane, micro- and small-scale biogas plants, and technologies for selective collection of municipal biowaste, among others. Testing the technology in real-world conditions and full-scale demonstration will be key to the planned projects.

Understanding the importance of biomethane, which is essential for the decarbonization of industry and transportation as well as the stabilization of the power system (peak fuel), the NCRD and its offer fit into the synergy of efforts for this sector by filling the technology gap. With the support of innovations from domestic players, we want to introduce to the Polish market new technologies for the production of biogas, biomethane, and safe bio-fertilizers that are competitively priced, reliable, and highly efficient.

Adam Orzech

CEO
NATURALNA ENERGIA.plus
Sp. z o.o.

Can we already say that the conditions in Poland are conducive for the business explosion of biogas, which will enable the effective development of investments? Looking at the quality of inquiries from potential investors and the variety of proposals from contractors, I can say – yes, this is the moment!

However, I should keep my emotions in check and evaluate the facts with a cool head. Investors' decisions are always facilitated by the clarity of applicable legal and financial regulations. We have made significant progress in this area: the status of digestate from agricultural biogas plants is being clarified, and further regulations specifying the status of individual types of biogas plants are awaiting adoption. The low attractiveness of the FiT/FiP tariffs is compensated by the "Energy for the Countryside" program. There was also a program to support investments in wastewater treatment plants.

How much more interesting would the situation be if the funds from the National Recovery Plan (NRP) were unblocked? Several of my potential clients are already delaying project work under this very pretext. We also hear that many projects are being held up by a lack of public acceptance of large biogas investments. Investments that are further hampered by limitations in network quality and connection of large generation sources. These impediments will not stop the growth of new investments. I would like to highlight two elements that will help keep this development on track: maintaining fair competition among solution providers and offering investors a variety of scale and technology choices. By fair competition, I mean equal access to potential investors and substrates, and not discrediting proposed solutions or suppliers. In Poland, there is already a large group of well-prepared investors who are able to assess the experience of individual contractors and verify the quality of operating facilities.

In turn, allowing investors to choose the size of the plant and the digestion technologies used means that both individual farmers and entire producer groups can tailor the investment to their needs. Smaller installations may have lower unit efficiencies than large ones, but they are distributed and perfectly meet the local needs of investors.

There is a lot of room in Poland for the development of multiple technologies and the use of facilities of different sizes. I believe that only by maintaining this diversity can we achieve the long-awaited explosion of the biogas business in Poland.

8th Biogas Congress

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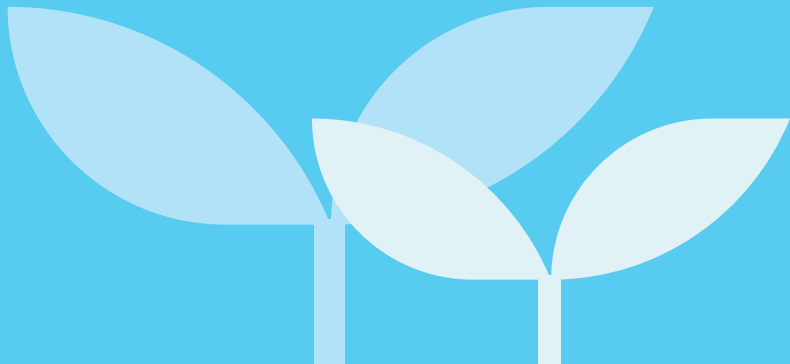


THE BIOGAS MARKET HAS TAKEN OFF, WHAT ABOUT BIOMETHANE?

THE EUROPEAN GREEN DEAL, FIT FOR 55, GAZPROM'S GAS BLACKMAIL, THE WAR IN UKRAINE – THESE ARE JUST SOME OF THE EVENTS THAT HAVE SHAKEN THE EUROPEAN ENERGY AND FUEL MARKETS IN THE LAST THREE YEARS AND WILL HAVE A VERY STRONG IMPACT ON THE POLISH ECONOMY IN THE CURRENT DECADE, BUT ALSO IN THE PERSPECTIVE OF 2050. PRICE VOLATILITY ON THE NATURAL GAS, OIL, AND COAL, BUT ALSO ELECTRICITY, HEAT, AND FUEL MARKETS, HAS LED TO A HIGH LEVEL OF INVESTMENT UNCERTAINTY AND A SIGNIFICANT INCREASE IN INTEREST IN BUILDING OWN RES INSTALLATIONS (LINKED, AMONG OTHERS, TO THE IMMINENT CARBON LABELING OF PRODUCTS AND THE NEED TO MAKE PRODUCTION "GREENER").

In the last 2 years, there has been a tremendous increase in interest in investing in biogas plants, especially in the small agricultural sector (50-499 kW), subject to a quick and simplified legislative path. It should be emphasized that this is a potentially huge investment market, both in agriculture and agri-food processing. Many investors (companies, farmers) with large substrate potential consciously decide to build a biogas plant with a capacity below 0.5 MW. They want to simplify the procedure and at the same time minimize the risk of public protests, so that the full process of expanding the biogas plant can take place later, after the local residents get used to a functioning biogas plant. In view of the numerous public protests (it is estimated that there are currently more than 60 in Poland) against the planned biogas plants, such a course of action seems to make the most sense – especially if the residents can experience the benefits of the plants. For example, in the village of Przybroda, on an experimental farm owned by the Poznań University of Life Sciences, a biogas plant with a capacity of 499 kW was put into operation, and in autumn 2022, heat from its cogeneration unit was supplied to approx. 1/3 of the village's inhabitants. Currently, the support for the expansion of the installation by another 0.5 MW is so great that during the required consultations, at a meeting in March 2023, all the Przybroda residents present voted unanimously in favor of the investment. This year, there are plans to extend the heat pipeline to the entire village of Przybroda, and the local authorities (both the Rokietnica commune and the Poznań district) are supporting the planned investment with kindness. It is also worth mentioning that the commune head Bartosz Derech, seeing the extremely positive effects of the biogas plant in Przybroda, decided to start the procedure of planning a similar installation based on municipal waste (kitchen and green waste, wastewater sludge) in Rokietnica.

SINCE PROBLEMS WITH BIO-WASTE MANAGEMENT AND HIGH PRICES OF ENERGY AND HEAT ARE WIDESPREAD IN COMMUNES, A REAL INVESTMENT EXPLOSION IN THE MUNICIPAL SECTOR SHOULD BE EXPECTED IN THE COMING YEARS.

From the point of view of local governments, technology transfer from the agricultural biogas sector to the municipal biogas sector has nothing but advantages: much lower investment costs, higher efficiency of digestion and, above all, solving the problem of bio-waste in the commune and producing energy and heat for own needs. Since problems with bio-waste management and high prices of energy and heat are widespread in communes, a real investment explosion in the municipal sector should be expected in the coming years. These are likely to be biogas plants that produce electricity and

heat, but with the requirement for 30% zero-emission buses by 2028, some communes are also interested in producing bioCNG for their own use. Purchasing and operating buses with CNG installations and powering them with biomethane from their own waste is the most economical and ecological solution for local governments today (electric buses powered by electricity from the network, with over 70% share of electricity from coal, have their "exhaust pipes" in Bełchatów and other power plants).

The main problem with the rapid development of this market is legislation, as all municipal biogas plants must undergo a lengthy process of consultations and obtaining permits. Thus, an agricultural biogas plant with a capacity of 499 kW (as in Przybroda) can obtain a permit in a simplified procedure in only 3-4 months, while the construction of a half smaller plant (250 kW) using the same technology will take up to one and a half years or longer – even though both plants may be technologically identical.

Following the example of the special biogas act, which is intended to facilitate investments in the sector of agricultural biogas plants, it is also worth introducing the abolition of environmental proceedings (report, social consultations, etc.), simplifying the construction of small (below 0.5 MW) municipal biogas plants, which will immediately result in a large increase in the number of investments.

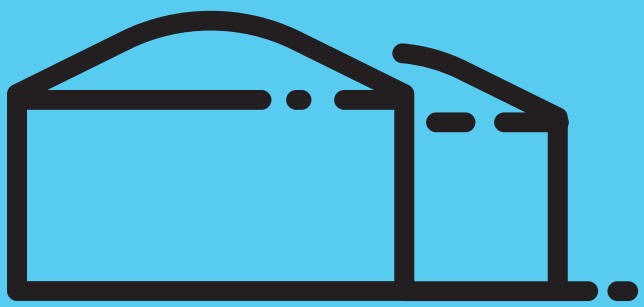
In the opinion of many experts in the field (including myself), the main obstacle to investment in the coming years will not be complicated administrative procedures, but public resistance. The biogas industry (or rather its representatives) is partly to blame for this, because due to several poorly run biogas plants, where perishable substrates were inadequately stored and/or undigested material was stored and spilled, resulting in strong odors in the area and protests from local residents, the bad reputation of our sector, publicized by the sensation-hungry media, has been dragging on for more than a dozen years, which can be summed up as: "biogas plants stink". It is completely untrue, because a biogas plant as a gas installation must be leak-proof by its very nature. What "stank" in the several cases described and publicized was the mess around the biogas plant caused by negligence, ignorance, and mistakes in the biogas plant investment (lack of lagoon and digestate tank covers), combined with poor process management, resulting in the digestate emitting a foul odor. The adverse impact of some biogas plants on the environment is primarily due to the human factor: carelessness and ignorance among operators and owners. That is why it is so important to educate staff and promote good examples to neutralize bad opinions about biogas plants. Over the past three years, almost 12,000 people have visited the experimental farm in Przybroda, which belongs to the Poznań University of Life Sciences. They were able to learn about the perfect integration of the biogas plant into the local community (in addition to cheap heat, the residents emphasize the reduction of unpleasant smells that used to spread three times a year during the fertilization of the surrounding fields with animal manure from the farm). However, there is a need for far more such examples, as we have 6-8 thousand farms with animal production alone, where a biogas plant could be built. The industry also has to deal with the lack of free connection capacity for RES installations, although thousands of megawatts of power can be released today in a very simple way by enabling the connection of biogas plants with energy storage (enlarged biogas domes) to local medium-voltage networks to operate in peak mode, i.e. in the morning and evening peaks. Let us hope that the legislative changes in this direction will be implemented as soon as possible, and the result will be a gigantic number of investments in the next few years.

THE INDUSTRY ALSO HAS TO DEAL WITH THE LACK OF FREE CONNECTION CAPACITY FOR RES INSTALLATIONS, ALTHOUGH THOUSANDS OF MEGAWATTS OF POWER CAN BE RELEASED TODAY IN A VERY SIMPLE WAY BY ENABLING THE CONNECTION OF BIOGAS PLANTS WITH ENERGY STORAGE TO LOCAL MEDIUM-VOLTAGE NETWORKS TO OPERATE IN PEAK MODE.

And what about biomethane? Despite so many investment announcements, great potential, and needs, the biomethane market still does not exist. It is likely that the first operating biomethane plant in Poland will be an investment made within the framework of the "Innovative Biogas Plant" competition under the auspices of the National Center for Research and Development and the Poznań University of Life Sciences at the Brody experimental farm, from which biomethane will hopefully start flowing at the turn of 2023/4. It is truly ironic that such an investment is led by the scientific community and not private investors. However, given the scale of the problems encountered during planning and construction, it is not surprising that many of them choose the electric biogas market, where CAPEX and OPEX, as well as potential problems, are well known and investments are much easier to implement. Hopefully, however, the biomethane market will soon take off and unlock at least some of the huge potential of 8 billion cubic meters of "green" gas lying in animal manure and other biomass.

Jacek Dach, Eng, PhD, DSc, ProfTit
Poznań University of Life Sciences

BIOGAS
IN POLAND



DEVELOPING NEW TECHNOLOGIES FOR THE BIOGAS AND BIOMETHANE SECTOR

THE BIOGAS SECTOR IN POLAND IS A FLEDGLING MARKET, CURRENTLY COMPRISING 146 AGRICULTURAL BIOGAS PLANTS. THE HUGE UNTAPPED POTENTIAL OF RESOURCES IN THE FORM OF WASTE AND RESIDUES FROM AGRICULTURE AND INDUSTRY PREDISPOSES OUR COUNTRY TO BUILD UP TO SEVERAL THOUSAND BIOGAS AND BIOMETHANE PRODUCTION PLANTS, AS IS THE CASE IN WESTERN EUROPEAN COUNTRIES.

The REPowerEU plan, which is the European Commission's response to the disruptions that shook the global energy market, has set the goal of increasing the annual production and use of biomethane in the European Union to 35 billion m^3 by 2030. This is 10 times the amount produced last year. With the idea that 10% of the biomethane target could be produced in Poland, more than 1,000 installations would have to be put into operation, depending on their size. The scale of the expected market development is impressive. Many installations for the production of biomethane are currently in preparation.

Most of the biogas plants built in Poland were based on Western technologies, using foreign components and equipment. In view of the expected and necessary development of the biogas and biomethane sector, the promotion of the "local content" model is highly justified from the point of view of increasing the added value of the national economy through the use of technologies and equipment developed and produced in Poland – using the potential of domestic companies and scientists.

THE NCRD HAS ANNOUNCED MARKET CONSULTATIONS PRECEDING THE PREPARATION OF FURTHER PRE-COMMERCIAL PROCUREMENTS IN THE AREA OF MODERN TECHNOLOGIES FOR THE BIOGAS AND BIOMETHANE SECTOR

INVOLVEMENT OF THE NCRD USING THE EXAMPLE OF "INNOVATIVE BIOGAS PLANT"

The National Center for Research and Development, with European funds under the Smart Growth Program, has taken specific actions to support the development of innovative technologies for the biogas and biomethane sector – so important for achieving a higher level of technological and pro-ecological advancement of the country. As a result of its dialog with the market, the NCRD launched the research project "Innovative Biogas Plant", in which three different technologies of a universal substrate biogas plant operating on waste and residues were developed and put into operation last year in the form of agricultural biogas micro-installations.

The main requirements set by the NCRD for the innovative technology are: odorlessness, stability of operation with changing feedstock (versatility), energy self-sufficiency of the technology, production of biomethane with parameters that allow feeding into the gas distribution network, and safety in the use of the produced biofertilizers. The micro-installations were built in Brody in Wielkopolska and were used for several months of technology testing to confirm substrate versatility, work stability, and achievement of the assumed parameters of the technology (Fig. 1).

A full-scale demonstration plant is currently being built in Brody as part of the "Innovative Biogas Plant", based on the technology developed by Instytut Energii Barczewo Sp. z o.o. The odorless

fot. NCBiR

THERE IS AN URGENT NEED IN POLAND TO CLOSE THE TECHNOLOGY GAP BY SUPPORTING THE DEVELOPMENT OF MODERN TECHNOLOGIES

plant will enable the production of 800,000 m^3 of biomethane per year, the recovery of biogenic CO_2, and the production of enriched mineral-organic fertilizers. The size of the demonstration plant was limited to an eq capacity of 499 kWe, so that a simplified administrative procedure can be applied and the investment can be completed in 2023.

It is worth mentioning that, according to Instytut Energii Barczewo, which is implementing the technology demonstrator, the share of expenditures for equipment, components, and works contracted to domestic contractors and suppliers reaches 80% of the investment budget. Many key elements of the installation, such as digesters, equipment used to prepare the feedstock for the digestion process, refood packaging separation, biogas purification, valorization of the post-digestion mass, are implemented using the Institute's own production potential. This confirms the deep sense of supporting technologies that can be developed and implemented with great determination and skills of Polish manufacturers.

PROPOSALS FOR NEW TECHNOLOGY COMPETITIONS FOR THE BIOGAS AND BIOMETHANE SECTOR

The NCRD has announced market consultations preceding the preparation of further pre-commercial procurements in the area of modern technologies for the biogas and biomethane sector, which will be financed under the European Funds for a Modern Economy Program for 2021-2027. The pre-commercial procurement formula, under which the "Innovative Biogas Plant" project and 8 other Green Deal projects are being implemented, has proved to be an excellent tool for pull innovation, stimulating domestic innovators to develop technologies of great social and economic importance.

The market consultations will help the NCRD, as the contracting authority, to determine the requirements for innovative technologies, the number of project phases, the budget, and the evaluation criteria to be defined in the pre-commercial procurement documentation. We proposed 7 competitions, 6 of which concern the development of technology. An integral part of the competitions will be technology testing and the presentation of the developed solution in the form of a technology demonstrator ready for further commercialization.

One of the technological problems in the Polish biogas sector is the low flexibility of operation with regard to the substrates used, which results in low efficiency and reduced stability of operation. Therefore, the NCRD plans to repeat the "Innovative Biogas Plant" project and conduct a technology race that will result in the development and testing of other technologies to convert various waste materials into biogas/biomethane and biofertilizers. The challenge is to process the hydrated digestate into biofertilizers that can be easily distributed in agriculture.

Various technological solutions are being used in Europe to convert biogas to biomethane. Their costs still constitute a very large share in the total costs of a biomethane installation. In Poland, there is an urgent need to develop a technology with high efficiency of biogas treatment, which is reliable, maintenance-free, and competitive with technologies used abroad. Contractors who apply for participation in the competition are left free to choose their own technical solutions (membrane, cryogenic, adsorption, other methods). The technology developed should be scalable and, unlike solutions offered in Western Europe, suitable for relatively small installations due to the dispersion of raw material sources in Polish agriculture.

Obtaining liquefied biomethane as bioLNG is important for direct use in transportation. In addition, many potential biomethane installations that could be built in agricultural areas cannot be connected to the gas network due to its remoteness or insufficient absorption capacity. In this situation, liquefaction of biomethane and transporting it by cryogenic tankers may be a reasonable solution. The NCRD is considering the procurement of an innovative biomethane liquefaction technology that is highly efficient, reliable, maintenance-free, and cost-competitive with technologies used abroad.

MARKET CONSULTATIONS WILL HELP THE NCRD, AS THE CONTRACTING AUTHORITY, TO DETERMINE THE REQUIREMENTS FOR INNOVATIVE TECHNOLOGIES, THE NUMBER OF PROJECT PHASES, THE BUDGET, AND THE EVALUATION CRITERIA TO BE DEFINED IN THE PRE-COMMERCIAL PROCUREMENT DOCUMENTATION

The market needs modern micro- and small-scale biogas technologies that are easy to use, efficient, and, above all, affordable. They are intended for livestock farms and processing plants. The aim of the competition planned by the NCRD is to develop, test, and demonstrate biogas production technology in micro- and small installations. The substrate in this case is most often homogeneous and repeatable. The key feature of the procured technology is to be low investment outlays with regard to maximizing the efficiency and simplicity of plant operation.

A new important area in our country is the management of selectively collected biowaste of municipal origin, i.e. kitchen and catering waste, expired food, etc. Biogas technologies for selectively collected municipal biowaste, which have been available in European countries for years, are now being offered in Poland. Due to the very high investment outlays, they are beyond the reach of many Polish local governments and put into question the economic viability of the installation.

In response to this problem, the NCRD is planning a competition for the development of an urban biomethane plant technology that will be cheaper than the solutions offered from abroad, as universal as possible in terms of feedstock, odorless, and will allow the acquisition of high quality biofertilizer.

As the size of the plant increases, the big challenge becomes the management of the digestate. In the EU, we have legislation that promotes the use of fertilizers made from organic or recycled materials. The availability of digestate, on the one hand, and the drastic increase in the price of artificial fertilizers, on the other, make digestate a desirable product for agriculture, allowing the return of biogenic elements to the soil. The management of digestate can be looked at more broadly. Advanced methods are being sought to process the digestate into high value-added products, such as biomaterials, plant/animal breeding preparations, etc.

The National Center for Research and Development is thus meeting the needs of the Polish economy in the field of green technologies, including by preparing further pre-commercial procurements for technologies in the biogas and biomethane sectors. By funding research and development, the NCRD significantly reduces the risk for innovative companies associated with creating and preparing for commercialization of new solutions. The introduction of new, highly efficient and competitively priced technologies and equipment developed in Poland will expand the available market supply for the domestic biogas and biomethane sector.

We encourage you to cooperate and participate in market consultations. The announcement is available at:https://www.gov.pl/web/ncbr/1-23-KR-nowoczesne-technologie-dla-sektora-biogazu-i-biometanu

Ewa Krasuska, PhD
Milosz Krzyminski
National Center for Research and Development

CURRENT SITUATION IN THE BIOGAS INDUSTRY

THERE IS A GROWING INTEREST IN BIOGAS IN POLAND – 2022 WAS EXTREMELY SUCCESSFUL IN TERMS OF THE NUMBER OF NEW INSTALLATIONS COMPARED TO PREVIOUS YEARS. NEW INVESTMENT PLANS OF BOTH STATE-OWNED COMPANIES, LOCAL GOVERNMENTS, INDIVIDUAL FARMS, AND FOREIGN FUNDS MEAN THAT WE ARE ON THE VERGE OF A REAL BOOM. WHAT IS THE CURRENT MARKET SITUATION AND WHAT NEEDS TO BE DONE FOR THE INDUSTRY TO DEVELOP EVEN BETTER?

Perseverance – this is undoubtedly one of the words that could be used to describe the activity of investors and specialists in the biogas industry over the past dozen or so years. Despite not always favorable conditions, especially in the legislative field, the consistency and determination of their actions have resulted in a very significant increase in interest in biogas and a higher number of new plants under preparation or construction. Investments are planned by both large corporations (fuel, agri-food), many medium-sized companies, local governments, and farms. The versatility of biogas and the possibility of using it for the production of "green" energy, heat, or fuels, as well as for the decarbonization of many sectors, is its greatest advantage. In addition, by replacing fossil fuels, it improves energy security and ultimately reduces the price of energy for end users.

Despite the high potential of biogas and the significant amount of available substrate, only a small fraction of it is used in biogas plants – only 5.7 million tons of waste from the agri-food sector in 2022. The total number of biogas plants in Poland (increasing month by month) is currently 383 installations, of which 148 are agricultural biogas plants, 194 municipal biogas plants, and 41 micro biogas plants producing energy mainly for own use. Their total capacity oscillates around 280 MW, and their electricity production is about 2.352 TWh. According to these figures, the share of biogas in the overall structure of renewable electricity generation is less than 2.5%. In addition, since virtually all biogas plants operate in cogeneration, roughly the same amount of heat is generated. Due to the relatively high fragmentation of agricultural production in Poland, the installed capacity of most installations does not exceed 1 MW.

SUPPORT SYSTEMS FOR BIOGAS

The small number of biogas installations, compared to the potential, is mainly related to the lack of adequate legislation to support this market. There have also been claims that the current support system, particularly the auction system for new agricultural biogas plants above 1 MW, is no longer serving its purpose. This is evidenced by the fact that this year's auctions were not resolved due to lack of bids, i.e. lack of bidders. However, the lack of new contracts awarded so far in the auctions is not entirely synonymous with the lack of new installations. The alternative is PPAs

THE VERSATILITY OF BIOGAS AND THE POSSIBILITY OF USING IT FOR THE PRODUCTION OF "GREEN" ENERGY, HEAT, OR FUELS, AS WELL AS FOR THE DECARBONIZATION OF MANY SECTORS, IS ITS GREATEST ADVANTAGE.

(*Power Purchase Agreements*), which are long-term power supply contracts between a producer and its consumer or seller. Due to high energy prices on the exchange, the rate per MWh produced from biogas and sold under such a contract may be higher than that offered under the auction system. In addition, biogas producers in Poland can benefit from support in the form of feed-in premiums (FIP) and feed-in tariffs (FIT). The amount of support under both systems is determined by the reference prices announced each year by the President of the Energy Regulatory Office. Even though the reference prices actually increased by 10-25% compared to last year and still guarantee a return on investment, it is impossible not to notice that

when comparing them with prices on the exchange (before the maximum prices introduced by the government in autumn 2022) they do not seem as appealing as before. The currently introduced periodic regulations have significantly reduced price levels. In connection with the war in Ukraine, the crisis on the energy market, and the reforms planned by the EC (European Green Deal, Fit for 55, extension of the ETS system to other sectors of the economy, etc.), it should be expected that biogas production, as a fully controllable RES and independent of weather conditions and seasons, will turn out to be particularly profitable in the near future. This is especially true for biogas plants that operate as peaking plants, generating electricity in response to network demand, and for biomethane plants that produce "green" fuel, which, unlike "green" hydrogen, can be readily used in the economy today thanks to the existing infrastructure for natural gas, CNG, and LNG.

SPECIAL BIOGAS ACT

Regardless of the fact that the current events are conducive to the development of RES, top-down and systemic support is still needed, especially in the area of unification and simplification of biogas production regulations. Of particular interest is the draft special act prepared by the Ministry of Agriculture and Rural Development for agricultural biogas plants with an annual capacity of up to 14 million m^3 of biogas and 8.4 million m^3 of biomethane. The main objectives of the proposed changes are to facilitate the investment process, increase the use of local substrate potential, and allow for better management of digestate (finally digestate will no longer be treated as waste). Of particular importance to the industry are provisions to reduce the waiting time for the issuance of network connection conditions and to change the definition of some substrates – from waste to by-product. To a large extent, the act was drafted in accordance with the recommendations and with the participation of industry specialists, which is why its implementation has a real chance of increasing biogas production in the country. Nevertheless, the industry is waiting for the introduction of biomethane regulations that would finally unlock its production. The lack of even one biomethane plant in Poland proves that the lack of regulations in this area prevents domestic and foreign companies from investing. Although regulations for the production and injection of biomethane into the gas network should have been adopted at least a few years ago, the good news is that, as in the case of biogas, the most recently published proposals take into account expert opinions. According to them, the first step is to define biomethane, introduce transmission and distribution tariffs for end users and, most importantly, a support mechanism for producers. Based on the analysis of other European markets, it is clear that without a support system for biomethane – and significantly above the profitability of electricity production from biogas plants using the same substrates – its production in Poland will not be profitable for the time being and will remain at zero.
Another step taken by the government to increase biogas production is the announcement in January this year of the "Energy for the countryside" program, under which farmers and energy cooperatives will be able to obtain loans or co-financing for the construction of biogas plants ranging from 10 kW to 10 MW.
The money obtained will help to decarbonize small and medium-sized farms, for which the financial aspect is the main obstacle to the construction of such installations. The great interest in the program in the coming year will undoubtedly contribute to the creation of new agricultural biogas plants.

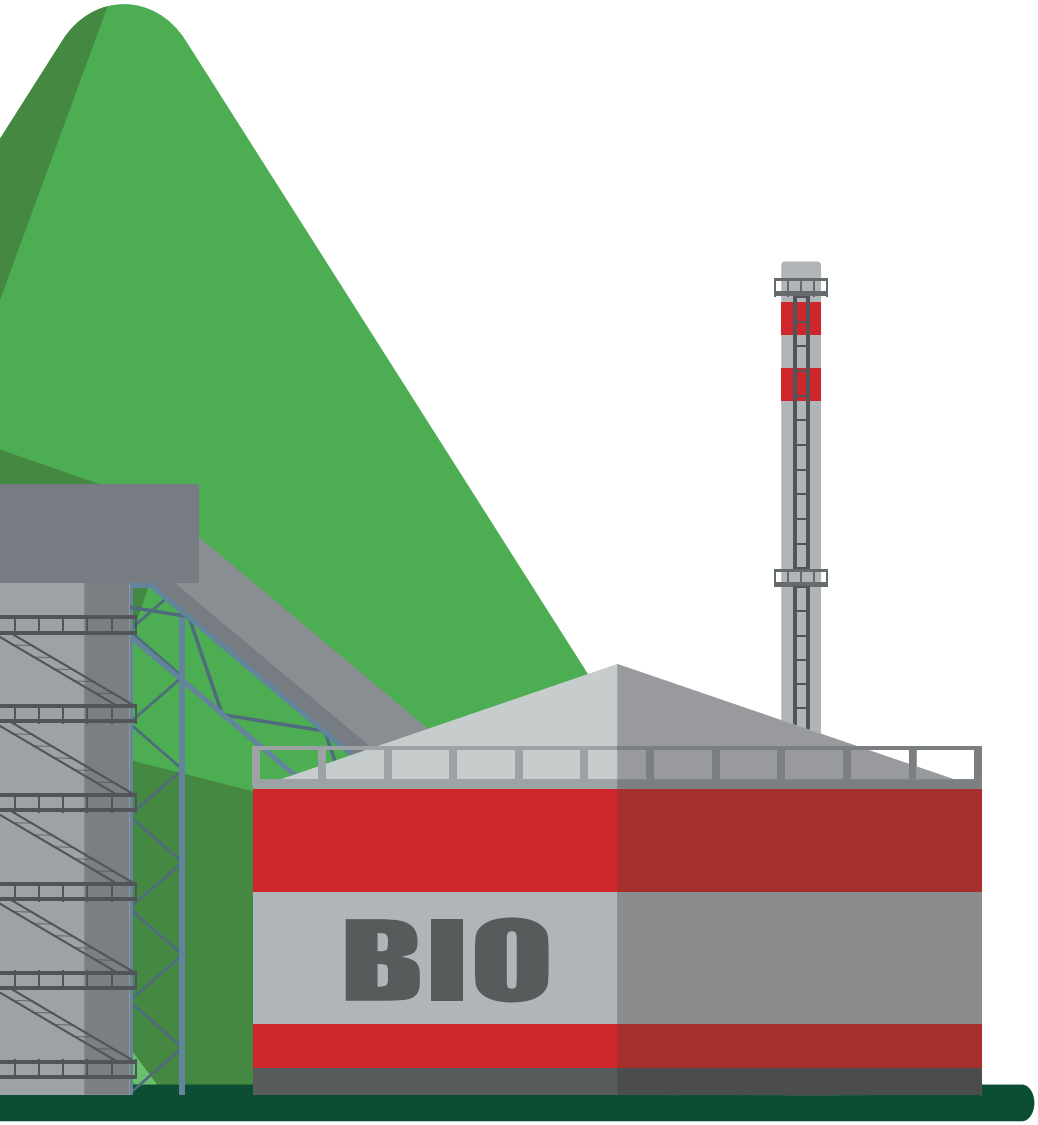
LACK OF REGULATIONS DOES NOT HINDER MARKET DEVELOPMENT

Although shortcomings in the regulatory environment are holding back the biogas sector somewhat, it would be wrong to say that they are completely preventing it from operating. Currently, there are model installations on the market achieving electrical efficiency of more than 90% of theoretical efficiency (according to the data of the Ministry of Energy from 2019, the average electrical efficiency of a biogas plant is less than 60%). It should be noted that Polish biogas technologies are characterized by high process efficiency and the possibility of using an increasing number of substrate mixtures, especially waste. It was in the "Innovative Biogas Plant" program that the National Center for Research and Development organized a competition, the first results of which were presented last December. The winner of the first stage, and thus the contractor of a full-scale biomethane plant, the so-called Technology Demonstrator, was a consortium consisting of the Barczewo Energy Institute and the Warmia Institute of Industrial Automation. According to the assumed criteria, their technology provided the best degree of odorlessness, substrate versatility, energy self-sufficiency, and production of high-quality digestate and biomethane. In addition, by the end of 2023, a plant producing 0.9 million m^3 of biomethane per year will be commissioned on the premises of the experimental farm in Brody, which belongs to the Poznań University of Life Sciences. It is also to be hoped that by then all the regulations for the production of biomethane - in particular the level of subsidies - will be in place, as it is difficult to imagine a situation in which the biomethane produced cannot be fed into the network due to legislative shortcomings.

IT IS ASSUMED THAT IN THE COMING YEAR, IN ADDITION TO THE FIRST BIOMETHANE PLANT, THE FIRST BIOGAS PEAKING PLANTS WILL ALSO BE BUILT, STABILIZING THE POWER SYSTEM AND LARGELY SOLVING THE PROBLEM OF THE LACK OF ABSORPTION CAPACITY OF THE POWER NETWORK DURING THE MIDDAY PEAK AND POWER SHORTAGES IN THE EARLY MORNING AND EVENING.

NEW TECHNOLOGIES, INNOVATIVE SOLUTIONS – THE KEY TO DEVELOPMENT

Innovative solutions are also being developed and tested by private entrepreneurs. The domestic market has a relatively large number of companies providing biogas technologies, so the product offered must be competitive with others. The primary goal of the improvements introduced has always been to increase the efficiency of the digestion process. It is assumed that in the coming year, in addition to the first biomethane plant, the first biogas peaking plants will also be built, stabilizing the power system and largely solving the problem of the lack of absorption capacity of the power network during the midday peak and power shortages in the early morning and evening. However, in the context of power generation, it is speculated that more and more plants will be connected to Virtual Power Plants, i.e. several interconnected distributed units coordinated by a single control system. More attention is already being paid to heat management, as evidenced by the growing number of towns and cities powered by heat from cogeneration, as well as various alternative technologies such as cooling, electricity from ORC, etc. The construction of heating pipelines for local communities (e.g. in Sieńsk or Przybroda) confirms that it is technically feasible and economically justified, and the result is a very strong "mental" integration of the residents with the operating



biogas plants, which provide them with cheap and fully ecological heat. Despite the fact that the Polish economy produces enough substrates for more than ten thousand biogas plants, the increase in the number of plants in the future may cause competition on the substrate market (especially biowaste), so it is necessary to constantly look for new areas from which they can be obtained and to study their performance and the possibilities of increasing the efficiency of digestion. In the coming years, the use of "bio" waste – especially from the municipal sector – will increase due to the increasing production mass and the ongoing work to adapt biogas technologies to this material. It should be emphasized that the dry digestion technologies used to date cannot be used for the treatment of so-called kitchen waste, since the result of its digestion is always a liquid digestate with several percent dry matter content. From a legal point of view, this liquid is considered waste. However, extensive research conducted in 2018-23 at the Ecotechnology Laboratory of the Poznań University of Life Sciences showed that it is a sanitary and environmentally safe material with very beneficial fertilizing properties.

THE IMPORTANCE OF EDUCATION

In the development of the sector, it is particularly important to continuously educate the public about biogas production. The aforementioned biogas plant in Przybroda, located on the experimental farm belonging to Poznań University of Life Sciences, has been visited by nearly 12,000 people (students, schoolchildren, farmers, agricultural advisors, investors, specialists, government and local government officials, parliamentarians, and foreign guests from 4 continents) since its launch in 2019. Visitors were able to see that the plant does not have a negative impact on the environment, and also met representatives of the local community, who are pleased to receive low-cost heat. National campaigns in favor of biogas plants, some of which are already visible in the media, should focus primarily on explaining how a biogas plant works and combating untrue myths (such as "a biogas plant stinks"), which are often used by local residents during protests and which in most cases block planned investments. The Ministry of Agriculture and Rural Development plays an important role in this regard, which is why it is so important that it continues to support biogas. It should also be emphasized that due to the high level of innovation of Polish biogas technologies, some of them could be exported to world markets, to non-European countries where the biogas sector is still developing.
In summary, it should be emphasized that the investment potential of the Polish biogas sector is huge, currently the largest in Europe. If the analysis of domestic substrate availability carried out by the Poznań University of Life Sciences shows that the total capacity of biogas plants operating on a linear (continuous) basis is more than 6.7 GW, then in the case of investments in peaking plants (operating 12 h/day in the morning and evening peak), the national potential increases to more than 13 GW of capacity (fully controllable), making this sector one of the most important players in the future energy market.

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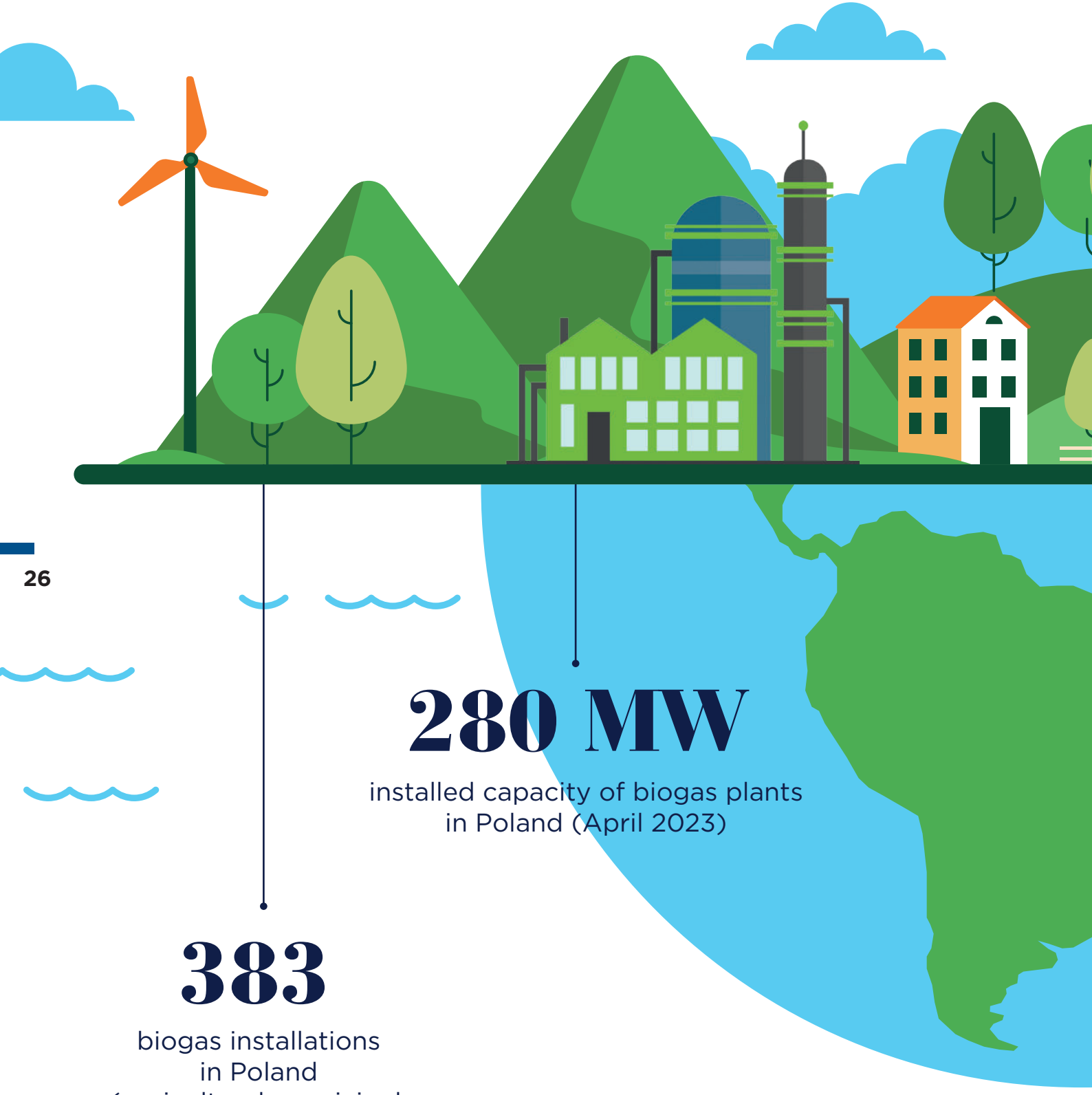
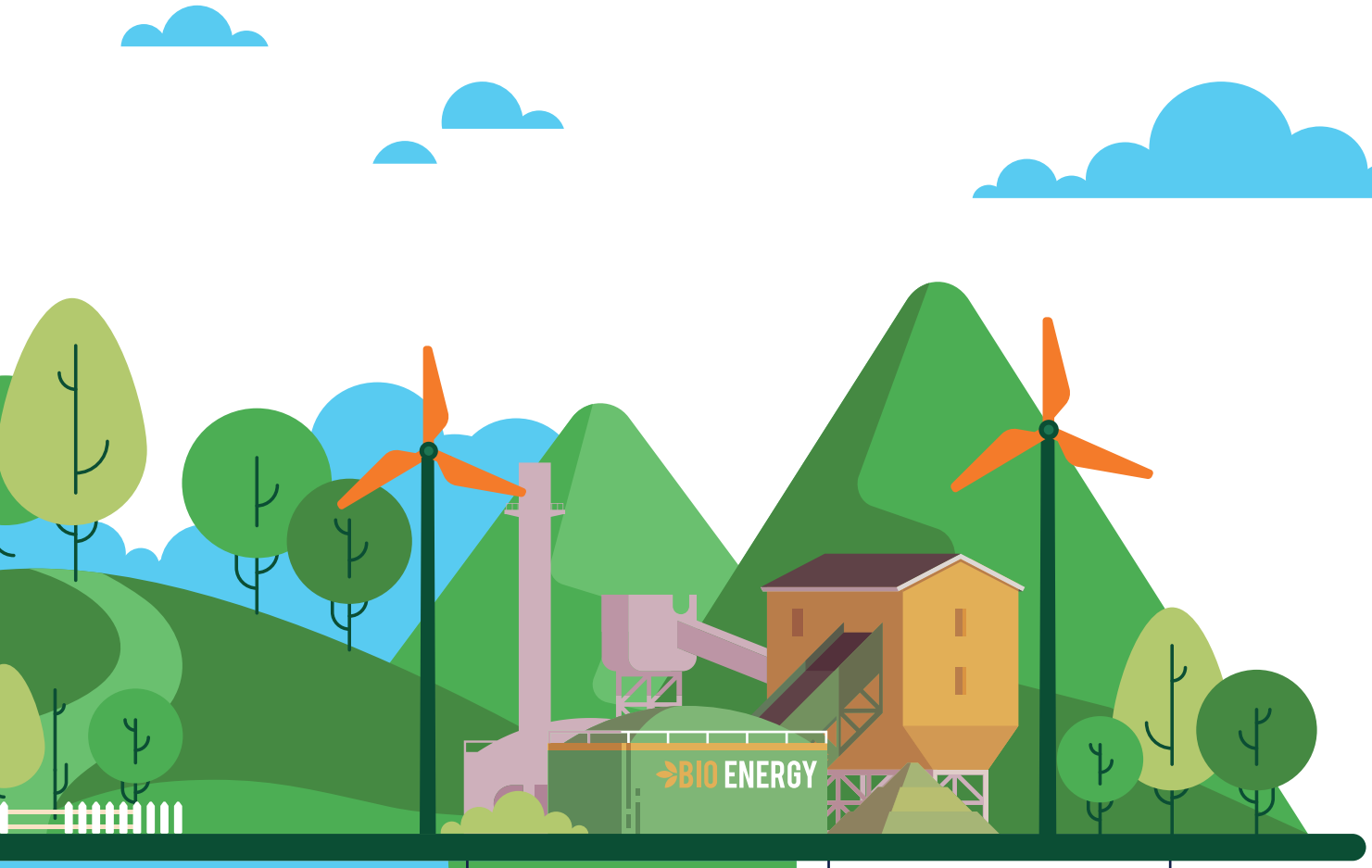


280 MW

installed capacity of biogas plants
in Poland (April 2023)

383

biogas installations
in Poland
(agricultural, municipal,
wastewater treatment plants)



approx.

2.352 TWh

production of electricity from biogas in Poland

5.7 million tonnes

amount of waste from the agri-food sector used in biogas plants in 2022

5-8 billion m³/year

biomethane potential in Poland

THE POTENTIAL OF SUBSTRATES FOR BIOGAS PRODUCTION IN POLAND – IUNG-PIB BIOMASS SUPPLY MONITORING SYSTEM

THE SYSTEM WAS COMMISSIONED BY THE MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT. SINCE 2021, THE MONITORING HAS BEEN CARRIED OUT AND UPDATED WITHIN THE FRAMEWORK OF THE TARGETED SUBSIDY OBTAINED FOR THESE PURPOSES BY THE INSTITUTE OF SOIL SCIENCE AND PLANT CULTIVATION – STATE RESEARCH INSTITUTE IN PUŁAWY. THE MAIN REASON FOR THE CREATION OF SUCH A DECISION SUPPORT TOOL WAS AND STILL IS THE NEEDS OF THE SECTOR AND THE ACTIVITIES INCLUDED IN THE ROADMAP FOR THE TRANSITION TO CIRCULAR ECONOMY – THE STRATEGIC PROJECT OF SRD.

During the first year of construction of the biomass supply monitoring system (SMZB), the following were developed: objectives, methodology of data acquisition and geoprocessing. It was determined that the final product of the system will be a geoportal presenting the obtained results in the form of maps and tables. It was made publicly available on the Bioeconomy Platform – developed as part of the work of the Department of Bioeconomy and Systems Analysis of IUNG-PIB. Access at: http://geoportal.biogospodarka.iung.pl/

The main information presented publicly on the geoportal is the assessment of the biomass supply, mainly of agricultural origin, which represents the potential that could be used for bioeconomy purposes. The methodology for estimating these resources assumes that biomass can be obtained without compromising agricultural activity – that is, without depleting the soil, threatening the environment, or compromising the quality and level of food production – both crop and livestock.

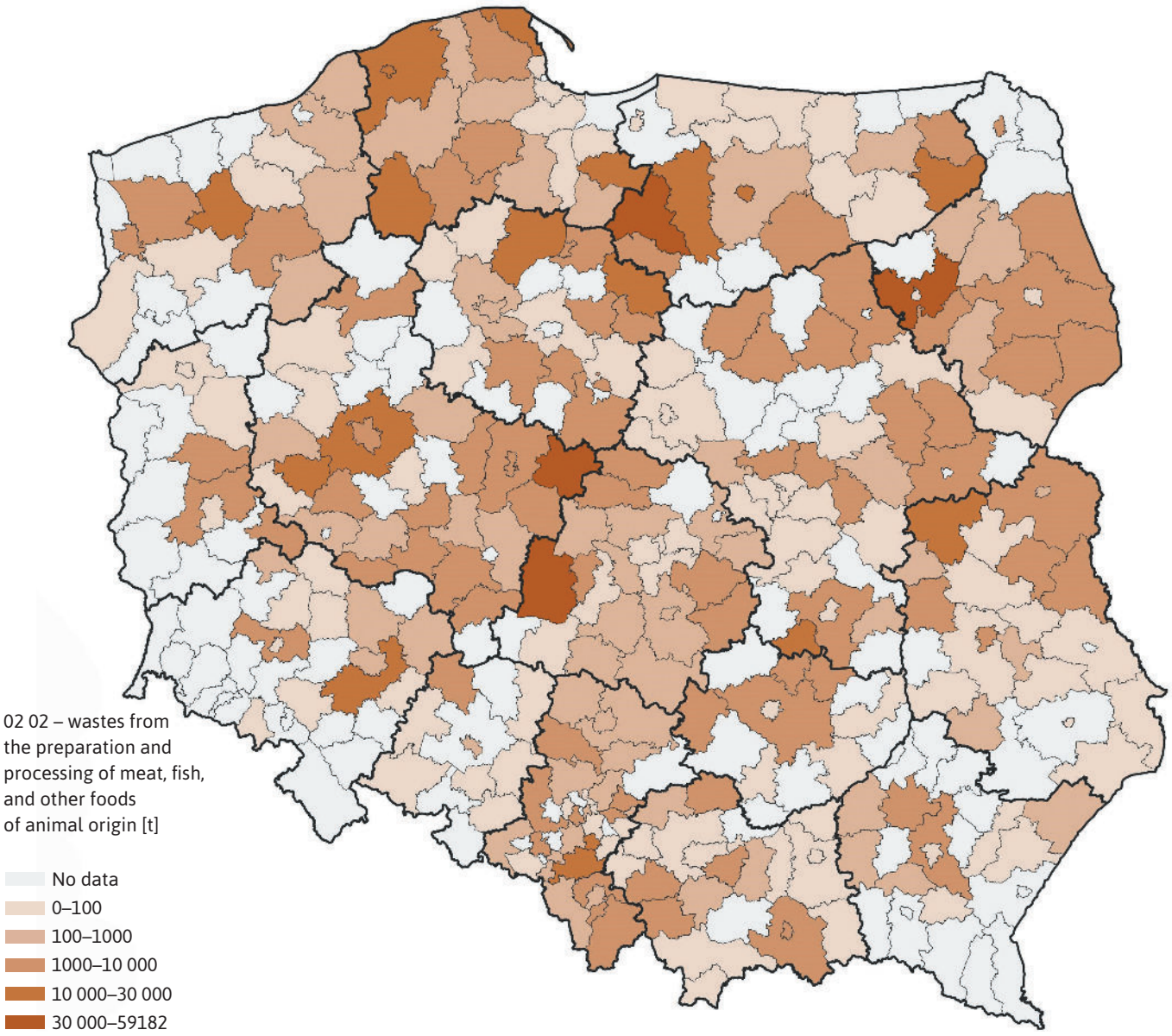
IN 2022, THE AGRICULTURAL BIOMASS MONITORING SYSTEM WAS SUPPLEMENTED WITH AN ASSESSMENT OF THE REGIONAL VOLUME OF BIODEGRADABLE WASTE SUPPLY FROM AGRICULTURE, FOOD INDUSTRY, AND MUNICIPAL MANAGEMENT

Another important data quality assumption of the system is the principle of using spatial data with high geopositioning accuracy. In connection with this assumption, the Institute asked the Agency for Restructuring and Modernization of Agriculture (ARMA) to provide data on the production declared by farmers at the farm level. This information made it possible to develop a methodology for assessing the "circulation" of biomass at the producer level – with particular attention to the need to replenish soil organic matter, maintain and protect it from erosion, practices that reduce the impact of drought, reduce greenhouse gas emissions, and optimize the use of biomass for livestock production.

The level of detail of the Agency's production-level data and IUNG's spatial data (e.g., soil maps, agricultural drought hazard maps) allowed for modeling and monitoring biomass supply at the level of agricultural plots.

Ultimately, this data is generalized to administrative units (communes) for public purposes. Currently, the geoportal presents spatial distributions for the following types of biomass resources:

FIG. 1
EXAMPLE MAP SHOWING THE POTENTIAL OF WASTE CODE 02 02



- ✓ surplus straw from farms specializing in crop and mixed (crop and livestock) production;
- ✓ surplus manure from zero-acreage farms;
- ✓ surplus manure from mixed farms;
- ✓ surplus hay.

The geoportal also reports average yields (grain and straw) and straw balances in communes.
In 2022, the agricultural biomass monitoring system was supplemented with an assessment of the regional volume of biodegradable waste supply from agriculture, food industry, and municipal management. For this purpose, data was obtained from the Product, Packaging, and Waste Management Database (BDO). The following codes were used for biomass mapping and modeling:

- ✓ 02 01 – wastes from agriculture, horticulture, aquaculture, forestry, hunting, and fishing;
- ✓ 02 02 – wastes from the preparation and processing of meat, fish, and other foods of animal origin;
- ✓ 02 03 – wastes from fruit, vegetables, cereals, edible oils, cocoa, coffee, tea, and tobacco preparation and processing; conserve production; yeast and yeast extract production, molasses preparation and fermentation;
- ✓ 02 04 – wastes from sugar processing;
- ✓ 02 05 – wastes from the dairy products industry;
- ✓ 02 06 – wastes from the baking and confectionery industry;
- ✓ 02 07, 20 01 – wastes from the production of alcoholic and non-alcoholic beverages;
- ✓ 20 02 – garden and park wastes.

For analytical purposes, the system was supplied with data defining

TAB. 1. ESTIMATED AVAILABLE BIOMASS SUPPLY

ID	Voivodeship	Surplus straw in [thousand tons]	Surplus of natural fertilizers in [thousand tons]	Surplus hay in [thousand tons]
1	dolnośląskie	893	186	119
2	kujawsko-pomorskie	708	605	106
3	lubelskie	709	670	237
4	lubuskie	314	168	123
5	łódzkie	277	1341	114
6	małopolskie	94	403	31
7	mazowieckie	304	2619	392
8	opolskie	521	237	60
9	podkarpackie	141	235	62
10	podlaskie	123	639	349
11	pomorskie	612	305	133
12	śląskie	176	230	52
13	świętokrzyskie	140	415	56
14	warmińsko-mazurskie	588	676	301
15	wielkopolskie	765	2752	252
16	zachodniopomorskie	828	511	173
Poland		**7 200**	**12 000**	**2 570**
Calorific value [GJ/t]		**13.1**	**1.2**	**13.4**
Total energy [PJ]		**94.3**	**14.4**	**34.4**
As coal equivalent* [in million tons]		**3.63**	**0.55**	**1.32**

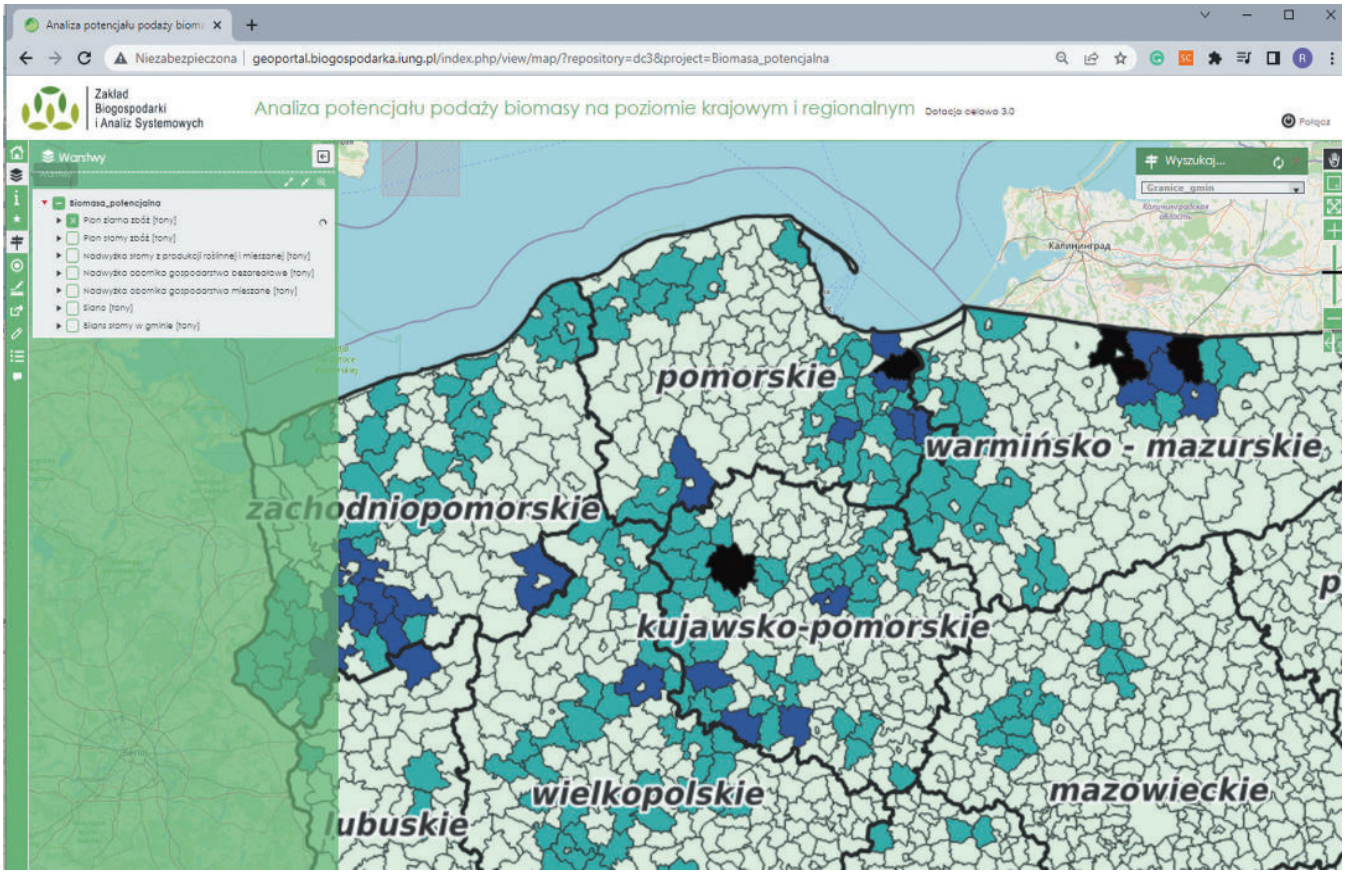
production point by point (in a given plant). To visualize the data, potential maps were developed for all waste types (51 maps in total). An example of one of them is shown above.
In 2023, the biomass monitoring system will be expanded to include more potential biomass sources that can be used in the bioeconomy:

- ✓ biomass from the maintenance of production forests;
- ✓ biomass from the maintenance of green areas and traffic lanes.

In a pilot project, satellite sensing methods will be used to precisely determine the diversity of biomass locations and types with an accuracy of 10x10 m.

BIOMASS MONITORING SYSTEM AND BIOGAS PRODUCTION DEVELOPMENT STRATEGY

As mentioned in the introduction, the biomass monitoring system was developed as a decision



Biomass supply monitoring system on the IUNG-PIB Bioeconomy Platform geoportal

support tool, mainly at the administrative level. However, due to its nature and detailed data, it can also be used to plan individual projects and indicate the best locations in terms of availability and logistics of biomass, lack of environmental nuisance, or, for example, the possibility of effective use of the electricity and cogenerated heat produced. Thanks to the possibility of geoprocessing data in the geographic information system, it is also possible to model investment scenarios, e.g. to assess whether the manure currently used for fertilization purposes (in the vicinity of the planned investment) can be replaced with digestate – if it is used in whole or in part for the production of biogas – and how deficiencies in the target raw material (e.g. manure) can be compensated by another type of biomass available in the vicinity (e.g. late-harvested hay, which has already lost its fodder properties, or biomass

POLAND'S TOTAL ANNUAL STRAW PRODUCTION IS ESTIMATED AT ABOUT 30 MILLION TONS +/-15%. HOWEVER, NO DATA IS AVAILABLE ON THE PRODUCTION STRUCTURE OF NATURAL FERTILIZERS: MANURE, LIQUID MANURE, SLURRY

obtained from mowing traffic lanes). Scenarios of this type are possible thanks to the precision of the data, which can be point-based (livestock production, processing plants), area-based (agricultural parcels), or sensed remotely (from a satellite).
In the near future, the biomass monitoring system will power the Geomatics Center for Agriculture. This Center, created at IUNG-PIB, will be, according to the current assumptions, a research and development unit of the Institute responsible for the complete monitoring of the agricultural production area, mainly using remote sensing methods.
The data generated will be publicly available through digital communication tools – mainly e-services, API services, dedicated systems, and geoportals.

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BIOGAS PRODUCED FROM MUNICIPAL WASTE

CURRENTLY, THE MAIN WASTE STREAM WITH SIGNIFICANT BIOGAS POTENTIAL IS SELECTIVELY COLLECTED KITCHEN AND GARDEN BIOWASTE. HOWEVER, IN ORDER FOR IT TO BE USED EFFECTIVELY IN THE DIGESTION PROCESS, CERTAIN CONDITIONS MUST BE MET. NEVERTHELESS, THE DEVELOPMENT FORECASTS FOR THIS SECTOR OF THE BIOGAS INDUSTRY ARE OPTIMISTIC

Any landfill where biogas is produced should be equipped with a facility for its collection and disposal, in accordance with the Regulation of the Minister of the Environment of April 13, 2013. The Regulation requires that a landfill where biodegradable waste is to be stored must be equipped with a landfill gas removal system. According to current trends, the construction of new landfills is being limited, and the waste sent to landfills is characterized by a decreasing amount of organic matter content, followed by lower residual biogas production. With the implementation and improvement of selective municipal bio-waste collection, its content in residual waste is gradually decreasing, and thus its content in the stabilized waste produced from this waste stream is decreasing as well. As a result of these changes, the main waste stream with significant biogas potential is currently selectively collected kitchen and garden biowaste. These are collected together or separately, depending on their subsequent management as well as energy or fertilizer use. Each of these streams has radically different properties and different biogas potentials. Kitchen biowaste is highly hydrated and has a high biogas potential, but its volume is much smaller and the odor generated requires a special collection system. Most communes, considering the cost and inconvenience of collecting kitchen waste separately, opt for combined collection of both. Depending on the type of buildings, season, and weather conditions, the share of individual streams varies. Achieving the right purity of the raw material is also a problem. Apart from the lack of careful segregation at the source, the main contamination of biowaste is the bags in which it is collected. In order for this waste to be used effectively in the digestion process, it must be collected at the appropriate frequency and delivered to the plant as quickly as possible. It is recommended to collect it in buckets intended for this purpose. In addition to reducing the inconvenience associated with collecting biowaste in bags, ventilation of the bins also stops odor-producing anaerobic processes.

THE DOMINANT PROBLEM FOR MOST FACILITIES IS THE TIME IT TAKES TO CHANGE ADMINISTRATIVE DECISIONS, WHICH IMPOSES REAL COSTS ON THE FACILITY AND IS INDIRECTLY REFLECTED IN THE WASTE MANAGEMENT FEES PAID BY RESIDENTS

METHANE DIGESTION INSTALLATIONS PROCESSING MUNICIPAL WASTE

The first Polish municipal biowaste digestion facilities started to be built after 2010. Since selective collection of bio-waste was not mandatory at the time, communes conducted it sporadically, especially as part of pilot programs. The facilities mainly received selectively collected green waste in small quantities, while kitchen waste was delivered along with other residual waste in the mixed waste container. The biowaste content was 10-30%, depending on the type of buildings served and the season. Ash from domestic stoves was also a significant proportion, reaching 60-80% of the mass in extreme cases during winter. This morphological composition and the inability to obtain clean, selectively collected raw material with a high organic fraction content led the first plants to process the biofraction separated from the mixed municipal waste stream. It was separated on a sieve and then cleaned mechanically. The high ash content negatively affected the quality of the biogas, and the high mineral fraction content accelerated the mechanical wear of the installation. With the implementation of selective collection of biowaste in 2017-2020, the construction of installations based on this stream has become economically and operationally justified.

fot. Piotr Szewczyk, ZUOK „Orli Staw"

ZUOK "Orli Staw" – digestate and biogas tank, cogeneration unit

The table on the adjacent page presents the municipal waste processing plants currently operating in Poland. As can be seen, no new installations have been put into service in the last four years. Currently, the installation in "Orli Staw" is undergoing acceptance tests, and a second digester at WCR Jarocin will be put into operation at the end of 2023.

The majority of the currently operating digestion plants are working on the concept of modernizing the existing technology to introduce selectively collected biowaste into the process instead of the mixed municipal waste fraction. These activities are carried out along two main paths. If there are two digesters – change the type of raw material fed to one of them.

If there is a single digester – add a second one or change the feedstock of the digester to biowaste. In the long term, the goal of such modernization is the complete replacement of raw materials with selectively collected biowaste. Despite its apparent simplicity, it requires a significant reconstruction and expansion of the installation, both in terms of feedstock preparation as well as dewatering and aerobic stabilization of the digestate. Another issue to consider is the need to obtain a decision from the Minister of Agriculture to market a fertilizer product, i.e. solid and liquid digestate. This involves implementing and certifying an HACCP system and conducting the process under veterinary supervision. It almost always also requires adaptation of the installation and therefore significant investments.

DIRECTIONS FOR MODERNIZATION AND MODIFICATION OF CURRENTLY OPERATING "WASTE" DIGESTION PLANTS

For the purposes of this report, the author conducted a survey of digestion plants operating in Poland to identify planned investment and modernization intentions. All 9 installations currently operating in Poland shared their plans in this regard, agreeing to their publication. The Orli Staw installation has no operational experience, but has a plan for expansion and modernization based on initial assumptions and the changing economic and regulatory environment.

Only WCR Jarocin is planning to build a second digester in the near future, which is expected to be completed in 2023. MZK Stalowa Wola plans to expand the installation by adding a second digester in order to increase capacity and switch to selectively collected biowaste. The plant in Orli Staw, which has been prepared from the beginning for a second stage of expansion by adding a second digester, also for selectively collected biowaste, will join this group in the future.

An interesting picture is provided by the analysis of the waste codes that can enter the digestion process according to the administrative decisions issued. Apart from the almost standard codes 20 08 01 and 20 02 01, the others are very diverse, including waste from groups 02, 16, 19, and 20. This is due to the laborious development of standards of conduct in this area by the decision-making bodies.

A national unification and standardization within this framework would be advisable, taking into account the local specificity of the available raw materials that could potentially be used in the process. Plans for plant upgrades and expansions also vary. The installations at ZKGZL in Wólka Rokicka, ZGO Gać, WCR Jarocin, and MZK in Stalowa Wola are planning to completely change the input stream to selectively collected biowaste. This is a direction that adapts the operation of the plant to the current needs, which, in addition to energy production, also include fertilizer production. Such a high quality product

TAB. 1. MUNICIPAL WASTE DIGESTION PLANTS IN POLAND

Installation	Technology	Main type of waste	Capacity [Mg/year]	Launch date	Number of digesters
MZO Leszno – Muszynia	OWS Dranco	biofraction from mixed municipal wastes	31 000	2010	1
BWiK WOD-Kan Biała Podlaska	Eisenmann	biofraction from mixed municipal wastes	20 000	2013	2
Master Tychy	Strabag Laran	biofraction from mixed municipal wastes	18 000	2015	2
ZGO Gać	Vinci Compogas	biofraction from mixed municipal wastes	31 000	2015	2
MZK Stalowa Wola	Strabag Laran	biofraction from mixed municipal wastes	15 000	2015	1
WCR Jarocin	Vinci Compogas	biofraction from mixed municipal wastes	16 000	2015	1
PGO Kielce_ Promnik	Strabag Laran	biofraction from mixed municipal wastes	26 000	2016	2
ZKGZL Lubartów – Wólka Rokicka	WTT	biofraction from mixed municipal wastes	18 000	2017	5 reactors
ZZO Poznań Suchy Las	Eggersmann Kompoferm	biowaste	24 000	2016	7 reactors
ZUOK „Orli Staw" – during start-up	Strabag Laran	biowaste	15 000	2023	1

can only be obtained from selectively collected, contaminant-free biowaste entering the plant. Almost all installations in Poland operate in dry horizontal continuous technology. Only the plants in ZZO in Suchy Las and in ZKGZL in Wólka Rokicka are percolation installations operating in dry feedstock (periodic) technology. Each of the current facilities has been in operation for 7 to 13 years, and the staff has extensive operational experience and knowledge of a wide range of digestion technologies gained over the years. Despite the emerging information and concepts for wet digestion applicable to municipal biowaste, none of the plants even mention switching to it as part of their expansion. There are also no industrial applications of this type of solutions on a larger scale on the European market. This is certainly due to the industry's experience and excellent knowledge of the characteristics of the specific feedstock that is municipal biowaste.

Several plants, responding to the current trends in the management of the energy contained in biogas, are planning to increase their ability to periodically store biogas and use it in specific time zones, depending on their own energy needs or the possibility of selling the generated energy during peak hours. The additionally installed peaking units, allowing for greater flexibility in energy production, serve the same purpose. Such activities have been carried out by WCR Jarocin and ZGO Gać, and they are planned or under implementation at MZK Stalowa Wola, PGO in Promnik, and ZUOK "Orli Staw".

PLANS FOR PURIFICATION OF BIOGAS AND PRODUCTION OF BIOMETHANE AND/OR BIOCO$_2$, PERCEIVED AS PIONEERING AND INNOVATIVE IN POLAND, ARE A COMMON STANDARD IN WESTERN EUROPEAN COUNTRIES

The change in input material requires the necessary reconstruction and modernization of the feedstock preparation system as well as the digestate management system. The digestate extracted from the digester, after its separation into solid and liquid fractions, requires storage (liquid fraction), while the solid fraction must be stabilized in an aerobic process. The solid fraction after the aerobic process then needs to be valorized to produce a fertilizer in the form of compost or a product that improves soil properties. These activities require additional investments and often the reconstruction of existing machinery and technological equipment. They were carried out in WCR Jarocin, and planned in the following installations: BPWiK Biała Podlaska, MZK Stalowa Wola, MZO Leszno in Dobrzeń, ZGO Gać, ZKGZL in Wólka Rokicka, ZZO Suchy Las, and ZUOK "Orli Staw". As can be seen, this is the majority of currently operating installations in Poland.

PROBLEMS AND CHALLENGES ALONG THE WAY

Each installation has its own specific problems, but there is one that almost all of them report. It is the length of procedures related to changing administrative decisions. It is not uncommon for an application to change an integrated permit to take 2 or 3 years to process. An infamous record holder is the application submitted in 2019, which has not yet been finalized in the form of a decision to change an integrated permit. Such situations, apart from postponing changes to adapt the operation of the installation to current needs and legal requirements, also cause real costs on the part of the installation, which are indirectly reflected in the fees paid by residents for waste management.

Several installations report their plans for deep biogas purification and production of biomethane and/or biocarbon dioxide. Such activities, perceived as pioneering and innovative in Poland, are already a common standard in Western European countries. Almost every new biogas plant there produces "green" biomethane, which is fed into the gas network or used to power vehicles. In Poland, despite the positive declarations of decision-makers and the supposedly favorable atmosphere, no one has yet managed to overcome the official fortifications and entanglements. A similar problem of a formal nature is obtaining the decision of the Minister of Agriculture and Rural Development authorizing the marketing of a fertilizer obtained in the process of organic recycling R3 after aerobic and anaerobic processes. The procedure usually takes over a year, although the process and raw material composition are almost identical in most plants. This delays activities that are so necessary for the Polish economy and our natural environment, which is waiting for ecological fertilizers rich in humus.

The selective collection of biowaste, which has been gradually introduced by communes in Poland since 2017, has become an integral part of the selective waste collection system. We have made tremendous, almost revolutionary progress in this area. However, there is still much to be done in this area. Most digestion installations report a problem with high levels of contaminants in the supplied biowaste. The main problem is all types of plastics as well as glass and mineral impurities. The basic element that needs to be changed quickly is the replacement of bags with containers, which will significantly reduce plastic pollution. It is also postulated that a permanent, nationwide education and information campaign should be conducted in the field of correct, selective collection of biowaste. Only high-quality selective collection is able to provide high-quality fertilizer products without incurring excessive costs associated with their production.

PLANS AND ACTIVITIES FOR THE NEAR FUTURE

The deficiencies in the field of biowaste management infrastructure are significant, reaching billions of zlotys. These needs are met by a new co-financing program launched by the National Fund for Environmental Protection and Water Management entitled "Development of cogeneration based on municipal biogas". It has at its disposal a fund of PLN 1.5 billion for both repayable and non-repayable support mechanisms. This is a significant amount, but in relation to the investment gap estimated in the report published by the Institute of Environmental Protection – National Research Institute (IEP-NRI), it is only a small part of the funds needed for investment activities.

It is clear that real action is needed, but in addition to funding sources, time is also required to implement the investment. One must also consider the longer time required for implementation, which is often caused by social resistance. Only widespread best practices and availability of information can dispel these bad myths that a part of our society still lives by.

This is what needs to be done to obtain renewable, clean energy and high-quality natural fertilizers available to every citizen from our daily municipal biowaste.

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Regional Municipal Waste Treatment Facilities (Rada RIPOK)
Municipal Solid Waste Treatment and Neutralization Plant "Orli Staw" (ZUOK "Orli Staw")

TREATMENT PLANT BIOGAS – ENERGY FROM WASTEWATER

THE WATER AND WASTEWATER INDUSTRY HAS BEEN STRUGGLING WITH SERIOUS DIFFICULTIES SINCE 2022. THE OUTBREAK OF WAR IN UKRAINE AND THE RISE IN INFLATION CONTRIBUTED TO A SIGNIFICANT INCREASE IN THE PRICE OF ENERGY NEEDED TO PROVIDE SERVICES RELATED TO THE TREATMENT AND SUPPLY OF DRINKING WATER AND THE COLLECTION AND TREATMENT OF WASTEWATER.

The entrepreneurship of water and wastewater utilities and their ability to produce their own energy have helped reduce financial losses caused by high prices for electricity and the raw materials used to produce it. Water utilities most often produce electricity at wastewater treatment plants, in biogas installations running on wastewater sludge. It is worth following the process of wastewater treatment to see what it looks like now and what it may look like in the future.

WASTEWATER TREATMENT IN A NUTSHELL

The first step in the wastewater treatment process is mechanical treatment. This process has been underestimated, but it is becoming a key element due to the rising costs of waste management and higher electricity consumption. It starts as soon as the wastewater enters the treatment plant. In the bar screen chamber special sieves remove the so-called screenings – large impurities, such as plastic packaging, food leftovers, branches, or hygiene products. The next step is the removal of sand in the so-called grit chambers. In the context of the circular economy

A BIOGAS PLANT FUELED BY WASTEWATER SLUDGE AT A TREATMENT PLANT CAN HAVE A POSITIVE ECONOMIC IMPACT ON COMPANIES FROM THE WATER AND WASTEWATER INDUSTRY

policy, more and more water and wastewater companies are making efforts to ensure that the separated sand is no longer treated as waste, thanks to which the costs of its management would be significantly reduced or it could be used for their own needs. The wastewater prepared in this way goes to the primary settling tanks, where large organic suspensions are separated by sedimentation. This process produces what is known as primary sludge, which is used for anaerobic digestion and the production of electricity and heat.

At this point, mechanical treatment ends and biological treatment conducted in bioreactors begins. Special microorganisms grown there reduce contaminants invisible to the human eye through aerobic and anaerobic decomposition. From the bioreactors, the wastewater moves to the final stage of treatment, the secondary settling tanks. As in the case of primary settling tanks, the surplus sludge is separated and sent to the digestion process, like the primary sludge. Some of this sludge is returned to the biological reactors to maintain the process. The treated wastewater is discharged directly into receiving bodies such as rivers.

ENERGY PRODUCTION AT A WASTEWATER TREATMENT PLANT

• BIOGAS

The main form of energy generation in wastewater treatment plants is the production of biogas. It is created by anaerobic digestion of wastewater sludge: primary and surplus. The sludge is digested not only to produce energy, but also to reduce its weight and hygienize it for further processing and use.

Prior to digestion, the sludge is thickened to about 6% d.m. [1] (primary sludge) 4% d.m. (surplus sludge), then mixed and fed into separate/enclosed digesters. The process is mostly carried

out under mesophilic conditions, which allows a good balance between the heat required to maintain a constant temperature in the chambers and the energy yield in the form of biogas. Increasingly, it is being claimed that biogas can be produced not only by digesting sludge, but also by digesting the screenings from the first stage of the wastewater treatment process.

Biogas produced in wastewater treatment plants has good parameters (relatively high methane content) that allow it to be used for energy purposes. Therefore, treatment plants prefer to use biogas for their own needs, such as heat for digesters and other process facilities, and electricity for technological and social needs. For this purpose, biogas is burned mainly in cogeneration units, heating boilers, and sometimes in the boilers of digested sludge drying installation. Only in exceptional cases (failure of other receivers) should biogas be flared to avoid direct emission of methane (a potent greenhouse gas) into the atmosphere.

The goal of a wastewater treatment plant should be to maximize biogas production, store it in appropriately sized tanks, and use it at the most convenient times when the plant's energy needs are greatest. This is relatively easy to forecast and results mainly from the amount of wastewater flowing into the wastewater treatment plant.

Unfortunately, the development of the market for biogas produced in wastewater treatment plants has stagnated in recent years. This is shown by the data provided by the Central Statistical Office [2].

The graphs show a slowdown in the growth of biogas-to-electricity conversion. This is probably due to the fact that the plants have reached the limit/design parameters, and further increases require large investment outlays, which are problematic today without obtaining subsidies.

Another reason for the current situation is the increasingly difficult access [3] to high quality co-substrates, such as fat waste from animal production and waste from the distillery industry. These types of substrates are co-digested with wastewater sludge to increase the efficiency of the process. Their absence can lead to a significant reduction in biogas production capacity, which, in the context of rising operating costs, will be very unfavorable for the budgets of water and wastewater companies. Companies are looking for alternative power generation solutions to achieve zero energy plant status and energy independence, as well as to reduce their carbon footprint.

FIG. 1.
ENERGY YIELD FROM TREATMENT PLANT BIOGAS IN POLAND IN 2017-2021 [TJ]
SOURCE:: CENTRAL STATISTICAL OFFICE

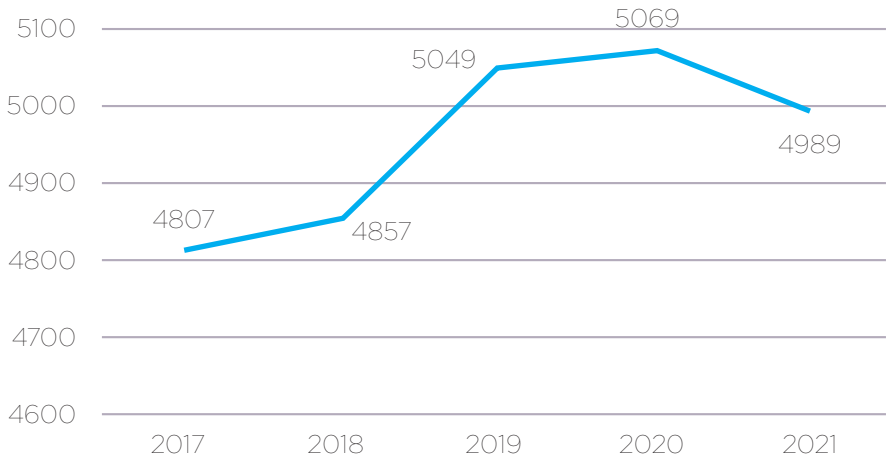


FIG. 2
GENERATION CAPACITY OF POWER PLANTS USING BIOGAS FROM WASTEWATER TREATMENT PLANTS IN POLAND IN 2017-2021 [MW]
SOURCE:: CENTRAL STATISTICAL OFFICE

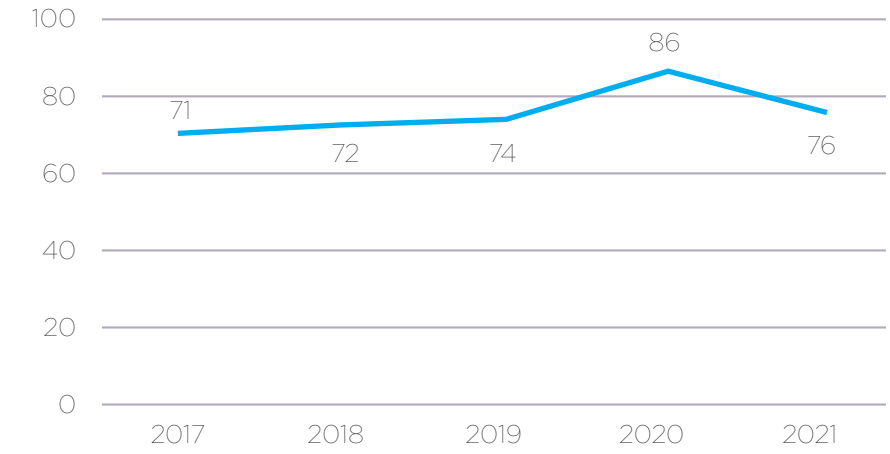


FIG. 3
PRODUCTION OF ELECTRICITY FROM BIOGAS IN WASTEWATER TREATMENT PLANTS IN POLAND IN 2017-2021 [GWH]
SOURCE: CENTRAL STATISTICAL OFFICE

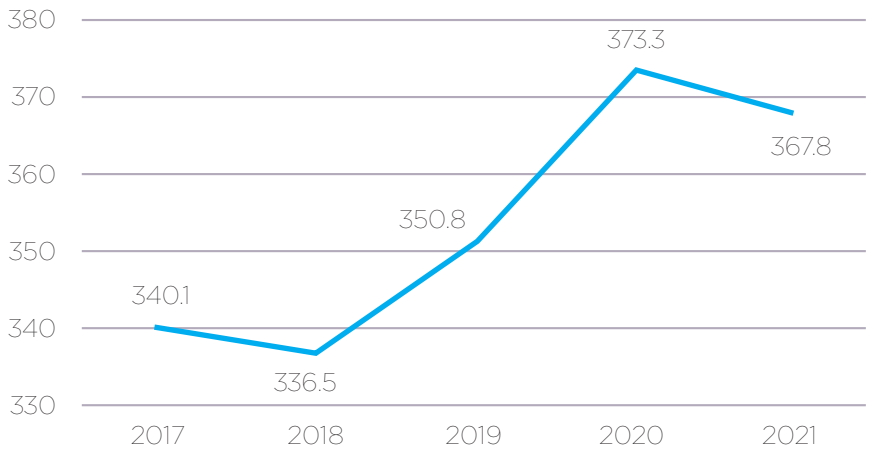
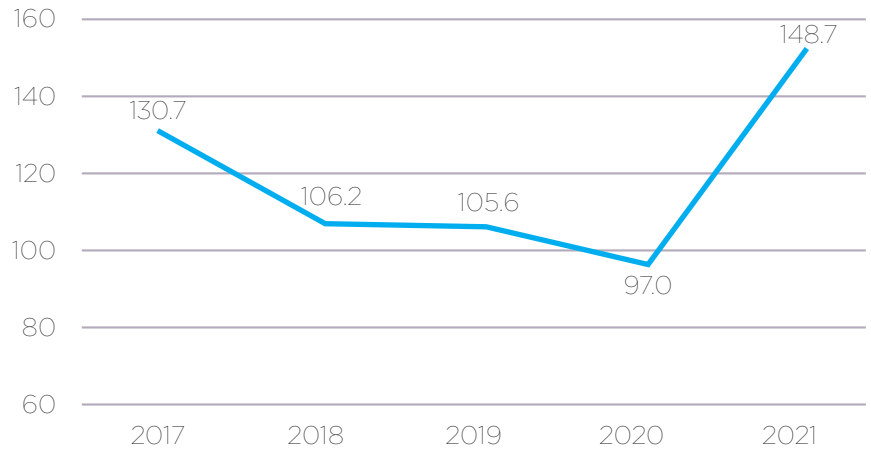


FIG. 4
PRODUCTION OF HEAT FROM BIOGAS IN WASTEWATER TREATMENT PLANTS IN POLAND IN 2017-2021 [TJ]
SOURCE: CENTRAL STATISTICAL OFFICE



OTHER WAYS OF PRODUCING ENERGY IN WASTEWATER TREATMENT PLANTS

• HEAT PUMPS

Not only wastewater sludge, but also the wastewater itself can be the basis for energy production. In Poland, wastewater has a temperature range of about 20°C in summer to about 10°C in winter, which is a sufficient energy source for modern heat pumps. The first plant in Poland to use treated wastewater as a heat source was the plant in Szlachęcin near Poznań, commissioned in 2020 and built by Veolia Energia Poznań on the premises of a wastewater treatment plant owned by Aquanet from Poznań.

In Wrocław, an investment project to install a 12.5 MW heat pump has begun at the Port Południe wastewater pumping station. Untreated wastewater will serve as the heat source, and the installation will be the largest of its kind in Poland and will mark the beginning of a move away from non-renewable energy sources in the heating system of Wrocław [4].

A similar investment will soon begin in Poznań, where the city will work with Veolia and Aquanet on projects to improve energy efficiency. The parties have signed a cooperation agreement to assess the possibility of utilizing the potential of waste heat, with particular emphasis on recovering heat from municipal wastewater from the Central and Left Bank Wastewater Treatment Plants for the city's district heating network [5].

THE GOAL OF A WASTEWATER TREATMENT PLANT SHOULD BE TO MAXIMIZE BIOGAS PRODUCTION, STORE IT IN APPROPRIATELY SIZED TANKS, AND USE IT AT THE MOST CONVENIENT TIMES WHEN THE PLANT'S ENERGY NEEDS ARE GREATEST

• WATER TURBINES

Another interesting solution is the use of small water turbines at the outlets of wastewater treatment plants. The treated wastewater is clean enough for the equipment to function efficiently. The regular flow of wastewater through treatment plants and its correlation with current energy consumption can increase the energy self-sufficiency of the facilities. Such solutions are used, among others, at the wastewater treatment plant in Toruń [6] and

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at the Płaszów wastewater treatment plant owned by MPWiK Kraków [7].

WHAT WILL THE FUTURE BRING?

According to the European Parliament's draft of a new directive on wastewater treatment, presented in October 2022, from the end of 2040 all wastewater treatment plants above 10,000 p.e. (population equivalent) must be climate-neutral [8]. Achieving this goal will require not only increasing energy production, but also optimizing its consumption. In this context, artificial intelligence is becoming increasingly popular, as it can help control processes at a wastewater treatment plant in the most energy-efficient way while ensuring consistent quality of treated wastewater. This further reduces the burden on process supervisors and operators and minimizes the risk associated with the human factor – having little time to make the right decision in a crisis situation.

At the same time, it should be noted that the requirements proposed by the EU for Polish water companies will be a great challenge both in organizational and financial terms.

Wastewater treatment plants, having the potential to produce electricity, over time can become enterprises producing energy not only for their own needs and utilizing not only wastewater sludge, but also other municipal and agri-food processing waste. In the coming years, wastewater treatment will be only a part of its activities. Modern technologies will therefore become indispensable to achieve the intended climate neutrality goals.

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SOURCES:

1. https://stat.gov.pl
2. https://wroclaw.pl
3. https://poznan.pl
4. https://wodociagi.torun.com.pl
5. https://wodociagi.krakow.pl
6. https://eur-lex.europa.eu

NOTES:

1. Dry mass – percentage of the solid phase in the substance
2. https://stat.gov.pl
3. Recently, smaller biogas plants are being built, even in small production facilities, to take advantage of the potential to generate energy from waste, which fits perfectly with the circular economy and reducing carbon footprints.
4. https://wroclaw.pl
5. https://poznan.pl
6. https://wodociagi.torun.com.pl
7. https://wodociagi.krakow.pl

SMALL MUNICIPAL WASTEWATER TREATMENT PLANT WITH ITS OWN BIOGAS PLANT

ON AVERAGE, POLISH WASTEWATER TREATMENT PLANTS PRODUCE MORE THAN 585,000 TONS OF DRY SLUDGE EACH YEAR, WHICH NEEDS TO BE MANAGED WHEN STILL IN ITS LIQUID FORM. THIS SLUDGE IS PRODUCED BY ABOUT 3,280 TREATMENT PLANTS. 2,450 OF THEM USE MECHANICAL AND BIOLOGICAL SYSTEMS AND GENERATE WASTE RESIDUES SUITABLE FOR FURTHER BIOLOGICAL TREATMENT. THE FIGURES ARE CHANGING DYNAMICALLY, BUT IT IS CERTAIN THAT WITH THE DEVELOPMENT OF THE WASTEWATER NETWORK, THE SIZE AND SCOPE OF WASTEWATER TREATMENT PLANTS IN POLAND IS GROWING, AND SO IS THE AMOUNT OF SLUDGE.

Sludge management is regulated by law, which obliges wastewater treatment plants to reduce the amount of sludge and its negative impact on the environment through: disintegration, deep stabilization, hygienization, and dewatering. There are many ways to meet this obligation, but anaerobic digestion technologies have shown very high efficiency in this area. This approach, but combined with power generation, has been financially supported by the National Fund for Environmental Protection and Water Management (NFOŚiGW) since February 2023 under the program "Development of cogeneration based on municipal biogas".

The use of sludge anaerobic digestion units in Poland is currently at a relatively low level. There are several reasons for this, although the widely held assumption that the profitability of biogas investments can only be maintained for large treatment plants with a capacity of more than 5,000 m^3 of wastewater per day has certainly had a negative impact. We have about 290 such plants in Poland and only 117 biogas plants operate on them. This leaves almost 3,000 other treatment plants. The vast majority are very small facilities, but 20% are able to manage their sludge with their own small on-site biogas plants. These are treatment plants with a capacity of 1 to 5 thousand m^3 of wastewater per day, producing enough sludge to power biogas plants with a capacity of 20 to 75 kW_e.

OUT OF MORE THAN 3,000 THOUSAND WASTEWATER TREATMENT PLANTS IN POLAND, ONLY 117 USE ANAEROBIC DIGESTION NODES, ALTHOUGH THE POSSIBILITIES ARE MUCH GREATER

SOLUTION FOR SMALL TREATMENT PLANTS

The solution developed for small municipal wastewater treatment plants is to use either surplus sludge or mixed sludge: fresh and surplus sludge. The second variant allows for higher energy yields, but it will be rarely used, as there are few such plants in Poland. However, each option assumes maximum use of existing infrastructure and its adaptation to new purposes. Substrate preparation, digestion, and power generation require the construction of new technologically related facilities.

Each concept is best illustrated with a specific, completed investment. Such a facility was put into operation in January 2023 at Spółka Wodna "Łeba". It is a municipal wastewater treatment plant of the mechanical-biological type, with an average wastewater flow of 2,200 to 5,700 m^3/day, serving a highly seasonal region. The biogas plant produces 20 to 38 tons of surplus sludge per day, thickened to 5% d.m. This amount of substrate allows

Zdj. NaturalnaEnergia.plus

The agricultural micro biogas plant at Spółka Wodna "Łeba" has been operating since January 2023

the operation of a methane digester node with an active digester capacity of 868 m^3 and a 44 kWe/88 kW_{th} cogeneration system. The concept of the solution was developed by JV Technology, and the contractor for the investment was NATURALNA ENERGIA.plus.
The investment included:

- ✔ installation of agitators in the existing surplus sludge tank,
- ✔ construction of a sludge thickening unit (from 1% to 5% d.m.),
- ✔ construction of a buffer tank for thickened sludge, located in one of the existing sludge tanks,
- ✔ installation of a complete anaerobic digestion unit by BIOLECTRIC,
- ✔ construction of power and communication connections and a set of process pipelines,
- ✔ adaptation of one of the existing tanks for digestate collecting,
- ✔ adaptation and modernization of the sludge dewatering station for digestate management,
- ✔ installation of a control system and connecting it to the plant's master monitoring system.

Due to the seasonal inflow of municipal wastewater, the installation in Łeba is also prepared for the possible reception of additional, local materials from the local catering industry.
SW "Łeba" benefited from the financial support of "NORWAY grants". Other wastewater treatment plants already have a program from the National Fund for Environmental Protection and Water Management at their disposal. The current investment outlay for a similar project ranges from PLN 6 to 8 million net. This depends on the adaptability of the existing infrastructure and the choice of scale of the digestion node. The payback period therefore varies, as do the purchase costs and the amount of electricity required to treat 1 m^3 of wastewater (from 0.5 to 2.3 kWh/m^3).
For small municipal wastewater treatment plants that also use small biogas plants, the formal procedures are similar to those for large projects. They are long and unnecessarily generate social emotions. Simplification of procedures for this category of treatment plants and biogas plants would be a welcome stimulus.

Adam Orzech

SIMPLIFICATION OF ADMINISTRATIVE PROCEDURES WOULD UNLOCK THE POTENTIAL OF BIOGAS IN SMALL MUNICIPAL WASTEWATER TREATMENT PLANTS

USE OF HEAT FROM BIOGAS PLANTS

THE OPERATION OF A BIOGAS PLANT BRINGS A NUMBER OF BENEFITS TO BOTH THE ENVIRONMENT AND THE LOCAL COMMUNITY. IT FULFILLS A RECYCLING FUNCTION BY ALLOWING THE MANAGEMENT OF MUNICIPAL BIOWASTE AS WELL AS WASTE AND RESIDUES FROM THE AGRICULTURAL SECTOR. THE PRODUCED BIOGAS ENABLES THE GENERATION OF ENVIRONMENTALLY FRIENDLY ELECTRICITY AND HEAT. IN ADDITION, AGRICULTURAL BIOGAS PLANTS ENABLE THE IMPLEMENTATION OF THE CIRCULAR ECONOMY MODEL.[1]

A typical agricultural biogas plant with a capacity of 1 MW_{ee} produces approx. 4 million Nm^3 of biogas per year, which is most often used in cogeneration installations. In this way, energy is converted into approx. 8,300 MWh of electricity and 8,600 MWh of heat. The electricity is used for own needs (on average 8-15%) and, above all, sold to the local operator and distributed to power networks. The thermal energy is generated by an internal combustion engine or turbine – thanks to combined heat and power (CHP) technology, a certain portion of it is used for the operation of the biogas plant (usually 15-30%). Heat is obtained by recovery in various forms – so-called low-temperature (90-93°C) from engine cooling and high-temperature (260-340°C) from exhaust gas cooling.[2]

Biogas installations are usually located far from human settlements, i.e. locations to which the heat generated in the production of electricity can be transferred. The average distance between a CHP plant and potential heat consumers is between 1-4

A TYPICAL AGRICULTURAL BIOGAS PLANT WITH A CAPACITY OF 1 MWEE PRODUCES APPROX. 4 MILLION NM³ OF BIOGAS PER YEAR

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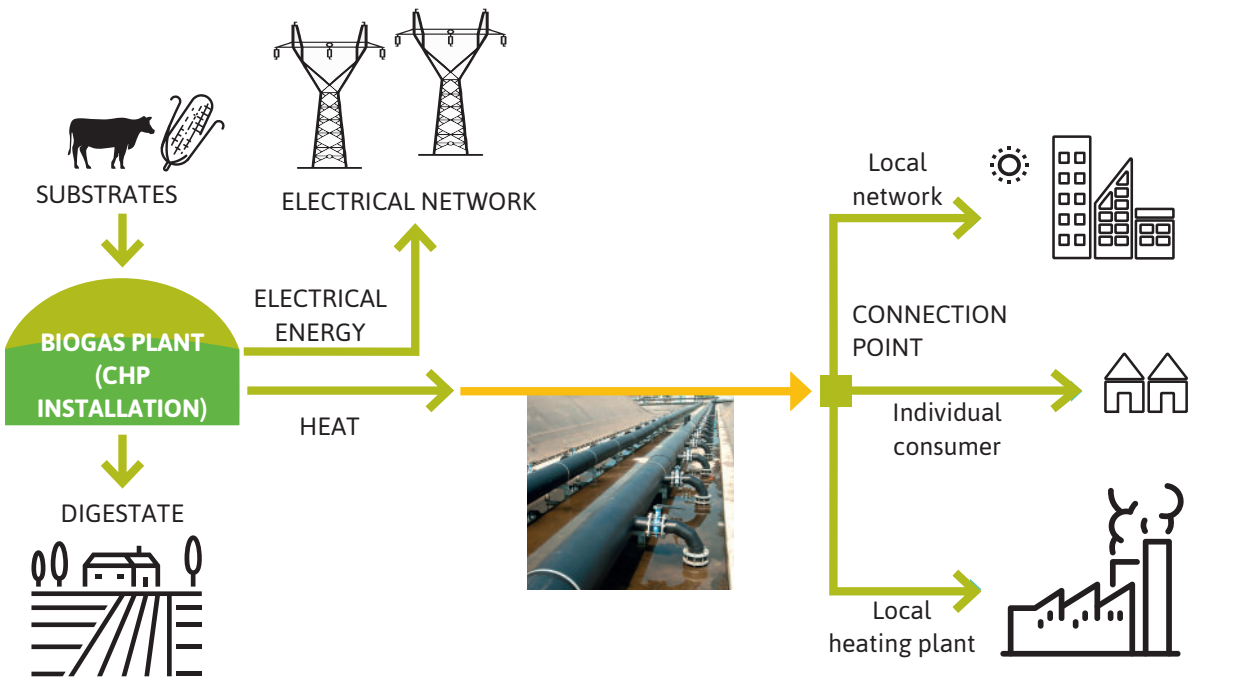
FIG. 1. DIAGRAM OF HEAT SUPPLY FROM A BIOGAS PLANT TO A LOCAL NETWORK



SOURCE: OWN WORK.

kilometers, often more. For this reason, the use of heat by biogas plants is a major challenge, as its transmission over long distances requires the construction of a heat pipeline. As a result, the heat from a biogas plant is difficult to use commercially, unless the biogas plant is an integral part of a facility generating biowaste, in which case it is essentially used only for the biogas plant's own needs. In this case, if no source of heat reception has been found, the energy is irretrievably lost and released into the atmosphere.

TECHNICAL SOLUTIONS FOR HEAT TRANSFER FROM BIOGAS PLANTS

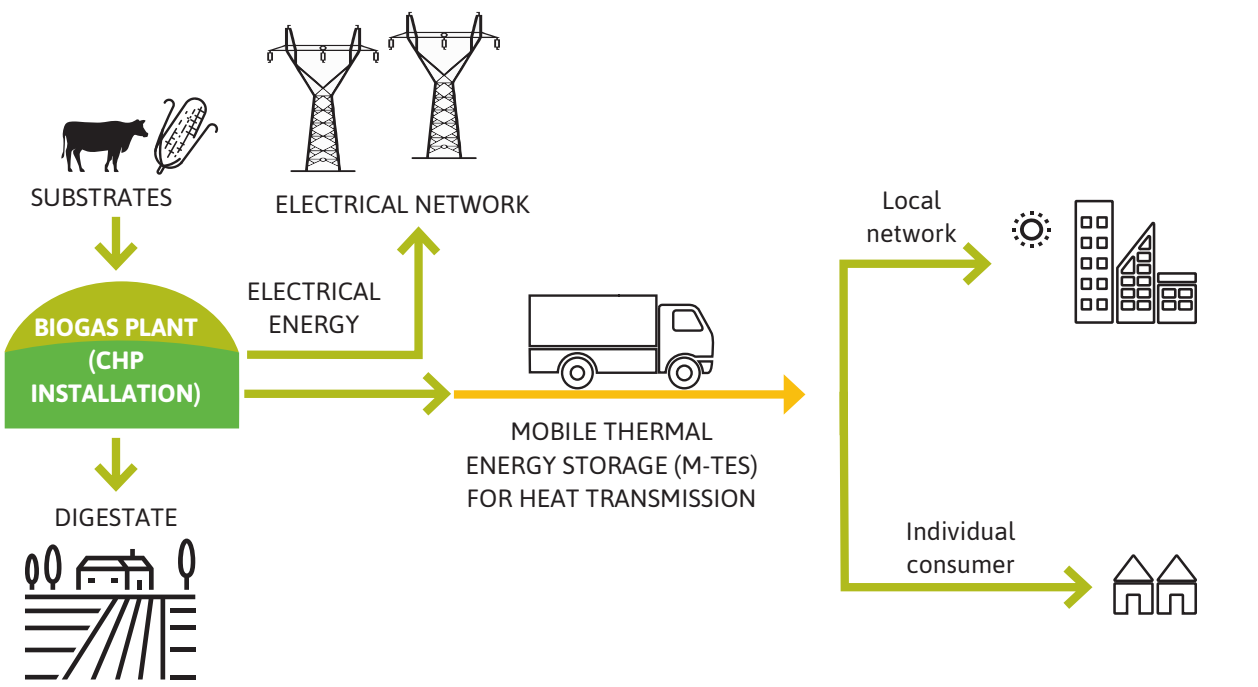
• LOCAL HEAT PIPELINES

Providing heat to the local community can be accomplished in several ways. One of them is to build a heat pipeline, i.e. a system of pipelines together with infrastructure ensuring effective transmission of heat energy to the point of consumption. This allows the transportation of heat in several variants, depending on the needs of the local community and the infrastructure operating in the area. A heat pipeline can lead from a biogas plant to a certain area where individual heating is currently operating, or it can deliver heat from a biogas plant to a connection point with a heating network operating in a certain area.
Another way to deliver heat from a biogas plant is to transfer the energy produced directly to a local heating plant. This reduces the use of fossil fuels by the district heating plant in the area, as part of the heat delivered to consumers comes from the biogas plant.
The described models of heat supply from biogas plants are presented in the figure above.

• MOBILE THERMAL ENERGY STORAGE

An alternative solution to heat supply via a heat pipeline is Mobile Thermal Energy Storage (M-TES). The technology uses tanks filled with Phase Change Material (PCM). It allows energy to be stored in the form of latent heat associated with the phase change process. M-TESs are used in cases where the construction of a heating network is uneconomical, there are ownership problems with the land where the heat pipeline is planned, or

FIG. 2. DIAGRAM OF HEAT SUPPLY FROM A BIOGAS PLANT TO A LOCAL HEATING PLANT



SOURCE: OWN WORK.

natural terrain obstacles prevent the implementation of the project. The use of heat transportation tanks usually means financial savings compared to the use of fossil fuels and allows a more efficient use of biogas.
A schematic drawing is shown in Figure 2.
Mobile Thermal Energy Storage is a device that allows thermal energy to be stored and transported using road infrastructure. The M-TES system consists of two tanks (tank semi-trailers) that can store thermal energy. The two tanks operate in parallel – one is being loaded and the other is being unloaded at the same time. A system designed in this way allows for uninterrupted heat supply to the point of reception.
Examples of PCM materials include sugars, paraffins, hydroxides.

THE HEAT PRODUCED IN THE BIOGAS PLANT IS USED, AMONG OTHERS, BY THE RESIDENTS OF POTĘGOWO, THE MUNICIPAL WATER PARK "THREE WAVES" IN SŁUPSK, BOLESZYN, MROCZNO, SIEŃSK, AND SOKOŁÓW PODLASKI

A tank filled with phase change material can store six times more heat than if it were filled with water.[3] The stored thermal energy can be transported to facilities located a short distance from the site of generation – depending on the conditions, the economic limit is 30 km. By choosing the right phase change material for a specific application, heat can be stored at any temperature, even up to about 120°C, making it suitable for heating needs in buildings where the temperature of the heating medium is typically around 60-70°C. The energy can be stored for approx. 2 weeks. Own heat losses do not exceed 2% per day.
In summary, thanks to the use of heat pipelines or M-TES, the thermal energy generated in a biogas plant can be used by the local community as well as for technical or industrial purposes. This is possible if the biogas plant is located near an industrial plant that is a heat consumer. Most often these are dairies, distilleries, and pig or cattle farms.

The key is the distance of potential heat consumers from the biogas plant. For longer distances, running heat pipelines may not be cost-effective due to heat loss and high construction costs. Each site must be considered individually, as accurate calculations can only be made on a project-by-project basis after a detailed heat pipeline route has been established.

BENEFITS OF USING HEAT ENERGY FROM A BIOGAS PLANT

Agricultural biogas plants convert energy from biogas into electricity and heat through cogeneration installations. It is a stable heat source with preferential and predictable fees for a potential biogas plant heat consumer.

By using the heat generated in biogas plants, it is possible to move away from fossil fuel energy resources. Reducing the carbon footprint, the amount of greenhouse gases emitted into the atmosphere, improves the standard of living of the local community. Around biogas plants that use thermal energy, air quality improves, especially in the fall and winter.

In 2021, carbon dioxide emissions in Poland amounted to 192 million tons. Households have a significant impact on environmental pollution. In Poland, according to statistical data, they are responsible for as much as 38% of CO_2 emissions.

Residential heating is responsible for the majority of cases where acceptable air pollution standards are exceeded. The most dangerous chemicals in polluted air are nitrogen dioxide and the carcinogen benzo(a)pyrene (coming from burning garbage and plastics, among other things), which accumulates in the human body. Individual household heating contributes to global warming, climate change, the ozone hole, smog, acid rain, and civilization diseases.[4]

The use of heat from biogas plants is therefore an alternative to heating with coal or wood, commonly used in single-family homes. Biogas energy conversion can be an effective way to reduce CO_2 and other greenhouse gas emissions in households.

THE USE OF HEAT FROM BIOGAS PLANTS IS AN ALTERNATIVE TO HEATING WITH COAL OR WOOD COMMONLY USED IN SINGLE-FAMILY HOMES

The popularization of the use of thermal energy generated by biogas plants for heating nearby houses and public buildings will undoubtedly improve the perception of biogas plants by local communities. This is important because residents usually have a negative attitude towards the construction of biogas plants near their homes.

The ability to use the thermal energy produced also increases the profitability of biogas plants by increasing the interest of potential investors in such projects, which is important in the context of the relatively small number of biogas plants currently operating in the country.

In addition, when analyzing the price of energy resources, the heat produced by biogas plants is one of the cheapest alternatives on the market. A low cost heat source means lower heating costs for the potential customer. This is undoubtedly a great advantage of the described "green" energy. According to information obtained from industry organizations, in 2021 the average sale price of heat from coal was about PLN 52/GJ, from heating oil PLN 76/GJ, and from gaseous fuels PLN 72/GJ; while the average sale price of heat from biogas plants was very close to the cost of producing heat from coal.[5] The current dynamic increase in prices of all carriers can be reduced by using heat from biogas plants.[6]

The energy produced by a biogas plant is also the least sensitive to price fluctuations, which is largely due to its independence from the import market of energy raw materials from abroad. The use of heat generated by biogas plants increases the energy independence of local communities. Biogas plants offer the opportunity to become independent of energy price increases on global markets.[7]

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DIGESTATE – POSITIVE CHANGES ON THE MARKET

THERE IS NO NEED TO CONVINCE ANYONE THAT DIGESTATE HAS EXCELLENT FERTILIZING PROPERTIES. DURING THE FIRST YEARS OF OPERATION OF AGRICULTURAL BIOGAS PLANTS, IT WAS TREATED WITH MISTRUST BY FARMERS, BUT TODAY THE INTEREST IN DIGESTATE IS GROWING, UNDOUBTEDLY INFLUENCED BY THE INCREASE IN THE PRICE OF ARTIFICIAL FERTILIZERS. THOSE WHO HAVE STARTED USING DIGESTATE AS A FERTILIZER ARE NOT GIVING IT UP, AND MORE AND MORE INTERESTED FARMERS ARE CONTACTING BIOGAS PLANTS.

We wrote about the environmental impact of digestate in last year's Report (see Biogas in Poland 2022 – editor's note) in the context of reducing agricultural emissions thanks to biogas plants. Replacing artificial fertilizers with post-digestion mass is one of the most important elements in reducing the environmental impact of agriculture, especially livestock production. The benefits of digestate are also being recognized by lawmakers, who are creating new regulations and simplifying procedures for the use of digestate as fertilizer.

AMENDMENTS TO THE ACT ON FERTILIZERS AND FERTILIZATION

Currently, the act on facilitating the preparation and implementation of investments in the field of agricultural biogas plants, as well as their operation, is being processed. A large part of the provisions contained in the draft amends the Act of July 10, 2007 on fertilizers and fertilization (Journal of Laws of 2023, item 569). The definition of a post-digestion product appears there as follows:

"post-digestion products" – liquid or solid organic substances intended for agricultural use, resulting from the agricultural biogas production process as defined in Article 2(2) of the Act of February 20, 2015 on Renewable Energy Sources (Journal of Laws of 2022, items 1378, 1383, 2370, and 2687, and of 2023, item...) produced from:

1) biomass in the form of animal manure, straw, and other non-hazardous natural substances from agricultural or forestry production or
2) other substrates used for the production of biogas that do not pose a threat to the health of humans, animals, or the environment, as specified in the regulations issued pursuant to Article 4(3) of the Act of ... on facilitating the preparation and implementation of investments in the field of agricultural biogas plants, as well as their operation (Journal of Laws, item ...).

REPLACING ARTIFICIAL FERTILIZERS WITH POST-DIGESTION MASS IS ONE OF THE MOST IMPORTANT ELEMENTS IN REDUCING THE ENVIRONMENTAL IMPACT OF AGRICULTURE, ESPECIALLY LIVESTOCK PRODUCTION

Subsequently, amendments are made to the text of the act, adding post-digestion products to every provision regulating the production, marketing, and use of fertilizers and plant growth promoters. Thus, post-digestion products become the third group of fertilizer preparations (along with fertilizers and plant growth promoters) with the same legal status. The proposed amendments will also eliminate the need for the costly and lengthy process of obtaining a marketing permit for post-digestion products. The following obligation is introduced in its place: "An entity authorized to operate in agricultural biogas plants, which for the first time uses a post-digestion product for its own needs or places it on the market, shall notify in writing the voivodeship plant health and seed inspector competent for the place of residence or registered office of such entity of its intention to use the product for its own needs or to place it on the market, together with the following information:

1) name of the post-digestion product;
2) name, surname, place of residence, and address or name and registered office and address of the entity authorized to operate in agricultural biogas plants which places the post-digestion product on the market;

3) start date of own use or marketing of the post-digestion product;
4) address of the place where the post-digestion product was produced;
5) form of the post-digestion product;
6) information that the post-digestion product has been produced from animal by-products or derived products or contains animal by-products or derived products;
7) information on the substrates from which the post-digestion product was produced;
8) information on the estimated annual average amount of post-digestion product that it intends to use for its own needs or to place on the market.

The above information shall be submitted to the voivodship inspector no later than 14 days before the post-digestion product is used for own purposes or placed on the market. In the event of a change in the substrates from which the post-digestion product was produced, the entity authorized to operate in agricultural biogas plants shall provide such information to the voivodeship inspector no later than 7 days before the post-digestion product is used for own purposes or placed on the market."

The legislator structured the regulations to prevent potential abuse and soil contamination – a concern often raised in discussions about simplifying the process for using digestate as fertilizer. Therefore, the provisions of the act provide for appropriate quality control of the post-digestion product and its compliance with the regulations.

The post-digestion product must meet the requirements for the minimum content of fertilizing components and organic matter, and must not exceed the content of impurities (heavy metals, pathogenic organisms, and parasite eggs), as was the case before. The compliance of the post-digestion products with these requirements must be demonstrated by tests of chemical and biological parameters carried out in regional chemical and agricultural stations or in other accredited laboratories. Therefore, the digestate will be tested (as before), which will ensure environmental safety, but

BIOGAS PRODUCERS, WHO SEE DIGESTATE AS AN OPPORTUNITY FOR MORE INCOME, MAY CONSIDER ENTERING THE EU MARKET WITH A CERTIFIED FERTILIZER PRODUCT

without the need to go through a complex procedure before being placed on the market.

The ban on the use of fertilizers, including post-digestion products, on frozen, flooded, water-saturated, or snow-covered soils is maintained. On the other hand, the use of post-digestion products in liquid form, as well as natural fertilizers, is not allowed during the growth of plants intended for direct human consumption.

The entry into force of the Act on facilitating the preparation and implementation of investments in the field of agricultural biogas plants, as well as their operation in the current form, will facilitate the use of digestate for fertilization, while guaranteeing environmental safety.

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DIGESTATE AS AN EU FERTILIZING PRODUCT

New opportunities for increased revenue from biogas plant operations are provided by regulations governing the marketing of digestate to European Union markets. Digestate can become a fertilizer product, which is defined as: "a substance, mixture, microorganism, or any other material, applied or intended to be applied to plants or their rhizosphere (...), either alone or after mixing with another material, for the purpose of providing nutrients to plants or fungi or for improving the efficiency of nutrient use." In order for a fertilizer product so understood to be made available on the EU market, it must have the appropriate label, which is awarded on the basis of a conformity assessment, i.e. a demonstration that the requirements of Regulation (EU) 2019/1009 for an EU fertilizer product have been met. Such compliance is assessed by specialized units operating in various EU countries. The first Polish body notified by the European Commission in this regard is the Polish Center for Research and Certification since 2021. The certification of a fertilizer product can also be carried out in other countries, but it is necessary to check whether the given body is notified for the appropriate module, i.e. testing of individual materials contained in the fertilizer product. Among the materials, labeled CMC and numbered from 1 to 15, we find two references to digestate:

- CMC 4 – post-digestion products from fresh plants,
- CMC 5 – post-digestion products other than CMC 4.

In Poland, it is rather difficult to find a biogas plant that digests only plant material, let alone fresh, so the digestate will fall under the designation CMC 5. The module covering pre-market testing of CMC 5 material in EU markets is module D1. A number of activities and tests are performed as part of the conformity assessment process. The notified body relies on the information provided by the producer of the material (in our case – the producer of the digestate). The producer prepares technical documentation, ensures control of the production process, and after certification, properly labels the fertilizer product and prepares an EU declaration of conformity. In turn, the notified body selected by the producer evaluates the quality system of the production process, its compliance with the requirements of the regulation, and conducts an audit covering both the production process and the composition of the digestate and/or any additives that may be mixed with the digestate. The CE certification process for fertilizer products may seem complicated, but it allows access to international markets, which can bring significant revenue. The cost of certifying an EU fertilizer product is determined on a case-by-case basis for each producer after consultation with the Polish Center for Testing and Certification. Information on the details of the certification process can be obtained from this institution, as well as by attending trainings and meetings where the Center's staff explain these seemingly very complex issues. However, after completing the training, it can be concluded that the certification process is somewhat similar to the process of obtaining a permit to market digestate as a fertilizer, currently performed at the Ministry of Agriculture and Rural Development. The coming months will show whether the Act on facilitating the preparation and implementation of investments in the field of agricultural biogas plants, as well as their operation, will come into force – and if so, in what shape. Will it actually be possible to obtain the facilitations already indicated in the name of the Act? For digestate, this would be a very beneficial solution and, importantly, safe for the environment. Biogas producers, on the other hand, who see digestate as an opportunity for more income, may consider entering the EU market with a certified fertilizer product. The domestic market also favors the marketing of digestate, a natural, valuable and environmentally friendly material that adds nutrients and organic matter to the soil.

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BIOGAS, BIOMETHANE, BIOLNG, OR BIOCNG – WHICH IS MORE PROFITABLE?

ANSWERING SUCH A QUESTION, EVEN SUPERFICIALLY, WOULD REQUIRE A MUCH LARGER ANALYSIS, SO IN THIS MATERIAL WE WILL LIMIT OURSELVES TO A COMPARISON OF CHP PRODUCTION AND BIOGAS PRODUCTION "TO THE NETWORK".

The analysis looks at profitability from the investor's point of view, choosing one of the following investment scenarios, taking into account the existing operational support system for the production of electricity in cogeneration from agricultural biogas and the hypothetical support system for the production of biomethane (reference price equal to the guaranteed price).

Other options, in particular the further processing of biomethane into a liquefied form (bioLNG) or a highly compressed form (bioCNG), are deliberately omitted, because even for "normal" biomethane alone, analyses indicate that decisions should be postponed until an operational support system with a higher guaranteed price is in place, or the regulator determines the amount of the compensatory payment for failure to meet the obligation to have a certain amount of biomethane for biohydrogen production[1] to meet the National Indicative Target.

In the first half of 2023, electricity generated in a given renewable energy facility can benefit from:

1) support system for certificates of origin (green[2] certificates);
2) support system for agricultural biogas certificates of origin (blue[3] certificates);
3) support system in the form of a guaranteed price (negative balance coverage);
4) auction[4] support system;
5) prosumer settlement[5];
6) settlements with energy cooperatives[6].

From the above options, we choose the support system from point 3, because it is the only one available for new installations, and the only one that is really good and operationally attractive.

Table 1 shows the current 2023 reference prices for different RES energy carriers and different sizes of these installations. The support system works for these installations in the range from practically 0 to 2.5 MW of installed electrical power.

The reference prices shown are maximum prices[7] for bids submitted at auctions announced by the President of the Energy Regulatory Office at least once a year, separately for individual energy carriers. For producers of electricity from biogas, biomass, and hydropower, the above prices have additional significance – they are a reference to determine the amount of sales prices in the FiT/FiP support system.

SUPPORT SYSTEMS FOR BIOGAS

The FiT[8] system consists in a producer being granted the right to conclude an agreement with an obligated seller[9] for the sale of electricity at a fixed price, which is 95% of the reference price. This system is intended for installations with a total installed electrical capacity of less than 500 kW.

The FIP[10] system is based on a premium added to the market price, i.e. covering 90% of the value of the so-called negative balance, which is the difference between the reference price announced for a given installation and the average market value of electricity sales[11]. This system is intended for installations with a total installed electrical capacity of not less than 500 kW and not more than 2.5 MW in the case of biogas and hydropower installations, or not more than 1 MW in the case of an installation using only biomass to generate electricity in that RES installation.

The fixed purchase price is subject to annual adjustment by the average annual consumer price index from the previous calendar year, as determined by the announcement of the President of the Central Statistical Office, published in the Official Journal of the Republic of Poland "Monitor Polski". In both cases, the differences between market values and FiT/FiP prices are covered by the Zarządca Rozliczeń S.A. company.

In April 2023, an installation with a capacity of e.g. 1 MW produced stable energy and generated 720 MWh per month (this is the maximum production – assuming

TAB. 1. REFERENCE PRICES FOR RES INSTALLATIONS DEPENDING ON THE TYPE AND SIZE

2022	Primary energy carrier/installed capacity in kW	<500	500-1000	>1000
BR	Agricultural biogas	PLN 785/MWh	PLN 715/MWh	PLN 700/MWh
BRK	Agricultural biogas in cogeneration	PLN 920/MWh	PLN 840/MWh	PLN 800/ MWh*
BS	Biogas from landfills	PLN 730/MWh	PLN 705/MWh	
BSK	Biogas from landfills in cogeneration	PLN 820/MWh	PLN 800/MWh	
BO	Biogas from wastewater treatment plants	PLN 515/MWh	PLN 470/MWh	
BOK	Biogas from wastewater treatment plants in cogeneration	PLN 640/MWh	PLN 590/MWh	
BI	Other biogas	PLN 570/MWh	PLN 525/MWh	
BIK	Other biogas in cogeneration	PLN 645/MWh	PLN 605/MWh	
H	Hydropower	PLN 770/MWh	PLN 705/MWh	PLN 675/MWh
B	Biomass combustion	PLN 525/MWh		
TO	Thermal treatment of waste	PLN 420/MWh		
TOK	Thermal treatment of waste in cogeneration	PLN 580/MWh	PLN 550/MWh	
BP	Bioliquids	PLN 520/MWh		
WL	Wind on land	PLN 340/MWh	PLN 340/MWh	PLN 295/MWh
WG	Geothermal energy	PLN 515/MWh	PLN 515/MWh	PLN 515/MWh
PV	Solar radiation energy	PLN 375/MWh	PLN 375/MWh	PLN 355/MWh

* THE PRICE OF PLN 800/MWH WITH 90% VALUE COVERAGE (I.E., PLN 720/MWH) WAS USED FOR THE CALCULATIONS IN TABLE 2.

the operation of the cogeneration unit at full load, without service breaks and unplanned shutdowns by the network operator). In the negative balance coverage system (effectively guaranteed price), it should have a sales value of 720 MWh x PLN 720 = PLN 518,400. Selling on the Polish Power Exchange (TGE) at the BASE price at the exchange rate of the day, it would obtain a sales value of PLN 412,179, so the so-called negative balance of PLN 518,400 - PLN 412,179 = PLN 104,700 will be transferred by Zarządca Rozliczeń S.A. to the producer's account, so that the producer can obtain income in a guaranteed amount.

In the example above, the price of PLN 720 is 90% of the reference price for installations with an installed capacity of more than 1 MW. For installations with a capacity of less than 1 MW (e.g. 0.999 MW), the above calculation would look like this: PLN 756 (90% of the reference price for installations larger than 500 kW and smaller than 1 MW, i.e. 90% x PLN 840/MWh) x 719 MWh = PLN 543,564, i.e. the negative balance would be over PLN 132,000. It is not important at what price it was actually sold, the mechanism is based on the guarantee of a certain revenue from a certain amount of energy produced.

EXAMPLE OF BIOMETHANE SUPPORT SYSTEM

Let us imagine a similar support system for biomethane energy, e.g. for a gas distribution network.

We assume a realistic gas-to-electricity conversion factor, corresponding to an electrical efficiency of 40% (we assume the same factor for the available heat energy from cogeneration, taking into account the additional 12-15% of the heat used for heating the digesters). To produce 720[12] MWh of electricity, a biogas producer must use 720/40% = 1,800 MWh of gas energy.

However, for the sake of profitability comparison, let us assume a different installed electrical capacity – at the maximum allowed by this support system, i.e. 2.5 MW (this is about the lack of profitability of building and operating small biomethane plants – as opposed to biogas plants that produce electricity). In an example month, the installation would produce: 30 days x 24h x 2.5 MW = 1,800 MWh of electricity, consuming 4,500 MWh of gas energy. The revenue of the electricity producer would be 1,800 MWh x PLN 720 = PLN 1,296,000 in the example month.

If they can reasonably manage the heat from cogeneration, the selling price of "green" heat (without distribution) can be assumed as PLN 100/GJ (although it should be noted that the use of heat from biogas cogeneration is quite often problematic). In the example month, additional revenue could be obtained from the use of 1,800 MWh of thermal energy, i.e. 6,480 GJ, so the additional revenue would amount to PLN 648,000 at this price.

The total revenue from the sale of electricity at the guaranteed price and heat from cogeneration (at a

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price of 2/3 of the maximum price, significantly below the market price) would amount to PLN 1,944,000.
Other revenues, mainly from the sale of digestate, will be the same in both considered variants, as will raw material costs and a portion of operating expenses. The financial costs and depreciation will differ (which is due to significantly higher investment costs – we estimate the cost of a biomethane plant at about 150% of the cost of an electric plant of equivalent capacity).
According to information from various sources, the government is establishing a support system for the production of biomethane in the amount of PLN 475 per 1 MWh (in 2023 prices). The investor will first compare the revenues: in the example month, the revenue from the production of biomethane would be PLN 2,137,500 (4,500 MWh x PLN 475), and the revenue from the production of electricity and heat would amount to PLN 1,944,000.
The difference would therefore be only PLN 193,500 "in favor" of biomethane.
Given that both plants in the "biogas" part use the same amount of electricity, the differences in electricity consumption in the "downstream" part are very significant.
A high-capacity CHP cogenerator consumes no more than 5% of the energy produced for its own needs (even less if the heat is used outside, because the cooling system is not operating), while energy expenditures for upgrading[13] biogas to biomethane are 2-3 times more, so in the case of biomethane production, we must an additional expense in amount of approx. PLN 100,000 in this example month. If we assume (very conservatively) that the cost of such a biomethane plant (comparing the investment costs between CHP and a biomethane treatment and packaging installation) is higher for the values given above by approx. PLN 8-10 million, then the financial costs themselves increase (with current cost of capital) by at least PLN 100,000 per month. After adding depreciation and increased maintenance and external service costs, we get a margin on biomethane about 200k lower than for electricity and heat production under the support system cited at the beginning. In this situation, the investor will probably decide to invest in a biogas plant producing electricity and heat in cogeneration, as a known, proven, and simpler technology with a stable support system.

ANALYSES FOR LARGE BIOMETHANE PLANTS FOCUSED ON BIOLNG PRODUCTION ARE ECONOMICALLY VERY FAVORABLE. THERE ARE LOCATIONS IN POLAND WHERE THE HIGH AVAILABILITY OF SUBSTRATES ALLOWS FOR HIGH CAPACITY INSTALLATIONS.

INDUSTRY RECOMMENDATIONS

The Polish Biomethane Association reported to the Ministry of Climate and Environment on the need to set the first reference price for biomethane for 2023 at 600 PLN/MWh, based on the French experience (the first support price in France was 120 EUR/MWh). We believe that relatively high reference prices for "electric" biogas plants, with disproportionately low guaranteed prices for biomethane, will result in low interest in biomethane investments.
We believe that the best solution would be to "loosen" the corset irreversibly defining the produced energy carrier. In the practice of agricultural biogas plants, there are already precedents, as there exist the following categories:
• production of electricity from agricultural biogas in a cogeneration system;
• production of agricultural biogas for other uses: combustion for thermal energy in a gas burner (boiler) and in a feed material dryer;
• production of agricultural biogas for other uses – sale of agricultural biogas to another producer;

there are also mixed scopes and types of activities.
It seems that in the long term, electricity production from agricultural biogas and biomethane production in at least one form – a single renewable energy plant – is the best and most future-proof solution[14].
Completing the comparison of various scenarios for the use of

TAB. 2. REVENUES FROM THE SALE OF ENERGY FROM A BIOGAS PLANT WITH A CAPACITY OF 1 MW ACCORDING TO THE DAILY PRICE ON THE POLISH POWER EXCHANGE (ASSUMING A GUARANTEED PRICE OF PLN 720 - EXAMPLE MONTH).

Day of the settlement period	Price referred to in Art. 93 sec. 2 point 1 [PLN/MWh]	Daily TGeBase price referred to in Art. 93 sec. 2 point 2 [PLN/MWh]	Amount of energy sold referred to in Art. 93 sec. 2 point 1 [MWh]	Value of energy sold in a given month [PLN]
1	720	548.05	24	13 153
2	720	376.22	24	9 029
3	720	573.84	24	13 772
4	720	663.03	24	15 913
5	720	691.55	24	16 597
6	720	641.16	24	15 388
7	720	633.70	24	15 209
8	720	585.15	24	14 044
9	720	527.11	24	12 651
10	720	475.55	24	11 413
11	720	592.57	24	14 222
12	720	660.47	24	15 851
13	720	687.17	24	16 492
14	720	642.67	24	15 424
15	720	558.39	24	13 401
16	720	555.54	24	13 333
17	720	647.18	24	15 532
18	720	604.55	24	14 509
19	720	592.20	24	14 213
20	720	587.85	24	14 108
21	720	580.28	24	13 927
22	720	548.38	24	13 161
23	720	399.77	24	9 594
24	720	598.73	24	14 370
25	720	591.88	24	14 205
26	720	528.63	24	12 687
27	720	561.00	24	13 464
28	720	575.17	24	13 804
29	720	566.30	24	13 591
30	720	380.03	24	9 121
Total for the entire settlement period			**720 MWh**	**412 179**

biogas, it is also worth mentioning two promising concepts of market development, which differ greatly in terms of plant size, final product, and mode of operation. These include peaking biogas plants operating in the small plant range (e.g. biogas plants with a linear biogas capacity of 250 kW, but with a 499 kW engine installed) and large biomethane installations (with a capacity of several or over a dozen MW) with the production of bioLNG. The first group of biogas plants has great prospects for development, but it is necessary to legally enable the connection of such installations to the medium-voltage power network – especially where there is theoretically no free connection capacity, which is often the case due to existing or planned photovoltaic farms, although in practice they use a maximum of several percent of the network capacity on average per year. Meanwhile, a peaking biogas plant, as an installation capable of accumulating the produced biogas in domes over digestate and/or digestion tanks for a period of several hours, is very well suited for peak operation (e.g., 12 h/day), during early morning (when PV is not yet running) and afternoon/evening (when PV stops producing electricity). Currently (May 2023), there is still no legal possibility for such connections, but allowing biogas peaking plants (with energy storage in chemical form – biogas) to be connected to the network would free up thousands of MW of additional capacity at virtually no cost to operators for plants that produce green energy in a fully controllable manner, regardless of weather conditions or season.

Preliminary economic analyses conducted at the Poznań University of Life Sciences show high profitability for such investments.

Analyses for large biomethane plants focused on bioLNG production are also economically very favorable. There are locations in Poland where the high availability of substrates allows for high capacity installations (the largest project we know of is expected to have up to 26 MW of gas power). It should be noted, however, that although large-scale installations are very suitable for the production of bioLNG, their construction (as in the case of most planned biogas plants with a capacity of over 0.5 MW) may be associated with more or less intense public protests. In the perspective of the next decade, with restrictions on the use of fossil fuels in transportation planned by the EC, an increase in interest and profitability for both bioCNG and bioLNG production can be expected.

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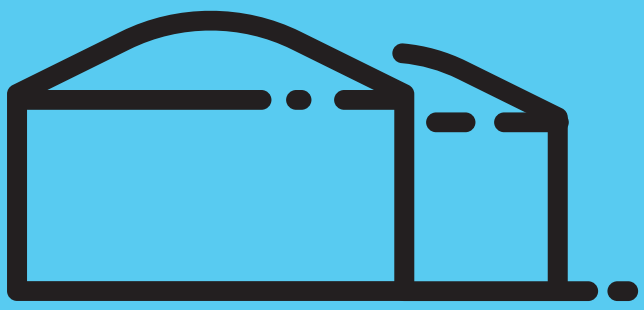
NOTES:

1. Biohydrogen is produced in a hydrogen plant that uses biomethane obtained from biogas as raw material. According to current estimates, this creates a market for approx. 500 million Nm^3 of biomethane in 2030.
2. The current market price is approx. PLN 200/MWh.
3. This form of support, limited only to biogas installations producing electricity before June 30, 2016, currently applies to approx. 70 installations, the current market price (unchanged for 7 years) is approx. PLN 300/MWh.
4. The auction system, unsafe for sources that have to buy substrates, has not worked well for biogas plants – few installations participate.
5. Most likely only for the smallest producers, rarely used system in the biogas industry.
6. The register kept by the DG of the National Support Center for Agriculture currently (end of April 2023) includes seven energy cooperatives with only PV installations with a total capacity of 1.387 MW, i.e. capable of producing approx. 1200-1300 MWh per year.
7. Energy sales offers with higher prices are not considered.
8. Feed-in-tariff is a guaranteed price system, intended for electricity producers in installations with an installed capacity of less than 500 kW.
9. The obligated seller is the seller of electricity with the largest volume of sales to end customers connected to the distribution network of a given operator in the area of operations of this operator, designated annually by the President of the Energy Regulatory Office. As of 2023, 183 obligated sellers have been appointed for 189 distribution system operators and one transmission network operator (Polskie Sieci Elektroenergetyczne).
10. Feed-in-premium is a system of subsidizing the market price, intended for electricity producers in installations with an installed capacity of more than 500 kW and less than 2.5 MW (also with a capacity of less than 500 kW after a declaration to sell unused energy to entities other than the obligated seller).
11. Based on daily quotations of the Polish Power Exchange (TGE).
12. The assumed values serve only to illustrate the issue of profitability, the actual figures would be different, although the authors of the article know biogas installations that produce electricity with 97% utilization of installed capacity throughout the year.
13. We assume that the treatment, i.e. the elimination of water and hydrogen sulphide, is the same in both scenarios of biogas use.
14. Already in 2011, we saw an installation in Germany that produced both electricity for the network (approx. 2 MW in peak hours), electricity for own needs, and biomethane for the network.

BIOMETHANE IN POLAND



BIOMETHANE IN POLAND – WHERE IS THE MARKET HEADING?

THE EUROPEAN GREEN DEAL SETS A TARGET FOR THE EU TO ACHIEVE CLIMATE NEUTRALITY IN 2050 IN A WAY THAT CONTRIBUTES TO THE RECOVERY OF THE EUROPEAN ECONOMY, ECONOMIC GROWTH, AND EMPLOYMENT. THE WAR IN UKRAINE, THE RELATED ENERGY CRISIS, AND THE GENERAL SENSE OF ECONOMIC INSECURITY HAVE FOSTERED A TENDENCY TO "POSTPONE" THE TOPIC OF CLIMATE NEUTRALITY "FOR LATER". THAT TIME, HOWEVER, IS OVER.

The crisis has clearly shown us all how dangerous dependence on fossil fuels can be, and how relatively well countries with a high share of renewable energy in total energy consumption have survived the difficult months of 2022 and 2023.

The European Union as a whole exceeded its targets for the share of renewable energy in gross final energy consumption in 2020 (22% instead of the targeted 20%), and the target of a 45% share of renewable energy in gross final energy consumption at the Union level by 2030 appears feasible, which will also allow the EU's greenhouse gas reduction target to be met.

Our (biomethane) interests include (according to the Commission's communication of 18 May 2022 entitled "REPowerEU Plan") increasing the production of sustainable biomethane to at least 35 billion Nm^3 by 2030.

Poland is particularly predestined to play an important role in achieving this goal. We still have a strong agriculture, capable (at least for now[1]) of achieving good results in export production.

Our biogas sector (biomethane is non-existent) is one of the least developed in Europe, which means that we have a lot of unused substrates, including the most interesting ones, i.e. animal waste and lignocellulosic raw materials.

According to the information of the National Support Center for Agriculture from 2022, agricultural biogas plants processed 35 substrates (or groups of substrates), with just a few of them securing 85% of energy production by both weight and energy, and more than 20 had a biogas energy share of less than 1% of the total energy produced.

The degree of substrate utilization is best demonstrated by liquid manure, which is the second most widely used mass substrate in Poland, right after stillage. Its consumption in agricultural biogas plants in 2022 amounted to 935 thousand tons, which is only about 2% of the liquid manure production of dairy cows, of which we have nearly 2 million (out of a total of 6 million). The management of manure, the largest emitter of greenhouse gases (primarily methane), is negligible, at less than 100,000 tons, below the statistical error.

So we have the famous "potential", which is estimated differently, but the usual figure given is a production capacity of 7-8 billion Nm^3 of biomethane per year. The Polish Biomethane Association approaches these estimates with caution because the sources of these substrates are very dispersed and most of them come from industry, which unfortunately is not a reliable source.

BIOMETHANE MARKET IN POLAND – LEGAL STATUS

Since the beginning of 2023, we have had quite a "burst" of legislative activity in an area that may be of interest to readers of this Report. This is due to a number of factors, the most important of which are our obligations to the European Union resulting from the almost two-year delay in implementing the RED II Directive into Polish law (the deadline was 30 June 2021).

The draft act on biomethane solutions and energy clusters is a milestone indicated in the National Recovery and Resilience Plan (NRP) as part of the B2.2 reform. "Improving the conditions for the development of renewable energy sources" in terms of milestone – B22G "Entry into force of acts amending the legislative framework for renewable energy communities and biomethane: amendments to the RES Act, amendments of legislation concerning energy market, and entry into force of a regulation to the RES Act".

The above draft assumes the adoption and entry into force of amendments to legal acts and regulations, including amendments to the Act of February 20, 2015 on renewable energy sources (RES), which will reformulate the rules for the operation of energy clusters, implementation of collective energy prosumer models, new renewable energy communities, etc. For biomethane, the last provision of this "milestone" is important – the commitment to amend the RES Act, which sets out the rules for doing business in the biomethane sector.
The milestones are monitored by the EU and the so-called qualitative indicators for them are mercilessly specific and in the case of B22G read as "(...) Entry into force of acts amending the legislative framework for renewable energy communities and biomethane: amendments to the RES Act, amendments of legislation concerning energy market, and entry into force of a regulation to the RES Act (...)". A qualitative indicator is simply the emergence of "(...) provisions in the amended legal acts and regulation indicating their entry into force (...)". The deadline for the implementation of this task has already passed (first quarter of 2023), but since this is not the most "pressing" milestone for Poland, nothing bad is happening yet. It would be worse if, due to the upcoming elections and only a few sessions of Parliament before the elections, these provisions could not be passed in the current term of office.

IMPORTANT REGULATIONS

Below we present the most important national legal regulations concerning the biogas industry and determining the development of the biomethane industry in Poland.

• Draft act amending the act on biocomponents and liquid biofuels and certain other acts (UC110).

The draft act, formally submitted by the Ministry of Climate and Environment on February 15, 2022, is currently at the stage of the Committee for European Affairs addressing the Standing Committee of the Council of Ministers (March 27, 2022), with a recommendation to consider the draft act (along with a record of divergences taking into account the unaccepted comments of some Ministers[2]), after appropriate submission by the Minister of Climate and Environment.
From the point of view of biomethane, the most important provision in this act is that the entity implementing the National Indicative Target is obliged to ensure in a given calendar year at least a minimum share of advanced biocomponents contained in liquid and gaseous fuels or biofuels used in all modes of transportation. In addition, the entity implementing the National Indicative Target, which has a license for the production of liquid fuels within the scope of processing crude oil and intermediate products of refining crude oil or other hydrocarbons, is obliged to ensure in the above mentioned share the share of biohydrogen produced from biomethane, embedded in fuel particles during refining processes, in the total amount of liquid fuels and liquid biofuels produced for use in road and rail transportation. The share of so-called advanced biocomponents cannot be less than 0.70% in 2024 and must gradually increase to 3.50% in 2030, and the share of biohydrogen produced from biomethane cannot be less than 0.10% in 2024-2025 and must gradually increase to 1.75% in 2030.
Thanks to the description in the Regulatory Impact Assessment attached to this draft act, we know that this means a demand for 500-600 million Nm^3 of biomethane in 2030, which requires the construction of over 100 large installations producing biomethane.
Still missing, however, is the very important information on the amount of the compensatory payment for failure to fulfill these obligations and the amount of penalty for failure to fulfill the obligation and pay the compensatory payment. According to our assessment, the compensatory payment may be around PLN 500-600, and the penalty may be twice as much.

• Draft act amending the act on renewable energy sources and certain other acts (UC99).

The project, formally submitted by the Ministry of Climate and Environment on February 25, 2022, implements the provisions of European Union law, specifically Directive (EU) 2018/2001 of the European Parliament and of the Council of December 11, 2018 on the promotion of the use of energy from renewable sources.
On March 6 this year, the Ministry of Climate asked the Legal Committee to submit the draft for consideration as soon as possible[3].
The draft act in February and March 2023 underwent significant changes with regard to the production of biomethane. Contrary to the previous assumptions, its latest amendments primarily introduce an operational support system for biomethane (admittedly, only for the network and with limitations as to the capacity of the gas installation[4]), probably due to the understanding that without a guaranteed price, the scarcely produced biomethane in the form of liquefied bioLNG will simply be shipped abroad, from where it will have to be purchased at significantly inflated prices by entities obligated under the Act on biocomponents and liquid biofuels and certain other acts, i.e. mainly PKN Orlen.
The support system resulting from the UC99 Act will make it possible to achieve this goal in a significantly cheaper way.
Hopes for starting biomethane production by state-owned entities have not yet been confirmed, and the goal of producing 1 billion Nm^3 of biogas from its own installations in 2030, declared by PKN Orlen, is difficult to achieve because it would require (if based

on the maximum size of installations covered by the support scheme) construction of approx. 250 installations producing biomethane for the network.
In accordance with EU regulations, the draft also provides for the implementation of guarantees of origin, which should be extended to gas from renewable sources. This would provide a consistent way to prove the origin of renewable gas such as biomethane to end users and facilitate the development of cross-border trade in such gas. As a result, it would also be possible to introduce guarantees of origin for another renewable gas – hydrogen. Polish guarantees of origin would apply to energy generated from renewable energy sources in RES installations: electricity, biomethane, heat or cold, renewable hydrogen, but also biogas and agricultural biogas.
The guarantees, expressed in MWh, will be the only document that certifies to the final recipient that the amount of energy specified therein was generated from renewable energy sources in renewable energy source installations and injected into, respectively, the electrical, gas, heating, or cooling network, to which at least one recipient other than an entity generating, respectively, electricity, biomethane, heat or cold, renewable hydrogen, biogas or agricultural biogas is connected, or was injected at another location, that is:

- in the case of electricity – delivery either through a direct line or directly to a renewable energy installation producing renewable hydrogen or biomethane;
- in the case of renewable hydrogen, biogas, or agricultural biogas – the place of introduction into a means transportation other than gas networks;
- in the case of biomethane – the point of introduction into a means of transportation other than gas networks or the point of introduction into an installation for refueling motor vehicles with biomethane, if there is no need to transport biomethane.

THE IMPLEMENTATION OF THE NATIONAL INDICATIVE TARGET BY THE OBLIGATED ENTITIES IN ACCORDANCE WITH THE ANTICIPATED SHARE OF ADVANCED BIOCOMPONENTS MEANS DEMAND FOR 500-600 MILLION NM3 OF BIOMETHANE IN 2030, WHICH REQUIRES THE CONSTRUCTION OF 100 LARGE INSTALLATIONS

These regulations mean quite revolutionary, as for Polish conditions, equalization of all energy sources and practically all methods of their transfer (transportation), which until recently was at least questionable.
It is not entirely clear whether the subsequent provision on the transferability of the guarantee of origin (and especially the wording that the issuance and disposal of the guarantee of origin takes place regardless of the use of mechanisms and instruments to support energy production) does not constitute state aid.

• Draft act on facilitating the preparation and implementation of investments in the field of agricultural biogas plants (UD485).

In the regulatory impact assessment (RIA), the authors of the draft act state that the prepared act facilitates the preparation and implementation of investments in the field of agricultural biogas plants, without imposing additional obligations on beneficiaries that are disproportionate to the scope of the changes.
Among the solutions adopted, it is important to point out the significant simplifications proposed, which are important both in the investment phase and in the operation of the plant:

- the solution that in the case of an agricultural biogas plant meeting the conditions set out in Art. 4(1), located on a farm recognized as land with an area of not more than 1 ha occupied by buildings, the structures and equipment of the agricultural biogas plant shall be classified as agricultural land within the meaning of Article 2(1) of the Act of February 3, 1995 on farm and woodland conservation (Journal of Laws of 2022, item 2409),
- no need for an administrative procedure related to the possibility of using a specific substrate in an agricultural biogas plant. A list of such "safe" substrates will be indicated in secondary legislation issued on the basis of the delegation of legislative powers under Article 4(3),
- placing on the market post-digestion products specified in the regulation of the Minister competent for agriculture without the need to obtain the permission of the minister competent for agriculture.

Facilitations in the procedure for obtaining a land development decision include:

- specifying that the land development decision should be issued within 65 days. It should be noted that in the light of the provisions of the Act of March 27, 2003 on Spatial Planning and Development, failure to comply with this deadline will result in imposing a fine on the authority;
- establishing a closed catalog of parties to the proceedings for the issuance of a land development decision for an agricultural biogas plant. These are exclusively the applicant and the owners and perpetual usufructuaries of the real estate located in the area affected by the investment.

It is difficult to say in which direction the biomethane market is heading, as it does not yet exist

in Poland. The above information on the specific regulations already planned indicate that conditions are being created for such a market to emerge.

WHO WILL BE THE PARTICIPANTS OF THE BIOMETHANE MARKET?

In our opinion, there will be a far -reaching polarization of producers – in line with common sense, following in the footsteps of our western and northwestern neighbors. In Germany, apart from one exceptional installation in Penkun[5], the average size of a biogas plant expressed in terms of electrical power is approx. 400 kW, although there are also smaller ones, such as the 170 kW biogas plant near Leipzig, which I had the opportunity to visit in 2009. Taking into account the number of animals reared by the farmer (both cattle and pigs) and the acreage owned, such installation capacity will manage all animal excrements and meet over 75% of the farm's fertilization needs. It should be similar in Poland, which of course does not exclude larger installations, e.g. on large livestock farms or, what would be most interesting, on the basis of neighborly agreements between animal breeders and plant producers, not necessarily within cooperatives. However, given the approach of our farmers to the idea of cooperation, this direction would require a stronger stick (emissions) and carrot (investment grants).

Another group is likely to be large players, including those with foreign "roots", who will be primarily focused on the production of biomethane for the network, but also for transportation purposes. They will seek to create agreements with agricultural producers and processors on the basis of common interests, and nothing unites them more than concern about their "carbon footprint". Increasingly, our dairy and fish producers are receiving – for now – innocuous-sounding questions about the carbon footprint of their products, with thinly veiled information about competitors' activities in this area.

HOPES FOR STARTING BIOMETHANE PRODUCTION BY STATE-OWNED ENTITIES HAVE NOT YET BEEN CONFIRMED, AND THE GOAL OF PRODUCING 1 BILLION NM3 OF BIOGAS FROM ITS OWN INSTALLATIONS IN 2030, DECLARED BY PKN ORLEN, WOULD REQUIRE THE CONSTRUCTION OF APPROX. 250 BIOMETHANE INSTALLATIONS

There will also be a third group – the largest entities operating in the areas of highly profitable investments, which will focus on the processing of lignocellulosic substrates – a practically inexhaustible resource of highly concentrated energy, from which, in a combination of two or even three conversion processes, nearly 100% of the potential energy contained in these substrates can be obtained. Currently, the energy contained in biomass is many times greater than its consumption.

However, activities in this area require significant financial resources, assuming a certain risk associated with new technologies. The solutions already operating on a smaller scale indicate the high profitability of such projects.

"Where to build?" – the answer is trivial and always true – this requires a very serious analysis. The times when we would build a biogas plant in a specific place, based on the opinions of random people, are long gone.

In simple terms, the location is determined by what we want to produce, and that in turn results from the economic environment and sales opportunities.

Who will invest in biomethane? For the time being, potentially interested parties are watching the legislative process – confidence in the stability of our country's RES solutions (in relation to the years 2012-2015 and the deliberate collapse of the certificate of origin system) is still too fragile to rush into serious investments. We hope that this will change in the coming months.

Marek Pituła
Polish Biomethane Association

NOTES:

1. However, there is an urgent need to address the carbon footprint of our export products. If nothing is done about it by the producers themselves, we may have problems selling them, as fish processors, larger dairies, as well as fats and oils processing plants are already noticing.
2. For example, the Ministry of Infrastructure opposes the abolition of the compensatory payment resulting from the implementation of the National Indicative Target as a source of funding for the Fund for the development of public utility bus transportation, the Ministry of Finance is worried about the same issue, and is concerned about the increase of budgetary costs resulting from the growing number of full-time positions at the Energy Regulatory Office, among others.
3. On February 15 this year, the European Commission contacted Poland for failing to notify measures to transpose the RED II Directive into national law (the deadline of June 30, 2022 passed 11 months ago).
4. The support system for biomethane to the network in the form of guaranteed prices is limited to the equivalent of 1 MW of electrical capacity, the regulator assumes the electrical efficiency of the CHP unit as 41%, or a gas capacity of 2.439 MW, or about 220 Nm3/h, or just under 2 million Nm3 of biomethane per year.
5. At the beginning of the 21st century, a huge biogas plant with a capacity of 20 MW was built there, sucking substrates from Brandenburg and our Western Pomerania, devastating the environment, etc.

BIOLNG IN POLAND – TECHNOLOGIES, COSTS, AND DEMAND

BIOLNG, OR LIQUEFIED BIOMETHANE, IS AN INCREASINGLY POPULAR RENEWABLE FUEL USED BY ENERGY-INTENSIVE INDUSTRIES. THE DEMAND FOR THEM IS GROWING RAPIDLY ACROSS EUROPE, AND POLAND – WITH ITS BIOGAS POTENTIAL – CAN BE AN IMPORTANT PART OF THE EUROPEAN BIOLNG MARKET.

BIOGAS – WHAT IT IS AND WHAT IT IS USED FOR

Biogas[1], considered a renewable energy source, is a gas produced from biomass, while agricultural biogas[2] is a gas produced from biomass in the process of anaerobic digestion[3]. This means that biogas produced, for example, by gasification or pyrolysis of biomass is also considered biogas, but not agricultural biogas.

Biogas contains methane (CH_4), so it can be burned. For small installations, it is often the best choice, especially prevalent in China and India, where there are tens of millions of home installations. The combustion of biogas can also be justified in technological processes where a large amount of high-performance thermal energy from renewable sources is needed during the manufacture of another product. Due to the increase in prices of all energy carriers, the use of biogas in local heating systems is also being considered.

Biogas can also be used to produce electricity and heat in cogeneration, but this process requires at least getting rid of water vapor and reducing the hydrogen sulphide content to a level acceptable by the engine manufacturer. Capstone, a leading manufacturer of gas turbines, allows the use of gaseous fuel with a hydrogen sulphide content of up to 5,000 ppm.

Unfortunately, biogas also contains other gases, such as carbon dioxide, hydrogen sulphide, and water, components that are no longer so useful and for other applications must be eliminated or at least reduced.

In Polish, we do not yet have a stabilized nomenclature for biogas-related technological processes.

In practice, there are terms such as *uzdatnianie* (treatment), *uszlachetnianie* (upgrading), *separacja* (separation), and even *modernizacja* (modernization) of biogas. It seems that the word *oczyszczanie* (purification) should be reserved for the elimination of water vapor (moisture), solid particles, and hydrogen sulphide, and the term *uzdatnianie* (treatment) for the process of biogas separation, i.e. separation of the methane stream from carbon dioxide and possibly other gases. With liquefaction, one should also find a Polish equivalent for the English "polishing" (one possible option is the word *polerowanie*), i.e. the elimination of trace amounts of the remaining carbon dioxide to almost zero values. If these gases can be completely removed, what remains is pure methane, which is called biomethane because of its origin.

FROM BIOGAS TO BIOMETHANE

In Polish law, biomethane is a biogas with a gross calorific value under normal conditions[4] of not less than 34 MJ/Nm^3, which corresponds to approx. 85% of the methane content in biogas. Biomethane can remain in the gas phase, in a more or less compressed state. If we inject it into the distribution network, we can (usually) limit the compression to approx. 0.5 MPa. When injecting into the transmission network, we have to assume as much as 8.5 MPa. When used as bioCNG for road transportation, very high pressures of 20-25 MPa are already required.

This study is devoted to the most advanced form of biomethane, namely liquefied biomethane, which has already been given the name bioLNG in Polish.[5]

Biomethane is treated biogas. Biogas is separated into two gas streams, in which the main components are methane (CH_4) and carbon dioxide (CO_2). The captured carbon dioxide can be purified and also liquefied for further use. The separated biomethane can be injected into the gas network, and when this is not possible, it can be liquefied (bioLNG). The produced bioLNG can be transported to a location where it can be used as transportation fuel or, after vaporization, as biomethane. Liquefaction can only occur at the right pressure and temperature: for methane it is about -162 °C at atmospheric pressure.

TAB. 1. EXAMPLE DISTRIBUTION OF CAPEX AND OPEX COSTS OF A BIOLNG INSTALLATION[7]

	UNIT	M	A	P	C
CAPEX	million PLN	34.10	29.98	33.64	31.70
Electric energy consumption	kWh/Nm^3 of biogas	0.76	0.64	0.86	0.78
Heat consumption	kWh/Nm^3 of biogas	-	0.99	-	-
Maintenance + parts	million PLN/year	1.16	0.64	1.00	1.02
Total costs OPEX	million PLN/year	7.08	7.04	7.70	7.08
Total costs OPEX	PLN/Nm^3 of biogas	0.83	0.83	0.91	0.83

Where: M – membrane technology; A – amine technology; P – PSA technology; C – cryogenic technology

Most often, however, biomethane is compressed to a few bars so that it can be liquefied at a higher temperature.

CAPITAL EXPENDITURES AND OPERATING COSTS FOR BIOLNG INSTALLATIONS

Financial outlays (CAPEX) and operating costs (OPEX) depend on the combination of methods of treatment and liquefaction of biogas to bioLNG. Table 1 shows an example cost breakdown for a plant with a capacity of 1,000 Nm^3 of biogas per hour (estimate based on early 2022 prices). The data presented in the table refer to the combination of individual biomethane and carbon dioxide treatment and liquefaction technologies, where the main division criterion was the method of biogas treatment[6]. All treatment methods (except cryogenic technology) require the use of a liquefaction unit based on one of the technologies described in the article.

TECHNOLOGIES FOR THE PRODUCTION OF BIOLNG

In order to safely liquefy biomethane in a continuous manner, it must be purified to the smallest values of carbon dioxide or water. Both water and carbon dioxide must be removed as they could solidify at low temperatures and damage the system. The process of cleaning biomethane is called "polishing". Typically, TSA (Temperature Swing Adsorption) technology is used for this. The installation typically consists of three columns filled with an adsorbent material (such as zeolite). The columns work in a predetermined time cycle, according to the following phases:

- adsorption,
- regeneration,
- cooling.

There are two basic methods of bioLNG liquefaction:

• Mixed refrigerant cycle

Modification of the cascade cycle using only one compressor and one refrigerant, which is a mixture of hydrocarbons. The gas is first pre-cooled in the first exchanger and then cooled with a mixture of hydrocarbons. This method is slightly more energy-intensive than the classic cascade cycle. It has the advantage of fewer installations needed for the process. Due to lower operating costs, different variants of this method are used more often than the classic cascade cycle.

• Expansion cycle using a turboexpander

Gas liquefaction installations using the method based on the expansion cycle operate on a principle similar to the classic Joule-Thompson method and installations producing liquid oxygen and nitrogen using low-temperature air fractionation. In this process, part of the gas is expanded in a device called a turboexpander, and then cooled to a very low temperature. The cooled gas is then used to liquefy another portion of the gas flowing through the installation. This method is relatively simple and does not require a large investment. It is characterized by high energy consumption needed to compress the gas[8].

EXAMPLES OF BIOMETHANE LIQUEFACTION TECHNOLOGIES

• Mixed refrigerant cycle (MR)

The compressed MR is cooled to a partially liquefied state and separated in a separator into a liquid fraction and a vapor fraction. The MR is further cooled in a heat exchanger to typically -155 to -160°C. The stream then passes through an expansion valve. The stream is expanded to a pressure

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close to the suction pressure of the compressor, which leads to a temperature drop of several degrees. The cold MR stream is partly used to cool the MR itself and partly to condense the biomethane. The MR stream is mixed with the liquid stream from the separator, reintroduced to the heat exchanger where it is superheated and sucked into the screw compressor. The heart of the MR circuit is a screw compressor with a high-performance oil separation system at the outlet.

• Rankine cycle

The refrigerant is continuously regenerated and goes through four stages: compression, liquefaction, expansion through a Joule-Thompson valve, and vaporization. The refrigerant is a mixture of hydrocarbons that allows biomethane to be cooled more efficiently. The refrigerant mixture contains components that allow it to be partially or completely liquid over a large temperature range, thus providing latent heat continuously throughout the heat exchanger. Inside the liquefaction unit, the mixture is liquefied and expanded. Expansion allows for further cooling of the refrigerant, which creates colder conditions for liquefaction and subcooling of the biomethane.

• Linde cycle

The process consists of three stages: compression, cooling, and liquefaction. The inlet stream is compressed by a reciprocating compressor to a pressure suitable for liquefaction. In order to achieve optimal liquefaction conditions, the gas is subjected to various phases of pre-cooling, using a single recirculation flow coming from the cryogenic zone and the chiller. Cryogenic temperatures are achieved by the cooling power of the two main stream baffles, which are subjected to pressure drops through Joule-Thomson valves. The decompressed cooling streams are then recovered and recirculated inside the installation.

BIOLNG AS A FUEL ALSO HAS ITS DISADVANTAGES: HIGH INVESTMENT OUTLAYS, GOOD PRICE ONLY WITH NEGATIVE GHG EMISSIONS (AND THIS LIMITS LOCATIONS), LONG WAITING TIME FOR KEY PLANT COMPONENTS

• Stirling cycle

IT is a closed cycle where the internal working gas never comes into contact with the liquid being cooled. The technology involves alternating compression and expansion of the working gas. The process can be divided into four stages. First, the gas is compressed, which increases the temperature of the gas. It then passes through a cooler where the heat of compression is dissipated into the cooling water, lowering the temperature of the gas. Subsequently, the working gas flows through the regenerator. Using the cold that has been stored in the regenerator over the previous cycle, the working medium is cooled down to near final operating temperature. The last and main stage is the expansion of the gaseous refrigerant. To start a new cycle, the system returns to the initial position. The regenerator is cooled by the flowing working gas, storing the cold for use in the next cycle.

WHO CREATES THE DEMAND FOR BIOLNG?

Demand for bioLNG is primarily driven by regulations that create demand for e.g. low emission fuels. When it comes to its liquefied form, it is the additional connection requirements for the gaseous form

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as well as the fashion for energy storage, where liquefied biomethane is one of the best energy storage technologies available (much better than hydrogen). Fuel companies use the process of mixing bioLNG with cheaper liquefied natural gas (so-called blending). This allows fuel stations to maintain stable prices while offering attractive prices to bioLNG producers. Companies operating in energy-intensive industries are obliged to gradually reduce greenhouse gas emissions. These institutions are interested in the purchase of biomethane produced from substrates included in Annex IX of the RED II Directive, as they allow double counting of the energy value of the biomethane used. The liquefied form of biomethane is a solution for transportation, for example, when a biomethane plant cannot be connected to the gas network.

ADVANTAGES OF BIOLNG: GOOD PRICE AND LENGTH OF CONTRACTS, BIOLNG IS EXCELLENT FOR ENERGY STORAGE – ONE CRYOGENIC TANKER IS 300 MWH OF ENERGY; EASE OF SALE (NO NETWORK CONNECTION CONDITIONS)

BIOLNG MARKET IN EUROPE

According to data from the statistical report on the biogas and biomethane industry in 2022 published by the European Biogas Association, there were 34 bioLNG plants in operation in Europe at the end of last year, located in 10 European countries (Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Sweden, and the United Kingdom). The average biomethane energy production for these installations was 60 GWh/year. Another 45 installations are scheduled to come online in 2023.
Some of the bioLNG installations currently in operation are owned by companies that produce installations for the treatment and liquefaction of bioLNG. The biomethane plants currently in operation use a variety of substrates, ranging from wastewater sludge to waste from the agri-food industry.

BIOLNG MARKET IN POLAND

In Poland, interest in biomethane investment is shown both by those who own substrates (e.g. multi-hectare farms or livestock farms) and by companies interested in using biomethane for their own needs or for sale. The

market is still in its infancy, and we can only anticipate the direction of its development based on the experience of our neighbors and the tasks related to biomethane, including for transportation purposes, set by the European Commission. We would recommend caution in this area, both on the part of potential investors and recipients. There is no doubt that all energy carriers (or rather their prices) are in a complex relationship with each other. The last LNG price at the gas station in Śrem shown on the chart is for March this year (PLN 7.75 gross per kg of LNG), in April it was already PLN 7.09 gross per kg, about 8% lower. On May 2, 2023, the price of natural gas on the Polish Power Exchange (TGE) was PLN 189.89/MWh, i.e. at the NBP exchange rate of PLN 4.5889/euro, it approached EUR 40/MWh. Converted to liquefied natural gas, this price was PLN 2.62/kg net[9] (PLN 3.22/kg gross), i.e. after taking into account transportation, margin, and profit of the seller, it could be close to the lowest quotations in recent years, such as in 2020.

On the same day, the price of electricity was PLN 475.99/MWh, almost exactly 2.5 times higher per unit of energy than natural gas. The 2.5:1 ratio, or in other words gas price = 40% of electricity price, results from the efficiency of gas-to-electric energy conversion, which is on average 40%. This relationship has been going on (with short to mid-term deviations, of course) for a very long time.

The situation is similar with probably the most important energy carrier, which is crude oil. The current prices of approx. USD 80/barrel (with a forecast of approx. USD 60/barrel) are approx. twice as high as in the summer of 2020, i.e. a relationship similar to the price of natural gas.

Are we in for a period of cheap energy? In our opinion, we can expect a return to prices from 2 years ago "with a + sign", i.e. gas will no longer cost EUR 20/MWh, but, for example, EUR 25-30/MWh. In the long term, with the development of low-cost RES sources in the area of electricity generation (primarily wind farms in our latitudes and PV in areas further south), we can expect a gradual decrease in the price of energy carriers, despite the "going green" policy, which, contrary to most popular opinions, will increasingly reduce, or at least not increase, energy prices.

Thus, one should be very cautious about the price declarations of potential bioLNG recipients, which does not mean, of course, that production of bioLNG with a negative carbon footprint cannot be profitable. According to the Polish Biomethane Association, at the current prices and natural gas price forecasts, the payback period for the best-configured bioLNG projects has simply increased to at least 4 years (with financing in EUR), i.e. it remains attractive, although not as attractive as it was a year ago.

Marek Pituła
Polish Biomethane Association

** The material was prepared in April 2023 - since then the reference prices of biomethane in Poland have changed.*

NOTES:

1. Definition of biogas: Article 2(1) of the RES Act: biogas – gas obtained from biomass, in particular from animal or plant waste processing facilities, wastewater treatment plants, and landfills.
2. The definitions of agricultural biogas from Article 2(2) of the RES Act and the new so-called special biogas act (UD485) differ from each other. In UD485 the definition is expanded to include, among others, out-of-date or unusable food products, sludge from industrial plants (and not just from agri-food processing), provided that industrial wastewater is separated from other types of sludge and wastewater.
3. In which organic matter decomposes in an environment devoid of oxygen.
4. Conventional reference conditions where the gas is at a temperature of T = 0.00ºC (equivalent to a temperature of t = 273.15 K) and a pressure of p = 1 atm (equivalent to a pressure of p = 101,325 Pa).
5. LNG – Liquefied Natural Gas; natural gas usually contains gases that never occur in biomethane, such as ethane and propane – gases with a much higher calorific value than methane.
6. I.e., if we give CAPEX for amine technology, for example, it means that the treatment itself is done with this technology, but the price also includes the liquefaction section. This does not apply to cryogenic technology, which by its nature is a single-stage, continuous process, in which, as the biogas temperature is lowered, its various components are liquefied at different times. Note – the prices apply only to the part of the installation that purifies and treats biogas into biomethane and its liquefaction (and carbon dioxide), they do not apply to the biogas part, i.e. digesters, feeding systems, blending, electricity production for own needs, etc.
7. Applies to installations with a capacity to produce 83,000 MWh of biogas energy, i.e. about 12.5 million Nm3 of biogas with a methane content of 60%, producing electricity for its own use, with a sales capacity of about 3,500 Mg of bioLNG per year. The price applies to the purification and treatment installation only (with polishing), with carbon dioxide liquefaction (bioCO2)
8. Jacek Molenda „Gaz ziemny. Paliwo i surowiec." Wydawnictwa Naukowo-Techniczne, Warsaw 1996
9. Such a price is definitely more attractive for the road transportation sector than the current diesel fuel price.

THE POWER NETWORK AND THE DEVELOPMENT OF BIOGAS IN POLAND

A DISTRIBUTION NETWORK IS A COLLECTION OF DEVICES THAT WORK TOGETHER TO ACCOMPLISH THE TASK OF DELIVERING ELECTRICITY TO CONSUMERS. THE MAIN ELEMENTS OF THIS NETWORK ARE OVERHEAD LINES, UNDERGROUND CABLE LINES, AS WELL AS TRANSFORMER AND DISTRIBUTION SUBSTATIONS. THE CONDITION OF THE DISTRIBUTION NETWORK IS CRITICAL TO THE SUSTAINABLE DEVELOPMENT OF A COUNTRY AND THE SECURITY OF ELECTRICITY SUPPLY.

The development of electrical infrastructure must be closely linked to economic growth – which drives increased demand for electricity – the development of decentralized sources, and the goals and priorities of national and EU strategic documents.
There are more than 200 distribution system operators ("DSOs") in Poland, and the shape of the distribution network is mainly determined by the five largest, i.e. Enea Operator Sp. z o.o., Energa Operator S.A., PGE Dystrybucja S.A., Stoen Operator Sp. z o.o., and Tauron Dystrybucja S.A. Distribution networks can be divided according to their rated voltage into: high (HV), medium (MV), and low voltage (LV). The basic volumes characterizing the distribution networks of the above operators are shown in Tables 1 and 2.
The HV network (110 kV) is used to distribute electricity, but unlike the medium or low voltage networks, it works in a similar way to the transmission network – most 110 kV substations are fed from both sides. Since the operation of the 110 kV network directly affects the operation of the transmission network, its operation is partly supervised by the transmission system operator. From a statistical point of view, the high-voltage network consists mainly of overhead lines, and only 631 km (1.8%) are cable lines. There are 1,569 high-voltage substations in this network, of which more than 90% are transformer substations, with 2,845 transformers installed with a total capacity of 63,726 MW.
The most extensive part of the distribution networks are the medium and low voltage networks, which ensure the supply of electricity to a large number of medium and small consumers. MV and LV lines and

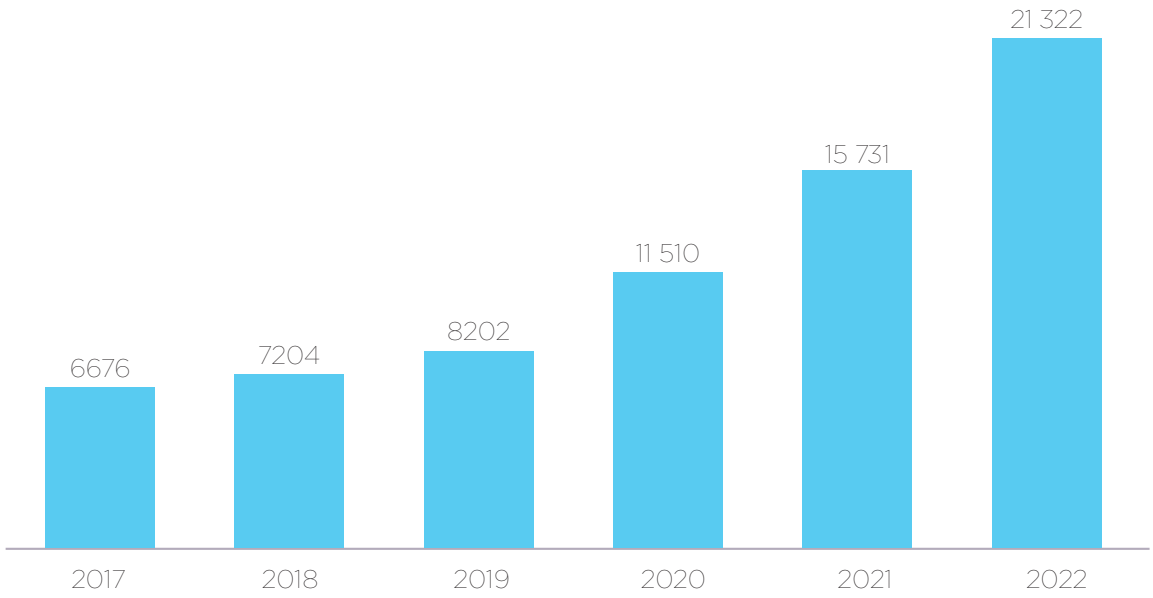
TAB. 1. LENGTH OF POWER LINES AT THE END OF 2022 [1]

Voltage	Line length [km]		
	overhead	underground cable	total
HV	33 551	631	34 182
MV	216 362	90 766	307 128
LV	279 443	169 426	448 869

TAB. 2. NUMBER OF ELECTRICAL SUBSTATIONS AT THE END OF 2022 [1]

Voltage	Number of substations [pcs.]
HV	1 569
MV	266 940

FIG. 1 CAPACITY OF RES CONNECTED TO DSO NETWORKS IN MW [1]



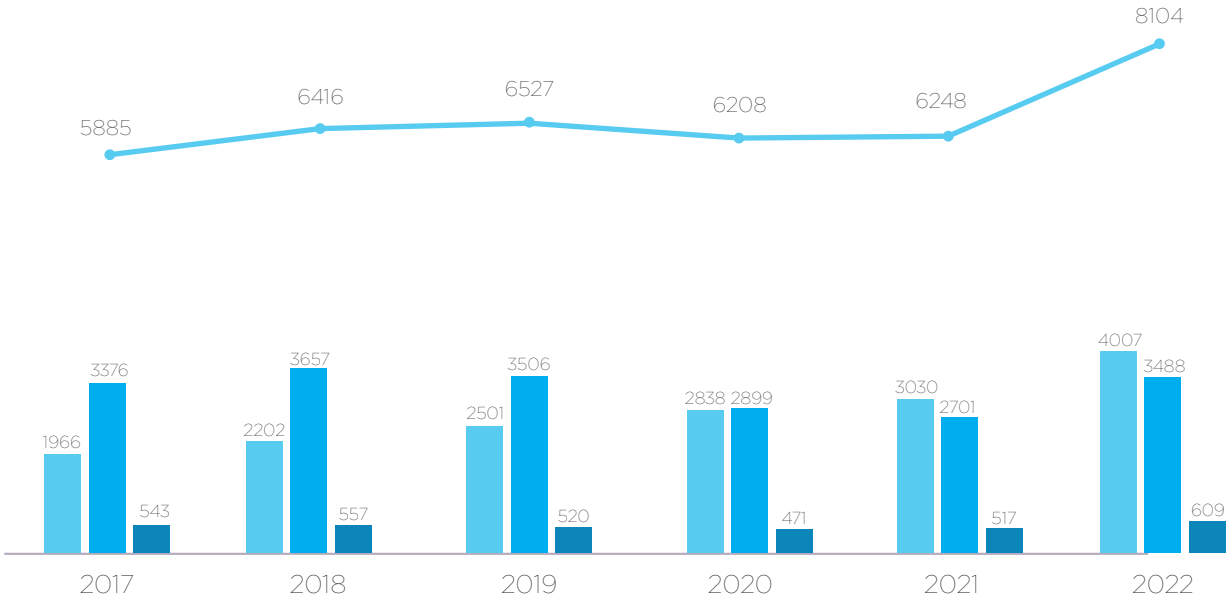
MV/LV transformer substations are an important element of the distribution network of each DSO. They are critical to the quality of the electricity supply to consumers. Among the 266,940 MV substations, the main group consists of MV/LV transformer substations (99%), which are used to supply the low-voltage network, i.e. they ensure the supply of electricity to millions of consumers, mainly households. MV/LV substations can be divided into indoor (including container) and overhead (including overhead-indoor) substations based on their construction. Nearly 70% of the substations are overhead substations, most of which are pole -mounted. It should be noted, however, that the number of pole -mounted substations has decreased in recent years in favor of indoor substations, which is probably related to the standard for constructing medium-voltage lines as underground cable lines, which is preferred by DSOs. Medium- and low-voltage power lines are most often overhead lines. 70.4% for MV and 62.3% for LV are of this type. They are usually located outside of highly urbanized areas. In city centers, almost all low- and medium-voltage lines are made as underground cable lines, which are gradually replacing the existing overhead lines.

THE BIGGEST CHALLENGE CURRENTLY FACED BY DSOS IS TO INCREASE THE POTENTIAL FOR CONNECTING NEW RES TO THE NETWORK

CHALLENGES OF DISTRIBUTION NETWORK OPERATORS

The biggest challenge currently faced by DSOs is to increase the potential for connecting new RES to the network. At the end of 2022, the total capacity of RES sources connected to the network by the five DSOs was 21.3 GW, including more than 9.2 GW of PV micro-installations. This is an increase of 36% compared to 2021.
Such a rapid development of RES means that the technical and economic conditions for connecting new sources to the network are exhausted under the current plans for the development of the electrical network. As a result, as the number of network connection conditions issued by DSOs increases, so does the number of refusals to issue these conditions. Recognizing the rapid development of distributed sources, the increase in the number of active consumers (prosumers), and the dynamic process of energy transformation in recent years, all of which have a significant impact on DSOs, the President of the Energy Regulatory Office, together with a wide range of stakeholders, has been working on the Charter for the Efficient Transformation of Poland's Power Distribution Networks ("KET"). An important stage was completed with the signing of an Agreement in November 2022. Within the framework of the KET, the necessary investments, i.e. those resulting from legal regulations, the expenses required for these investments, and the possible sources of financing – tariffs and external

FIG. 2 DSO INVESTMENT OUTLAYS IN THOUSANDS OF PLN [1]



aid funds – were defined. A significant role in the discussion was played by the estimation of further potential, but also the possibility of developing RES and connecting further capacities to the network. In the perspective of 2030, the installed capacity of RES (with the participation of prosumers) is expected to increase to more than 50 GW, i.e. by about 230%, which will result in a share of RES in the electricity mix of 50% (including the capacity connected to the transmission network).

Distribution System Operators must meet this challenge. The necessary modernization of the network is unfortunately a long and costly process, but it is inevitable. However, the operators' expenditures on the development and modernization of the network are disproportionate to the development of renewable energy sources expected by the market. However, without additional external funding sources, it will not be possible to create significant additional connection capacity at the distribution network level.

Figure 2 shows the investment outlays over the last few years.

RAPID DEVELOPMENT OF RES MEANS THAT THE TECHNICAL AND ECONOMIC CONDITIONS FOR CONNECTING NEW SOURCES TO THE NETWORK ARE EXHAUSTED UNDER THE CURRENT PLANS FOR THE DEVELOPMENT OF THE ELECTRICAL NETWORK

It can be seen that there has been a significant increase in the amount spent on connecting to the network and expanding the network for connections, which has led to a decrease in the amount spent on restoring and modernizing network assets. Therefore, annual investments in the network do not have a significant effect on its level of restoration (change in the age structure of the network). Many network elements are characterized by a high degree of wear. The best example here are MV and HV overhead lines, about 50% of which were built over 40 years ago.

So how do you address this situation while optimizing the impact of increased investment on customers through tariffs? Solutions are being sought and worked out by various bodies. The Energy Act has already clarified the so-called commercial connections, where, in the absence of economic conditions for the connection, the distribution system operator may conclude a network connection agreement, in which it stipulates a connection fee in the amount agreed with the entity requesting the network connection. Such an entity may also ensure, in agreement with the energy company, the construction and expansion of network sections used to connect its installations. In addition, cable pooling solutions, i.e. the sharing of connections by different installations, preferably combining different complementary technologies, are being considered for introduction into national law. This solution, which already exists in some European countries such as the Netherlands, can be used by biogas plants if it is possible and appropriate to locate other sources at their site.

PEAKING BIOGAS PLANTS IN THE POWER SYSTEM

Taking into account the characteristics of biogas plant operation and the possibility of storing biogas, special rules may also be considered, e.g. the issuance of network connection conditions together with a pre-arranged period for the producer to feed energy into the network – not arbitrarily around the clock, but within a specified interval, depending on the season. The ability to store biogas and feed in electricity during periods of higher electricity demand or lack of PV generation would result in optimal use of the local distribution network and, in many cases, the ability to offer connection terms at all (which would not be possible without such a contractual time limit). From the point of view of the electricity system, peaking biogas plants (equipped with biogas storage) do not have the element that characterizes other RES, i.e. weather-dependent power generation. A major advantage of this type of biogas plant is the ability to produce electricity during certain hours of the day. This not only makes it easier to connect it to the network, but also has a positive effect on balancing the system by producing energy during peak load periods and not feeding energy into the network during, for example, periods of peak photovoltaic generation.

One of the elements to support connection possibilities will be the purchase of flexibility services in DSO networks, already provided for in the so-called market directive[1] and awaiting implementation into national law. The draft amendment to the Energy Act[2] defines flexibility services as services provided to an electricity distribution system operator by an aggregator or by system users who are active consumers, producers, owners of electricity storage facilities,

CABLE POOLING SOLUTIONS, I.E. THE SHARING OF CONNECTIONS BY DIFFERENT INSTALLATIONS, PREFERABLY COMBINING DIFFERENT COMPLEMENTARY TECHNOLOGIES, ARE BEING CONSIDERED FOR INTRODUCTION INTO NATIONAL LAW.

whose networks, installations, or equipment are connected to the electricity distribution system, excluding the coordinated 110 kV network, in order to ensure the safety and increase the efficiency of the development of the distribution system, including the management of network congestion in the electricity distribution system, excluding the coordinated 110 kV network. The scope, conditions, and manner of using flexibility services by DSOs, as well as the specification of standardized market products for the purpose of providing flexibility services, are to be included in a system regulation[3], which will be adapted after the amendment of the Energy Act.

Cooperation of a biogas plant with a DSO network may also take place within the framework of a new collective entity planned in the aforementioned amendment – civic energy community. It is to be an entity with legal capacity, that:

> is based on voluntary and open participation and in which decision-making and control powers are vested in members, shareholders, or partners who are exclusively natural persons, local government units, micro-entrepreneurs, or small entrepreneurs and whose business in the energy sector is not the main business activity,
> has as its primary objective the provision of environmental, economic, or social benefits to its members, shareholders, or partners, or to the local areas in which it operates,
> may, among other things, engage in the production, consumption, storage, or sale of biogas, agricultural biogas, biomass, and agricultural biomass.

As can be seen from the actions and directions of the legislation, remedial measures are being taken to enable the connection of more RES capacity and to optimize its interaction with the electricity network, both in terms of investment and regulation – using the potential of existing networks.

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NOTES:

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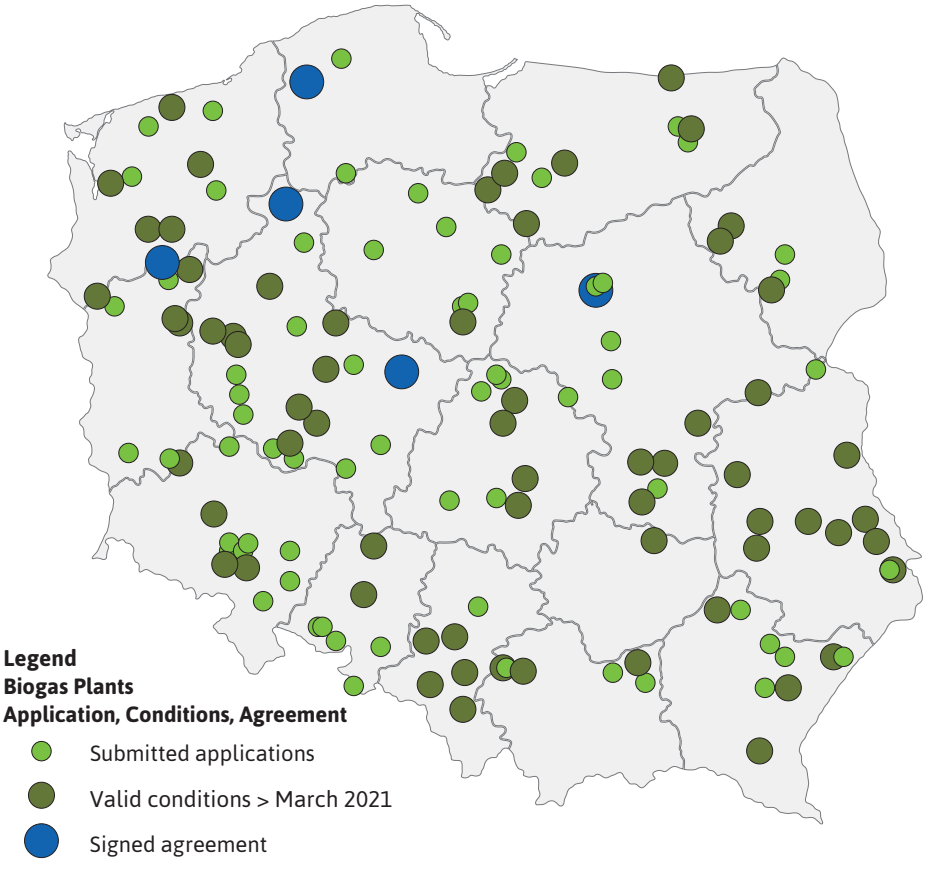
2. Draft Act amending the Energy Act and certain other acts (UC74, version of February 28, 2023)
3. Regulation of the Minister of Economy on detailed conditions for the operation of the electric power system of May 4, 2007 (Journal of Laws No. 93, item 623, as amended).

THE ROLE OF THE GAS DISTRIBUTION NETWORK IN THE DEVELOPMENT OF THE BIOMETHANE SECTOR – OPPORTUNITIES AND CHALLENGES

THE ONGOING ENERGY TRANSFORMATION IS AIMED AT REDUCING THE IMPACT OF THE ENERGY SECTOR ON THE NATURAL ENVIRONMENT AND INCREASING THE USE OF OWN RENEWABLE ENERGY RESOURCES, WHICH WILL CONTRIBUTE TO INCREASING THE SECURITY OF ENERGY SUPPLY TO CONSUMERS. LOCAL SOURCES OF BIOMETHANE WILL PLAY AN IMPORTANT ROLE IN THIS PROCESS.

In order to fully exploit their potential and importance, the renewable gas fuel they produce – biomethane – should be injected into the gas network, so that it can be delivered to all entities interested in using renewable gas fuels. Taking into account the areas where biogas plants can be built and the current state of development of the gas network, it is most likely that entities producing biomethane will be connected to the gas distribution network. However, it should be taken into account that the functioning gas distribution network managed by the largest distribution system operator, Polska Spółka Gazownictwa Sp. z o.o. (PSG), was designed and built to distribute natural gas supplied to the system from large sources – gas mines, imported supplies – through the gas system of the TSO.
The energy transformation of the gas sector is mainly associated with a change in the direction of gas fuel supply – from large sources (imports, gas mines) to

FIG. 1. DISTRIBUTION OF CURRENT PSG NETWORK CONNECTION CONDITIONS AND SIGNED CONNECTION AGREEMENTS.



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local distributed sources (biogas plants) and is aimed at decentralization of the system. From a technical point of view, i.e. the materials used, construction technology, etc., the gas networks managed by PSG are adapted to the transportation of biomethane, the quality parameters of which comply with current legislation. However, the functioning distribution system has certain limitations regarding the amount of biomethane that can be absorbed, referred to as the absorption capacity of a zone. It should be understood as the quantity of gaseous fuel that can be received by the gas network operator in one hour in a distribution zone, corresponding to the minimum hourly quantity of gaseous fuel consumption that can be received by all final consumers supplied from this distribution zone. This absorption capacity results, among others, from the parameters adopted in the design of the network (diameter and pressure) and the number of consumers using the gaseous fuels. Most of the biogas plants interested in connecting to the PSG are located in those regions of the country where the gas network is not sufficiently developed to receive the total amount of biomethane declared by the interested entities, with a constant production level throughout the year.

FROM A TECHNICAL POINT OF VIEW, THE GAS NETWORKS MANAGED BY PSG ARE ADAPTED TO THE TRANSPORTATION OF BIOMETHANE, THE QUALITY PARAMETERS OF WHICH COMPLY WITH CURRENT LEGISLATION

QUALITY PARAMETERS OF BIOMETHANE

Another challenge for the distribution system operator is to ensure (maintain) appropriate quality parameters of the transported gaseous fuel. PSG, as the operator of the distribution system, is obliged to take care of (maintain) the quality parameters of the gaseous fuel supplied to the distribution system in accordance with the applicable regulations. The quality parameters of this fuel cannot deteriorate during transportation through distribution networks. On the other hand, the determined average calorific value of gaseous fuels for a given day, in terms of the calorific value of settlement areas defined by the distribution system operator, should not differ by more than ±3% from the calorific value of gaseous fuels defined at any point in this area. Taking into account the directions of gaseous fuel supplies to Poland, the quality parameters of gaseous fuel distributed through PSG's network currently significantly exceed the quality parameters specified in the applicable regulations.

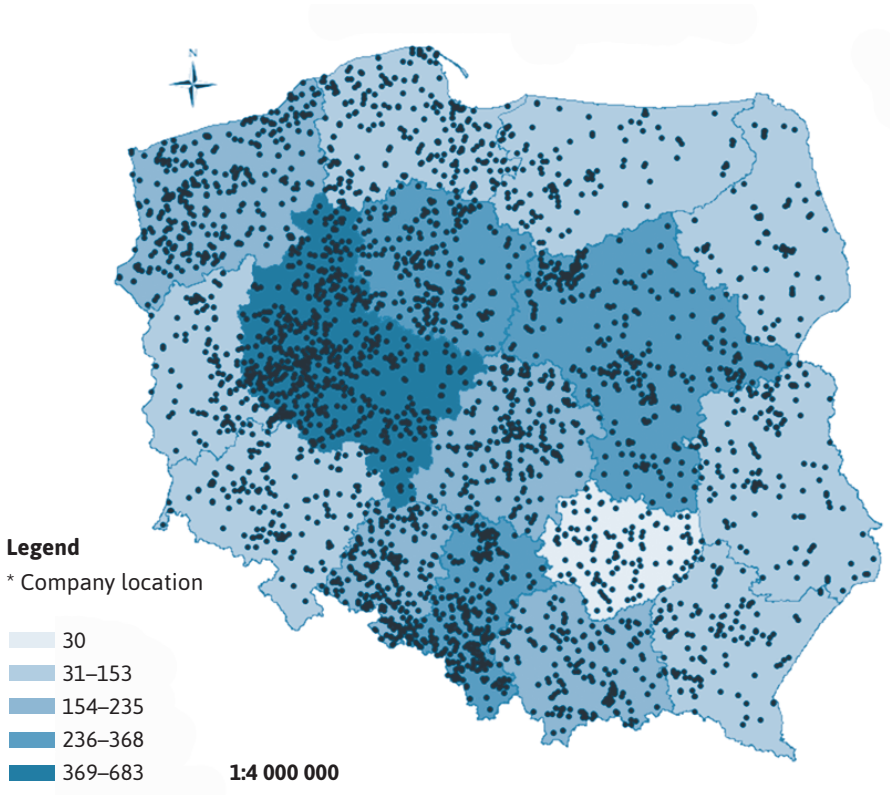
As of March 23, 2023, the distribution system operator PSG Sp. z o.o. has received 175 requests for connection conditions or information on the possibility of connection; 137 connection conditions or information on the possibility of connection were issued. On the other hand, the period of validity of the issued connection conditions specified in the regulations is 2 years – as of March 23, 2023, 93 connection conditions or information on the possibility of connection were valid. Six contracts for connection to the distribution network of PSG Sp. z o.o. were signed. Figure 1 shows the distribution of current connection terms and signed connection agreements.

ENERGY TRANSFORMATION PROGRAM

Taking into account the challenges related to the energy transformation, PSG launched the Energy Transition Program, the main objectives of which are: preparing PSG's structure for Poland's energy transformation, connecting professional and industrial sources to the gas network, supporting PSG in acquiring new professional recipients, and developing the network for the use of biomethane.

As part of the Energy Transformation Program, work is being carried out to identify areas with limited biomethane absorption capacity and investment plans are being developed to eliminate any identified barriers. The goal is to have no restrictions on connecting and receiving biomethane in the areas of greatest interest to biogas producers. The analyses conducted show that the greatest potential of substrates that could be used for biogas production is located in Wielkopolska, Śląsk, and Lubelszczyzna regions. Figure 2 shows the location of entities that can supply the substrate used for the production of biomethane, while Figure 3 shows the limits of the absorption capacity of the gas network.

FIG. 2. LOCATION OF ENTITIES THAT CAN SUPPLY THE SUBSTRATE USED FOR THE PRODUCTION OF BIOMETHANE.



ON THE BASIS OF THE ANALYSES CARRIED OUT, 62 INVESTMENT PROJECTS WITH A TOTAL VALUE OF APPROXIMATELY PLN 492 MILLION WERE IDENTIFIED, THE PURPOSE OF WHICH IS TO ELIMINATE TECHNICAL LIMITATIONS IN THE CONNECTION AND INJECTION OF BIOMETHANE INTO THE GAS DISTRIBUTION NETWORK

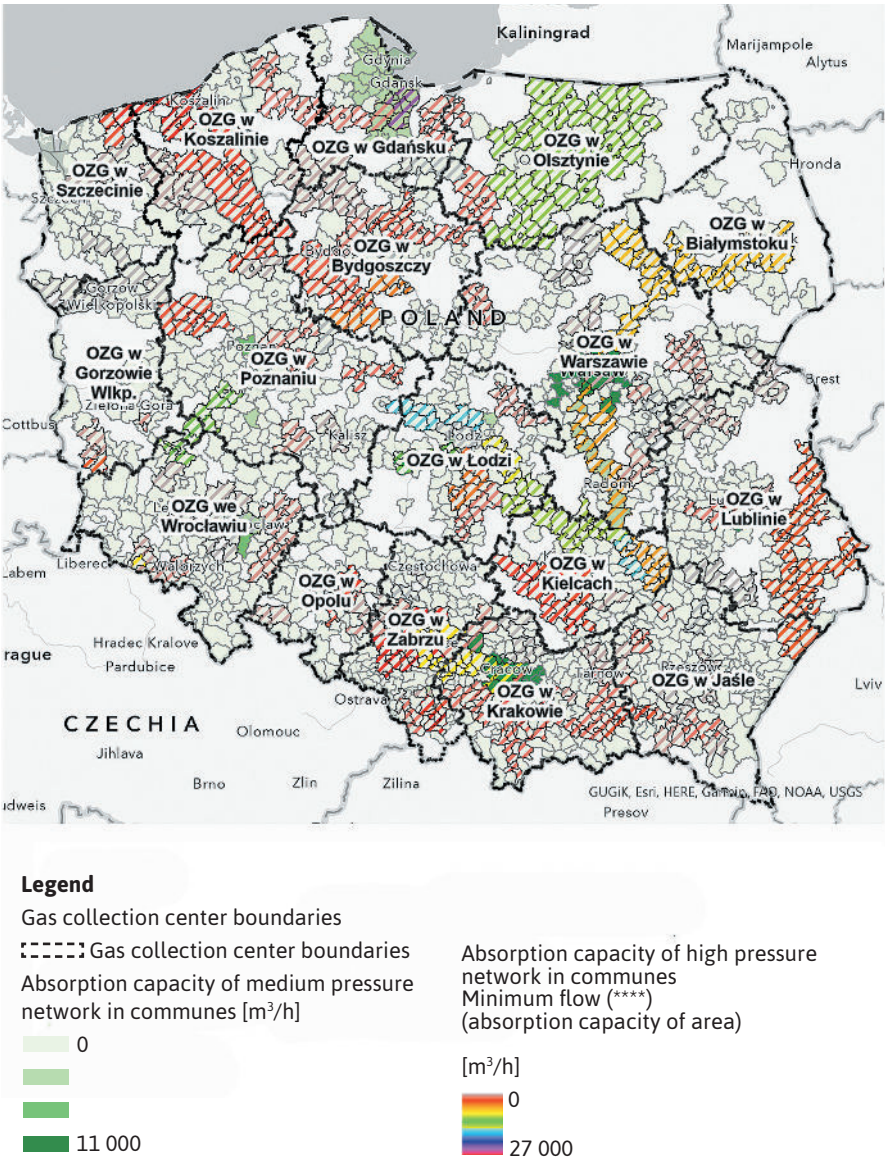
On the basis of the analyses carried out, 62 investment projects with a total value of approximately PLN 492 million were identified, the purpose of which is to eliminate technical limitations in the connection and injection of biomethane into the gas distribution network. Due to the importance of these investments for the biogas and gas sectors, they were submitted to the European Funds for Infrastructure, Climate, and Environment (FENiKS) program. The aim of this program is to improve the conditions for the development of the country through the construction of technical and social infrastructure in accordance with the assumptions of sustainable development.

CONNECTING BIOGAS PLANTS TO THE NETWORK – FORMAL AND LEGAL CHALLENGES

In addition, an intensive dialog is being conducted with the government administration on the design of legal regulations regarding the quality parameters of biomethane fed into the gas network. During these discussions, the distribution system operator proposes changes to the current regulations in order to take into account the interests of the parties involved (biomethane producers, distribution system operators, gaseous

AS OF MARCH 23, 2023, THE DISTRIBUTION SYSTEM OPERATOR PSG SP. Z O.O. HAS RECEIVED 175 REQUESTS FOR CONNECTION CONDITIONS OR INFORMATION ON THE POSSIBILITY OF CONNECTION

FIG. 3. ABSORPTION CAPACITY LIMITS OF THE GAS NETWORK.



fuel consumers) and to ensure that as much biomethane as possible is fed into the gas network. Another problem related to the connection of a biogas plant to the gas network is a complicated and lengthy formal and legal procedure – obtaining approvals, permits, project implementation takes about 24-36 months. In order to ensure the rapid connection of biogas plants in areas where there is insufficient infrastructure for the reception of biogas or insufficient network absorption capacity, PSG carries out analyses on the collection of biomethane in the form of CNG, its transportation through "virtual gas pipelines", and injection into the gas network where there are no technical limitations. It should be emphasized that this solution does not require such lengthy and complicated formal and legal activities as in the case of the construction of gas pipelines, which allows a quick "connection" of the biogas plant to the PSG network and the use of "virtual gas pipelines" until the traditional gas network is built.

The biogas market in Poland has great potential, both from the economic point of view – the possibility of creating a new branch of industry, increasing employment, etc. – as well as from the point of view of the country's energy needs. In order for it to develop, a long-term development plan for this industry is necessary. It is about a predictable system of support for biogas producers – e.g. guaranteeing a minimum price for the biogas produced. On the other hand, from the perspective of the gas Distribution System Operator, it would seem reasonable to revise the regulations in force. The current ones were adopted during the creation of the natural gas market, where the main emphasis was put on diversification of natural gas import directions, while local sources of biogas production were not fully taken into account in this system. Therefore, it seems reasonable to take fully into account the importance and potential of the biogas sector in the energy transformation and in ensuring the continuity of gaseous fuel supply to consumers, and to adopt regulations defining the mutual relations between biogas plants and gas network operators, which would respond to the challenges related to the energy transformation.

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THE FUTURE OF TRANSPORTATION – ELECTRIC, HYDROGEN, BIOMETHANE, OR BIOLNG?

ACCORDING TO THE EUROPEAN ENVIRONMENT AGENCY, ABOUT 25% OF THE EU'S TOTAL CO_2 EMISSIONS IN 2019 CAME FROM THE TRANSPORTATION SECTOR, 71.7% OF WHICH CAME FROM ROAD TRANSPORTATION. AS PART OF CARBON REDUCTION EFFORTS, GREENHOUSE GAS EMISSIONS WILL NEED TO BE REDUCED BY 90% FROM 1990 LEVELS BY 2050 TO ACHIEVE CLIMATE NEUTRALITY.

Transportation is the only sector where greenhouse gas emissions have increased by 33.5% over the past three decades (1990-2019). In the segment of passenger cars and vans, manufacturers focused on the transformation towards electric drives powered by batteries (BEV) or fuel cells (FCEV), mainly hydrogen.
For the purposes of this article, however, I will focus on heavy road transportation of goods, for three reasons:

- 27% of CO_2 emissions in EU road transportation come from trucks (over 3.5 tons gross vehicle weight);
- Poland is a leader in the segment of international road transportation of goods in the European Union (we transport more than 30% of the freight carried), and our transportation companies, employing about 750,000 people, generate 6% of the GDP of the Polish economy;
- heavy transportation over 12 tons of permissible total weight relies almost 100% on diesel fuel and is the no. 1 source of NO_x emissions, which cause the premature deaths of some 50,000 Europeans annually.

There are two more very important facts that one needs to know when analyzing the energy transformation of heavy road freight transportation (HDV – vehicles over 12 tons of GCM).

- obligations imposed on manufacturers of heavy-duty vehicles;
- obligations imposed on carriers.

So we can confidently talk about the action and responsibility of the entire sector. On the one hand, the EU has imposed obligations on vehicle manufacturers, whose interest will be to encourage carriers to purchase low-emission vehicles. On the other, the carriers themselves will be obliged to replace their fleets with low-emission ones by having to report their carbon footprint. Both of these activities are of course intended to support the overarching goal of achieving EU climate neutrality in 2050.
On July 14, 2021, the European Union announced the "Fit for 55" package. The new intermediate goal in the pursuit of climate neutrality in 2050 is to achieve a 55% reduction in CO2 (previously it was 40%) by 2030 compared to 1990 emissions.

The package will include:

- reform of the current emissions trading system (EU ETS), the so-called mini ETS, i.e. the inclusion of new sectors of the economy in emission allowances (including land transportation);
- carbon duty on the EU border to strengthen the competitiveness of the EU economy against countries without a climate policy;
- higher RES targets in the EU;
- stricter emission standards for the land transportation sector.

In addition, all freight carriers will already face new issues in the next three years that are directly related to environmental protection and the transition to alternative fuels.
> ESG (Environmental Social Governance) includes reducing emissions in the supply chain, zero-emission cars, circular economy, and the draft battery regulation;
> Taxonomy (EU regulation) is a signpost for classifying various types of activities as environmentally sustainable and redirecting capital there;

> CSRD directive mandating sustainability reporting and defining its scope;
> ESRS are the common European sustainability reporting standards required for CSRD reporting (after implementation of this directive).

WHAT DOES THIS MEAN FOR ROAD CARRIERS?

If Polish transportation companies want to maintain a leading position in international road transportation of goods in the European Union, they should already be investing in environmentally friendly means of transportation. From 2025-2027 (successively, depending on size), every company based in the EU will be required to have an ESG strategy in place and, as a result, to require environmental measures from its contractors in the supply chain. Financing institutions will first direct their capital (for the purchase, financing, leasing, rental, and operation of vehicles) to those transportation companies that have in their fleet heavy-duty vehicles meeting the minimum EURO VI Stage E emission standard (compulsory registration from 01.01.2022) or higher, as well as low- or zero-emission vehicles.

The above facts lead us to conclude that regardless of the current financial analyses and people's natural "resistance to change", we are facing an energy transformation of transportation in the coming years.

Referring to the energy transformation of heavy transportation, the first, transitional stage involves saving energy consumption (reducing fuel consumption) and introducing new technologies capable of using energy from renewable sources. It is happening now. It is only in the next, final stage of the transformation that the sources of alternative fuels will be replaced. For example, instead of using electricity generated from coal, we will replace it with energy from the sun or wind. Instead of methane from natural gas, we will replace it with gas from biomass.

REGARDLESS OF THE CURRENT FINANCIAL ANALYSES AND PEOPLE'S NATURAL "RESISTANCE TO CHANGE", WE ARE FACING AN ENERGY TRANSFORMATION OF TRANSPORTATION IN THE COMING YEARS

TRANSPORTATION OF THE FUTURE – VEHICLES

So what could the transportation of the future look like? From the point of view of engines in drive systems, we can today divide the transportation of the future into the following types:

- trucks powered by electric motors *(EV – Electric Vehicle)*;
- trucks powered by internal combustion engines *(ICE – Internal Combustion Engine)*;
- hybrid (combustion engine + electric). Currently, they are rarely used for heavy transportation, although, for example, Scania has them in its offer.

We can divide heavy-duty electric vehicles into two types depending on the method of energy storage used:

- BEV *(Battery electric vehicle)* – energy stored in traction batteries powers electric motors;
- FCEV *(Fuel cell electric vehicle)* – electricity generated on board the vehicle in fuel cells (usually hydrogen), directed to a small traction battery that powers the electric motors.

The term electric trucks also includes vehicles commonly referred to as "hydrogen" vehicles. We do not have a single such car registered in Poland yet. There are, however, hydrogen buses, but the principle of operation is the same in both cases. The cost of purchasing a car with hydrogen cells is about twice as high as an electric car, and twice as high as a gas (LNG) car, which in turn is 20% more expensive than a diesel one. In countries where the power network is well-developed and a sufficiently dense and efficient network of high-powered electric chargers can be installed, BEV battery cars will dominate. However, where such a network cannot be established, hydrogen stations must be built to increase the distance between refueling stops.

In Poland, we are just beginning the process of building dedicated infrastructure for truck charging. The growth rate of the fleet of zero-emission trucks delivering goods will depend on its development. There are many challenges related to infrastructure. Fortunately, there are dedicated EU projects aimed at building infrastructure of chargers for the transportation of goods.

INTERNAL COMBUSTION ENGINE TRUCKS – THE FUTURE

The issue of internal combustion engine trucks is still under discussion at the European Commission. The new EU draft on reducing emissions heavily tightens the previous version, but fortunately does not ban the registration of new cars with internal combustion engines even after 2040.

To reduce CO_2 emissions, we need to move away from fossil fuels. The energy transformation of heavy transportation is, in the first stage, the introduction of new technologies capable of using energy from renewable sources. We therefore need to replace diesel with another alternative fuel, which will come from renewable sources in the final stage of the transformation.

We can divide internal combustion engine trucks into several types depending on the method of energy storage used. Among the many possible alternative fuels to internal combustion engines (fuels

that can be produced from renewable sources) that have been tested, three have emerged that seem most likely:
> HVO *(Hydrogenated Vegetable Oil)* is a high-quality diesel replacement product, made entirely from renewable raw materials, i.e. vegetable oils and fat waste;
> biomethane can be stored as compressed bioCNG or as liquid bioLNG. Today, methane is widely used as natural (mine) gas, but its production from biomass is rapidly developing. Combusted in a single-fuel engine (OTTO thermodynamic cycle) or in a dual-fuel engine (diesel cycle);
> hydrogen – in this case, a dual-fuel engine is used, ignition is done with a small dose of HVO, and the main injection is hydrogen gas.

METHANE VEHICLES

- **CNG** (Compressed Natural Gas) – compressed high-methane natural gas stored in gaseous form at a pressure of 200 bar. Methane produced from biomass is called CBG (Compressed Bio Gas) or popularly bioCNG.
- **LNG** (Liquefied Natural Gas) – high-methane liquefied natural gas exists in liquid form, at a temperature below -162 °C and at atmospheric pressure. For transportation purposes, it is carried in cryogenic tankers (1-7 bar), and in cars it is stored in cryogenic tanks at a pressure of about 5-10 bar (temperature from -134 °C to -120 °C). Methane produced from biomass is called LBG (Liquefied Bio Gas) or popularly bioLNG.

Since 2018, trucks fueled by natural gas, whose main component is methane (CH_4), have become very popular. In addition to a nearly 20% reduction in CO_2 emissions, truck engines running on this gas have lower noise emissions and very low NO_x emissions.

• CNG trucks

Trucks with CNG tanks are most often ordered for urban distribution, due to the relatively small amount of energy that can be stored in pressurized cylinder batteries. And that comes with a limited range. Most manufacturers equip such vehicles with a spark-ignition engine. The purchase price of a CNG-powered car is approx. EUR 20,000 higher than a diesel equivalent.

THIS IS THE SECOND STAGE OF THE ENERGY TRANSFORMATION IN TRANSPORTATION. WE NEED TO REPLACE FOSSIL SOURCES WITH RENEWABLE ONES

• LNG trucks

Due to the properties of methane, which reduces its volume by 620 times after liquefaction, it is possible to store more energy in the tanks of trucks than in the case of CNG. And this makes it possible to travel long distances of 800-1500 km with gas cars on a single refueling. That is why cars with cryogenic tanks for LNG have been used in long-distance transportation.
Depending on the topography of the terrain and the weight of the vehicle, gas trucks in international transportation burn approx. 20-27 kg of LNG/100 km. On the same routes, fuel consumption in trucks with traditional diesel engines reaches a similar level of +10%, but in liters of ON/100 km. For many years, natural gas was much cheaper than diesel.
At the beginning of February 2021, the average price of LNG in Poland was PLN 2.50 net/1 kg, and at the same time you had to pay PLN 3.60/1 liter for diesel. If you add to this the exemption from German tolls for gas-powered trucks, the business was very profitable, despite the higher price per vehicle (about 35,000 euros).
However, the turmoil on the gas market related to, among others, the conflict in Ukraine caused the price of gas to grow disproportionately fast in relation to the price of diesel fuel. As a result, between July 2022 and the end of January 2023, it was better to leave the gas cars in the yard than to generate losses. The price of 1 kg of LNG during this period ranged from PLN 9.50 to 17.50 per kg of LNG (the maximum was in September 2022). Currently, the situation is beginning to normalize again. In June this year the price of LNG at stations is about PLN 4.0-4.5 net per 1 kg, and for diesel – about PLN 5.0 net per liter.
Unfortunately, the situation described above has strongly hampered the development of methane-powered trucks. Fortunately, from February 2023, we can see a return to this technology, mainly due to the increased CO_2 reduction in the transition from LNG to bioLNG. There are already 100% bioLNG stations in Europe. In Poland, we are still waiting for the first biomethane plant with biomethane liquefaction.

ENERGY TRANSFORMATION – ALTERNATIVE FUELS

We create cars that are technically zero-emission, but the final reduction in greenhouse gas emissions is primarily determined by the energy source. This is the second stage of the energy transformation in transportation. We need to replace fossil sources with renewable ones. This is a process that needs to start today in order to achieve the assumed goals by 2035-2040.

• Electrical energy:

If we consider 100% electric cars in terms of energy generation, it turns out that their final CO_2 reduction will depend on the source of electricity. Therefore, the energy mix of each country is very important. We must strive to produce electricity from renewable sources. Their availability depends on the regional conditions of each country or region individually. The tropics can rely heavily on the sun,

mountainous areas use river currents, coastal regions focus on wind energy, and agricultural countries should use biomass. The production of energy from the atom is debatable, but effective.

• HVO synthetic diesel
As mentioned earlier, emissions can be reduced up to 90% with 100% HVO. The result is greatly influenced by the vegetation period of the plants from which the oil is extracted for hydrogenation. Plants absorb CO_2 from the atmosphere while growing, and emit it during processing and combustion. The balance seems quite satisfactory.

• Hydrogen
Hydrogen, depending on the technology of its production, is divided into 9 colors. In terms of decarbonization, green hydrogen is the most desirable, followed by blue. In Poland, we produce the most gray hydrogen. Other colors have been omitted due to their minor importance.

> green hydrogen
This is the most desirable color of hydrogen in view of the decarbonization of the global economy. At the same time, it is the most supported by the European Union's new policy, which focuses on financing projects that will enable the expansion of green hydrogen production capacity in member states over the next two decades. Green hydrogen is produced by electrolysis using only electricity from renewable sources.

> blue hydrogen
It is often referred to as the most economically advantageous transition stage of the energy transformation – from gray to green hydrogen. Blue hydrogen is produced using fossil fuels, with carbon capture methods used in the process to reduce pollution.
Until recently, blue hydrogen was thought to be nearly emission-free (allowing up to 95% emission reductions). However, research published in the middle of last year by scientists who took into account the full life cycle of blue hydrogen showed that its production can result in even higher emission rates than burning fossil fuels, so its use does not meet current reduction requirements.

> gray hydrogen
Produced in the process of steam methane reforming (SMR), which is characterized by high emissions (estimated 9-12 kg CO2/kg H_2).
It is produced from natural gas, coal, and even some waste fractions from oil processing. The emphasis on the use of natural gas (methane) in the SMR process is not accidental. It is a raw material that currently provides high efficiency, resource sufficiency, and relatively low costs in relation to other methods using conventional fuels.

BIOMETHANE
This type of renewable energy seems to be available at our fingertips. Unfortunately, not in Poland for now. The first biogas plant in Poland capable of processing biogas into biomethane and liquefying it into bioLNG is expected to be built by the end of 2023 or the beginning of 2024.
A very important aspect of transporting methane in the form of liquefied LNG is the amount of energy transported per shipment. One cryogenic tanker containing 18,500 kg of bioLNG supplies the recipient with approximately 280,000 kWh of energy stored in the gas. Transporting the same amount of energy in the form of compressed hydrogen would require as many as 11 trucks carrying a bundle of pressurized cylinders.
Poland already has a network of CNG stations and a network of LNG stations. More than 4,000 methane-powered trucks over 12 tons of GCM are registered. Neither the stations nor the vehicles require any structural changes for blending or switching from natural gas to 100% biomethane.

THE FIRST BIOGAS PLANT IN POLAND CAPABLE OF PROCESSING BIOGAS INTO BIOMETHANE AND LIQUEFYING IT INTO BIOLNG IS EXPECTED TO BE BUILT BY THE END OF 2023 OR THE BEGINNING OF 2024

In terms of CO_2 reduction, biomethane is excellent compared to other solutions. A completely closed energy cycle can be created, and thanks to the use of animal waste in the form of liquid manure, manure, poultry waste, food production waste unfit for human consumption, etc., we avoid the natural emission of greenhouse gases into the atmosphere. The EU allows certain substrates to be double counted in terms of CO_2 emission reductions by taking into account so-called avoided emissions.

SUMMARY
What is the future of transportation? There is no single good answer to this question. Depending on the availability of renewable energy sources in a given region, the answer may be different. All the technologies and methods described above, leading to decarbonization and reduction of greenhouse gas emissions into the atmosphere, are very good. The overarching goal is to stop climate change on Earth. We must not forget that.
There is every indication that urban and short-distance intercity freight transportation will soon shift to battery electric vehicles (BEVs). Regional and long-distance transportation will be based on one of the following technologies: HVO, bioCNG, bioLNG, H_2HPDi, and in the next 7-15 years, perhaps also on hydrogen cell technology (FCEV).

Paweł Węcłowski
Sobanscy Energy

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DOMINION Polska is part of the international DOMINION GLOBAL group. We have been operating in Poland for over 25 years. Initially as KARRENA, then BEROA, and now as DOMINION, we provide engineering and construction services to sectors such as conventional and renewable energy and industry. We build and invest in renewable energy installations and solutions supporting the achievement of climate neutrality, such as wind farms, biogas and biomethane plants, and large-scale PV farms. We erect silos and reinforced concrete tanks using climbing formwork.

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GICON is an independent engineering and consulting company. We plan agricultural and industrial biogas plants utilizing biogenic residues of agricultural origin, food waste, organic residues from mixed waste, as well as biogas upgrading plants according to various procedures. This includes the entire engineering shaping process: from feasibility studies to design, implementation, and commissioning of installations.

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We are a Polish specialist in the treatment and digestion of the organic fraction of municipal waste and all kinds of organic substrates. Our plants operate on proven and modern technology, producing biomethane, LNG, and CNG. We provide a stable process with maximum guaranteed biogas yield, without the need to add silage or other expensive substrates. We also modernize existing facilities to maximize their efficiency.

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Instytut Energii Barczewo Sp. z o.o. operates in the waste treatment and renewable energy industry. The company won the "Innovative biogas plant" project and is currently implementing the second stage, which is to build a 499 kW technology demonstrator. The main goal of the project is to implement an innovative technology for a substrate-universal and completely odorless biogas plant where the biogas produced is upgraded to biomethane. The ANABIOREC technology enables highly efficient and stable processing of waste into biomethane.

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Integrotech Sp. z o.o. is a Polish private engineering, production, and service company, which performs tasks ranging from technical and financial consultations, through design and administrative arrangements, to commissioning and maintenance of facilities (including biogas plants). Since 2001, we have been working on key gas infrastructure installations in Poland and abroad. Being a partner of FARMTEC a.s. (Czech Republic) since 2020, we can combine the market experience and executive potential of our companies.
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ZBM provides engineering support for all low-emission fuel projects such as biomethane, LNG, CNG, and hydrogen. As part of our services, we support specialized technology companies in the process of: DD of land plots, feasibility studies, obtaining environmental and construction permits, as well as execution of construction works. Thanks to our experience and understanding of the unique requirements of the technology industry, we are able to provide comprehensive solutions that allow our clients to build and maintain their structures and installations.

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AGIMIX® Poland Sp. z o.o. designs and manufactures process agitators with vertical and horizontal axes, used in the production of biogas (digestion) from crops, liquid manure, slaughterhouse waste, and municipal and industrial wastewater treatment. Individual projects.

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Axiom Polska has 15 years of international experience in the field of renewable gaseous fuels. Among other things, we design and optimize gas separation processes as well as construct and commission biogas and renewable hydrogen treatment facilities for commercial projects. In the research field, we have numerous successes in evaluating new paths for obtaining renewable gaseous fuels, as well as in the construction of prototype devices.

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BP Techem has been specializing in providing compressed air and vacuum systems and installations as well as blowers and compressors for pumping and compressing biogas, biomethane, natural gas, coke oven gas, and other gases since 1990. The company offers CL side-channel blowers, CM multi-stage blowers, TBT turbotron, and MCF centrifugal fans for pressures up to 1000 mbar. The offer also includes water- and air-cooled vane compressors for pressures up to 10 bar and high-pressure compressors for CNG gas for pressures up to 400 bar.

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Centrum Elektroniki Stosowanej CES Sp. z o.o. is a company with over 30 years of experience, which – together with many partners – combines knowledge and experience to provide industrial installations for the preparation and use of biogas for energy purposes. It offers comprehensive services for cogeneration systems and biogas plant equipment: biogas tanks, analyzers, blowers, desulfurizers, dryers, flares. CES provides professional services at every stage of the investment: selection, design, delivery, and commissioning.

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e-mail: marketing@elteco.pl
www.elteco.pl

We offer comprehensive services in the selection, supply, installation, and servicing of 20-4300 kWe gas-fired cogeneration units, biogas treatment systems (desulfurization plants, filters, dryers, blowers, flares, tanks, analyzers) and backup power equipment. As part of our maintenance service, we provide scheduled inspections, repairs, intermediate and general overhauls including engine replacement. We also offer original spare parts for gas engines and consumables at attractive prices

ISKRA Zakłady Precyzyjne Sp. z o.o.
ul. Mielczarskiego 47
25-709 Kielce
tel.: +48 41 365 52 03
e-mail: info@iskra-kielce.pl
www.iskra-kielce.pl

ISKRA Zakłady Precyzcyjne Sp. z o. o. is the only Polish manufacturer of spark plugs with over 50 years of experience. We offer spark plugs for engines used in biogas plants, including manufacturers such as Caterpillar/CAT, MWM, MAN, PERKINS, CUMMINS, DEUTZ. The products we offer are replacements for the original spark plugs used by the engine manufacturer. The electrode system we designed, made of 99.9% iridium and covered with a cap, ensures the correct parameters of the spark, its flash-over time and energy, guaranteeing the ignition of the biogas mixture every time.

KSB Polska Sp. z o.o.
ul. Świerkowa 1D
05-850 Ożarów Mazowiecki
tel.: +48 602-707-463
e-mail: marek.borkowski@ksb.pl
www.ksb.com/pl-pl

KSB has been a leading supplier of pumps, agitators, and fittings since 1871. Our research and development efforts result in high-performance and durable products that guarantee low operating costs and maximum investment efficiency. We supply heat pumps, water and wastewater pumps, fire pumps, valves – for the industrial, chemical, and energy sectors. For biogas plants, we offer reliable PHANTOM mixers in HEAVY DUTY design. We offer service all over Poland - modern service centers in Warsaw, Gliwice, and Leszno.

NANOSENS Sp. z o.o.
ul. Skórzewska 35
62-081 Wysogotowo
tel.: +48 61 814 64 11
e-mail: biuro@nanosens.pl
www.nanosens.pl

NANOSENS is a Polish company with 30 years of experience, producing equipment that helps optimize and control the process of producing clean energy from biogas. Our offer includes stationary biogas analyzers in three versions: BIOTEX SINGLEPOINT, BIOTEX MULTIPOINT, and BIOTEX XL with continuous analysis of gas mixture components, as well as portable analyzers of the DP-28BIO series. NANOSENS provides long-term after-sales support in the form of spare parts and maintenance services.

Novo-Tech Sp. z o.o.
ul. Młynowa 80 lok U1
15-404 Białystok
tel.: + 48 724 724 501; +48 502 317 161
e-mail: leszek.budohoski@novotech.waw.pl; kontakt@novotech.waw.pl
www.fermentor.plus

Fermentor.plus – agricultural micro biogas plant is a patented innovative device. Scalable, sizes adapted to the needs of farms, households, and small local communities. It fits perfectly into the circular economy policy and allows waste to be disposed of on-site, making the waste producer independent of external energy sources. We offer biogas plants with the power of 1, 5, 10, and 20 kW, complete with a power generator synchronized with the power network.

NOXON Poland Sp. z o.o.
ul. W. Sieroszewskiego 14/4
81-376 Gdynia
tel.: +48 605 072 838
e-mail: biuro@noxon.com
www.noxon.com

NOXON Poland Sp. z o.o. has been supplying decanter centrifuges for wastewater sludge and digestate in biogas plants for 31 years. Nearly 100 units in Poland. Supplier of the most advanced equipment on the market. Also offered:
authorized service, mobile sludge dewatering units – construction and rental,
laboratory equipment for testing methane potential in gases.

Benedykt i Rafał Bródka „POL-PLAN”
Zakład Produkcji Plandek Sp.j.
ul. Wrocławska 42/44
62-060 Stęszew
tel.: +48 61 813 56 09
e-mail: hale@pol-plan.com.pl
www.pol-plan.com.pl

For 40 years Pol-Plan has been producing durable tent halls, adapted to local wind and snow conditions, which are an attractive alternative to traditionally built warehouses and industrial halls. These halls have a durable structure made of aluminum profiles, span up to 60 m, wall cladding made of trapezoidal sheet metal, sandwich panels, or PVC.

Zespół Innowacyjny PROMIS Sp. z o.o.
ul. T. Hołówki 3/43
00-749 Warszawa
tel.: +48 22 839 84 14; +48 603 607 111
e-mail: zipromis@zipromis.pl
www.zipromis.pl

For over 30 years, the company has been offering equipment for the purification of biogas, air, and other gases in wastewater treatment plants, landfills, and biogas plants. Our BIOSULFEX® unit is a compact solution that guarantees desulfurization efficiency (99.9%). Used in wastewater treatment plants and biogas plants. AgroBIOSULFEX® converts agricultural odors into a multicomponent fertilizer. Efficient removal of hydrogen sulfide (H2S) odors and siloxanes by conversion to commercial sulfur – no waste.

Sieć Badawcza Łukasiewicz
– Instytut Nowych Syntez Chemicznych
Research and Development Center NITROSYNCAT
al. Tysiąclecia Państwa Polskiego 13A
24-110 Puławy
tel.: +48 607 704 678, +48 81 473 14 65
e-mail: bartosz.moszowski@ins.lukasiewicz.gov.pl
www.ins.lukasiewicz.gov.pl

Research and Development Center NitroSynCat operates in the following technologies: biogas purification to biomethane meeting natural gas quality parameters, high-purity hydrogen purification, CCU, hydrogen and syngas production, ammonia production, nitric acid production, NOx and N2O emission reduction, heat recovery. We are a producer of catalysts and sorbents. We carry out investment tasks in the EPC formula, turnkey deliveries of installations with licenses and know-how, we develop and implement new solutions and technologies.

SJ Construction Sp. z o.o.
ul. Staromiejska 1
11-700 Mrągowo
tel. +48 726 550 111
e-mail: office@sjconstruction.pl
www.sjconstruction.pl

SJ Construction is a company with many years of experience in the field of design, delivery of technology, and construction of biogas plants in the "design and build" formula. We approach each investment individually, allowing us to select the best solutions and optimize costs right from the design stage. We offer complete installations for the pasteurization of cat. 2 and 3 animal by-products at agricultural biogas plants, biogas treatment stations, heat distribution installations, pumping stations, flares, as well as stainless steel tanks, filling hoppers, and grinders. We are looking forward to cooperating with you!

SUMA Rührtechnik GmbH
Martinszeller Str. 21
87477 Sulzberg, Germany
tel.: +49 151 10865 598
e-mail: LyR@suma.de
www.suma.de

SUMA, a manufacturer of agitators since 1957, is now a supplier of equipment for the biogas, municipal, agricultural, and industrial sectors. We offer submersible, rod, center, and lateral agitators – optimally selected for the project using CFD flow simulations and tested on a test bench at the factory. In recent years, we have delivered over 100,000 agitators to 64 countries, including Poland. Our highly qualified team provides expert advice and service worldwide. Our goal is high quality and the highest level of user satisfaction.

TAKA Sp. z o.o. Sp. k.
Warzyn 5A
88-140 Gniewkowo
tel.: +48 796 780 100
e-mail: biuro@taka.com.pl
www.taka.com.pl

Since 2012, we have been operating in the biogas sector with a focus on: delivery and service of generating units, delivery and service of biogas preparation equipment, formal and legal preparation along with investment feasibility analysis, preparation of documents including the construction permit.
Design and construction of turnkey biogas plants based on biogas production technology solutions adapted to the substrate mix. Delivery of biogas plant equipment. Comprehensive warranty and post-warranty service, biogas plant operation with 24/7 remote supervision.

Veolia Water Technologies Sp. z o.o.
Warsaw, ul. Puławska 2
tel.: +48 22 568 83 00
Kraków, ul. Balicka 48,
tel.: +48 12 423 38 66
Tychy, ul. Metalowa 3,
tel.: +48 32 217 82 06
e-mail: info.poland@veolia.com
www.veoliawatertechnologies.pl

Veolia Water Technologies provides solutions, technologies, and equipment in the field of water and wastewater treatment, including anaerobic wastewater treatment with biogas production and energy recovery, as well as MemGas™ membrane technology that converts raw biogas into biomethane.
The company also provides maintenance services, a digital support platform, and water and wastewater treatment chemicals.

Vogelsang Sp. z o.o.
al. San Francisco 9
55-020 Rzeplin
tel.: +48 71 798 95 80, +48 71 798 95 81
e-mail: poland@vogelsang.info
www.vogelsang.info

Manufacturer of PreMix and CC-Mix component dispensers for biogas plants, CC and VX positive displacement pumps (screw and rotary), R-type agricultural pumps, RotaCut macerators, and X-Ripper grinders. New XSplit ergonomic liquid manure and digestate separators! The offer includes specialized equipment for agriculture, e.g. pumps on slurry tankers, liquid manure loading and spreading systems, and separators for cultivation units. We provide comprehensive service and sale of spare parts.

Zakłady Maszynowe „Hamech" Sp. z o.o.
ul. Armii Krajowej 3
17-200 Hajnówka
tel.: +48 607 425 110
e-mail: sekretariat@hamech.pl
www.hamech.pl

Producer of dryers and boiler room equipment. The offer of Z.M. Hamech includes consultancy, design, and comprehensive implementation of dryers. We tailor dryers to the individual needs of the biogas plant, enabling the most efficient use of energy potential. We have state-of-the-art technologies that make it easy to monitor and optimize processes. We carry out investments throughout Europe. Feel free to contact us.

TRANSPORTATION >>>>

Iveco Poland Sp. z o.o.
al. Wyścigowa 6
02-681 Warsaw
tel.: +48 22 578 43 00
www.iveco.pl

IVECO is a leader in the field of low-emission drives, a brand that offers green solutions for fleets of vans and trucks. Since 1996, the company has been developing drives powered by natural gas, liquid gas (LNG), or compressed gas (CNG) and offers vehicles adapted to run on biomethane. IVECO also offers the eDaily, an electric twin of the popular model. In the heavy range, IVECO is implementing the energy transformation of transport with Nikola Tre BEV trucks, and in the near future, the FCEV as well. IVECO vehicles have been recognized for many years for their reliability, contribution to sustainability, and return on investment.

WEIDEMANN POLSKA
ul. Polna 124/126
87-100 Toruń
tel.: +48 56 639 05 97
e-mail: p.suchocki@weidemann.de
www.weidemann.pl, www.hoftrac.pl

We are the Polish representative of the German manufacturer of yard loaders, compact loaders, telescopic tool carriers, and working tools for the above-mentioned machines. We provide service and access to spare parts during and after the warranty period throughout Poland through a professional dealer network.

ANALYSIS, DIAGNOSTICS, TECHNOLOGICAL SUPERVISION, AND MAINTENANCE >>>>

Pracownia Ekotechnologii
Department of Biosystems Engineering
Poznań University of Life Sciences
ul. Wojska Polskiego 50
60-627 Poznań
tel.: +48 609 610 877
e-mail: andrzej.lewicki@puls.edu.pl
www.biogazplus.pl

BIOGAZ+ is an analytical application designed for Polish biogas plants. Its goal is to increase the profitability of these installations. This is achieved through the organization and analysis of data and the optimization of ongoing processes. The effect of its use is easier management and greater profit, as many biogas farmers have already found out – join them. The basic package is PLN 300 per month. If you want to know more about the capabilities of BIOGAZ+, please contact us.

Biogaz Serwis W. Ciemno-Czołowski
ul. Chemiczna 15/9
22-100 Chełm
tel.: +48 500 407 289
e-mail: kontakt@biogaz-serwis.eu
www.biogaz-serwis.eu

The company distributes roofing membranes from Baur Folien GmbH. Installation and service of membrane roofs. Protection of concrete and metal tanks with PEHD film. Repair of lagoons, welding of geomembranes. Biogas plant service. We are looking forward to cooperating with you!

BIO-INDUSTRY
ul. Grobelna 5/412
89-600 Chojnice
tel.: +48 660 000 427
e-mail: biuro@bio-industry.pl
www.bio-industry.pl

We have been providing technical and environmental consulting services to the biogas and biomethane industry for 15 years. We obtain environmental permits, develop project documentation, conduct due diligence audits, and acquire all operational permits. Our technical department starts-up biogas plants, provides continuous technological supervision, laboratory tests, and supplies products: micronutrients, desulfurization preparations, activated carbon, defoamers, enzymes, biogas analyzers, and flow meters.

POLBIOTECH LABORATORIUM Sp. z o.o.
ul. Rubież 46, budynek B
61-612 Poznań
tel.: +48 61 822 73 53
+48 601 056 137
e-mail: laboratorium@polbiotech.pl
www.polbiotech.pl

Since 2006, we have been providing research and analytical services for designed, commissioned, and operating biogas plants. We test: substrates (e.g. value estimation and biogas yield tests), digester samples, biogas composition, we determine the fertilizing value and microbiology of digestate. We can help turn waste into organic fertilizer. We provide supplementation of micronutrient deficits (Acinor 1000). We test engine oils. Our key service is biotechnological monitoring of biogas plants. We interpret test results and advise on how to maintain a stable, efficient, and profitable biogas production process.

A-Consult Sp. z o.o.
ul. Czorsztyńska 2
60-474 Poznań
tel.: +48 61 866 07 27
e-mail: info@aconsult.pl
www.aconsult.pl/.dk/.de/.co.uk

A-Consult has been designing, manufacturing, and installing prefabricated reinforced concrete tanks for a wide range of applications for over 30 years. The offer includes tanks with a height of up to 14 m and a diameter of up to 70 m.

Precon Polska Sp. z o.o.
ul. Domaniewska 47
02-672 Warsaw
Zakład produkcyjny
ul. Roosevelta 20, 64-915 Jastrowie
tel.: +48 22 622 22 09
e-mail: info@precon.com.pl
www.precon.com.pl

Precon Polska Sp. z o.o. is a leader in the production of airtight, prefabricated, reinforced concrete tanks – ACONTANK. Our own design department and 27 years of experience in production and assembly allow us to adjust the tank to the needs of our clients. The company also offers the ACONSILO T mobile silos, ready for self-assembly, with a height of 1.8 meters; 2,5 m; 3.2 m, and ACONSILO type S silos, 3.0 m and 4.2 m high. Our prefabricated elements are delivered from the Polish plant throughout the country.

Wolf System Sp. z o.o.
ul. Budowlana 17
41-100 Siemianowice Śląskie
tel.: +48 32 605 37 00
e-mail: mail@wolfsystem.pl
www.wolfsystem.pl

Wolf-System is one of the largest European producers of monolithic reinforced concrete tanks and silos, including tanks for biogas plants. We build more than 5000 facilities of various types annually. The diameters of our tanks and silos range from 4 to 40 m. The heights range from 2 to 40 m. We have a patented steel formwork system that ensures fast and economical construction. We are particularly proud of our dedicated engineering staff and installation teams. Our clients can count on expert advice, professionally prepared design, and fast, precise construction.

GENERATION OF ELECTRICAL AND THERMAL ENERGY >>>>

2G Polska Sp. z o.o.
ul. Piekarska 86/18
43-300 Bielsko-Biała
tel.: +48 33 818 80 50
e-mail: info@2-g.pl
www.2-g.pl

2G units are an ideal solution for anyone who wants to reduce energy costs in the long term and protect themselves against further increases in electricity prices. As a pioneer, innovator, and one of the world's leading producers of distributed energy generation systems using cogeneration, we have commissioned thousands of technologically advanced, highly efficient modules since 1995. Satisfied clients in 43 countries attest to the quality, performance, and reliability of our products and solutions. The 2G product range covers cogeneration systems from 20 to 4000 kW.

BERGERAT MONNOYEUR Sp. z o.o.
Izabelin-Dziekanówek, Modlińska 11
05-092 Łomianki
tel.: +48 22 201 36 60
e-mail: kogeneracja@eneria.pl
www.eneria.pl

We implement cogeneration and biogas projects, installations of photovoltaic panels and thermal solar collectors, as well as heat pumps. We specialize in the design, construction, and operation of energy and cost-efficient installations based on CAT® gas gensets and Solar Turbines gas turbines. The wide range of services we offer allows us to support the economy in implementing an economic decarbonization strategy using renewable energy solutions – RES.

EPS System
ul. Harcerska 16
32-540 Trzebinia
tel.: +48 32 623 66 88
e-mail: biuro@epssystem.pl
www.epssystem.pl

Leading Polish manufacturer of guaranteed power supply systems. In addition to GETOR™ diesel power generators and uninterruptible UPS power supplies, we manufacture EKOGEN™ cogeneration units powered by various types of gas, including biogas. The company's 20 years in business have seen more than 4000 implementations in Poland and countries in Europe and Asia. We design generators for specific investments, so we can meet specific client requirements. Specialized service teams ensure high availability of equipment.

Selena Green Investments Sp. z o.o.
ul. Legnicka 48A
54-202 Wrocław
tel.: +48 539 148 762
e-mail: kontakt.sgi@selena.com
www.selenagreeninvestments.pl

Selena Green Investments is a company from the Selena Group. We invest in renewable energy sources and solutions supporting sustainable development, such as biomethane, biogas, photovoltaic, and wind projects. We conclude partnership agreements with developers, production companies, and substrate suppliers. We are developing our own team responsible for the development and operation of biomethane and biogas projects. Selena Green Investments provides its partners with stable terms of cooperation, long-term contracts for the collection of substrates, as well as cooperation in technology development.

LUBRICANTS AND OILS FOR BIOGAS PLANTS >>>>

W.P. SIGMA Sp. z o.o.
ul. Słowackiego 5
62-025 Kostrzyn
tel.: +48 61 89-70-400
e-mail: biuro@power-gen.pl
www.power-gen.pl

SIGMA sp. z o.o. is an experienced partner in the field of oil products on the biogas market. As an authorized and exclusive distributor of MOTUL oils from the Power Generation sector, it supplies the highest quality oils for biogas engines throughout the country, ensuring their optimal operation. Comprehensive advice on choosing the right oil, ongoing service, in-house storage facilities, and more than 30 years of experience guarantee a quick response and ensure the continuous operation of engines.

Syntaco Sp. z o.o.
General Distributor of Q8Oils for Poland
ul. Lutycka 11, 60-415 Poznań
tel.: +48 783 005 006
e-mail: przemysl@syntaco.pl
www.syntaco.pl/www.olejeQ8Oils.pl

Q8Oils is part of the Kuwait Petroleum Corporation – the seventh largest oil company. The brand has been well known on the world markets for many years and is currently developing rapidly in Poland as well. The leading oil for gas engines is Mahler Q8, which has been in production for 20 years. It has approvals from leading engine manufacturers such as GE Jenbacher, GE Waukesha, Caterpillar. Long-term cooperation between Q8Oils and INNIO also resulted in the creation of Jenbacher S Oil 40 – an innovative lubricant for engines powered by specialty gases. Q8Oils oils are available on the Polish market through their authorized distributor – Syntaco Sp. z o.o.

SUBSTRATES
FOR BIOGAS PLANTS
>>>>

Biomasa Partner Group SA
ul. Bursztynowa 37, Modła Królewska
62-571 Stare Miasto
e-mail: biuro@biomasapartner.pl
tel.: +48 63 245 59 29
www.biomasapartner.pl

We are a leading producer and preferred supplier of: environmentally friendly, efficient, and certified ENplus A1 PL 027 wood pellets, pine lumber: main, side and unedged, wood briquettes, raw material for pellet production, and wood biomass for energy purposes. We also successfully operate in the straw pellet sector: for the purpose of energy, bedding, and biogas production – made from selected grain straw, high-quality pellets are an effective and efficient substrate that is successfully used in agricultural biogas plants.

PURCHASE AND SALE
OF ENERGY FROM RES
>>>>

Renewable Energy Fuels B.V.
Maria Katarzyna Pieśla
tel.: +31 634 824 332
e-mail: marysia@refuels.nl
www.refuels.nl

Biomethane today! Refuels is a pioneer in the biomethane industry and has been shaping the market across Europe since 2014. Today, we are a leading specialist in sourcing and supplying biomethane for transportation in Europe. We have a wide portfolio of suppliers with whom we have been cooperating for years. We understand the needs and limitations of biogas producers and offer our comprehensive services. We guarantee long-term contracts for the reception of biomethane, which enable producers to invest in biomethane production and ensure growth throughout the production chain. Let's start working together today!

Polska Grupa Biogazowa S.A.
ul. Gotarda 9
02-683 Warsaw
tel.: +48 22 548 49 00
e-mail: pgbiogaz@pgbiogaz.pl
www.polskagrupabiogazowa.pl
www.totalenergies.com

Polska Grupa Biogazowa is the leader in the production of electricity from biogas in Poland. The company's main business is the production of electricity and heat from agricultural biogas and the provision of services related to the renewable energy sector, such as photovoltaic farms. PGB currently owns and operates 17 installations in Poland with a total capacity of 18 MW. It also has 33 wood drying and 6 belt drying chambers. It also offers digestate collection. In 2023 Polska Grupa Biogazowa became part of the global conglomerate TotalEnergies.

LEGAL COUNSELING AND BUSINESS CONSULTING >>>>

BGC GROUP PROSTA S.A.
ul. ks. Piotra Wawrzyniaka 6
53-022 Wrocław
Emilia Maj
tel.: +48 601 320 412
e-mail: emilia.maj@bosetti.pl
www.energymixer.eu/pl/

Energy Industry Mixer is an international event in the form of in-person speed dating style meetings. The event will take place on June 16, 2023 at the LSSE Conference Center in Legnica. The aim of Energy Industry Mixer is to present Italian technology companies with new investment projects in Poland, which state, local government, and private entities as well as investment funds want to implement in the field of recovery of materials and energy from urban, industrial, and agricultural waste.

EKO ENERGIA BROKER
Mirosław Kreczman
ul. Morszyńska 68
82-300 Elbląg
tel.: +48 785 677 066
e-mail: m.kreczman@ekoeb.pl
www.ekoeb.pl

EKO ENERGY BROKER Mirosław Kreczman has been operating on the biogas plant insurance market practically since the beginning of the industry. We insured one of the first biogas plants already at the construction stage, and then during operation. We currently insure nearly 50% of the existing bioenergy facilities on the list of the National Support Center for Agriculture and 6 at the construction stage. So far, we have handled over 40 claims, and the total amount of compensation paid is almost PLN 14 million. Our greatest success is obtaining multimillion-dollar compensation within 44 days from the date of the incident.

Gałczyński Osowiecki Banasik Sp.k.
ul. Zamenhofa 5/3A
00-165 Warsaw
tel.: +48 602 139 290
e-mail: p.banasik@gobelgal.pl
www.goblegal.pl

GOB is a law firm providing a full range of legal services. We help in most legal issues related to renewable energy, including biomass, solar, wind, and others. We provide innovative and cost-effective advice in the changing energy industry. We provide comprehensive legal advice, including with: biogas investments from their first stage, investment agreements, biogas plant operation agreements, ongoing legal services for renewable energy producers.

SCIENCE, INNOVATION, INDUSTRY ASSOCIATIONS >>>>

Akademia Górniczo-Hutnicza im. Stanisława Staszica w Krakowie
Faculty of Drilling, Oil, and Gas
al. Mickiewicza 30
30-059 Kraków
e-mail: h2bio@agh.edu.pl
www.wnig.agh.edu.pl

The Faculty of Drilling, Oil, and Gas of the AGH University of Kraków invites you to participate in a post-graduate course entitled: "Hydrogen and biomethane – production, transport and use. Energy transformation" (planned launch of the new edition: October 2023). The Faculty carries out works related to biomethane obtained from agricultural and municipal biogas plants. Technologies for producing and storing green hydrogen with simultaneous use of the extracted oxygen for biological wastewater treatment processes are being developed.

Poznań University of Life Sciences
ul. Wojska Polskiego 28
60-637 Poznań
tel.: +48 61 848 70 01
e-mail: rektorat@up.poznan.pl
www.puls.edu.pl

Poznań University of Life Sciences is one of the most prominent natural science universities in the country. Its educational mission is closely related to scientific research, which takes into account new areas of knowledge and changing human needs. Thanks to the modern equipment of many units, scientific achievements can be disseminated on the national and international forum, being the subject of knowledge transfer to socio-economic practice and creating links with industry.

National Support Center for Agriculture
ul. Karolkowa 30
01-207 Warsaw
tel. +48 22 376 76 76
e-mail: kontakt@kowr.gov.pl

The National Support Center for Agriculture is an executive agency carries out tasks arising from state policy, particularly in the implementation and application of agricultural support instruments, active agricultural policy, and rural development. In terms of renewable energy sources, the Center, among other things, monitors the production of agricultural biogas and conducts information and promotion activities aimed at developing renewable energy sources, particularly in agriculture. These activities are signed with the "Agro OZE – Energia z rolnictwa" logo.

Polska Organizacja Biometanu
ul. Mokotowska 33/35
00-560 Warsaw
tel.: +48 22 370 2800
e-mail: biuro@bioCH4.org
www.bioch4.org

The Polish Biomethane Organization (PBO) was established on September 6, 2022, bringing together representatives of leading fuel, power, and heating groups operating on the domestic market and industry experts. The most important goal of the PBO is the development of the biomethane market, which can accelerate the process of energy transformation and help make the country less dependent on imported energy resources. The PBO represents the interests of organizations not only in Poland, but also internationally.

Polskie Stowarzyszenie Biometanu
ul. Grzybowska 87
Concept Tower
00-844 Warsaw
tel.: +48 608 550 931
e-mail: mp@biometan.org
www.biometan.org.pl

The goal of the Polish Biomethane Association is to develop the production and use of biomethane as a renewable, non-fossil energy source derived from biomass. The PBA is an expert organization composed of specialists in the biogas industry. Independently of its statutory activities, it provides consulting services for the construction and operation of methane biogas plants. The PBA is currently involved in projects with a total production capacity of 24 million Nm3 of biomethane per year.

Union of Producers and Employers of Biogas and Biomethane Industry
ul. Solec 18 lok. U 31
00-410 Warsaw
tel.: +48 22 550 91 00
e-mail: upebi@upebi.pl
www.upebi.pl

UPEBBI is an organization that brings together companies related to agricultural, wastewater, or landfill biogas. It is a strong representation of the interests of biogas entrepreneurs in relations with local and government authorities and other entities. Our overarching goal is to integrate the biogas and biomethane industry in Poland and work together for the biogas economy in our country under the motto TOGETHER FOR BIOGAS. We cooperate with scientific and research institutions to develop innovative technological solutions that contribute to more dynamic development of the industry in Poland and worldwide.

magazynbiomasa.pl
+48 790 439 216
biuro@magazynbiomasa.pl