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**USE OF NATURAL GAS FOR HEATING APARTMENTS, AS AN EXAMPLE
OF RESIDENTS' CARE FOR CLEAN AIR AND CLIMATE
OF THE OPOLSKIE VOIVODESHIP IN POLAND**

**ВИКОРИСТАННЯ ПРИРОДНОГО ГАЗУ ДЛЯ ОПАЛЕННЯ КВАРТИР
ЯК ПРИКЛАД ТУРБОТИ МЕШКАНЦІВ ПРО ЧИСТЕ ПОВІТРЯ ТА КЛІМАТ
ОПОЛЬСЬКОГО ВОЄВОДСТВА В ПОЛЬЩІ**

The paper presents the problem of access to and use of natural gas as a tool to fight for clean air used to heat apartments by the inhabitants of the Opolskie Voivodeship. Its purpose is to determine the state of development of the gas network in this region as well as the level and rate of increase in the use of blue fuel for heating purposes. These issues, now and in the near future, will affect the possibilities and activities of local authorities in the field of air and climate protection.

The article is also looking for an answer to the question about the current state and size of the gas exclusion of municipalities in the Opolskie Voivodeship and the prospect of its full elimination of this phenomenon, without which it seems impossible to complete a full energy transformation of the region, resulting in a departure from coal and wood as energy sources. Researches carried out for the purposes of this article was supported by statistical data collected by units of non-combined government administration and natural gas distributors, and from local authorities of this region.

Air and climate protection are now a common topic of discussion at the levels of government and in society. Thanks to the growing interest in this issue, there are more and more tending attitudes also in the Polish public space to involve citizens in solving this problem. One of such decisions is undoubtedly the choice of the method of obtaining thermal energy for heating households. The most obvious alternative in many cases is natural gas.

In addition to the increasingly popular renewable energy sources (RES), which draw energy from the sun or wind, it can become a tool for a quick and effective energy transformation. Its competitiveness against electricity or renewable energy is not only supported by the price, but also the possibility of using it regardless of the prevailing weather conditions.

Key words: natural gas, air and climate protection, energy transformation, distribution network.

Стаття нациана у контексті захисту повітря та клімату, що зараз є загальною темою дискусій на рівні уряду та суспільства загалом. Завдяки зростаючому інтересу до цього питання у польському громадському просторі появляється дедалі більше схильних поглядів щодо залучення громадян до вирішення цієї проблеми. Одним з таких рішень, безперечно, є вибір способу отримання теплової енергії для опалення домогосподарств. Найбільш очевидною альтернативою у багатьох випадках є природний газ.

На додаток до все більш популярних відновлюваних джерел енергії (ВДЕ), які черпають енергію від сонця або вітру, це може стати інструментом для швидкого та ефективного перетворення енергії. Його конкурентоспроможність щодо електроенергії та відновлюваних джерел енергії підтримується не лише ціною, але й можливістю використання, незалежно від переважаючих погодних умов.

У статті представлена проблема доступу та використання природного газу як інструменту боротьби за чисте повітря, яке використовується для опалення квартир жителями Опольського воєводства. Метою статті є спроба визначити стан розвитку газової мережі в цьому регіоні, а також рівень та швидкість збільшення використання блакитного палива для опалення. Ці питання як зараз, так і найближчим часом вплинуть на можливість та діяльність місцевої влади у галузі захисту повітря та клімату.

Стаття також є спробою надати відповідь на запитання про поточний стан та обсяги газової заборони в муніципалітетах Опольського воєводства та перспективу повного усунення цього явища, без якого здається неможливим завершити повну енергетичну трансформацію регіону, в результаті чого буде забезпечено відхід від використання вугілля та деревини як джерел енергії. Дослідження, проведені для цілей цієї статті, були підтверджені статистичними даними, зібраними підрозділами місцевої державної адміністрації, розподільниками природного газу та місцевими органами влади цього регіону.

Ключові слова: природний газ, охорона повітря та клімату, енергетична трансформація.

Introduction. Air and climate protection is all the more worth looking at what access to it looks like now and the level of use for heating apartments in one of the smaller ones, as well as less prosperous regions in the country, which is the Opolskie Voivodeship. Especially the economic situation of this region, which translates into the income of the inhabitants, may be one of the most important factors limiting the pace of energy transformation of households with the use of this fuel. Aim of this analysis, covering the years 2015–2018, is to identify the disproportions between municipalities in the state of development of the gas network in the voivodeship, as well as the progress of the inhabitants in the energy transformation of their households, based on the use of blue fuel. Article assumes three hypotheses. First, about the still existing one in the voivodeship there is an infrastructure gap in the existing natural gas transmission and distribution grid.

Second, about the persistent problem of gas exclusion of municipalities and their inhabitants in the voivodeship and the inability to use the benefits of this power source. Third, that concerns the situation in which the Opole Voivodeship still remains an area where the growth rate of the inhabitants' interest in natural gas for heating purposes remains insufficient.

In particular, statistical sources from the Local Data Bank of the Central Statistical Office of Poland, entities providing distribution services and local authorities are helpful in verifying the above hypotheses.

Natural gas as an energy source in Poland

It is a fuel the use of which in Poland seems to be insufficient, despite the fact that it is the third source in the country's energy balance, behind coal and oil [10]. It's use for the chemical and petrochemical industries, for which it is currently the main source of energy, benefit most from domestic extraction and foreign supplies. It's also needed for the processes of oil refining or ammonia synthesis in the production of fertilizers for agriculture [8]. It seems, however, that the most promising, though highly dispersed market for the growth of blue fuel consumption in Poland is not the energy sector, but households. They are already responsible for over 28% of the annual consumption of this fuel [10]. The growing interest of this group of customers in gas, thanks to the tightening policy of local authorities aimed at abandoning coal and wood, seems to be even more promising in the coming years. It also fits in a certain way with the *European Green Deal* policy, proposed by the European Union (EU), supporting environmentally friendly investments (The European Green Deal, 2020). Within its framework, the position of natural gas as a fuel with much lower carbon dioxide emissions has a chance to strengthen [13]. This has been demonstrated for several years by the mechanisms of the European Investment Bank, which in fact discriminate against coal projects [15].

In view of the current extraction of natural gas in Poland, which is not able to satisfy the domestic supply,

in order for it to become an even more popular source of used and low-emission energy in industry and households in the coming years, it is necessary to ensure the security of its external supplies [4; 7; 13]. This is done by the Polish authorities, which after many years of strong gas cooperation with the Russian Federation gradually reducing supplies from this direction. In 2016, imports from the east reached 10.25 billion m³ annually and accounted for 88.9% of the total volume of foreign natural gas supplies to the country. At the end of 2019, it was already 8.95 billion m³, which accounted for 60.2% of the share in blue fuel imports [3]. At the same time, domestic extraction, which in 2019 amounted to 3.9 billion m³ per year, allowed to meet about 1/5 of the internal market demand [3]. Despite the increases in natural gas consumption in Poland for several years, with consumption at the end of 2018 at the level of 19.7 billion m³ annually, we are far from the Italian and German economy, which then needed 69.2 billion m³ and 88.3 billion m³ [14].

Securing the future, increased needs of Poland in the field of using natural gas to heat apartments in place of coal and wood, for several years now the import of liquefied natural gas (LNG) from American, Norwegian and Qatar suppliers has also become. It takes place with the use of the LNG terminal in Świnoujście, which was commissioned in 2015 [18]. The current regasification capacity of this installation reaches 5 billion m³ per year [13], of which 3.43 billion m³ was used in 2019. It was more than a quarter more than the year before [3]. The modernization of the terminal, which has already started, is to increase its capacity to the level of 8.3 billion m³ per year [21].

Even greater reduction of blue fuel supplies from the eastern direction is to be guaranteed by a Polish-Danish gas investment transporting this raw material from Norwegian deposits. Currently, it has already obtained a set of environmental permits from both countries in the above-ground and offshore part. The green light for the project was also given by the Swedish government in connection with the use of the maritime part of the country's EEZ for the foundation of the pipeline [6]. The investment, referred to as the Baltic Pipe, has thus entered the implementation phase the completion of which is expected in autumn 2022 [6].

However, progress in securing new directions of natural gas supplies to Poland may prove to be an easier challenge than that associated with the expansion and modernization of the internal gas infrastructure. Recent years have brought many investments in the warehouse base, which seems to be the best prepared for both the storage of imported raw materials and domestic production [8]. Progress in the modernization of the transmission and distribution networks should be assessed with less optimism. The problem is mainly the age of the currently existing local gas pipelines. More than half of them are more than 30 years old [13], 2017). The oldest

of them were built before World War II [11]. Modernization delays at the municipal level are particularly severe, as the gas network manager himself, Polish Gas Company (PGC) notices pointing out that only investments planned for 2018–2022 will result in an increase in the level of gasification of Polish municipalities from 59.8% to 72% [16].

The benefits of using natural gas for heating purposes

To take full advantage of the growing opportunities for obtaining natural gas from external directions apart from internal activities aimed at improving the condition of blue fuel distribution infrastructure in individual regions and communes, the most difficult task seems to be to convince the inhabitants themselves to carry out the energy transformation of their households based on this raw material. Its use as a substitute for coal or wood brings many benefits. Due to its higher calorific value, its energy value is higher. It means that a shorter combustion period of even a higher amount of thermal energy than with solid fuels. Oxidizing methane does not cause ash formation, while emitting smaller amounts of carbon dioxide, sulfur and heavy metals into the atmosphere [19]. The problem with the management of ashes and the storage of the raw material for heating purposes in conditions ensuring its minimum humidity disappears [19]. Increasing the use of natural gas for heating buildings also brings social benefits. Tolerance is falling for people who break the rules of social coexistence, using old heating installations to burn waste or poor quality fuel. Also, the air becomes cleaner, thanks to the reduced emission of PM 10 and PM 2.5 dust, which consequently also causes less soiling of the building facades after rain or snowfall.

Thanks to access to the gas network, local governments also gain the possibility of using it for heating purposes in public utility buildings. The growing number of gas-heated houses also means specific changes in the municipal economy, in which less recyclable ashes appear in circulation. One should also not forget here on collective energy that can use fuel as a primary source of heat energy, then supplied to its recipients living in concentrated buildings. The possibilities of developing this form of using blue fuel for heating purposes of individual consumers seem to be very limited in rural areas.

Use of natural gas for heating apartments in the Opolskie Voivodeship

Considering the production of heat energy from solid fuels as one of the most harmful to air quality and climate activities of households it's worth looking at the possibilities of limiting this phenomenon with the use of natural gas, as well as the actions already taken by residents in this matter. In this case, special attention is focused on the Opolskie Voivodeship in 2015–2018. It also includes investment activities planned in this area by PGC by the end of 2022, the effects of which should improve the availability of blue fuel for the region's

inhabitants, and thus also in some way encourage them to use this source of thermal energy.

The Opolskie Voivodeship covers an area of 9,412 km², which is 3.0% of the entire country. It is the smallest region in Poland. At the end of 2018, it was inhabited by 986.5 thousand, and gradually depopulating, as shown by demographic data from 2016, when 993 thousand people lived there [20]. Density of population at the level of 105/km², it is also lower than the national average (123/km²), comparable to the Świętokrzyskie region. The capital city in the voivodeship is Opole. Region is divided into 11 poviats; brzeski, głubczycki, kędzierzyńsko-kozielski, kluczborski, krapkowicki, namysłowski, nyski, oleski, opolski, prudnicki i strzelecki. Basic level of self-government administration consists of 71 local communes including 3 urban (UC), 33 urban-rural (URC) and 35 rural (RC). Administrative shape of the region presents Fig. 1.

Opolskie Voivodship situated at the intersection of three geographical regions; Silesian-Krakow Uplands, the Silesian Lowlands and the Sudetes. It is characterized by a system of a trough open to the west, the central axis of which is the Odra River and its tributaries. The high average annual temperature and optimal rainfall levels, combined with a mild climate, make it the case it is an area favorable for the development of agriculture. Additionally, it is enhanced by fertile soil [20]. At the same time, it is not a region with a low urbanization rate. In 2018, it was 52.78% and turned out to be higher than in the Świętokrzyskie, Lubelskie, Małopolskie or Podkarpackie Voivodeships.

The possibilities of using natural gas for heating purposes are influenced, among others, by density of the active distribution network of this fuel. Its density in poviats of the Opole region is presented in table 1.

The table above shows a slow increase in the density of gas threads in most poviats of the voivodeship. At the end of 2018, the city of Opole was the leader in the development of blue fuel transmission infrastructure and the pace of its expansion. This was also the case after the expansion of the city's borders in 2017 (Regulation, 2016).

Apart from the capital of the voivodeship, the best-developed gas network is in the poviats krapkowicki, kędzierzyńsko-kozielski and nyski. Only there in 2018, its density exceeded the average for the region. However, since the network density increases the chances of its use by the inhabitants, it is worth checking whether it was so in this case. The necessary information presents table 2.

The data contained therein indicate that the inhabitants have access to natural gas within 4 years it increased by 0.2% in the region, without being particularly high. Most of its users are residents of Opole. Also, over half of the population living in the brzeski and kędzierzyńsko-kozielski poviats used this type of fuel in 2018. The poviats of głubczycki, kluczborski,



Fig. 1. Opolskie Voivodeship – administrative division in 2018

Source: Wiking Educational Publisher

Table 1

Length of the active gas network (km /100km²) in the Opolskie Voivodeship in 2015-2018

poviats/year	2015	2016	2017	2018
Brzeski	22,6	23,7	25,3	25,7
Głubczycki	20,5	20,7	20,7	20,7
kędzierzyńsko-kozielski	34,4	35,2	35,6	36,1
Kluczborski	26,6	26,9	28,4	28,8
Krapkowicki	45,9	47,0	47,4	48,7
Namysławski	9,8	9,9	10,4	10,6
Nyski	29,8	30,7	30,6	31,2
Oleski	15,8	15,9	15,9	16,1
Opolski	24,2	25,2	24,8	25,7
Prudnicki	20,8	20,9	21,3	21,3
Strzelecki	20,8	20,8	21,5	22,4
m. Opole	330,2	336,5	248,5	255,4
VOIVOEDSHIP	27,1	27,7	28,4	29,0

Source: own study based on data from the Local Data Bank of the Central Statistical Office of Poland

Table 2

Population (%) using the gas network in the Opolskie voivodeship in 2015-2018

poviats/year	2015	2016	2017	2018	change
brzeski	56,3	56,2	56,1	56,0	- 0,3
głubczycki	44,8	45,0	45,0	45,2	+ 0,4
kędzierzyńsko-kozielski	53,8	53,6	53,5	53,6	- 0,2
kluczborski	43,0	43,0	43,1	43,3	+ 0,3
krapkowicki	38,5	38,4	38,5	38,7	+ 0,2
namysławski	33,1	33,6	34,4	34,3	+ 1,2
nyski	47,9	48,2	48,4	48,1	+ 0,2
oleski	11,9	12,1	12,4	12,7	+ 0,8
opolski	12,8	13,1	13,6	14,9	+ 2,1
prudnicki	43,0	43,0	43,2	42,8	- 0,2
strzelecki	20,7	20,8	20,8	20,7	0,0
m. Opole	79,0	78,6	74,2	73,7	- 5,3
VOIVODSHIP	41,9	41,9	42,1	42,1	+ 0,2

Source: own study based on data from the Local Data Bank of the Central Statistical Office of Poland

nyski and prudnicki were also above the average for the voivodship. Krapkowicki and namysłowski poviats were weaker. Infrastructural deficiencies, already indicated in table 1, turned out to be one of the reasons for the poor use of natural gas by the inhabitants of the city Opole and oleski poviats.

Observed stagnation in the increase in the availability of natural gas for the region's population, and even its slight decrease as in Opole itself, is also disturbing. In this case, it can be partially explained by the expansion of the city's borders in 2017, which resulted in the connection of neighboring, less urbanized areas, where the availability of the gas network to the public was then lower. The data from table 1 and 2 show that the voivodship is still far from "saturating" the gas market, both in terms of the degree of development of the distribution network and the availability of this fuel to the inhabitants. At the same time, there is a systematic increase in the number of consumers who heat their households with natural gas. This is shown in the data collected in table 3.

The data indicated in table 3 indicate the growing interest in the use of blue fuel for the production of heat energy for heating purposes among the inhabitants of the voivodship. This proves the progressive energy transformation of households, limiting low emissions, and protecting the environment and climate. The number of gas-heated households in the Opolskie Voivodeship at the end of 2018 was over 10.15% higher than in 2016. However, the popularity of this heat production system varied. At the end of 2018, the largest number of residents who heat their apartments with gas lived in Opole (23.65%) and in the poviats of nyski (14.97%), brzeski (13.70%), kędzierzyńsko-kozielski (7.80%), prudnicki (6.24%).

In these five local governments there were nearly 66.35% of customers using blue fuel for heating. This type of use of natural gas was not popular in oleski and

strzelecki powiat. Between 2016 and 2018, new customers interested in transforming the energy economy of their households appeared in all poviats. The largest group of them was the inhabitants of Opole (21.67%) and the poviats namysłowski (12.67%), brzeski (12.59%), kluczborski (10.52%) and nyski (10.39%). Between 2016 and the end of 2018, 67.85% of all gas heating installations in the entire voivodship appeared in these units.

However, the growing number of consumers heating their homes with gas in the poviats of the region does not mean the same situation in communes. This is because the phenomenon of gas exclusion still persists there in the state in which in the area of the elected local government due to if there is no distribution network offered.

The data in table 4 inform about two points. First, out of 71 communes of the voivodship, only 49 of them offer access to the gas network. The gas exclusion still covers 22 local governments in the region, nearly 31%. Most of them are rural communes. The level of the distribution offer at the end of 2018 did not guarantee quick access to the network also in municipalities where the infrastructure is already in operation. Secondly, in the Opolskie Voivodeship in 2015–2018, natural gas was used for heating purposes by the inhabitants of 42–45 municipalities. The largest number of installations this type in the winter of 2018/2019, apart from Opole (23.65%), operated in local governments in Brzeg (9.45%), Kędzierzyn-Koźle (7.74%) and Nysa (7.69%). The years 2015–2018 were also the period when the largest number of new customers for blue fuel for heat production appeared in Opole, Namysłów, and Kluczbork. The communes that were the seats of powiat authorities turned out to be areas where the inhabitants decidedly more willingly and faster to use natural gas for heating purposes. However, the scale of the increase in the number of houses heated in this way within 4 years seems to be still limited. It is presented in Fig. 2.

Table 3

Customers heating their homes with gas by poviats in the Opolskie Voivodeship in 2015–2018

poviats/year	2015	2016	2017	2018	change
brzeski	5 376	5 385	5 620	5 874	+ 498
głubczycki	2 475	2 492	2 553	2 623	+ 148
kędzierzyńsko-kozielski	3 243	3 259	3 281	3 342	+ 99
kluczborski	2 214	2 311	2 423	2 630	+ 416
krapkowicki	2 299	2 345	2 453	2 550	+ 251
namysłowski	1 660	1 771	1 961	2 161	+ 501
nyski	6 008	6 091	6 256	6 419	+ 411
oleski	900	918	957	1 042	+ 142
opolski	2 094	2 242	2 089	2 372	+ 278
prudnicki	2 417	2 475	2 610	2 675	+ 258
strzelecki	958	990	987	1 053	+ 95
m. Opole	9 284	9 295	9 834	10 141	+ 857
VOIVODESHIP	38 928	39 674	41 024	42 882	+ 3 954

Source: own study based on data from the Local Data Bank of the Central Statistical Office of Poland

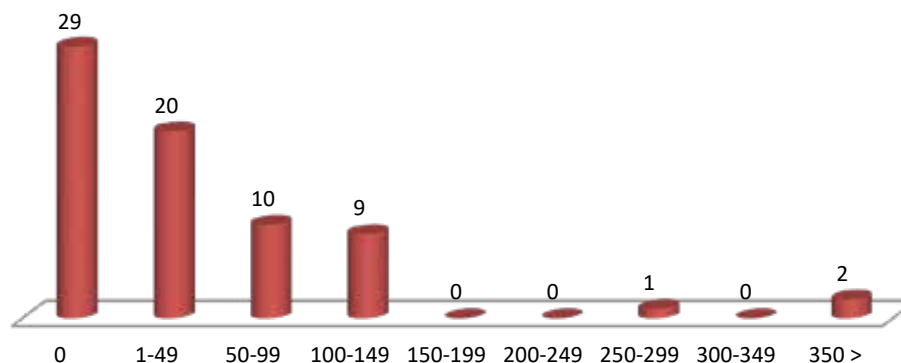


Fig. 2. New heating connections to the gas network in the communes of the Opolskie Voivodeship in 2015-2018

Source: own study based on the data in table 4

Until the end of 2018, there was no use of natural gas for heating households in 36.6% of municipalities in the Opolskie Voivodeship. In the next 45.07% in 4 years, fewer than 100 new customers appeared using it in this way. This shows that the energy transformation in these region households with the use of blue fuel until the end of 2018 was slow. This raises concerns that even now, the wider use of this source of heat as a tool to fight for clean air remains limited. Some hope for an improvement in the situation in 2019–2020 and in the near future is provided by the Program for accelerating investments in the Polish gas network for 2018–2022, already implemented in the Opolskie voivodeship by PGC. It assumes launching a distribution service for another 9 communes in the region, where it has not been provided so far. Despite the COVID-19 pandemic, investments did not slow down in the spring of 2020, which increases the chances that by the end of 2022, only 13 municipalities (18.3%) of the region will have gas exclusion. It will also certainly be a factor increasing the chances of a faster spread of the use of natural gas among the inhabitants.

Conclusions. The analysis undertaken for the purposes of this article leads to several final conclusions. Undoubtedly, natural gas remains one of the most promising conventional energy sources serving the energy transformation of households in Poland. Its properties and production method also contribute to the rapid improvement of air quality. However, it seems necessary to intensify actions aimed at improving its availability and use in heat generation.

The problem to be overcome is still the existence of white spots on the gasification map of Polish

municipalities, as well as gas investments where they do not exist anymore, but the density of the distribution network remains insufficient. Another challenge for the national and local authorities is to take steps to increase the interest in blue fuel among the residents who have used solid fuels so far. The above-mentioned measures may prove to be the most difficult to implement in rural areas, where both the condition of gas network infrastructure, the costs of its expansion, and the income of the inhabitants themselves may prove to be barriers difficult to overcome in the short term.

It shows the well-analyzed Opolskie Voivodeship, which to this day remains a region with a persistent problem of gas exclusion, most often affecting rural communes. Often the already existing active distribution network turns out to be too modest to serve the energy transformation of local communities. Moreover, the scale of investments in the expansion of the network proposed for the region by Polska Spółka Gazownictwa evokes mixed feelings. It also gives no illusions that before 2030, local governments in the voivodeship will be fully supplied with gas. Also, the number of consumers using natural gas to heat their homes, as well as its increase, remain below expectations, which is certainly the result of not only the level of income of the inhabitants of this area, but the persistent shortages of infrastructure networks in municipalities. Only the municipalities of the region and local governments being the seat of poviát authorities stand out. Therefore, it seems that the Opolskie Voivodeship still has a long way to go before it becomes an area where the use of blue fuel by the inhabitants will be limited only by its price.

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