AGH DRILLING, OIL, GAS • Vol. 35 • No. 3 • 2018

https://doi.org/10.7494/drill.2018.35.3.413

Marzena Jasiewicz*, Marzena Nadolna*, Maciej Stec, Oryna Słobodzian-Ksenicz***

NATURAL GAS CONSUMPTION BY COOKERS IN MULTI-FAMILY HOUSES

Abstract: This article presents the results of research on the natural gas consumption of cookers in two multi-family houses located in a large housing estate in a city with a population of 100,000 people. Monthly, daily, and hourly variations in natural gas consumption were analyzed. The actual maximum consumption was determined and compared with the calculated demand for natural gas.

Keywords: natural gas, natural gas consumption, simultaneity coefficient

* University of Zielona Góra, Zielona Góra, Poland
** EXALO Drilling S.A., Zielona Góra, Poland

1. INTRODUCTION

With its numerous advantages such as its ease of use, high calorific value, high-efficiency combustion process, and low emission of pollutants, natural gas is currently one of the basic non-renewable primary energy carriers used in municipal and industrial energy systems [1]. Plans for the sustainable development of the natural gas system include an assessment of the required capacity of the gas network and the profitability of the gas system [2]. The basic element in the process of planning, designing, and operating gas systems is an analysis of gas consumption and determination of peak gas consumption. It is the maximum demand for gas that has a significant impact on the selection of diameters for gas installations and networks as well as on the selection of the sizes of devices at natural gas stations. Natural gas consumption is highly irregular in the hourly, weekly, monthly, and annual cycles. The individual needs of the users and their preferences have a strong impact on the variability of fuel consumption. Natural gas is used for municipal purposes (such as the preparation of meals, domestic hot water, and heating rooms by individual users) and for non-municipal purposes (such as supplying public or industrial buildings and for technological purposes). The distribution of gas consumption is different for each of the abovementioned needs. The objective of this research was to determine the distribution and amount of the natural gas used in gas cookers. It was assumed that the increasing use of electrical devices in households, the use of energy-saving pots, pressure cookers, etc., or the preparation of ready-made products that did not require long cooking times had resulted in a decrease in natural gas consumption.

2. METHODOLOGY

Two buildings located in a large housing estate in a city of 100,000 were subjected to our research. In Building No. 1 (referred to as B1), there are 88 flats, and in Building No. 2 (B2) – 74. The flats are equipped with four-hob gas cookers with a gas oven. Thermal energy for the heating of the buildings is supplied from the district heating network. Domestic hot water comes from the water supply network. In the buildings, natural gas is only supplied to gas cookers that are used to prepare meals. The amount of gas supplied to the cookers is measured by a G16 gas meter, which is equipped with a recorder that enables hourly, weekly, and monthly gas consumption measurements. The buildings are supplied with Lw-type nitrated natural gas (formerly GZ-41.5).

3. MONTHLY NATURAL GAS CONSUMPTION BY COOKERS IN MULTI-FAMILY HOUSES

The results of the measurements of monthly gas consumption in the buildings under study are shown in Figure 1. In both buildings, the annual distribution of gas consumption was very similar. For both buildings, the lowest gas consumption occurred in June, amounting to 726 m^3 in B1 and 569 m^3 in B2. The highest gas consumption in B1 occurred in December – 1407 m^3; in January, this amounted to 1389 m^3. In B2, the peak consumption occurred in January – 1368 m^3.

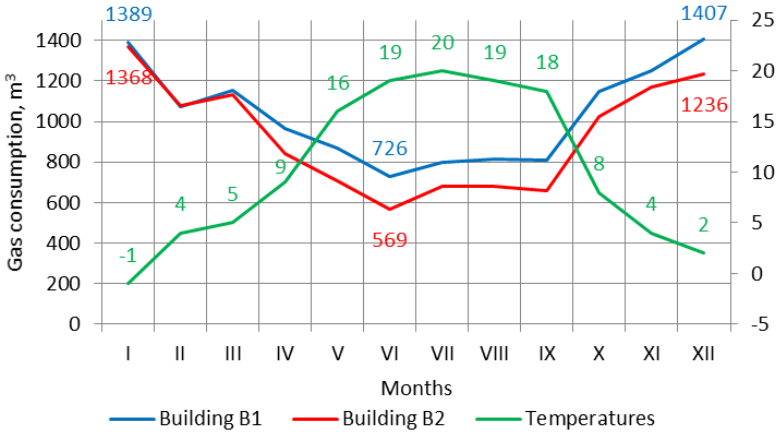


Fig. 1. Annual distribution of gas consumption by gas cookers in B1 and B2

As mentioned in the literature [3], there are clear differences in the monthly consumption of gas by the gas cookers; these are dependent on the outdoor temperatures at the buildings. During the summer months, the least amount of gas is consumed. The most likely reason for this may be holiday trips, less time spent at home, eating out, and changes in eating habits (i.e., eating uncooked products such as fruit, vegetables, etc.). In both buildings, increases in gas consumption were observed in March because of Easter (which occurred over March 26–28 in 2016). The reports mentioned in the literature saying that there was a significant increase in gas consumption during the autumn (mushroom season) due to the drying of mushrooms were not confirmed. This may be attributed to a wider use of electric dryers or a lesser interest in preserving mushrooms for the winter. The peak monthly gas consumption occurred in the months with the lowest outdoor temperatures and during Christmas, New Year, and/or Orthodox Christmas. Taking into account the number of gas appliances installed in the individual buildings, the annual distribution of the average gas consumption by individual users was calculated (Fig. 2).

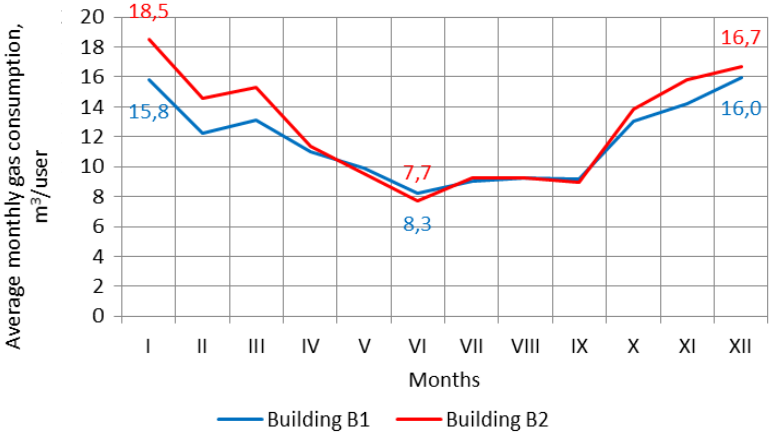


Fig. 2. Average monthly gas consumption by individual users in B1 and B2

The average monthly gas consumption by an individual user was between 8.3 and 16.0 m^3/month in B1 and between 7.7 and 18.5 m^3/month in B2. The average annual gas consumption by an individual user was 141.0 m^3/year in B1 and 180.2 m^3/year in B2.

4. DAILY GAS CONSUMPTION BY GAS COOKERS IN MULTI-FAMILY HOUSES

The variability of daily gas consumption during the monthly cycle is closely related to the weekly cycle. Figures 3–5 show the weekly gas consumption patterns for three exemplary months – January, June, and December. Sundays and holidays are marked in yellow.

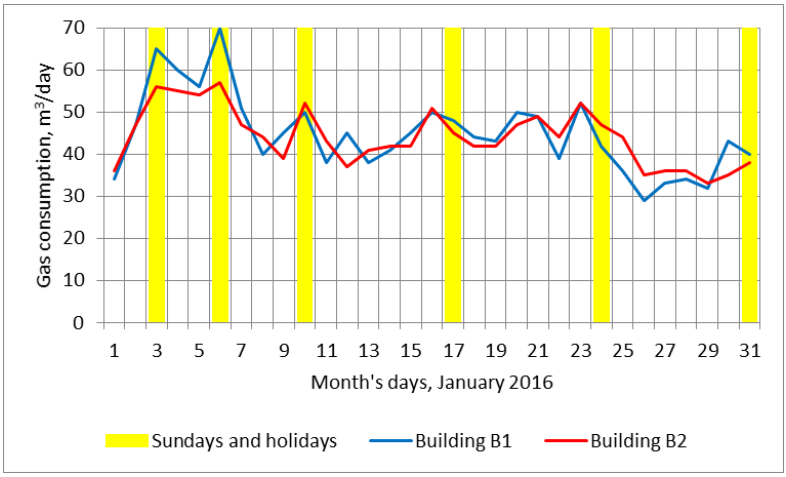


Fig. 3. Daily distribution of gas consumption in January 2016 in B1 and B2

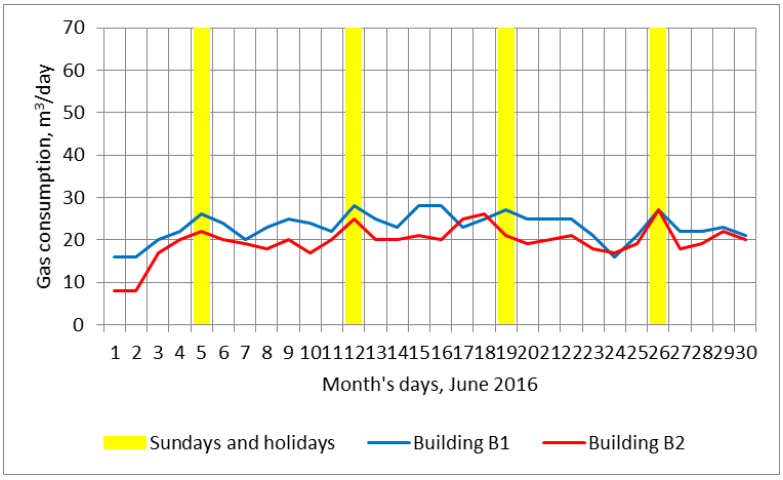


Fig. 4. The daily distribution of gas consumption in June 2016 in B1 and B2

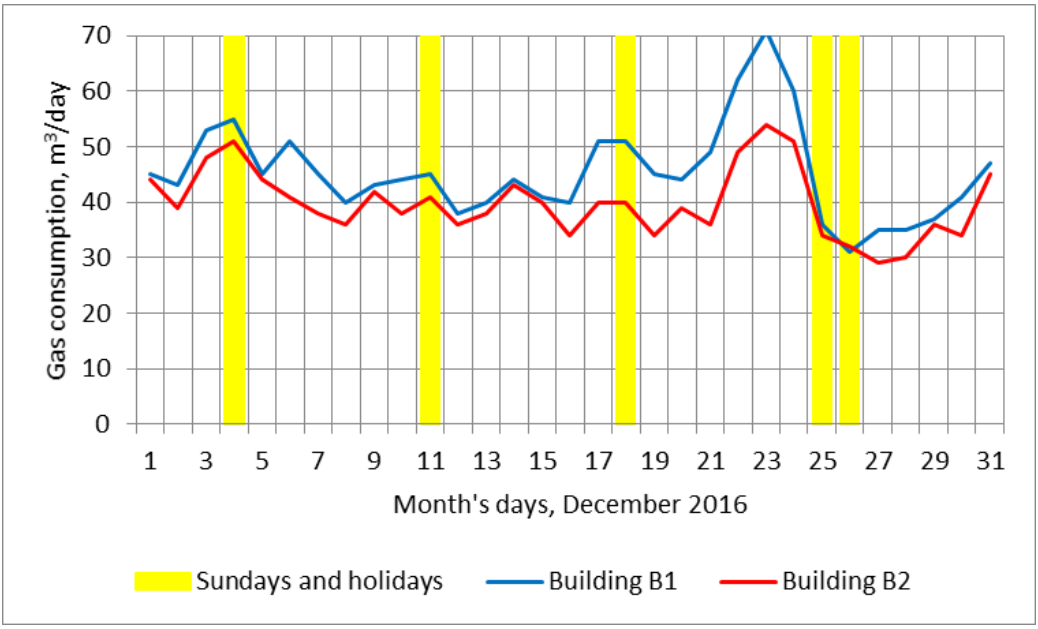


Fig. 5. Daily distribution of gas consumption in December 2016 in B1 and B2

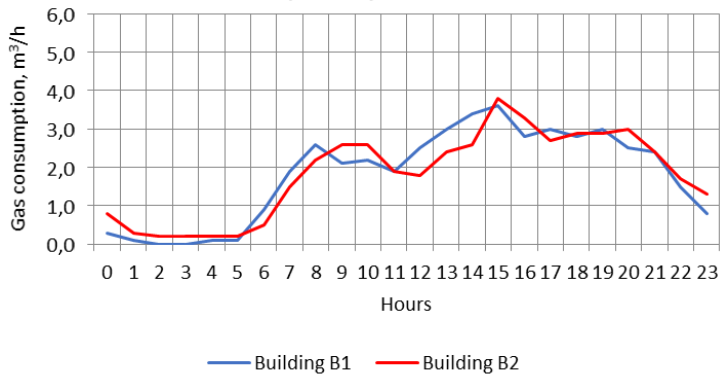
In both buildings, the weekly gas consumption patterns were very similar. The maximum and minimum consumptions often overlapped and occurred on the same days. There is always an increase in demand on days preceding holidays, days off from work, or weekends (especially on Sundays). No obvious pattern was observed during the week. According to the analysis of the daily gas consumption, peak consumption occurred on December 23, 2016 (i.e., 71 m^3/day in B1 and 54 m^3/day in B2) and January 6, 2016 (Three King's Day and the eve of Orthodox Easter), when daily gas consumption amounted to 70 m^3/day in B1 and 57 m^3/day in B2.

5. HOURLY GAS CONSUMPTION BY GAS COOKERS IN MULTI-FAMILY HOUSES

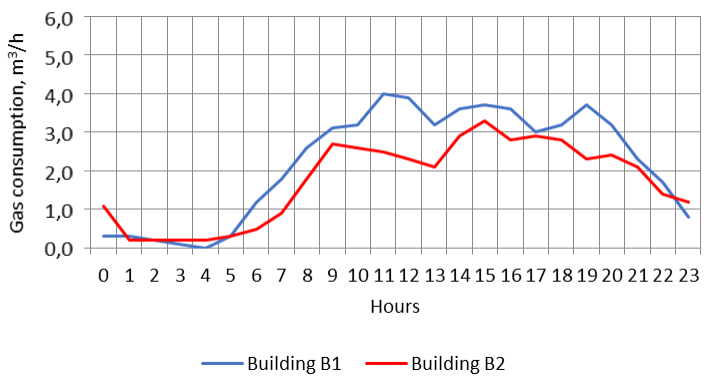
The basic factor that determines the selection of the diameters and components of gas installations is the maximum hourly demand for gas. An analysis of the hourly gas consumption makes it possible find a certain relationship between this and the lifestyles of gas users. On weekdays, the maximum gas consumption occurs during the afternoon (i.e., between 3:00 and 5:00 p.m.); in addition, there is another increase in gas consumption between 7:00 and 8:00 p.m. On Saturdays and Sundays, the maximum consumption usually occurs between 1:00 and 4:00 p.m., with peak consumption occurring at 2:00 p.m. (Fig. 6).

In both buildings, the maximum hourly gas consumption occurred on December 24 (Christmas Eve); in B1, this occurred at 3:00 p.m. (amounting to 6.5 m^3/h), and in B2 – at 5:00 p.m. (amounting to 5.6 m^3/h).

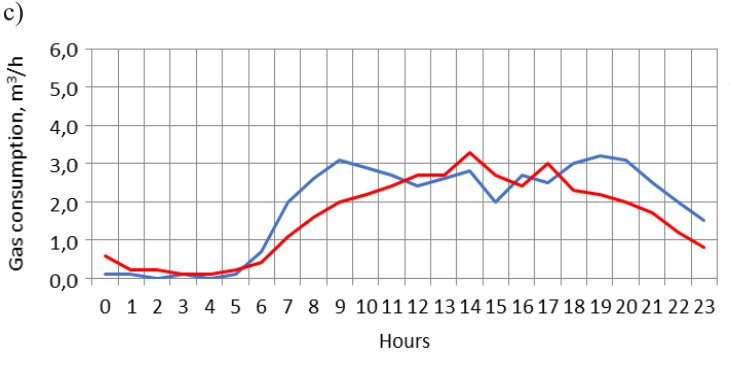
a)


Gas consumption, m³/h
6,0
5,0
4,0
3,0
2,0
1,0
0,0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hours
Building B1
Building B2

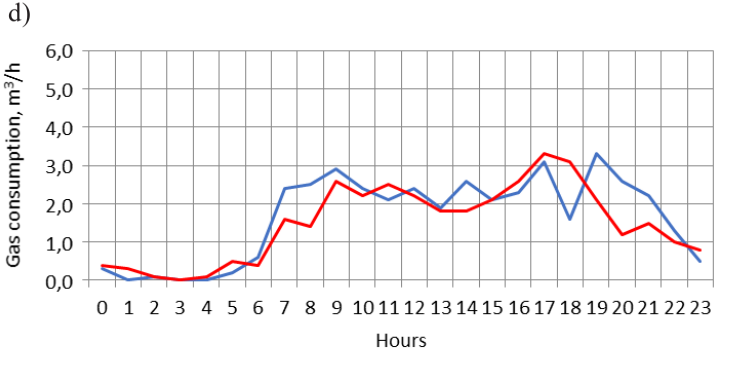
b)


Gas consumption, m³/h
6,0
5,0
4,0
3,0
2,0
1,0
0,0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hours
Building B1
Building B2

c)


Gas consumption, m³/h
6,0
5,0
4,0
3,0
2,0
1,0
0,0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hours
Building B1
Building B2

d)


Gas consumption, m³/h
6,0
5,0
4,0
3,0
2,0
1,0
0,0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hours
Building B1
Building B2

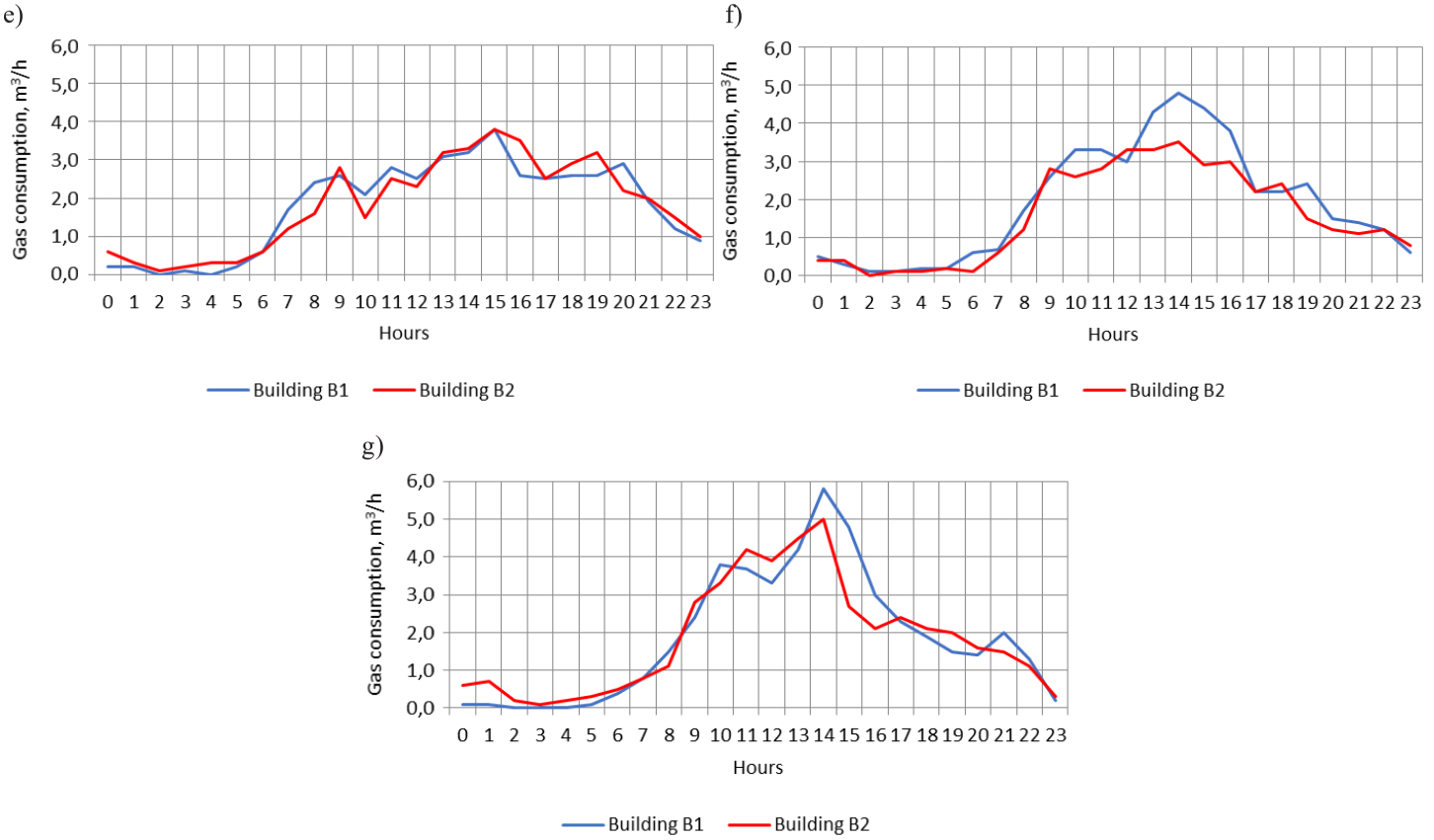


Fig. 6. Diagrams of distribution of hourly gas consumption on particular days of week in B1 and B2 a) Monday; b) Tuesday; c) Wednesday; d) Thursday; e) Friday; f) Saturday; g) Sunday

6. COMPARISON BETWEEN ACTUAL MAXIMUM HOURLY GAS CONSUMPTION AND CALCULATED DEMAND FOR GAS

While designing gas installations, it is necessary to determine the calculated gas demand. Since users do not all use their cookers at the same time, the actual gas consumption is much lower than would result from the sum of the nominal consumption by these appliances. Therefore, simultaneity coefficients are used to calculate the hourly gas consumption, which is necessary to select the diameters of gas installations. The simultaneity coefficient determines the ratio between the actual gas consumption and the sum of the nominal consumption by the devices installed. It is a dimensionless value [4].

$$f = \frac{Q_{\max}}{\sum n \cdot Q_{\text{nom}}} \tag{1}$$

where:

f – simultaneity coefficient for gas consumption,
$Q_{\max}$ – maximum actual gas consumption [m^3/h],
Q_{nom} – nominal gas consumption by appliance of particular type [m^3/h],
n – number of users in dwelling.

The value of the simultaneity coefficient depends on the unit gas consumption by the appliance and on the number of users (gas appliances). In order to determine the simultaneity coefficient for small groups of users, a formula by R. Zajda is used:

$$f = \frac{1}{n^{0.52}} \tag{2}$$

where:

f – simultaneity coefficient for gas consumption,
n – number of users in dwelling.

The buildings subjected to our research are equipped with four-hob cookers with gas ovens with a nominal consumption of 1.6 m^3/h of Lw type (GZ-41.5) natural gas. The number of appliances installed in B1 and B2 is 88 and 74 cookers, respectively.

The calculated demand for gas according to the formula by R. Zajda is as follows:

– Building B1: $Q_{\max} = 1.6 \cdot 88 \cdot \frac{1}{88^{0.52}} = 13.72$ [m^3/h]

– Building B2: $Q_{\max} = 1.6 \cdot 74 \cdot \frac{1}{74^{0.52}} = 12.63$ [m^3/h]

The calculated demand for gas is twice as high as the actual maximum consumption recorded in the buildings:

in B1, this was 6.5 $m^3/h < 13.72\ m^3/h$,

in B2, this was 5.6 $m^3/h < 12.63\ m^3/h$.

7. CONCLUSIONS

The lifestyles of users is a major factor that has an impact on the consumption of gas for the preparation of meals. The peak gas consumption coincides with holidays and days not at work. On weekdays, higher consumption usually occurs after 3:00 p.m. (i.e., after the residents return from work). However, the largest consumption occurs at lunchtime on weekdays (i.e., around 2:00 p.m.). The seasons and outdoor temperatures also have an impact on the level of gas consumption. In the summer months, gas consumption is half of what it is in winter. In the case of the buildings subjected to our research, the calculated demand for gas (which was the basis for the design of their gas installations) is overstated and does not reflect the actual gas consumption. Over the years, the habits of users have changed; we are more and more often using electrical equipment such as kettles, multicookers, steam cookers, fruit/vegetable dryers, etc. We like using pressure cookers or energy-saving pots with thick bottoms; these reduce cooking times. The current pace of life results in the fact that people lose interest in making preserves for the winter, preferring to use ready-made products instead that require only heating and not long cooking times. All of these factors result in the smaller amount of gas used for preparing meals. The calculation of gas consumption and the peak consumption by cookers affects the selection of diameters for the gas installations and planning the sustainable development of gas systems. The research indicates that it is necessary to further monitor the records of gas consumption in order to verify the gas consumption coefficients currently used for the calculations.

REFERENCES

[1] Molenda J., Steczko K.: *Ochrona środowiska w gazownictwie i wykorzystaniu gazu*. WNT, Warszawa 2000.

[2] Grządzielski W., Mróz T.M.: *Planowanie zrównoważonego rozwoju systemu gazowego*. KAPRINT, Lublin 2017.

[3] Bąkowski K.: *Sieci i instalacje gazowe: poradnik projektowania budowy i eksploatacji*. WNT, Warszawa 2007.

[4] Zajda R.: *Projektowanie sieci gazowych. Schematy obliczeniowe gazociągów*. Centrum Szkolenia Gazownictwa, Warszawa 2001.