

SELECTED ASPECTS OF ELECTRICITY CONSUMPTION IN HOUSEHOLDS

Mateusz Bajor^{1*}

¹ Czestochowa University of Technology, Faculty of Management, Poland


Abstract: Currently, households are faced with the problems of rising electricity prices. Every month, electricity suppliers try to force the Energy Regulatory Office to increase prices as much as possible for individual consumers. The aim of the article below is to indicate that responsible electricity management by means selecting a favourable tariff will largely contribute to lowering the economic bill of a household. During the study, we used our own data on the annual consumption of electricity in a household by the most frequently used appliances, and the current energy prices in the studied tariffs. The most advantageous option is the responsible use of the G12w tariff, supported by one's own photovoltaic micro-installation. Such a combination guarantees minimal costs resulting from the consumption of electricity.

Keywords: consumption, economy, households, tariffs

JEL classification: D14, R20

Introduction

Electricity consumption in each sector of the national economy is gaining ever more importance. Energy efficiency concerns both the broadly understood energy and climate policy, and is an important factor influencing the amount of production costs of enterprises (and thus their profits) as well as socio-economic development. The consequence of the irrational use of energy is the excessive consumption of energy resources, problems with environmental pollution, and the limited competitiveness of domestic enterprises on world markets. From the point of view of an

¹ Mateusz Bajor, MEng., ul. Dąbrowskiego 69, 42-201 Częstochowa, Poland, mateuszbajor@pcz.pl,
 <https://orcid.org/0000-0002-3459-7912>

* Corresponding author: Mateusz Bajor, mateusz.bajor@pcz.pl

individual consumer, energy efficiency is one of the main measures to reduce the share of electricity costs in the household budget. In recent years, the European Commission has made many efforts to reduce electricity consumption in households, including: promoting economical lighting, subsidies for renewable energy micro-installations in homes, the need for energy labelling of household appliances and the broadly understood liberalization of the electricity market. Additionally, the current global situation related to the armed conflict in Ukraine adversely affects energy prices on European markets. This is due to the lack of coal and gas – the necessary raw materials for generating electricity.

Characteristics of households in relation to energy demand

More recently, there has been increasing interest in the matter of energy consumption in households (Rahmani et al., 2020). Household energy consumption behaviour can be analysed in time (Zhobu et al., 2016), and here an ever-increasing demand for energy is observed (Heijs, 2006). In general, the residential sector has become the second largest consumer of electricity in the world after the industrial sector (Tian & Chang, 2020).

According to current data, 37 million 578 thousand people live in Poland, who make up 14.62 million households (Borowska et al., 2020). 50% of these entities do not exceed the volume of 200 m³ or 60 m² and are inhabited by 2-3 people (average 2.61). In recent years, there has been a systematic increase in the area and volume of premises and a systematic decline in the average number of people in the household (Zalega, 2007). In a year, the statistical household in Poland is able to use from 1.800 to 2.000 kWh of electricity in urban areas and up to 2.000 to 2.300 in rural areas, which is two times lower than the EU average. The characteristics of households, in terms of electricity consumption, were prepared on the basis of the guidelines described in the document published by Eurostat – Manual for statistics on energy consumption in households (MESH) and the data of the Central Statistical Office. Energy-consuming devices can be divided into 6 groups:

- devices for space heating,
- water heating devices,
- devices for cooking meals,
- room cooling devices,
- lighting, household appliances and electronics,
- other, not mentioned in other groups.

Only 5.3% of flats are equipped with the first group of devices. Due to significant costs and the large availability of other, less expensive energy carriers (in particular coal), heating with electric devices is not used on a large scale in Poland (Wojtulewicz et al., 2006). Electric heating devices are mainly employed as supplementary heat sources or in places where other types of heating cannot be used. Electric water heating devices (thermal baths, boilers) are installed in 23.5% of households. The number of these devices has remained stable in recent years. The average age of these devices is 9 years old, which proves that the devices are not technically

obsolete. Gas stoves with an electric oven can be found in every second household, while fully electric stoves (hob with oven) in every tenth (Mielczarski, 2021). It should also be mentioned that over 50% of households are equipped with a microwave oven. Air conditioners are installed in less than 0.5% of households, but their number has increased significantly in recent years, mainly due to newly built high-standard apartments. Most of them are devices designed for cooling individual rooms. Only 0.04% of flats have central air conditioning. The most largest group of energy-consuming devices includes household appliances, electronics and lighting. Almost every household is equipped with a refrigerator, washing machine and TV (Borzycki, 2012). On the other hand, the average power of installed bulbs (including energy-saving fluorescent lamps and LED sources) in a household is estimated at 550 W, while the power of installed bulbs per unit area is 7.21 W/m² (Eurostat, 2022). Figure 1 shows the electricity consumption for Poland according to the previously discussed groups of devices.

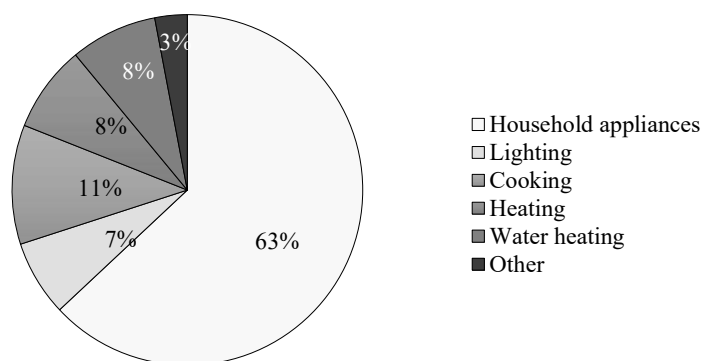


Figure 1. Energy consumption broken down into groups of devices

Source: Author's own compilation based on Statistics Poland (GUS, 2022)

The greatest differences can be noticed in the percentage of electricity consumption for the group of space heating devices and household appliances. In the case of the first group of devices, this fact can be interpreted as the lack of profitability of investments in the electric heating of rooms in Poland (Kott & Kott, 2014).

The excessive consumption of electricity by household appliances in the country is caused, among others, by the advanced age of these devices (Zou et al., 2019), therefore household appliances in Poland, and in particular in rural areas, are characterized by lower energy classes than similar household appliances in highly developed EU countries.

Methods

The research method consisted in observing and collecting data on electricity consumption by individual appliances in the household. The study should therefore be treated as a case study. These data were obtained using a digital wattmeter that was connected directly to each device to accurately measure power consumption.

Then, these data were compared with the data from the electricity meter, both physically installed and available in the Tauron eLicznik application. Each device was monitored for the same period of time. Then, based on the periodic energy consumption reading, the annual consumption of the equipment was forecast. Using these data and the current electricity rates, it was possible to calculate the annual cost of using a given piece of equipment in a specific tariff. At the end of the study, the forecasted annual electricity consumption was summed up and compared with the actual one coming from the physical meter installed. When analysing the market conditions of energy prices, the following companies supplying energy to households were taken into account: Tauron, Enea, E.ON, and Energa. When analysing the market conditions of energy prices, the following companies supplying energy to households were taken into account: Tauron, Enea, E.ON, and Energa.

Examples of electricity tariffs for households in Poland

The energy tariff is a specific offer per kWh, which is shown in Table 1, which consists of the sale price of electricity and its distribution to the customer in a given time zone. Thanks to the variety of energy tariffs, the consumer can choose the best offer for his needs and expectations (Mielczarski, 2014). Each energy tariff is assigned to a special tariff group. The division depends on the level of supply voltage that is required. Currently, there are four tariff groups: G, C, A and B. Electricity tariffs addressed to households belong to the tariff group marked with the letter G. It is the only tariff group where the Energy Regulatory Office orders energy suppliers to approve electricity prices (Woźniak, 2018). All the largest electricity suppliers in Poland have three standard tariffs in their offers, i.e.

- G11 – single-zone tariff, the price of electricity is the same regardless of the hour.
- G12 – a two-zone tariff that divides the day into peak hours, where electricity is more expensive than in the G11 tariff, and off-peak hours, where electricity is cheaper than in the single-zone tariff.
- G12w – a two-zone tariff, also known as weekend tariff, where the lower price for electricity outside the off-peak hours also occurs on weekends and all public holidays.

In addition to the above tariffs, individual suppliers, depending on the specificity of a given region, use extended tariff variants such as (Marzecki & Drab, 2022):

- G12n – a two-zone tariff, where the night tariff is also valid on Sunday.
- G12e – a two-zone tariff where the off-peak hours are valid only at night.
- G12g – a two-zone tariff, with more off-peak hours and less expensive hours on weekends.
- G12r – a two-zone tariff with less expensive hours at night and designated during the day.
- G13 – three-zone tariff, which divides the day into a morning and afternoon peak and the remaining hours.

Table 1. Electricity tariffs with price freeze

Tariff	Zone	Electricity price up to 2.000 KWh	Electricity price above 2.000 KWh
G11	Round the clock	0.65	0.96
G12	Zone I	0.76	1.14
	Zone II	0.38	0.57
G12w	Zone I	0.81	1.22
	Zone II	0.36	0.54
G13	Zone I	0.51	0.76
	Zone II	0.81	1.21
	Zone III	0.27	0.40

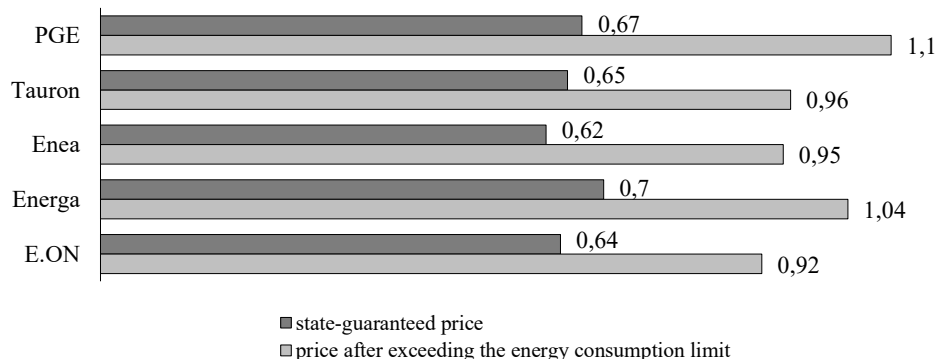
Source: Author's own compilation based on (Tauron, 2022)

The G11 24h tariff is the most popular among customers. It is the simplest tariff with the same prices for the purchase and transmission of electricity 24 hours a day. In part, this is because it is the default tariff that is assigned to all consumers from the vending machine (Piekarski et al., 2011). In general, it can be estimated, this tariff is used by approximately 10 million households in Poland.

Depending on the selected energy supplier, the price for 1 kWh may differ; the table below presents a list of the five largest infrastructural energy suppliers and two so-called virtual ones that do not have their own power plants or transmission lines (Pamuła, 2013).

The chart below shows that at the time of writing the article, Enea had the most advantageous price offer for the purchase of electricity in the G11 tariff for households, while PGE has the least profitable rate.

An alternative to the 24-hour tariff is the multi-zone tariff. Almost 3 million households decided to change the basic single-zone tariff into two or three-zone tariffs.

**Figure 2. Electricity prices at individual suppliers in G11 tariff up to 2000 kWh and beyond (in PLN)**

Source: Author's own compilation based on (Tauron, 2022)

The most popular two-zone tariff is the so-called G12 night tariff. With this tariff, there is no longer one price zone throughout the day, but two zones. One of the zones is less expensive – in off-peak hours, while the other is more expensive – during peak hours, as shown in Figure 3. Off-peak hours are usually at night from 22.00 to 6.00, and two hours during the day from 13.00 to 15.00. During other hours, i.e. from 6.00 to 13.00 and from 15.00 to 22.00, electricity prices are much higher.

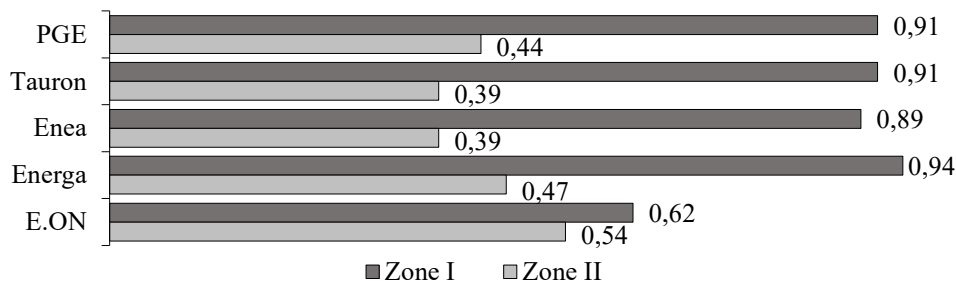


Figure 3. Electricity prices at individual suppliers in G12 tariff

Source: Author's own compilation based on data from offers of above entities (13/10/2022)

The above chart shows that conscious energy consumption in the second zone is the most profitable when buying energy from Enea and Tauron. This company offers the lowest price for 1kWh in off-peak hours. In turn, the E.ON company is characterized by a very small price difference between the electricity consumed in the first or second zone. On the other hand, Energa offers the most expensive electricity among all suppliers in the first zone. The hours in which electricity prices are higher or lower may differ depending on the supplier and distributor of electricity we use, which is illustrated in Table 2.

Table 2. Peak and off-peak hours of largest energy suppliers in Poland in case of G12 tariff

Energy supplier	Peak zone	Off-peak zone	Weekend
Enea	Monday – Friday 6:00 – 21:00	Monday – Friday 21:00 – 6:00	Saturday, Sunday and holidays 00:00 – 24:00
Energa	Monday – Friday 7:00 – 13:00 and 16:00 – 22:00	Monday – Friday 13:00 – 16:00 and 22:00 – 7:00	Saturday, Sunday and holidays 00:00 – 24:00
E.ON	Monday – Friday 6:00 – 22:00	Monday – Friday 22:00 – 6:00	Saturday, Sunday and holidays 00:00 – 24:00
PGE	Monday – Friday 6:00 – 13:00 and 15:00 – 22:00	Monday – Friday 13:00 – 15:00 and 22:00 – 6:00	Saturday, Sunday and holidays 00:00 – 24:00
Tauron	Monday – Friday 6:00 – 13:00 and 15:00 – 22:00	Monday – Friday 13:00 – 15:00 and 22:00 – 6:00	Saturday, Sunday and holidays 00:00 – 24:00

Source: Author's own compilation based on data from offers of above entities (13/10/2022)

The weekend tariff G12w is an extension of the night tariff. In the case of using it, electricity is less expensive not only between designated hours during the day and the night zone. Lower rates for electricity in the G12w tariff also apply on weekends and public holidays (statutory holidays), as shown in Figure 4. Usually it is assumed that the weekend starts on Friday at 10.00 p.m. and ends on Monday at 6.00.

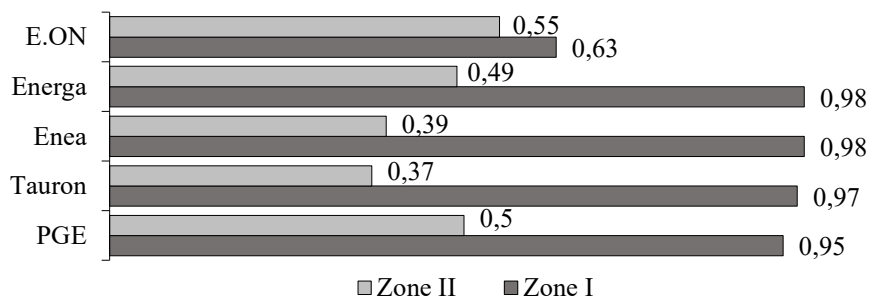


Figure 4. Electricity prices of individual suppliers in G12w tariff

Source: Author's own compilation based on data from offers of above entities (13/10/2022)

The chart above shows that the largest disproportion between electricity prices in the first and second zones occurs in the case of Tauron and Enea. These companies charge the lowest prices for electricity on the market in the second zone, and the most expensive in the first. It is assumed that for the zone tariff to be profitable for a household, it must consume at least 30-40 percent of the daily energy demand in the off-peak zone. These standards are often met by those who spend most of their working days away from home. Being in the G12w tariff, it is best to change your habits so that most of the work consuming electricity falls on the weekend. It is best to postpone activities such as: ironing, washing, vacuuming, mowing the lawn, washing, DIY, charging electrical devices to Saturday or Sunday.

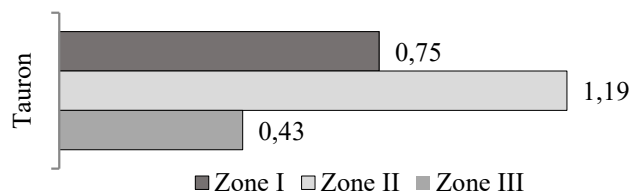


Figure 5. Electricity prices of Tauron in G13 tariff

Source: Author's own compilation based on data from offers of (Tauron, 2022)

The weekend tariff will be a good solution for many people living in the block who are on the G12 tariff. Due to the curfew at night, you cannot always turn on electrical appliances that generate too much noise. Another group that can benefit from the weekend tariff are people who use electricity to heat their homes.

Despite the fact that the G12w tariff is mainly addressed to households, it is also often used by, among others, dormitories, presbyteries, hospices, and orphanages.

The newest and even experimental tariff is the G13 tariff, introduced a few years ago. Currently, its purchase is possible in almost the entire area of the Silesian and Lesser Poland Voivodeships, provided that the energy distributor is Tauron. The G13 tariff schedule provides a relatively flexible way of use. The tariff is prepared for households that use electricity to heat their homes by means of electric heating devices such as storage electric stoves, and heat pumps. This is owing to the system of three energy price ranges: morning and evening peak and other ranges (reduced tariff), as shown in Figure 5. In the case of the G13 tariff, the period of less expensive energy per year is approx. 17h/day, including holidays, Saturdays and Sundays (statistically, there are about 114 of them throughout the year). In the winter period (from 01/10 to 31/03), this share is approx. 16 hours a day. In the range of days of the week from Monday to Friday, it is 13 hours a day in the winter season (01/10 to 31/03) and 15 hours a day in the off-season (from 01/04 to 30/09). During weekends and public holidays, a reduced tariff applies (24 hours per day). The mid-morning peak with an average energy price occurs 6 hours a day during the week from Monday to Friday. The evening peak is respectively 5 hours a day (from 01/10 to 31/03) or 3 hours a day (from 01/04 to 30/09) during work days.

Energy consumption costs in individual tariffs

Electricity bills can be managed by consumers. The final amount that appears on the invoice is influenced by many factors, including:

- the energy class of the device,
- the tariff,
- the energy supplier,
- the time of using a given device.

The easiest way to reduce your household electricity bills is to replace your outdated energy-consuming equipment with a new one with the highest energy class A+++, and install your own photovoltaic micro-installation. However, such a solution is costly and not every household can afford it. Changing the energy supplier or changing the tariff is a much cheaper solution. Table 3 below shows the costs of the annual use of electrical equipment when using tariffs G11, G12 and G12w. 365 days are assumed for a year.

Table 3. Annual costs of using selected electrical devices, taking into account three tariffs

Equipment	Annual energy consumption (kWh)	Tariff	Price/ kWh	Annual expenses	
Refrigerator	270	G11	24/7	0.65	175,5
		G12	I Zone	0.91	245
			II Zone	0.39	105
		G12w	I Zone	0.97	261
II Zone	0.37		100		
Washing machine Washer dryer	150 450	G11	24/7	0,65	97/292,5
		G12	I Zone	0.91	136,5/410
			II Zone	0.39	58/175
		G12w	I Zone	0.97	145/436
II Zone	0.37		55/166		

Equipment	Annual energy consumption (kWh)	Tariff		Price/ kWh	Annual expenses
Dishwasher	250	G11	24/7	0.65	162
		G12	I Zone	0.91	227
			II Zone	0.39	97
		G12w	I Zone	0.97	242
			II Zone	0.37	92
		Induction hob	750	G11	24/7
G12	I Zone			0.91	682
	II Zone			0.39	292
G12w	I Zone			0.97	727
	II Zone			0.37	277
Oven	500			G11	24/7
		G12	I Zone	0.91	455
			II Zone	0.39	195
		G12w	I Zone	0.97	485
			II Zone	0.37	185
		Boiler	2880	G11	24/7
G12	I Zone			0.91	2620
	II Zone			0.39	1123
G12w	I Zone			0.97	2793
	II Zone			0.37	1065
Iron	26			G11	24/7
		G12	I Zone	0.91	24
			II Zone	0.39	10
		G12w	I Zone	0.97	25
			II Zone	0.37	9,50
		Kettle	180	G11	24/7
G12	I Zone			0.91	164
	II Zone			0.39	70
G12w	I Zone			0.97	175
	II Zone			0.37	66
Hair dryer	55			G11	24/7
		G12	I Zone	0.91	50
			II Zone	0.39	21
		G12w	I Zone	0.97	53
			II Zone	0.37	20
		TV	350	G11	24/7
G12	I Zone			0.91	318
	II Zone			0.39	136
G12w	I Zone			0.97	339
	II Zone			0.37	129
LED lighting	350			G11	24/7
		G12	I Zone	0.91	318
			II Zone	0.39	136
		G12w	I Zone	0.97	339
			II Zone	0.37	129
		Laptop	150	G11	24/7
G12	I Zone			0.91	136
	II Zone			0.39	58
G12w	I Zone			0.97	145
	II Zone			0.37	55
Vacuum cleaner	160			G11	24/7
		G12	I Zone	0.91	145
			II Zone	0.39	62
		G12w	I Zone	0.97	155
			II Zone	0.37	59

Source: Author's own compilation

The above table presents electricity consumption by a household taking into account the three energy tariffs. During the year under review, the household consumed 6,221 kWh. The most energy, as much as 2,880, was used to prepare domestic hot water, while the iron consumed the least electricity. If this consumption took place in the G11 tariff, the annual cost of the electricity bill would be approximately 4043.65 PLN. In the case of the G12 tariff, with electricity consumption in peak hours 5661 PLN and off-peak hours 2426 PLN. On the other hand, in the G12w tariff, by purchasing electricity only in the first zone, 6,034.37 PLN, while only in the second zone, PLN 2,301.77 PLN.

Conclusions

Every year, households incur increasingly more financial expenses for electricity. This is partly due to the increasing number of new devices that consume electricity, the increasing duration of their use, as well as rising energy prices. The energy market is not monopolized; households can choose from many energy suppliers as well as several price variants of its purchase depending on their habits and preferences. The conducted research shows that the most economically advantageous variant for households to purchase electricity is the second zone of the G12w tariff. Such a situation, however, would be very burdensome in the normal functioning of the household, as it forces the use of devices in a specific time period. For this reason, the most optimal solution is to use at least 50% of all devices in both Zones 1 and 2 of both the G12 and G12w tariffs. If you use less than 50% of the energy purchased in Zone 2, the best solution will be to use the 24-hour G11 tariff. The surveyed household has a G12 tariff and a photovoltaic installation with a capacity of 7.92 kW, which in the annual period of the study, i.e. June 2021-May 2022, produced 7,611 kW, which, taking into account the 20% loss resulting from energy storage, allowed the bill to be reduced only by PLN 530 for the whole year.

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WYBRANE ASPEKTY KONSUMPCJI ENERGII ELEKTRYCZNEJ W GOSPODARSTWACH DOMOWYCH

Streszczenie: Obecnie gospodarstwa domowe borykają się z problemem rosnących cen energii elektrycznej. Co miesiąc sprzedawcy energii elektrycznej starają się wymusić na URE jak najwyższe podniesienie cen dla odbiorców indywidualnych. Celem artykułu jest wskazanie, że odpowiedzialne gospodarowanie energią elektryczną poprzez wybór korzystnej taryfy w dużej mierze przyczyni się do obniżenia rachunku ekonomicznego gospodarstwa domowego. W badaniu wykorzystano własne dane dotyczące rocznego zużycia energii elektrycznej w gospodarstwie domowym przez najczęściej używane urządzenia oraz aktualne ceny energii w badanych taryfach. Najkorzystniejszą opcją jest odpowiedzialne korzystanie z taryfy G12w wsparte własną mikroinstalacją fotowoltaiczną. Takie połączenie gwarantuje minimalne koszty wynikające ze zużycia energii elektrycznej.

Słowa kluczowe: konsumpcja, ekonomia, gospodarstwa domowe, taryfy

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