

Electrical energy consumption by the household - type consumers

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In the paper, selected results of analysis of the electrical energy consumption by the household-type consumer group as well as results for energy defined regarding the standard profiles for such a group are presented. In the analysis, a developed tailored IT tool has been used

1. Introduction

Forecast of the average electricity consumption by the individual consumers groups is an important topic regarding the electricity market. Good knowledge of the factors shaping the load graphs supports the electricity demand forecasting.

In technical practice, there are some forecasting methods for different time scale where the input parameter is the annual amount of electrical energy demand [1]. Regarding the measuring data on the previous year, the distribution companies' operators develop so called *average electricity load graphs* - standard profiles – for individual consumer groups showing some special features (voltage level, annual electricity consumption, use of a common tariff, way of space heating, etc.) [2, 3, 4].

In the paper, the results of research work on the electrical energy consumption in selected consumer group settled according to the G tariff are presented. The research was based on the results of the individual consumers' measurements and on the electrical load graphs for profiled consumers developed by Polish Association of the Electricity Transmission and Distribution (*PTPiREE*).

The analysis was aided by the developed purpose-oriented Excel file [5].

2. Selected analysis results

Characteristics of individual consumers under survey regarding consumer's location, electrical heating method applied and other features are shown in Table 1. In Table 2, the characteristics of the standard profiles developed by *PTPiREE* for household consumers are presented.

In Table 3, annual electrical energy consumption (E_r) by consumers under consideration in successive years of the electrical load recording is shown. Annual energy consumption found for four successive years when the profile graphs were valid are shown in Table 4.

Table 1. Characteristics of surveyed consumers by special features

Tariff group	Consumer type	Consumer features		Average for the group			Number of Persons in the household	Number of consumers in the group	Group code
	M – unicipal W – rural	Electrical water heating	Electrical space heating	Number of phases in the household power supply	Level of implementation of Electrical appliances	Household Space surface m^2			
G11	M	NO	NO	1	Low	50-75	up to 5	40	G11 M1
		YES	NO	1	Average	50-75	up to 5	24	G11 M2
	W	NO	NO	1	Average	75-100	5 to 10	25	G11 W1
		YES	NO	3	High	75-100	5 to 10	15	G11 W2
G12	M	NO	NO	1	Average	25-50	up to 5	42	G12 M1
		YES	NO	1	Average	50-75	up to 5	55	G12 M2
		YES	YES	3	High	75-100	5 to 10	49	G12 M3

Table 2. Standard profile types (for households) developed by PTPIREE

Profile name	Classification of profile of Electricity consumer		Approx. Number of Consumers classified into the Profile by survey year			
	Tariff group	Residential consumer meeting the requirements	2007	2008	2009	2010
A Profile	G11	Possesses a Single-tariff electrical energy meter	~700	~700	~600	n.d.
B Profile	G12	Possesses a double-tariff electrical energy meter and no electrical space heating .	~700	~500	~500	n.d.
C Profile	G12	Possesses a double-tariff electrical energy meter and electrical space heating other than dynamic	~80	~60	~60	n.d.
D Profile	G12	Possesses a double-tariff electrical energy meter and dynamic electrical space heating	~10	~10	~10	n.d.

n.d. – no data

Table 3. Annual electrical energy consumption in surveyed consumer groups

Group Code	Er kWh			
	2003	2004	2005	2006
G11 M1	2536	2615	2581	2603
G11 W1	2715	2684	2785	2740
G11 M2	5376	5452	4959	4789
G11 W2	6390	6257	6409	6153
G12 M1	5259	4986	5015	4862
G12 M2	6841	6590	6677	6421
G12 M3	10503	11843	10282	10503

Table 4. Annual electrical energy consumption per individual profile groups

Profile Name	Er kWh			
	2007	2008	2009	2010
A Profile	3904	5075	3449	1969
B Profile	4724	5449	4498	3941
C Profile	7835	6708	5807	4596

Total average annual electrical energy consumption for all of surveyed consumer groups settled according to the G11 tariff oscillates between 3672kWh and 3838 kWh, and average is 3769 kWh per 1 consumer in a year. However, electrical energy consumption for individual consumer groups differs significantly. Energy consumption by the consumers living in rural areas is a bit greater. Also, values of consumed energy determined according to the profiles developed for particular years are different. For instance, average annual consumption of electrical energy found referring to the A profile for 2008 is much higher than the values reported above whilst, for A profile 2010, the value is much lower.

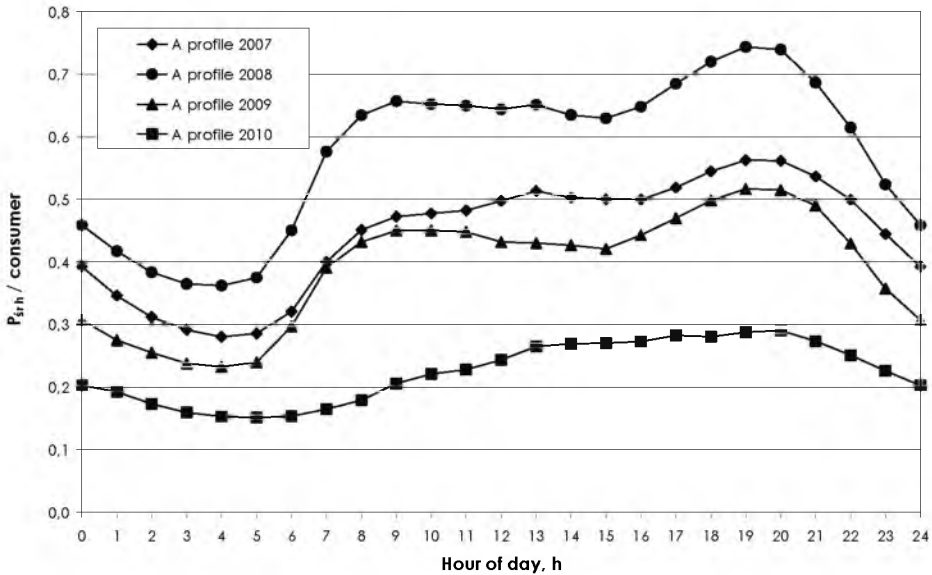


Fig. 1. Average annual load variation for standard A profile

In the shape of the load graph for a standard A profile, any explicit trend in variation is not found. Shape and values on the graph depend on contribution of the particular consumer group taken into account when developing the particular profile.

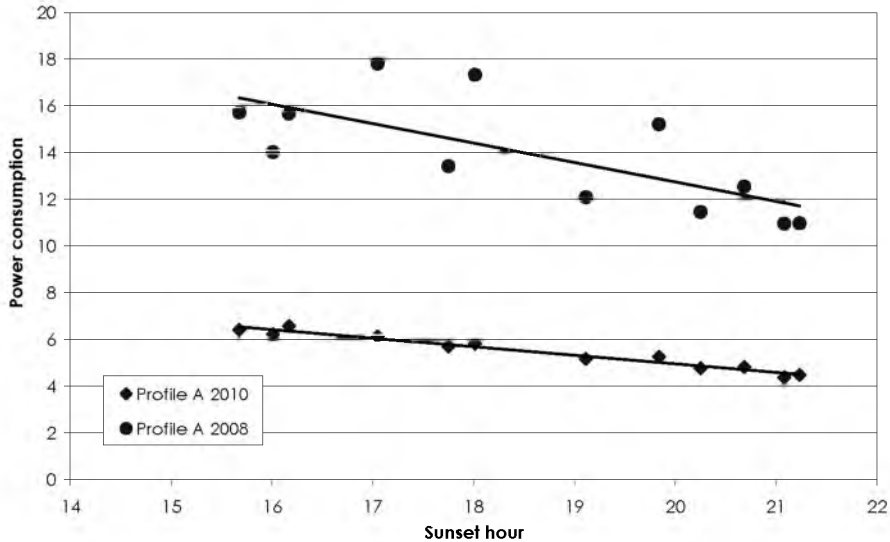


Fig. 2. Average annual power consumption variation versus sunset hour for A Profile consumer in 2008 and 2010

In Fig. 2, relationship between the average annual energy consumption and the monthly averaged sunset hour for two selected years when the A profile was in force are presented for 2008 and for 2010.

Regarding strength of relationship between magnitudes reported in Fig.2 for 2010, it can be defined using linear function in the form:

$$E_{\dot{s}rm} = 12,27 - 0,367 \cdot T_{zach \dot{s}rm} \quad (1)$$

where: $R^2 \approx 0,98$.

It indicates that, in the A profile for 2010, there is a high (deciding on the graph form) contribution of consumers with relatively high load resulting from lighting, i.e. high contribution of consumers belonging to the G11M1 and G11W1 groups who do not use electricity for heating. Such a conclusion is supported by small power consumption as compared to the consumption in other years for which the A profile has been developed (Fig. 1). For other years in A profile, the relationship under consideration is weaker. Especially, it is less evident in 2008 (Fig. 2) where the match coefficient is the lowest and is $R^2 \approx 0,51$.

These conclusions are confirmed by the test using the correlation coefficient Persona (r_{xy}) – (Fig. 3) concerning relationship between the energy consumption and sunset hour and temperature.

High values of r_{xy} coefficient in particular hours (late afternoon, early morning) indicate that electrical power is used for lighting purposes – A Profile 2010 (Fig. 3b). For consumers using electrical energy for heating the space, r_{xy} becomes high all day long (Fig. 3a).

Graphs for daily variation of correlation coefficient for consumed power, temperature and sunset hour shown in Fig. 3 runs like each other. It results from strong dependence between the sunset hour and air temperature.

The way of the space heating is a relevant parameter affecting the values of electricity consumed by the household [4].

In Fig. 4, the relationship between the monthly averaged energy consumption and the monthly averaged air temperature ($\vartheta_{\dot{s}rm}$) by the consumers of the G12 M3 group using electricity to space heating and C profile are presented.

Strong dependence presented in Fig.4 can be expressed with linear function in the form:

- for G12 M3:
$$E_{\dot{s}rm} = 45,05 - 1,75 \cdot \vartheta_{\dot{s}rm} \quad (2)$$

- for C Profile 2008:
$$E_{\dot{s}rm} = 29,4 - 1,17 \cdot \vartheta_{\dot{s}rm} \quad (3)$$

In both consumer groups shown in Fig.4, the determination coefficient is very high ($R^2 > 0,95$).

For economical reasons, significant part of electrical energy consumption by the G12 group consumers falls into the time period with lower energy price.

In Fig. 5, variation in value of correlation coefficient between the power consumption in day hours and the daily averaged temperature for the C profile consumer from 2008 is presented for two air temperature ranges.

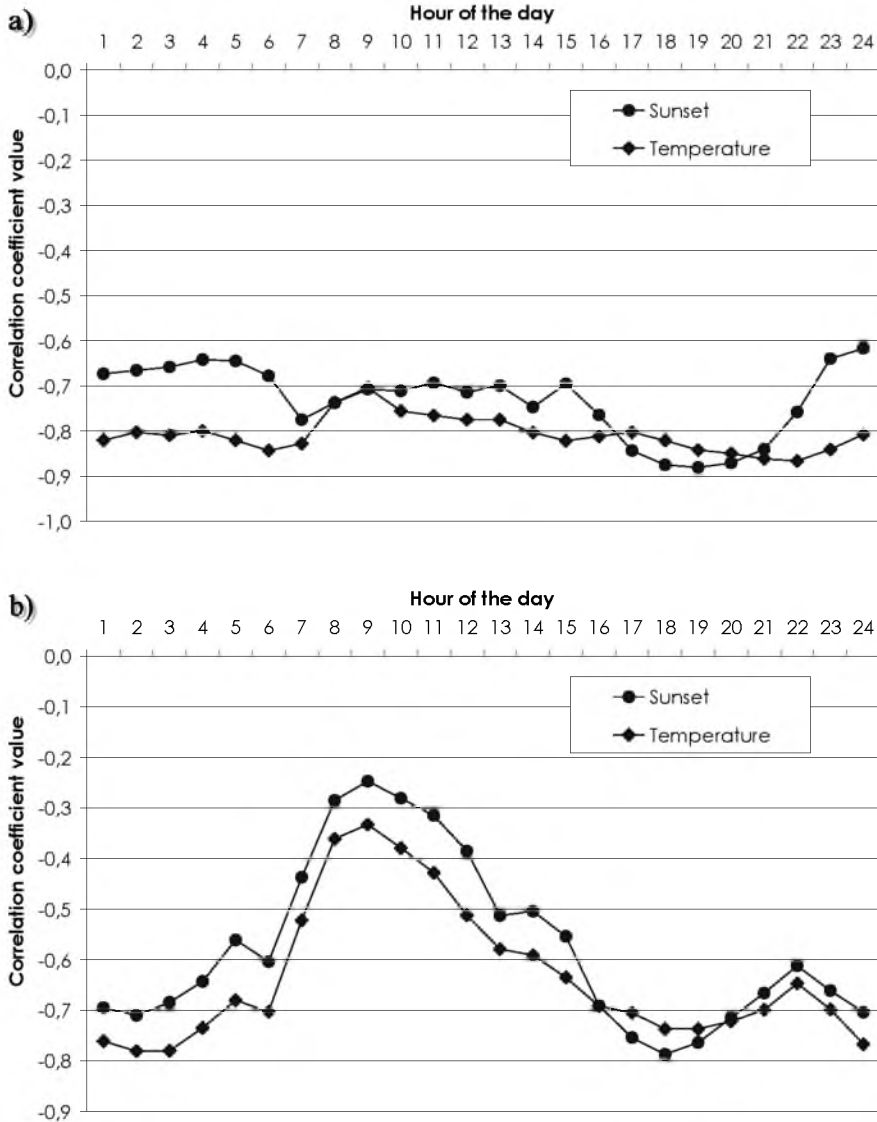


Fig. 3. Values of Correlation coefficient between energy consumption, temperature and sunset hour for A Profile in (a) 2008, (b) 2010

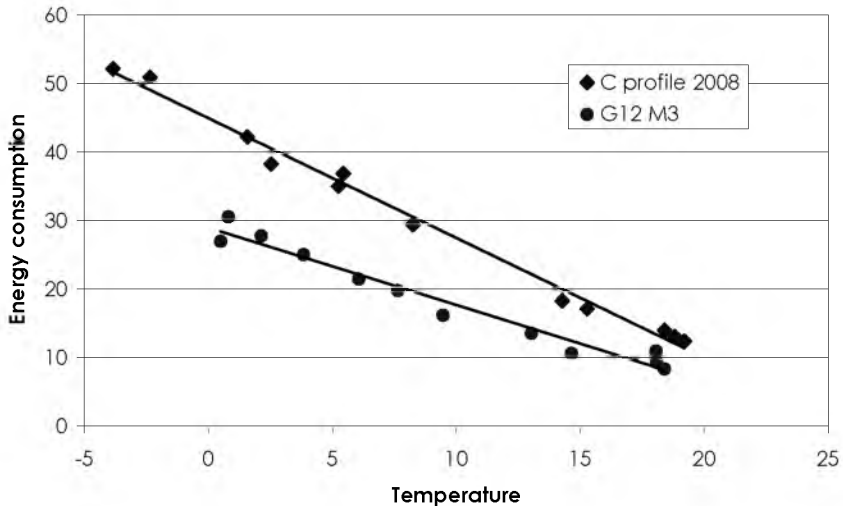


Fig. 4. Monthly averaged energy consumption versus monthly averaged air temperature for G12 M3 and C Profile 2008

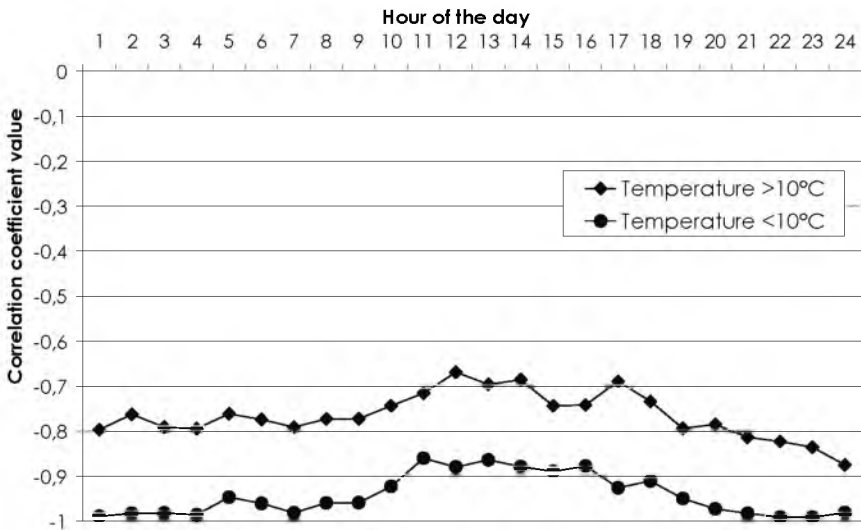


Fig. 5. Correlation coefficient between consumed power and air temperature for C profile consumer

High nominal power consumption of heating appliances as well as the period of their operation considerably affect the power consumption. It can be especially observed when the temperature falls below 10°C.

3. Final remarks

Specific features of an individual consumer as well as those of the consumer group considerably affect the shape and values of the electrical load graphs. The factors that, among others, have evident influence on the value of the consumed power value are the sunset hour and the air temperature. Any of the factors affects this value in different way. In the G11 M1 and G11 W1 group, the consumed energy value is mostly influenced by the sunset hour, whilst in the G12 M3 group – by the temperature. It is also reflected in the developed standard profiles.

The power consumption values depend strictly on the tariff type, localization and the way the electricity is used for heating purposes. For the G12 group living in rural areas, the electrical energy consumed by the consumers using the electrical heating of space and water (G12 M3) is approximately from 2 to 2,5 times greater than that consumed by the consumers using no electrical heating (G12 M1).

The A profile that includes different groups of consumers shows special features. Therefore, proper classification of consumers for the profile development purposes is crucial.

References

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