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Effects of unreliability of electricity distribution systems for municipal customers in urban and rural areas

***Abstract**. The paper presents current value of costs caused by interruption in the electricity supply. Econometric modeling and forecasting of the economic equivalent of the cost of enforced idleness residents were described. Researchers made use of commonly available statistical data. The data cover fifteen years of observation. The researchers used Statistica and Excel software to analysis, calculations and visualisation economic effects of not delivering electricity to municipal consumers.*

***Streszczenie.** W artykule zaprezentowano aktualne wartości ekonomicznego równoważnika strat przymusowej bezczynności mieszkańców miast i wsi k_{Ab}, spowodowanych przerwami w dostawie energii elektrycznej. Wykorzystując teorię Ekonometrii opracowano modele ekonometryczne ekonomicznego współczynnika strat przymusowej bezczynności kAb bazujące na powszechnie dostępnych danych statystycznych. Dane te pochodzą z okresu piętnastu lat. W badaniach wykorzystano pakiety Statistica i Excel, za pomocą których przeprowadzono analizy, opracowano wyniki badań i dokonano ich wizualizacji. **(Skutki zawodności układów dystrybucyjnych energii elektrycznej dla odbiorców komunalnych na terenach miejskich oraz wiejskich**).*

Keywords: individual electricity consumers, power quality, reliability of electricity supply, effects of power outages, costs of involuntary inactivity
Słowa kluczowe: indywidualni odbiorcy energii elektrycznej, jakość energii elektrycznej, niezawodność dostaw energii elektrycznej, skutki przerw w zasilaniu, koszty strat przymusowej bezczynności

Introduction

Electric power engineering is an indispensable component of civilization and economic infrastructure. Currently, almost all households located in the country are electrified. The increase in demand for power and electricity is a sign of the country's economic development. The problem of the reliability of the power system is such an important issue because of the requirements of the modern economy. The individual electricity recipient also has very high requirements regarding the quality and continuity of electricity supply. Possible interruptions in the supply of energy disorganize his life, expose him to material losses, and may even lead to a threat to his health or life. Such a situation forces constant development and modernization of distribution power grids.

The purpose of this paper is to present the issue of losses to municipal consumers, which are the result of interruptions in the supply of electricity. As shown in the article [1], the municipal recipient incurs significant costs of failures, which constitute the sum of the costs of forced inactivity losses and the costs of damage. This issue is so important and interesting that the Authors analyzed the costs of losses to energy consumers occurring as a result of the failure of electrical power systems, classifying recipients for their place of residence: city and village. The analysis carried out in the publication [1] showed that there are quite large discrepancies between urban and rural recipients and using the average economic coefficient of forced inactivity for all municipal consumers leads to significant errors in the estimation of failures. In the conducted research, households and small farms that do not conduct business activity are considered to be municipal (individual) consumers.

Although in recent years there has been development of rural areas and currently living standards in cities and villages are comparable, there is still a significant difference in technical and economical indicators for cities and villages.

The Authors have attempted to create econometric models of the economic equivalent of forced losses of inactivity of residents in households, resulting from a lack of power supply. Determination of the abovementioned indicator on the basis of definitional formulas is quite difficult due to the lack of reliable data in it. In the case of finding a reliable econometric model, it is possible to determine the value of the equivalent based on commonly available statistical data. The Authors are based on theories and formulas presented in publications [1, 9, 10, 12].

Economic consequences of failure to supply electricity to communal consumers

Electricity is considered to be the most important energy carrier in households. In many cases it is the only systemic energy carrier. A break in its delivery affects many aspects of the household's life. First of all, it limits consumer activity at home, forcing their temporary inactivity. This influence varies depending on the period during the day [8, 9, 10]. The first period covers the duration of natural lighting. Only a few activities performed at this time require electricity. Turning on the electric lighting is necessary in the second period. Then, the implementation of most household tasks requires the use of electricity. The negative aspect is the fact that the greatest activity of residents at home falls on the second period. In the event of a power shortage during this period, the recipient spends his time idly. Therefore, among the phenomena caused by interruptions in the power supply, one can mention the waste of time [8, 9, 10].

Another phenomenon arising as a result of a power failure is the destruction of perishable food products, it means those stored in refrigerators and freezers, as well as those that have already been partially processed during the preparation of meals [8, 13]. The values of the abovementioned losses depend primarily on the duration of the power interruption.

Annual unreliability costs of losses caused by emergency breaks in the electricity supply to households in a given area K_z are determined from the dependence [12]:

(1) $$K_z = k_{zj} \cdot T_p \cdot M$$

where: k_{zj} – unitary equivalent of unreliable losses of households – unit costs of failures caused by breaks in the delivery of electricity to domestic consumers, per one inhabitant and one hour of power outage in PLN / (h·M), (h – hour, M – resident), T_p – expected total annual duration of interruptions in the supply of domestic consumers (in a given area) [h], M – number of permanent residents residing in the considered area.

The unit equivalent of unreliable losses of households is expressed by the sum of unit costs of forced inactivity of residents k_{zbj} in PLN / (h·M) and unit costs of material damage k_{zzj} in PLN / (h·M) [12]:

$$k_{zj} = k_{zbj} + k_{zzj} \quad (2)$$

Determination of the costs of forced loss of inactivity of residents is conditioned by the determination of the coefficient k_{Ab}, which expresses the social value of the citizen's active time per unit of electricity supplied during its period of activity.

The dependence allowing to determine the economic equivalent of the loss of forced inactivity (wastage of time wasted) of residents, caused by interruptions in the supply of electricity to domestic consumers [PLN / kWh] takes the form of:

$$k_{Ab} = k_{zbj} \cdot \frac{T_m}{b \cdot A_m} = k_{zbj} \cdot \frac{T_{md}}{b \cdot A_{md}} \quad (3)$$

where: T_{md} – time of activity of a resident within the house within 24 hours [h], A_{md} – electricity consumption per day per one inhabitant [kWh / M], b – coefficient determining the share of daily energy consumption attributable to the period of activity of residents.

Material damage losses (which depend on the duration of power interruptions t_p) for one power interruption per one person in the household (it means unit destructive losses) k_{zjp}, expressed in the general analytical dependence [12]:

$$k_{zjp} = \begin{cases} 0 & for \quad t_p \le t_{p1} \\ \frac{k_{zg}}{\Delta t_p} \cdot (t_p - t_{p1}) & for \quad t_{p1} < t_p \le t_{p1} + \Delta t_p \end{cases} \quad (4)$$

where: t_{p1} – power supply interruption time, which does not cause any damage, k_{zg} – limit value of unit destructive losses k_{zjp}, Δt_p – the time interval in which the loss of damage increases in proportion to the time of power outage.

Adding the total annual costs of the losses of forced inactivity and the costs of damage to damage, the total costs of failures are obtained.

In publication [14] Author gives the following dependence to calculate the economic equivalent of undelivered electricity:

$$k_A = k_{Ab} = \frac{K_z}{\Delta A_n} = \frac{T_r}{A_m} \cdot \frac{K_{sp}}{T_m} \cdot \alpha \cdot \beta \quad (5)$$

where: T_r – annual working time of electric energy receivers at households, A_m – annual domestic electricity consumption by households (in households), per one inhabitant [kWh / M], K_{sp} – national annual fund of consumption of goods and services per one inhabitant [PLN / M], T_m – annual time of activity of a resident at home (outside of professional work) [h], α – the degree of loss of activity of a resident due to lack of electric power supply, α = 0.4 ÷ 0.7, β – the probability that non-delivery of electricity occurred during the activity of the resident, β = 0.8 ÷ 1.0.

Statistical indicators characterizing the costs of forced inactivity of a resident

Based on the statistical data of the Central Statistical Office and the Energy Market Agency, covering the years 2002-2017 [2, 3, 4, 5, 6, 7, 11], indicators describing the costs of forced inactivity of urban and rural residents caused by a break in power supply.

In publication [8], it was observed that the maximum values of k_{Ab} obtained on the basis of dependence (5) are similar to the values obtained as a result of applying the dependence (3). Therefore, the economic equivalent of the costs of forced inactivity was determined from the simplified dependence (5) for the maximum values of coefficients α and β ($\alpha_{max} = 0{,}7$ i $\beta_{max} = 1{,}0$). The obtained values are presented in Table 1. The comparison of the economic value of the equivalent of the costs of forced inactivity of the residents of the city and village within the house is also shown in Figure 1.

The minimum values of the k_{Ab} index for $\alpha_{min} = 0{,}4$ and $\beta_{min} = 0{,}8$ were also determined. The extreme values of the k_{Ab} index are presented in Table 2.

Econometric modeling of the value of economic equivalent of forced inactivity of residents

The Authors have attempted to create reliable and stable models of econometric equivalent of the cost of forced inactivity of residents resulting from non-delivery of electricity. The developed models were created on the basis of generally available data published in the Central Statistical Office publications, such as the Statistical Yearbook of the Republic of Poland [7], Statistical Yearbook of Industry [6], Statistical Yearbook of Agriculture [5], Household budgets [2], Innovation in industry [3]] and in the Polish Power Industry Statistics [11].

In the first step, based on extensive statistical surveys and after thorough analysis of the values affecting the value of the economic equivalent of the cost of forced inactivity of the resident in the house, as explanatory variables in the implemented model for the city adopted: X_1 – electricity consumption in households (city) [GWh / a], X_2 – average consumption of electricity in households per inhabitant (city) [kWh / (M·a)], X_3 – average consumption in household per capita per day (city) [kWh / (M·d)], X_4 – annual time of activity of a resident within the house [h / a], X_5 – annual time of use of electric lighting in a household [h / a], X_6 – annual use time of household electric devices [h / a], X_7 – daily number of activity hours of the average inhabitant in the household [h / d], X_8 – number of economically active people (city) [thous. persons], X_9 – number of passive (inactive) people professionally (city) [thous. persons], X_{10} – number of people of working age as at December 31 (city) [thou. persons], X_{11} – the number of people in non-working age as at 31 December (city) [thou. persons], X_{12} – population in Poland as of December 31 (city) [thou. persons], X_{13} – production of energy in Poland [GWh], X_{14} – production of energy in renewable sources (country) [GWh], X_{15} – households equipped with microwave (city) [% of households], X_{16} – households equipped with a dishwasher (city) [% of households], X_{17} – average monthly disposable income in households in total (country) [PLN per household dom], X_{18} – average monthly expenses for a total household (country) [PLN per one household house], X_{19} – electricity consumers, as of 31.XII (city) [thou. units], X_{20} – sold production of industry in general (country) [PLN million], X_{21} – total output (country) [PLN million] X_{22} – working according to working time (average number of hours worked in the week) (country) [h] , X_{23} – gross domestic product (country) [PLN million], X_{24} – expenditure on innovative activity in industry, total industrial enterprises (country) [PLN million] X_{25} – number of tourist accommodation establishments in total, as of 31.VII (country) [pieces] X_{26} – number of individual farms with an area of more than 1 ha of agricultural land (country) [pcs.].

Table 1. The values of the economic equivalent of the costs of forced inactivity of the residents of the city and the village in their homes k_{Ab} in the years 2002-2017, determined from the dependence (5)

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	**2017**
$k_{Ab_{city}}$ [PLN/kWh]	9,89	10,38	10,92	11,11	11,68	12,23	12,59	13,59	14,25	15,42	16,14	17,24	18,08	18,66	20,00	20,70
$k_{Ab_{village}}$ [PLN/kWh]	13,89	14,43	14,39	14,33	14,23	14,61	14,11	14,45	14,95	15,29	15,64	16,47	17,08	17,45	17,50	18,10

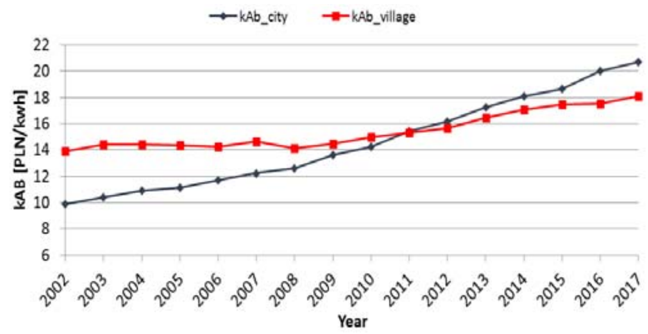

Fig. 1. Comparison of the economic value of the equivalent of the costs of forced inactivity of the residents of the city and the village in their homes k_{Ab} in the years 2002-2017

Table 2. Minimum and maximum values of the economic equivalent of the costs of forced inactivity of the residents of the city and the village in their homes k_{Ab} [PLN / kW·h] in the years 2002-2017, determined from the dependence (5)

Year	**city**		**village**	
	$k_{Ab_{min}}$	$k_{Ab_{max}}$	$k_{Ab_{min}}$	$k_{Ab_{max}}$
2002	4,52	9,89	6,35	13,89
2003	4,75	10,38	6,60	14,43
2004	4,99	10,92	6,58	14,39
2005	5,08	11,11	6,55	14,33
2006	5,34	11,68	6,50	14,23
2007	5,59	12,23	6,68	14,61
2008	5,76	12,59	6,45	14,11
2009	6,21	13,59	6,61	14,45
2010	6,51	14,25	6,83	14,95
2011	7,05	15,42	6,99	15,29
2012	7,38	16,14	7,15	15,64
2013	7,88	17,24	7,53	16,47
2014	8,27	18,08	7,81	17,08
2015	8,53	18,66	7,98	17,45
2016	9,14	20,00	8,00	17,50
2017	9,46	20,70	8,27	18,10

Input data for villages are as follows: X_1 – electricity consumption in households (wieś) [GWh / a], X_2 – average consumption of electricity in households per inhabitant (village) [kWh / (M·a)], X_3 – average consumption per household per inhabitant per day (village) [kWh / (M·d)], X_4 – annual activity time of the resident within the house [h / a], X_5 – annual lighting usage time electric in the household [h / a], X_6 – annual use time of household electric devices [h / a], X_7 – daily number of activity hours of the average person in the household [h / d], X_8 – number of economically active people (village) [thous. persons], X_9 –number of passive (inactive) people professionally (village) [thous. persons], X_{10} – number of people of working age as of December 31 (village) [thou. persons], X_{11} – the number of people at non-working age as at 31 December (village) [thou. persons], X_{12} – population in Poland as of December 31 (village) [thou. persons], X_{13} – production of energy in Poland [GWh], X_{14} – production of energy in renewable sources (country) [GWh], X_{15} – households equipped with microwave (village) [% of households], X_{16} – households equipped with a dishwasher (village) [% of households], X_{17} – average monthly disposable income in households in total (country) [PLN per one household dom], X_{18} – average monthly expenses for a total household (country) [PLN per one household house], X_{19} – electricity consumers, as of 31.XII (village) [thou. units], X_{20} – sold production of industry in general (country) [PLN million], X_{21} – total global production (country) [PLN million], X_{22} – general consumption in the households sector (rural areas) [PLN million], X_{23} – working according to working time (average number of hours worked in the given week) (country) [h], X_{24} – gross domestic product (country) [million PLN], X_{25} – expenditure on innovative activity in industry, total industrial enterprises (country) [PLN million] X_{26} – number of tourist accommodation establishments in total, status on 31.VII (country) [pieces] X_{27} – number of individual farms with an area of more than 1 ha of agricultural land (country) [pcs.].

In the next stage, a statistical procedure was used to select explanatory variables. Quasi-permanent that do not provide relevant information to the potential model have been eliminated. The correlation coefficients of the explained variable k_{Ab} with the potential explanatory variables were calculated. Next, the variables weakly correlated with the explained variable were eliminated from the set of potential explanatory variables. Among the remaining variables, the most strongly correlated variable with the explained variable was selected. The next step is the calculation of the matrix of correlation coefficients between potential explanatory variables. The variables that are too strongly correlated with the previously selected explanatory variable, it means those that reproduce the information provided by it, were eliminated. The last stage of modeling is the estimation of the parameters adopted in the studies of linear models using the least squares method. All developed models have been verified by determining the coefficient of determination R^2, coefficient of convergence φ^2, coefficient of random variation W_e and standard estimation error SE_e.

The list of developed econometric models and their matching measures for the city are presented in Table 3, while the list for the village is included in Table 4.

Forecasting the economic value of the equivalent of the costs of forced inactivity of residents

On the basis of the econometric models developed, a medium-term forecast k_{Ab} for 2018-2027 was made. The forecasted values for the city are presented in Table 5 and Figure 2, while for villages in Table 6 and Figure 3. The forecasts were made with the assumption of the trend of all explanatory variables.

Summary

The main purpose of this article was to analyze the economic consequences of not supplying electricity to individual urban and rural consumers.

On the basis of the presented methods, the Authors set the current values of the economic equivalent of the loss of forced inactivity (wastage of time wastage) of residents (in PLN / kW·h), caused by interruptions in the supply of electricity. The analyzes were carried out separately for city residents and villages residents. The research carried out by Authors, the results of which were presented in [1], showed that there are quite large discrepancies between urban and rural recipients and using the average economic coefficient of forced inactivity for all municipal consumers leads to significant errors in the estimation of failures. Hence the need to separate rural and urban recipients.

Table 3. Econometric models of the value of the economic equivalent of the cost of losses resulting from the forced inactivity of the resident within the house in the city

Nr	Model figure	a_0	a_1	a_2	R^2	φ^2	SE_e	W_e [%]
1	$k_{Ab} = a_0 + a_1 \cdot X_{16}$	9,61	0,4025	-	0,9908	0,0092	0,3407	2,34
2	$k_{Ab} = a_0 + a_1 \cdot X_{23} + a_2 \cdot X_{25}$	0,97	0,000009	0,0003	0,9912	0,0088	0,3336	2,29
3	$k_{Ab} = a_0 + a_1 \cdot X_{21} + a_2 \cdot X_{25}$	0,71	0,000004	0,0004	0,9837	0,0163	0,4550	3,13
4	$k_{Ab} = a_0 + a_1 \cdot X_{17}$	1,15	0,0048	-	0,9643	0,0357	0,6723	4,62
5	$k_{Ab} = a_0 + a_1 \cdot X_{20} + a_2 \cdot X_{25}$	0,81	0,00001	0,0004	0,9710	0,0290	0,6061	4,17
6	$k_{Ab} = a_0 + a_1 \cdot X_{18} + a_2 \cdot X_{25}$	-4,35	0,0067	0,0003	0,9513	0,0487	0,7853	5,40
7	$k_{Ab} = a_0 + a_1 \cdot X_{14}$	11,47	0,0017	-	0,8994	0,1006	1,1287	7,76
8	$k_{Ab} = a_0 + a_1 \cdot X_{26}$	42,13	-0,00002	-	0,8844	0,1156	1,2101	8,32
9	$k_{Ab} = a_0 + a_1 \cdot X_{15} + a_2 \cdot X_{25}$	-2	0,2325	0,0009	0,9723	0,0277	0,5922	4,07
10	$k_{Ab} = a_0 + a_1 \cdot X_{24} + a_2 \cdot X_{25}$	-2,8	0,0005	0,0009	0,8452	0,1548	1,4003	9,62
11	$k_{Ab} = a_0 + a_1 \cdot X_{25}$	2,23	0,0016	-	0,2624	0,7376	3,0563	21,01

Table 4. Econometric models of the value of the economic equivalent of the costs of losses resulting from the forced inactivity of the resident within the house in the village

Nr	Model figure	a_0	a_1	a_2	R^2	φ^2	SE_e	W_e [%]
1	$k_{Ab} = a_0 + a_1 \cdot X_{16}$	13,85	0,1660	-	0,9687	0,0313	0,2508	1,63
2	$k_{Ab} = a_0 + a_1 \cdot X_{14}$	14,17	0,0007	-	0,9551	0,4490	0,3003	1,95
3	$k_{Ab} = a_0 + a_1 \cdot X_{27}$	26,40	-0,00001	-	0,8831	0,1169	0,4844	3,14
4	$k_{Ab} = a_0 + a_1 \cdot X_{22} + a_2 \cdot X_{26}$	8,34	0,000005	0,0004	0,9645	0,0355	0,2668	1,73
5	$k_{Ab} = a_0 + a_1 \cdot X_{24} + a_2 \cdot X_{26}$	8,70	0,000003	0,0004	0,9610	0,0390	0,2796	1,81
6	$k_{Ab} = a_0 + a_1 \cdot X_{17}$	10,38	0,0018	-	0,8570	0,1430	0,5357	3,47
7	$k_{Ab} = a_0 + a_1 \cdot X_{21} + a_2 \cdot X_{26}$	8,617	$141 \cdot 10^{-8}$	$419 \cdot 10^{-6}$	0,9552	0,0448	0,2999	1,94
8	$k_{Ab} = a_0 + a_1 \cdot X_{18} + a_2 \cdot X_{26}$	6,98	0,0022	0,0004	0,9334	0,0666	0,3656	2,37
9	$k_{Ab} = a_0 + a_1 \cdot X_{20} + a_2 \cdot X_{26}$	8,65	0,000004	0,0004	0,9445	0,0555	0,3339	2,16
10	$k_{Ab} = a_0 + a_1 \cdot X_{15} + a_2 \cdot X_{26}$	9,08	0,0584	0,0005	0,9447	0,0553	0,3332	2,16
11	$k_{Ab} = a_0 + a_1 \cdot X_1 + a_2 \cdot X_{26}$	6,33	0,0006	0,0005	0,9335	0,0665	0,3653	2,37
12	$k_{Ab} = a_0 + a_1 \cdot X_{25} + a_2 \cdot X_{26}$	7,55	0,0002	0,0006	0,8281	0,1719	0,5874	3,81
13	$k_{Ab} = a_0 + a_1 \cdot X_{19} + a_2 \cdot X_{26}$	5,86	0,0009	0,0008	0,8462	0,1538	0,5556	3,60
14	$k_{Ab} = a_0 + a_1 \cdot X_{19}$	11,65	0,0009	-	0,3562	0,6438	1,1369	7,37

Table 5. Forecasted values of the economic equivalent of the cost of forced inactivity of a city resident at home k_{Ab} in 2018-2027 calculated on the basis of developed econometric models

Year	The number of the econometric model										
	1	2	3	4	5	6	7	8	9	10	11
	[PLN/kWh]										
2018	20,73	20,55	19,36	20,66	20,94	20,59	15,65	20,08	20,71	20,02	16,15
2019	21,46	21,28	20,03	21,38	21,67	21,30	16,08	20,73	21,43	20,65	16,33
2020	22,18	22,00	20,71	22,10	22,41	22,00	16,51	21,38	22,15	21,29	16,52
2021	22,91	22,72	21,38	22,81	23,14	22,71	16,93	22,03	22,88	21,93	16,71
2022	23,64	23,45	22,05	23,53	23,87	23,41	17,36	22,68	23,60	22,56	16,90
2023	24,36	24,17	22,72	24,25	24,61	24,12	17,79	23,33	24,33	23,20	17,08
2024	25,09	24,90	23,40	24,97	25,34	24,82	18,21	23,98	25,05	23,83	17,27
2025	25,81	25,62	24,07	25,69	26,07	25,53	18,64	24,63	25,78	24,47	17,46
2026	26,54	26,35	24,74	26,40	26,80	26,23	19,06	25,28	26,50	25,10	17,65
2027	27,27	27,07	25,41	27,12	27,54	26,94	19,49	25,93	27,23	25,74	17,83

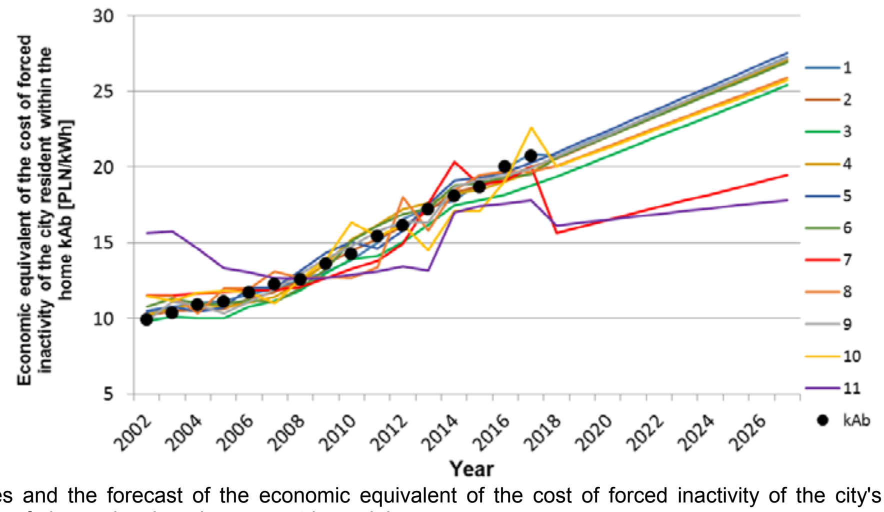

Fig. 2. Empirical values and the forecast of the economic equivalent of the cost of forced inactivity of the city's resident at home k_{Ab} designated on the basis of eleven developed econometric models

Table 6. Forecasted values of the economic equivalent of the costs of inactivity of the village resident at home k_{Ab} in the years 2018-2027 calculated on the basis of the developed econometric models

Year	The number of the econometric model													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	[PLN/kWh]													
2018	17,82	15,88	17,63	18,39	17,85	17,73	17,74	17,67	17,98	17,73	17,69	17,43	17,49	16,79
2019	18,10	16,06	17,89	18,69	18,12	18,00	18,01	17,93	18,26	18,00	17,96	17,66	17,73	16,95
2020	18,38	16,23	18,15	18,99	18,40	18,27	18,28	18,19	18,54	18,27	18,22	17,90	17,97	17,12
2021	18,66	16,40	18,41	19,29	18,68	18,54	18,55	18,46	18,82	18,54	18,49	18,13	18,21	17,28
2022	18,94	16,58	18,66	19,58	18,95	18,82	18,83	18,72	19,10	18,81	18,76	18,36	18,45	17,44
2023	19,22	16,75	18,92	19,88	19,23	19,09	19,10	18,98	19,37	19,08	19,02	18,60	18,70	17,60
2024	19,50	16,93	19,18	20,18	19,51	19,36	19,37	19,25	19,65	19,35	19,29	18,83	18,94	17,76
2025	19,78	17,10	19,44	20,48	19,78	19,63	19,64	19,51	19,93	19,62	19,55	19,07	19,18	17,92
2026	20,06	17,28	19,70	20,77	20,06	19,90	19,91	19,77	20,21	19,89	19,82	19,30	19,42	18,08
2027	20,34	17,45	19,96	21,07	20,34	20,17	20,18	20,04	20,49	20,16	20,09	19,53	19,66	18,24

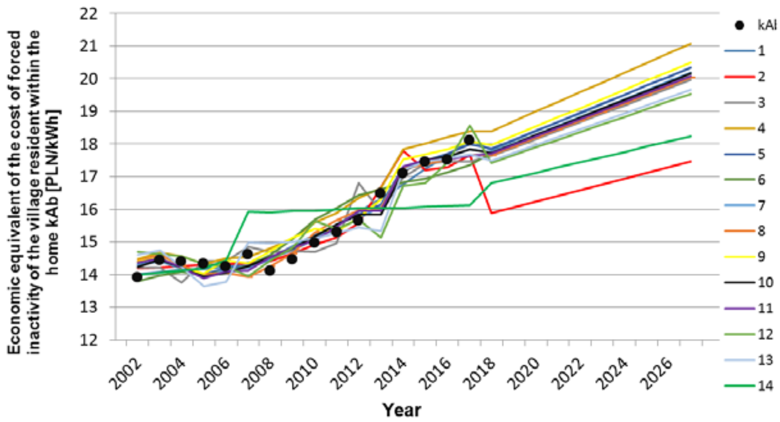

Fig. 3. Previous values and forecast of the economic equivalent of the cost of forced inactivity of a village resident at home k_{Ab} appointed on the basis of fourteen developed econometric models

Based on the theory of econometrics, the Authors elaborated eleven models of the economic equivalent of forced losses of inactivity of city residents and fourteen models of this equivalent for rural residents. These models make it possible to determine the equivalent based on the knowledge of commonly available statistical data. The first stage of the research was to select variables that could potentially affect the value of the k_{Ab}. These were data from various areas such as, for example, industry, agriculture, sociological data, demographic data, etc. Finally, the developed models are based on eleven statistical variables for the city and fourteen for the village.

The obtained econometric models are characterized by high correctness, which is evidenced by high values of the determination coefficient and low values of the standard estimation error. This means that the actual values of the economic equivalent of forced loss of inactivity in the home area differ from the theoretical values determined from the models by very small values, while the variability of the adopted explanatory variables largely explains the variability of the coefficient k_{Ab}.

On the basis of the developed models, a medium-term forecast was made of the value of the economic equivalent of forced loss of inactivity of city residents and villages for the years 2018-2027. The forecast values obtained for all developed models based on different statistical data are similar. This indicates the high stability and reliability of the developed models.

Analyzing both empirical data and prognostic values determined from econometric models, we can see a constant increase in the k_{Ab} ratio. This means that electrical devices play an increasingly important role in households. This illustrates the increasing social and economic value of the work performed by the electricity unit.

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