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ENERGY SAVINGS IN HOUSEHOLDS VIA BEHAVIORAL CHANGE DRIVEN BY CONSUMPTION VISIBILITY

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Abstract

Energy efficiency in households is closely related with energy poverty in particularly when it comes to developing countries. Namely, low households' incomes combined with low efficient buildings and low efficient home appliances are very common situation for these countries. Macedonia is not an exception. On the other hand, lower standard prevents the majority of the households to invest in energy efficiency improvements. This paper focuses on implementation of no cost measures affecting human behavior in order to improve energy efficiency and gain energy savings in households. The only change that will be introduced to influence that behavior is real time measurement (visibility) of the energy consumption for specific home appliances with customized energy savings kit. Each energy saving kit contains the following items: two electricity consumption's measurement devices operational with internet, two electricity consumption's measurement devices operational without internet, thermometer for temperatures measurements in the fridge and freezer, device for ambient temperature and humidity, two LED lightings, light socket, guidance for usage of the kit and diary for energy consumption's data collection and recording. The research is conducted within 43days period, over the two groups of households in Skopje – test group (8 households) and control group (8 households). Each household is assigned to one of these groups based on the Randomized Controlled Trial (RCT) principle. In order to analyze the effect of the energy consumption related behavior before and after the treatment/experiment, the Difference to Differences (DiD) method was used. The results show on average 15% lower energy consumption only due to behavioral changes driven by enabling consumption visibility. The savings are greater in the high electricity tariff for the both groups.

Keywords: Energy savings; energy savings kit; households; behavioral change; Difference – in –Differences

INTRODUCTION

Households are among the main contributors into the final energy consumption on a global level, holding significant burden in terms of energy resources depletion, urban pollution and energy costs. In 2020, residential sector (households) in EU member states, had a share of 27,4% (Eurostat, 2022) in total final energy consumption, while in North Macedonia this share for the same period is 28%. (Energy Community, 2022) Having in prospect the trends regarding North Macedonia's energy intensity (both in industry and residential sector), as a most common indicator for quantifying the energy efficiency, it could be pointed out that the situation is far from being acceptable. According to Eurostat, the North Macedonia's energy intensity in 2019 was 321,27 kgoe/1000€, while the EU27 average was 119,48 kgoe/1000€. In addition, compared to the EU average, North Macedonia has quite significant share of electricity in final energy consumption of the households, mainly due to the substantial usage of this commodity for residential heating. (State statistical Office, 2019) On the other side, the usage of renewable energy sources in final energy consumption and in particularly in the households is not satisfactory though the potential is quite significant. In addition, the citizens in North Macedonia are facing significantly higher rates of energy poverty compared to the EU average. Namely, in North Macedonia the energy poverty rate for 2019 was 33%, representing a share of the population with the difficulties to provide adequate heating of their dwellings. It is one of the highest energy poverty rates in the Western Balkans, while the EU countries average for the same period is slightly below 10 %.(Energy Community, 2021)

Hence, the problem with households' energy consumption becomes even more complex since low energy efficiency and significant energy poverty do not create favorable climate for promotion and wider acceptance of energy efficiency investments. Unlike the industry and other sectors, the implementation of energy saving and energy efficiency measures for households is quite simple process encompassing a standard set of actions, not requires significant investments and predominately has short payback periods. Moreover, there are numerous of no cost measures that could be implemented, based only on the change of human behavior. Namely, decisions related to energy use, including indoor temperature settings, adoption of star-labelled appliances, or participation in demand-response programs, are all intricately linked with human behavior. Thus, the actions and attitudes of individuals play a key role in cumulative energy consumption.

Having in prospect the awareness of the individuals concerning the importance of energy efficiency improvements and energy savings, their behavior could be changed in a positive direction if they understood "what should be done" and "why it should be done". The analyses shown that the cooperation with the behavioral sciences is of utmost importance, while having in mind these simple activities in changing behavior matters. One of the crucial factors affecting the energy consumption awareness is the visibility of the consumption. The research findings indicates that with enabling and raising of the visibility, the energy consumption in the households decreases up to 20%. (European Energy Agency, 2013) Although the energy costs reduction is among the main factors fostering behavioral changes, the level of education, available subsidies as well as the energy consumption visibility are often pointed out as significant drivers for changes.(Hassan et al., 2009) As per the above mentioned, this paper is focused on assessment of households' energy savings due to behavioral change initiated by enabling energy consumption visibility. The assessment process uses energy saving kits for enabling consumption visibility in the selected number of households, while Difference- in- Differenced (DiD) method is used for results' analyses.

METHODOLOGY

The herein presented research uses one of the most popular and widespread methods in impact evaluation studies – Difference-in-Differences (DiD). It is based on a combination of before-after and treatment-control group comparisons. In addition, it enables controlling from bias from unobserved variables that remained fixed during the analyzed time. (Zhou, 2016) Firstly, DiD considers an evaluation that is focused on estimation of the effect of a (non-randomly implemented) policy (treatment/action), by comparing outcomes in the treatment group to a control group, with data from after policy (treatment/action) implementation. Then, it is considered combining the after-before approach and the treatment-control group comparison. Hence, with two groups and two analyzing periods, as well as with a sample of data from a population of interest, the DiD estimate the policy (treatment/action) impact, that could be written as follows: (Fredriksson et al., 2019)

$$\mathrm{DiD} = (\bar{y}_{s=\mathrm{Treatment},t=\mathrm{After}} - \bar{y}_{s=\mathrm{Treatment},t=\mathrm{Before}}) - (\bar{y}_{s=\mathrm{Control},t=\mathrm{After}} - \bar{y}_{s=\mathrm{Control},t=\mathrm{Before}}) \quad \text{Eq. (1)}$$

where *y* is the outcome variable, the bar represents the average value (averaged over individuals, typically indexed by *i*), the group is indexed by *s* (indicating state level policy/treatment/action), and *t* is the time. Hence, having in prospect before and after data for treatment and control, four group of data are deriving and the herein explained double difference is estimate. One of the main assumptions of DiD is the "parallel trend" assumption, indicating that in the absence of treatment, the average outcomes of both treatment and test (comparison) group would follow parallel paths over time. (Abadie, 2005) The arrangement of the DiD estimation is presented on Figure 1.

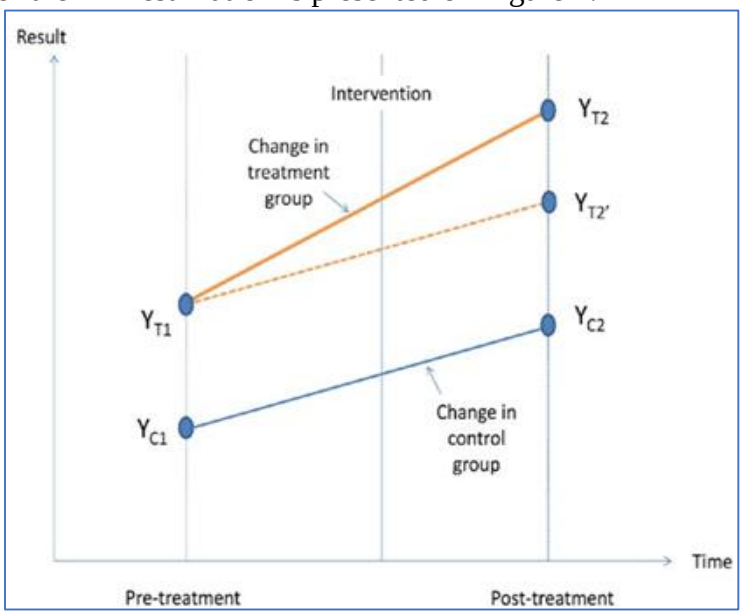

Figure 1. Illustration of the two group two period DiD estimate (Source:Morris, 2013)

As a research design to estimate causal effects, DiD approach is widely used in empirical economics predominantly for identification of certain policy measure and interventions effects that do not affect the entire population at the same time and at the same level. It is also used in social sciences research, such as behavioral change studies, as well as in number of other fields. (Lechner, 2011)

HOUSEHOLDS' ENERGY SAVINGS VIA BEHAVIOURAL CHANGE – EXPERIMENTAL RESEARCH

The herein presented research is focused on the electricity consumption in a number of households in Skopje, having in consideration several specific circumstances regarding the share and the manner of electricity consumption into this category. Namely, in the last few years the indicator energy consumption per capita on an annual basis (kWh/capita) is increasing, reaching in 2021 the maximum value recorded in the past seven years. (State Statistical Office, 2022) Further, significant share of the electricity in households is used for heating purposes and in an inefficient manner (electric heaters rather than inverters). Although the City of Skopje is the only city in the country that has district heating system, unfortunately less than 25% of the households are connected to this system. (State Statistical office, 2019) Thus, for majority of the households, the most used heating option is electricity along with firing wood. The household electricity price was kept bellow real market value despite the liberalization, via introducing universal supplier for a transitional period of 5 years. Creation of such uncompetitive and unfavorable environment for energy savings, is predominantly driven by social motives (preventing social turmoil). The tariff systems had only one category for the households (including low tariff and high tariff) regardless of the consumption level. Starting from July 2022, four different electricity tariffs for the households were introduced which could be outlined as a significant step towards energy savings incentives and behavior changing. On that path, understanding of the home appliances consumption, their features and efficiency via enabling consumption visibility is of significant importance. The herein conducted analysis is focused on monitoring and assessing of the selected households' behavior change via enabling electricity consumption visibility. It must be outlined that the analysis is not limited to energy efficiency, but covers all energy savings measures, since a lot of actions include slight changes in the occupational conditions/comfort. The electricity consumption's visibility test is conducted in 16 selected households from Skopje, via using energy saving kit. The households well selected upon a participation in a survey and submitted written consent. Namely, though 43 households applied for the test, 16 were selected based on the following predefined criteria – dwelling in the multi-apartment building, 3 to 5 household members as well as possessing an air-conditioner. Based on the Randomized Controlled Trial (RCT) principles, the selected households were divided into two groups – test group (8 households) and control group (8 households). RCT is a trial in which subjects are randomly assigned to one of two groups – one (the experimental group) receiving the intervention that is being tested, and the other (the comparison group or control) receiving an alternative (conventional) treatment. (Kendall, 2003) Thus, two groups are then monitored in order to detect any differences in the outcome. The obtained results are used to assess the effectiveness of the intervention/action. Thus, RCTs are the most stringent way of determining whether a cause-effect relation exists between the intervention and the outcome. In herein presented research, the test group is the one that receives the energy saving kit, while for the control group the energy saving kit is not available. The selection process is explained on Figure 2.

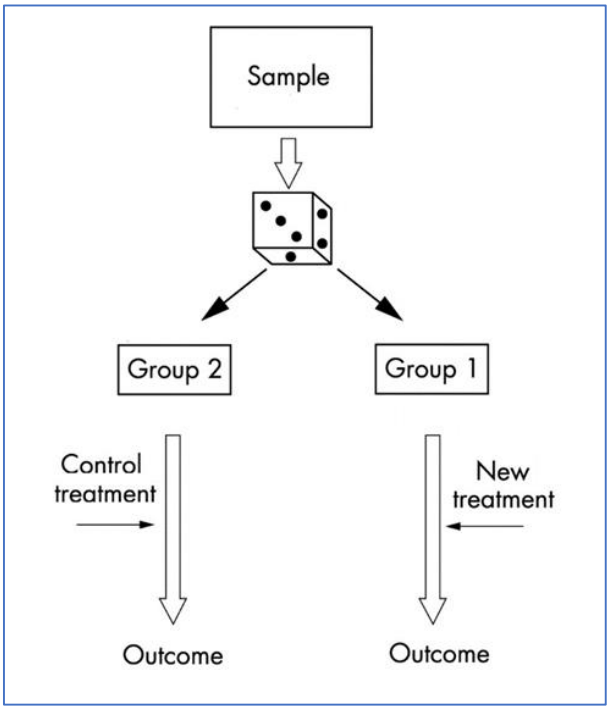

Figure 2.Test group and control group households' selection

Each energy saving kit contains the following items: two electricity consumption's measurement devices operational with internet, two electricity consumption's measurement devices operational without internet, thermometer for temperatures measurements in the fridge and freezer, device for ambient temperature and humidity, two LED lightings, light socket, guidance for usage of the kit and diary for energy consumption's data collection and recording. The energy savings kit's content is presented on Figure 3.

Figure 3. Energy savings kit's content

During the conduction of the research, each household from the test group is visited by a member of the project team (technical expert), in order to provide the necessary information and clarifications regarding the proper usage of the kit.

RESULTS AND DISCUSSION

During the implementation of the experiment, in the period from 01.08.2022 until 13.09.2022, six readings of the main electricity meter per household's were performed both in terms of the state in high and low electricity tariff. The periods in which both identified household's groups had a role of test group and control group was limited to 14 days. After

the completion of the planned electricity meters readings, the calculation of the electricity consumption between the readings is performed for each household both in high and low tariff. For example, the difference between the first and second reading's values is obtained by subtracting the meter's value for the first reading from the one registered in the second reading. Thus, the correspondent differences between the meter's readings are presented in table 1.

Table 1. Daily average values for household's electricity consumption

Period between the meter's readings	Test group (kWh)	Control group (kWh)
Total daily average values		
Period without the energy saving kit		
01.08.2022. – 08.08.2022	13,2	8,2
08.08.2022 – 15.08.2022	13,1	11,4
15.08.2022 – 22.08.2022	13,9	9,0
Period with the energy saving kit		
22.08.2022 – 30.08.2022	11,7	8,5
30.08.2022 – 13.09.2022	10,8	7,6
Daily average in high tariff		
Period without the energy saving kit		
01.08.2022 – 08.08.2022	7,8	4,1
08.08.2022 – 15.08.2022	8,0	5,7
15.08.2022 – 22.08.2022	8,0	4,6
Period with the energy saving kit		
22.08.2022 – 30.08.2022	6,9	6,3
30.08.2022 – 13.09.2022	5,8	4,0
Daily average in low tariff		
Period without the energy saving kit		
01.08.2022 – 08.08.2022	5,4	4,1
08.08.2022 – 15.08.2022	5,1	5,7
15.08.2022 – 22.08.2022	5,9	4,4
Period with the energy saving kit		
22.08.2022 – 30.08.2022	4,8	2,2
30.08.2022 – 13.09.2022	5,0	3,7

The average daily values of the electricity consumption (both high and low tariff), is presented on Figure 4. It could be noted that the control group has lower electricity consumption than the test group for all meter's readings. In addition, it could be emphasized that in the periods with the energy saving kit, both groups (test group and control group) have lower consumption compared to the periods without the saving kit.

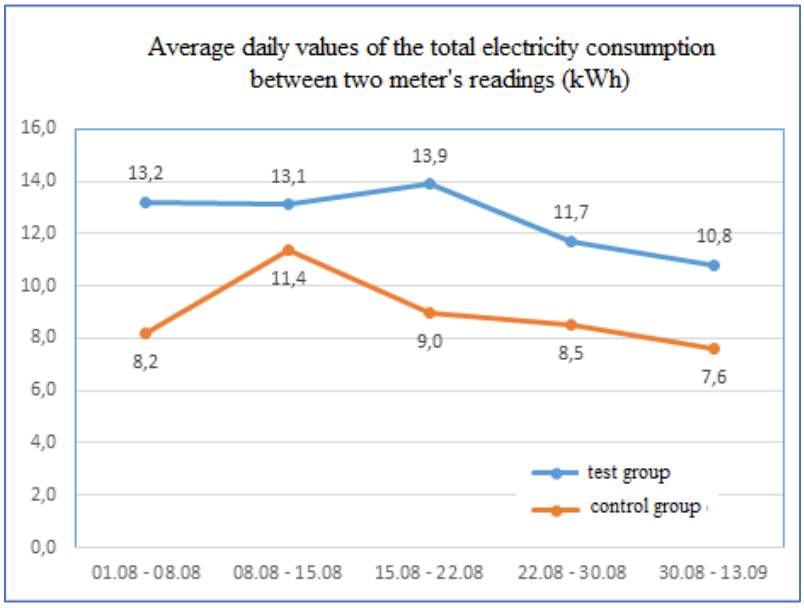

Figure 4. Average daily values of the total electricity consumption of the monitored households

Figure 5 represents the average daily values of the electricity consumption in high tariff for all monitored households. It is evident that in test group there is a sharp decline in consumption right after the receiving of the energy saving kit. On the other hand, the electricity consumption of the control group remains nearly the same, i.e. there is no significant changes in the electricity consumption habits.

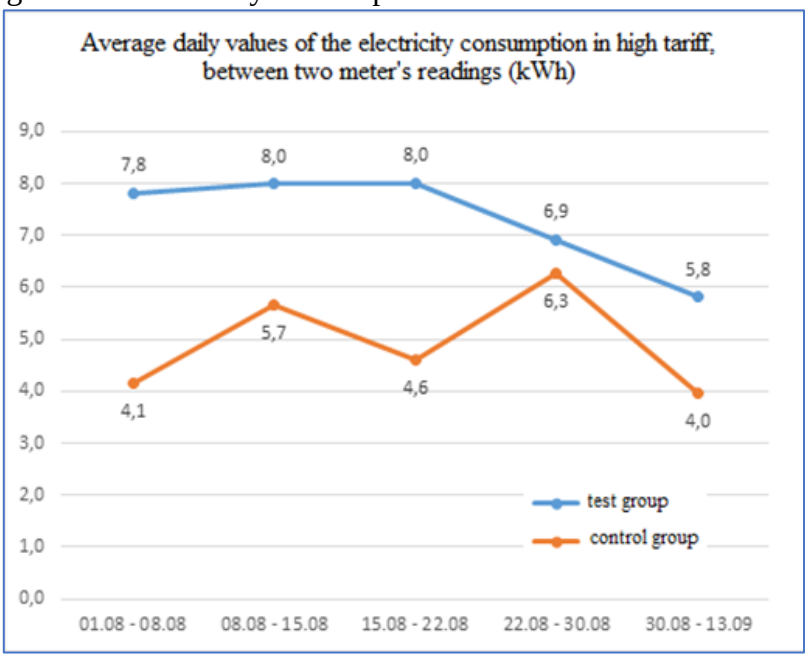

Figure 5. Average daily values of the high tariff electricity consumption of the monitored households

The average electricity consumption of the monitored households (test group and control group) in low tariff is shown on Figure 6.

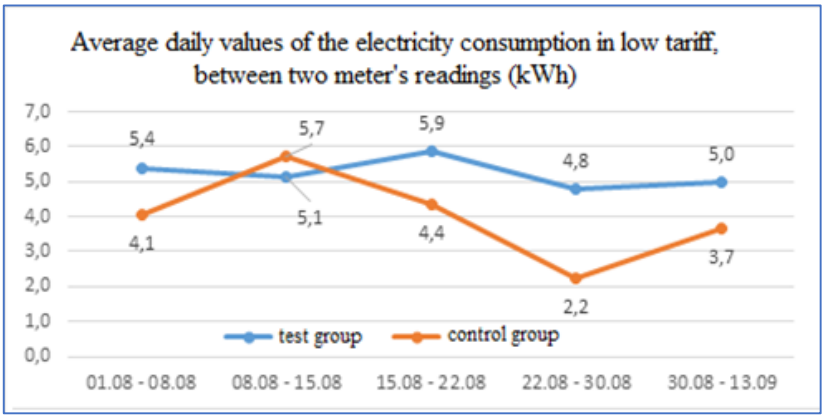

Figure 6. Average daily values of the low tariff electricity consumption of the monitored households

It could be noted that unlike the high tariff electricity consumption habits, in low tariff the habits remain almost the same for both groups regardless of the energy saving kit's possession. Figure 7 presents the total energy savings (both high and low tariff) of the test and control groups due to enabled electricity consumption visibility.

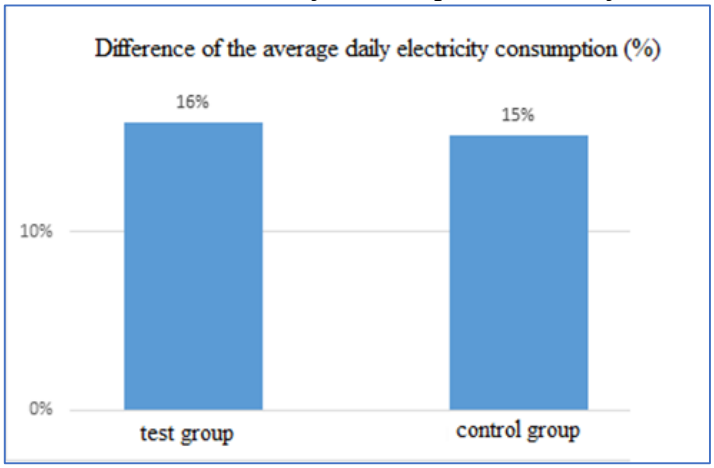

Figure 7. Difference of the total electricity consumption of the monitored households

Hence, the achieved total energy savings rates in the periods where the energy saving kits are exploited, are quite similar for both test group and the control group. As per the consumption differences in high tariff, the findings are presented on Figure 8.

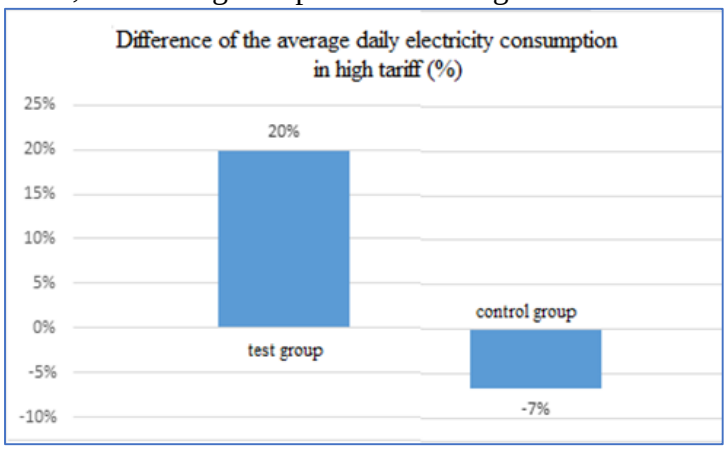

Figure 8. Difference of the electricity consumption in high tariff of the monitored households

Hence, in high tariff test group has even more significant savings, while among the households in the control group there is no improvement in terms of energy savings. Moreover, the electricity consumption trend for control group is negative. The electricity consumption trends in terms of low tariff are presented on Figure 9.

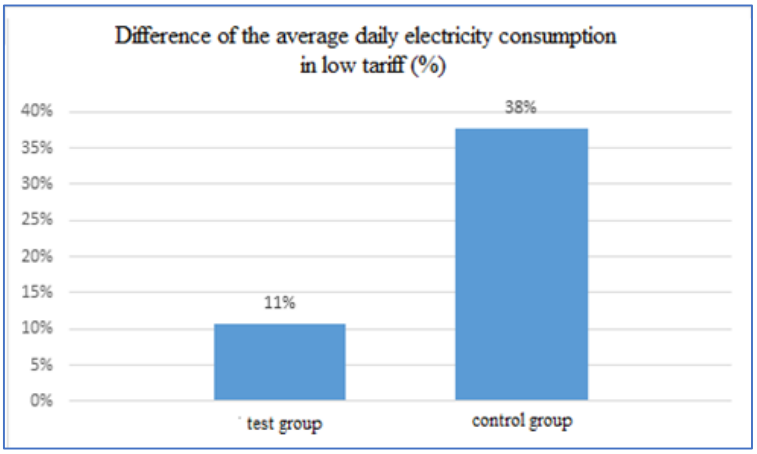

Figure 9. Difference of the electricity consumption in low tariff of the monitored households

The results in low tariff are even more diverging from each other. Namely, there is significant energy consumption difference in the control group. It must be emphasized that in general, in the households in North Macedonia, the major part of the electricity consumption is located in the low tariff, while regarding the high tariff the citizens have already developed energy savings habits, i.e., they avoid usage of the most significant energy users in high tariff. However, there is no doubt that enabled visibility of the critical appliances' consumption, resulted in behavior change and additional savings, in particularly in high tariff.

CONCLUSION

This research was conducted in order to quantify the effect of electricity consumption visibility on behavior changes towards increased awareness for energy savings. The specific period for its implementation was on purpose the same with the introduction of the block tariffs. Namely, the block tariffs also contributed to more significant high tariff energy savings, since the block tariff system quotas refers only to high tariff consumption. However, having in prospect the total average electricity consumption, the research confirms the assumed and previously assessed electricity consumption rates as a result of behavior change in the households, though it must be emphasized that a relatively small sample (number of households) for test and control group are used. The latter is mainly due to the limited number of available energy savings kits, the hesitation for participation in the experiment of the majority of households that was asked for a consent, as well as the specific season when the research was conducted (July – August – September). Hence, it was very challenging to provide the representative example for the research. Moreover, having in prospect that in this period most of the citizens are away for holidays, it was difficult to secure the consistent/timely intervals of the electricity meter's readings in the households. Nevertheless, the benefits from this research are not limited only to the achieved energy savings through enabled electricity consumption visibility. Energy savings kits provide useful information in identification of unusual electricity consumption of certain appliances that could be an alarm for a malfunction. In addition, the citizen become more aware for the benefits of energy efficient appliances as well as the implementation of energy saving measures.

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