The Evaluation of Energy Saving Potential of Household's

Zaneta Simanaviciene, Andzej Volochovic, and Daiva Dumciuviene

Abstract—Currently, climate change mitigation policy is a priority of environmental policy in the world. The energy efficiency and increased use of renewable energy resources are the main ways to reduce greenhouse gas emissions and the main objectives of EU energy and climate change mitigation policy. Lithuania is primarily focused on the supply side of the energy and industrial energy users. However, the possibilities of energy saving and sustainable use in Lithuanian households remained forgotten. Research shows that it is reasonable to suggest that an individual's behaviour is the basis for an environmental impact. Actions carried out by individuals or their choices - all this creates a direct and indirect impact on the environment, together make impact on personal and collective well-being. While sustainable consumption stands at the centre in the national and international politics, but in spite of cross-border agreements and individuals knowing, changes are happening slowly.

Keywords—Energy saving, households, behaviour, the experiment.

I. INTRODUCTION

ALTHOUGH households consume one third of the EU's energy and are responsible for roughly 30 percent energy-related CO^2 emissions, before considering private transport pollution, climate change mitigation policies in the EU and Lithuania is primarily focused on the supply side of the energy and industrial energy users [1]. After the second block of the Ignalina NPP closure in 2009 GHG emissions Lithuania average increase of 5 Mt/year due it replacement by the Lithuanian Power [2]-[3]. The new nuclear power plant construction plans are often associated with increased GHG reduction in Lithuania, and declined ability of the country to implement a post-Kyoto climate change commitments. Many studies in Lithuania have shown, that without requiring the new nuclear power plant, but implementing of all the measures to reduce GHG in Lithuania, these goals will not be achieved. However, the possibilities of energy saving and sustainable use in Lithuanian households remained forgotten. Intergovernmental Group on Climate Change, which is engaged in basic research on climate change, has set the challenge in the Fifth Assessment Report focusing research on lifestyle and environmental behaviour and preparation of recommendations in this area [4]-[5].

Research shows that it is reasonable to suggest that an individual's behaviour is the basis for an environmental impact. Actions carried out by individuals or their choices - all this creates a direct and indirect impact on the environment, together make impact on personal and collective well-being. While sustainable consumption stands at the centre in the national and international politics, but in spite of cross-border agreements and individuals knowing, changes are happening slowl [6]. Meanwhile, energy consumption is the main source of greenhouse gas emissions, and energy savings by changing people's behaviour towards sustainable energy can achieve remarkable energy efficiency and reduction of greenhouse gas emissions without additional costs and investments.

The aim - to assess households saving of energy potential. Energy-saving household survey, changing people's behaviour, has been carried out, forming the base, and energy-saving scenarios.

Research methods - literature analysis, qualitative method - experiment. The aim of qualitative method – experiment was to test the energy efficiency or climate change mitigation policies to the behaviour of the population. By these policies it could be improved the Lithuania Energy Saving Promotion household system. Another aim was to check out these new measures on household energy consumption and greenhouse gas emissions decline.

II. THE EXPERIMENT ORGANIZATION

The researchers of Kaunas University of Technology, using quantitative and qualitative research methods, carried out the energy savings potential of household assessment. The objectives for investigation were formulated:

• to evaluate the energy saving potential of households by using measures influencing their behaviour.

• to uncover the key barriers that disturb change in behaviour.

• to identify the key factors that determine the changes of population's behaviour.

This article presents a qualitative study - experimental results.

Household are called together living and having corporate economy persons. Family and household concepts are different, although sometimes interchangeable. Family - a group of two or more people related by marriage, blood ties or adoption, living together.

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In 2013 Lithuania has 1 425 thousand households. More than half (55 percent) households were without children, with one child - 22 percent with 2 kids - 17, with 3 or more children - 6 percent. In 2013 one person's households accounted for 23 percent. Average disposable household income per capita was 908 Lt. The average unemployment rate in Lithuania in 2013 amounted to 11.8 percent. In 2013 women accounted for 50.06 percent of the total population. Elderly population in Lithuania (60 years and older) were 701, 2 thousand which accounted for 21.6 percent. People of working age (20-59 years.) were 66.7 percent, up to 19-age people accounted for 12 percent. 80 percent of Lithuania's urban population lives in apartment buildings. 1.64 million Lithuanians live in multi-dwelling buildings. There are 547 thousand apartments (flats) in these buildings. There are 28 thousand of apartment buildings in Lithuania, which are designed before 1993.

According to the average household characteristics, a group or survey sample of households involved in the experiment was formed. Volunteers were selected by carrying out a survey questionnaire. The selection of households was done by matching the demographic characteristics of the population of Lithuania and the studied group (see Table 1).

TABLE I
THE DEMOGRAPHIC PROFILE OF LITHUANIAN POPULATION AND SURVEY'S PARTICIPANTS

Distribution of households by type	1 person	2 persons	3 persons	4 persons	5 and more persons	Total
The proportion Lithuanian households of the population, %	31,5%	26,5%	21,1%	10,5%	10,4%	100%
The number of households required for study	3	3	2	1	1	10 (24 persons)
Average disposable income per household per month in litas	1098,3	2103,8	3316,7	3195,0	3737,4	-
The average accommodation area, m2	48	50	64	64	80	-
Population distribution by age groups	**under 18**	**19-25**	**26-40**	**41-65**	**more than 65**	
The proportion of Lithuania's residents of the population, %	21,9%	7,8%	20,4%	33,4%	16,5%	100%
The number of persons required for study	5	2	5	8	4	24
man, %	51,2%	51,3%	50,4%	46,1%	34,7%	-
woman, %	48,8%	48,7%	49,6%	53,9%	65,3%	
Education	**Secondary, Professional and lover education**		**Higher**		**University**	
The part of population acquired education, %	16,8%		27%		56,2%	
Number of persons requires for investigation, who in the household will exhibit as having the highest level of education	1		3		6	

Source: [7]-[8]

Table 1 shows the statistics (2012-2013 period) which were converted to proportions (percentages) in order to make it clear how to form the test group that will have to reflect these proportions. To facilitate the selection of households participating in the experiment the core was formed from a representative of ten households, which reflects the proportion of the total population analysed.

In order to prepare the experiment and to create a control group, based on more detailed information about the household, it was necessary to carry out the questionnaire randomly selected households in the survey. The questionnaire was designed to complement the experiment in order to know thoroughly the household, to obtain more detailed information about the nature of the behaviour, identify barriers to behaviour change and select a control group of households to perform the experiment.

After the evaluation of the results of the questionnaire the control group of households was formed. The selection was based on the average demographical situation and Lithuania's statistical characteristics of the household, such as age, household size, education, income, place of residence.

The experiment was conducted under two scenarios: baseline and energy savings. Under the baseline and the energy savings scenarios energy consumption in households were recorded. Registration was carried out after preparation of the household activities register, which recorded all the household activities related to energy consumption, duration, and aggregate energy consumption per month register.

Having survey by questionnaire households results, which showed the lack of energy conservation measures, in order to change the current situation, the measures designed to change the behaviour of the household were proposed:

• the seminar on climate change issues and policies for reducing greenhouse gas emissions, the importance of energy saving and opportunities for households was conducted;

• elevated energy savings target - 20%, identifying, that for energy savings achievement will compete several households;

• the energy saving measures for households were proposed:

- reducing electricity consumption: electric lights off when leaving the room, less TV time and computer power, wash at a lower temperature, washing "eco" mode, the device off in standby mode, frequent defrosting of refrigerator.

- in the field of transport: the use of public transport, the cooperation with others to travel to work, the short-distance bridging by bicycle, "gentle" driving, speed reduction;

- lifestyle change: use of domestic products, the reduction of the quantity of meat.

Feedback mechanisms: one month after the opening of the

objectives energy consumption of the household will be tested.

After the implementation of energy-saving scenarios (raising the goals and planning saving measures) the energy savings was estimated by energy-saving scenarios. The summary of the data of one month from all households participating in the experiment registration records was performed.

In order to get to more accurate results, the study was carried out in a total of 4 months: 2 summer and 2 winter months. Energy savings were estimated according the baseline and energy savings scenario. Similar energy-saving measures were used in energy-saving scenario as well.

The study carried out on randomly selected families, living in Kaunas multi-dwelling buildings, after carried out a questionnaire survey in order to reflect the Lithuanian household situation. The most important characteristics of the surveyed households, affecting change of behaviour and energy saving, according which is necessary to select the families involved in the experiment, are the number of persons in the household, gender, age, education, incomes and employment.

Summarizing the survey data the 10 households were selected, which corresponded the statistical Lithuanian household. Half of selected households consist of two people, more than half of the surveyed households should have a higher education, the majority of surveyed household's monthly income should not exceed 900 Lt. The average household size should be 2.4. The people of working age (20-59 years) should take around 67 percent, people up to age 19 year would take 12 percent. As 80 percent of Lithuania's urban population live in apartment buildings, they were chosen as the target group.

Experimental procedure:
• Scenarios formation;
• Selection of measures, associated with the changes in energy consumption;
• Preparation of two types of registers;
• The selection of participants in the experiment, the control group;
• Information and training of experiment participants how to fill registers
• Setting of goals and anticipation of means;
• Feedback - setting of the achieved results;
• conclusions.

Assuming that household energy consumption in summer and winter time is different, an experiment was conducted in the summer and winter season. The study was carried out for four months, two months during the summer season, and two months during the winter season.

Two main scenarios were formed to carry out the experiments:
• Baseline scenario: every day one summer and one winter month until goal setting will be recorded in the register, the data of domestic activities related to energy consumption will be recorded, in order to evaluate the energy consumption of households without the measures.
• Energy-saving scenarios: after the initial assessment of the

situation, having goals and starting introduce the certain saving measures, every day one summer and one winter month the domestic activities data related to energy consumption was recorded in the register, in order to evaluate the energy savings in households applying energy-saving measures aimed at behavioural change.
• In order to determine the energy consumption the characteristics specified in the appliances, electricity and gas, and water meter readings were used.

Get the experimental data for each household was collected in a consolidated register. The average amount of savings of Lithuanian households was determined, based on the information obtained from summary registers of households involved in the experiment.

The main factors (age, education, family size, income, attitudes toward environmental protection and energy consumption, etc.) determining the energy savings potential of households was determined as well.

The main barriers influencing household behaviour were identified: lack of knowledge, distrust of sources of information, and the inertia, values and so on.

It should be noted that during the study the heat consumption in households was not evaluated – as multi-dwelling buildings are unable to control the heat consumption.

Total energy savings potential of households was estimated separately by groups of households, by summing of the registers' data. In particular, the resulting energy savings are converted into conditional fuel, using the fuel calorific value table.

The conversion of savings in electricity, natural gas and fuel in the same unit of measurement of energy resulting the total amount of savings for each of the household, who had attended the experiment. Under the baseline scenario the household energy savings within one month is presented in Table 2.

After the evaluation of average energy savings of 10 household examined, the result is that one household per month in the summer can save on average: 28.5 kWh of electricity, 0.9 m3 of natural gas, 20.9 l of gasoline or diesel fuel; for the winter respectively: 21, 5 kWh of electricity, 1 m3 of natural gas, 16.2 l of gasoline or diesel fuel.

In order to compare the results and to get the actual data in euros, the data obtained were recalculated according to the conversion factors. It has been calculated the energy-saving potential of GJ or tne. Savings in electrical energy is converted into GJ using coefficient 1MWh = 3.6 GJ. In order gasoline or diesel fuel in litters to convert into tone, it is necessary to estimate its density. The actual fuel density is determined by Aerometro (according the coefficients presented in catalogues). If it is impossible to determine the actual density of diesel and petrol, exceptionally, litters can be converted to tons by multiplying the coefficients: gasoline - 0.75, diesel - from 0.84. The results obtained are divided by 1,000. According the recalculation of the data obtained, one household on average per year due to behavioural changes can save 297 euro associated with the use of vehicles, 20.85 euro for natural gas savings, and 78.49 euro for the prudent use of

electricity. Total per year per one household due to behavioural changes associated with energy consumption can save an average of 396.78 euro. All households in Lithuania would save an average 564, 76 million euro / year. Given that the average pension in Lithuania is 240 euro, it can be said that it is quite a lot of savings.

TABLE II
HOUSEHOLD ENERGY SAVINGS PER MONTH IN WINTER AND SUMMER SEASON, IN-KIND UNITS

No.	Household Structure	Fuel savings, l		Natural gas savings, m^3		Electrical energy savings, kWh	
		During the cold season	During the warm season	During the cold season	During the warm season	During the cold season	During the warm season
1	1 person	44	70	2	2	30	20
2	1 person	27	27	1	1	20	5
3	1 person	3	8	1	1	50	30
4	2 persons	16	14	-	-	40	30
5	2 persons	13	24	1	1	20	30
6	2 persons	4	4	1	1	25	10
7	3 persons	22	27	-	-	30	20
8	3 persons	9	6	1	1	30	30
9	4 persons	6	2	1	1	10	20
10	5 persons	18	27	2	1	30	20
	Total	162	209	10	9	285	215

III. CONCLUSIONS

An experiment showed that changing the behaviour of households in Lithuania the heat emissions can be reduced by 16.6%. The experiment showed that household energy savings and greenhouse gas emission reduction potential of Lithuania through innovative mitigation instruments are not fully exploited. Lithuania must change mitigation policies and to direct it to the consumer sector. It is also suggested to focus on greater attention to climate change policy at local and regional level: set goals, to provide adequate support of knowledge and experience on how to deal with climate change and their daily activities, and implementing long-term projects. It is recommended climate change mitigation policies to steer away from expensive supply side financing projects and focus on soft, educating society and behaviour changing projects.

Over the years, one household, changing behaviour at no additional cost, can save about 2.2 MWh / year. This allows one household to save the average about 396.78 euro or 33euro/month. Total energy savings potential in Lithuania, changing people's behaviour by households amounted to 3.4 TWh / year and saves about 564, 76 mln. euro / year.

Comparing the energy saving potential of changing the behaviour of households and implementing innovation, it can be seen that the energy-saving potential implementing innovation is higher, but requires large investments. Innovating households there are almost twice the GHG emissions reduction potential than changing people's behaviour. However, the GHG emission reduction potential in Lithuania is guaranteed by a very high cost - over 580 euro/tCO2. Only for multi insulation, incandescent bulb replacement LEDs and electrical appliances are replaced evaluated the GHG emission reduction costs are relatively low and implementation cost is effective, but the GHG reduction potential of these innovations are relatively low.

While installing energy saving product innovation and new technologies allow households to save three times more energy than changing people's behaviour in households, but avoided GHG emissions are only about 2-fold lower than the avoided GHG emissions. Population changes in behaviour can save you a lot of energy especially related to the fuel consumption, which carbon intensity is significantly higher than the savings in heat, which are mainly savings innovating households.

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