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Methodology of demand side management Study course. experience of case studies

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Abstract. The role of environmental and energy security issues due to political issues are increasing and this stimulates governments to review sustainable energy strategies. One of the ways to reach the targets set by many countries for cuts in greenhouse-gas emissions, free competition and security of supply is energy efficiency. Energy efficiency can be achieved by demand side management (DSM) programs. DMS requires regular and intensive work with energy users and it makes a platform for introduction of DSM strategies in engineering education. The paper discusses the integration models of DSM in the engineering education, analyses the components significant for ensurance of sustainable engineering education and energy efficiency and climate change targets. Based on analysis a methodology for of integration of DSM is developed.

Methodology shows how to introduce environmental specialists, students and municipality employees with demand side management in public buildings and how to evaluate efficiency of such integration. Methodology is analysed through several case studies and conclusions and recommendations developed.

Key words: energy efficiency, energy audits, study program.

INTRODUCTION

Environmental and energy security issues are becoming more and more actual for politicians. Governments are looking for solutions to develop energy policies that can help reduce carbon emissions and increase energy security. One of the ways to reach targets is energy efficiency (Bergaentzlé et al., 2014).

Energy efficiency directive (2012/27/EU) determines that in 2020 there should be 20% increase in energy efficiency. (European Parliament, 2012) This means that member states have to look for solutions. One of the solution is demand side management (DSM) programs.

The term ‘demand side management’ (DSM) was first minted by Clark Gellings (Electrical Power Research Institute, USA) in 1894, where he gives the definition. ‘Demandside management (DSM) is the planning and implementation of those electric utility activities designed to influence customer uses of electricity in ways that will produce desired changes in the utility’s load shape. While the objective of any DSM activity is to produce a loadshape change, the art of successful implementation and the ultimate success of the program rests within the balancing of utility and customer needs' (Gellings, 1985).

DSM consists of three main categories: DSM policies, DSM implementers and DSM categories. DSM Categories includes energy efficiency (efficiency, conservation), demand side response (price-based, incentive payment-based) and on-site buck-up (generation, storage). DSM policies can be regulatory, market-based, voluntary and financial. DSM implementers are utility, customer, network operator, aggregator and government (Strbac, 2008; Warren, 2014).

Energy Efficiency Plan 2011 reports that the greatest potential for energy savings are energy intensive buildings, especially in public buildings. Higher energy efficiency can be achieved by overlooking public spending, renovation of public buildings, energy performance contracting and implementing energy efficiency on the ground (European Commission, 2011; Annunziata et al., 2014).

To use DSM for increasing energy efficiency to reach Energy Efficiency directives' (2012/27/EU) goals needs specialists with knowledge in DSM. In this paper a new methodology of practical work in DSM study course is developed and tested in Riga Technical University, Institute of Energy Systems and Environment.

METHODOLOGY

Algorithm of methodology for course paper includes 10 modules, see Fig. 1, from which the most important are selection of object, electricity data collection and processing as well as analysis of results and suggestions reduction of energy consumption in the object.

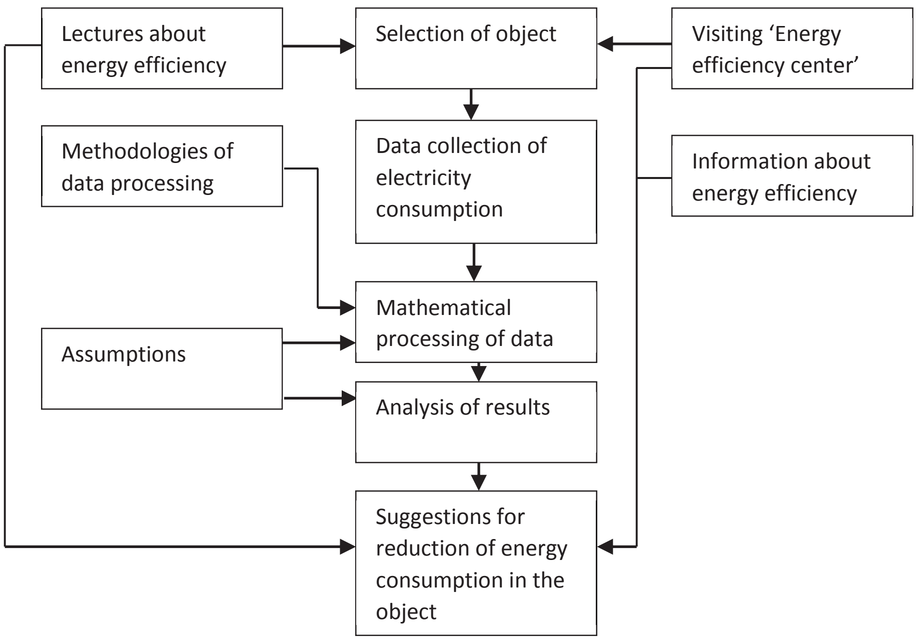

Figure 1. Methodology of practical work in DSM study course.

At the beginning, it is important to give basic knowledge about energy, energy efficiency, energy consumers and consumer's habits. In European Union energy consumption is distributed in five sectors, which are transport, household, industry, service and agriculture (Eurostat, 2014). Based on these sectors, draw up topics in lectures. After lectures students must have understanding about the existing situation, problems and possible solutions for increasing energy efficiency in each sector. Lectures about consumer's habits and equipment, that measures electricity consumption, need to be given too, so students are fully ready for practical part of course and they can give suggestions to reduce energy consumption.

To get better understanding about energy efficiency students visit 'Energy Efficiency Center'. There is possible to get to know energy efficient appliances and get practical advices from specialists about their usage. The resulting information from Energy Efficiency Center also can help in the end of practical work, where suggestions have to be given to increase energy efficiency.

To choose an object need to consider how easy will be data collecting. That is why it is recommended to choose an object that student knows. Students was obligated to choose a public building, because it there is the biggest potential to increase energy efficiency (European Commission, 2011). Students were recommended to choose the school where student studied before. It is a building, which student knows well enough and also knows people who work there, what can make course paper easier to write, because data will be easier to collect.

Data collection is a part of practical work, when students go to an object and do research. The object must been visited at least twice or even more. Data collection is divided in two parts. In the first visitation goal is to collect electric energy bills for last three years, so energy consumption is clear. As well in the first visitation form needs to be given to teachers and administrative staff to know time of every device and light system usage. Questions about usage time must be divided in summer time and winter time, work days and holidays. The second visitation is about collecting forms, measuring power of every device in the object and counting lighting units. Lighting units have to be subdivided by their power. Power of devices can be measured by plug-in power meter that shows momentary power.

Collected data must be mathematical processed. Power and time usage data of device need to be processed by simple formula.

$$Q_{el} = P \cdot t \qquad (1)$$

where: Q_{el} – electrical energy consumption, kWh; P – power, kW; t – time, h.

To get electric energy consumption of device or lighting unit, its power and usage time must be multiplied. Usage time must be given in hours per year, so it is possible to compare consumption later. Choosing data for theoretical energy consumption, it is necessary to consider the most trustable data for calculation of year consumption. In some month there can be reconstruction works or different condition that increases electric energy consumption that is why they should not be considered.

To analyze results of theoretical and practical electric energy consumption, data must be compered. The result of electric energy consumption in both data collecting ways must be close, divergence about 5%. It shows that practical work has been done well. If there is bigger divergence, collected data chosen in calculation must be reconsider. Very important part of analyzing results is trend line empirical model. It is necessary to choose independent and dependent variables, and analyze correlation between them.

After analyzing results students give suggestions for reduction of electric energy consumption. Lectures, visitation to 'Energy efficiency center' and information about electric efficiency from other sources should help them offer some DSM programs.

TESTING OF METHODOLOGY

Methodology was tested in Riga Technical University in Institute of Energy Systems and Environment. During study course of DSM, students were obligated to draft practical work. In this chapter one specific case study is examined.

Methodology was verified in Kandava Karlis Milenbahs Secondary School (Fig. 2). It is located in small town in Latvia. The school was built in 1978 and it is has not been renovated, except replacing all windows from 2001 to 2005. In October 2013, there were working 41 teachers, 13 administrative staff and studying 432 students. The building is made of four floors, basement and gym. It is made of white and red bricks and consists of classrooms, rooms for teachers and staff, dining room, workroom, assembly hall and shooting gallery. Rooms can be divided in two groups, which have undergone refurbishment work and which have not. Refurbishment work includes new lighting system and classroom equipment.

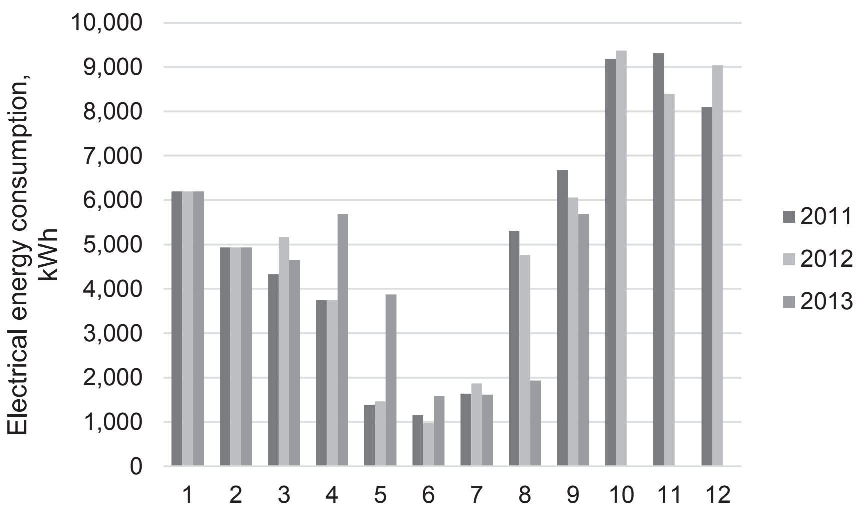

Figure 2. Electrical energy consumption in Kandava K. Milenbahs Secondary School.

To collect data there were three visitations in the object. In the first visit, energy consumption data for three past years were collected. In the building there are three energy meters, but for data processing were used two energy meters, because one shows energy consumption only in dining room. DSM in dining room was not included in practical work tasks. Month data from two energy meters were counted together and compared with other month. Some month data were not available; therefore these data were assumed the same with energy consumption data in specific month, previously year. There were no data for last three month in 2013, because practical work was taking place in October 2013.

The first part of the second and third visitation was about counting every electric device in the building measuring its power and counting every lighting unit and defining its power. The second part of this visitation was about to survey the habits of people that uses devices. The aim was to get information about how many hours they use definite electric device and lights. There is one responsible person in the each room, who knows how long each device or light unit is used per day.

RESULTS

After getting all data from the second part, it was possible to calculate practical energy consumption per year, which was 59,212 kWh. To get this number there had to multiply each electric device's power and usage time in hours per year and had to do the same with lighting units.

Analysing results of energy consumption per month, on April and May there is big difference between 2013, 2011 and 2012. Interviewing the responsible person for reasons, it was told, that in 2013 on April and May there have been refurbishment works. After analysing all aspects of collected data, it was decided to compare theoretical energy consumption per year in 2012, which was 61,983 kWh with practical data which have been calculated after the second part of visitations. Difference between practical and theoretical energy consumption is 2,771 kWh (per year)$^{-1}$. Mistake could be occurred because of incorrect usage time or incorrect assumed power of device which was not measureable. To see how lighting system affects electrical energy consumption night-time in workdays and energy consumption per month were analysed with correlation. Results show that correlation is big in this Case.

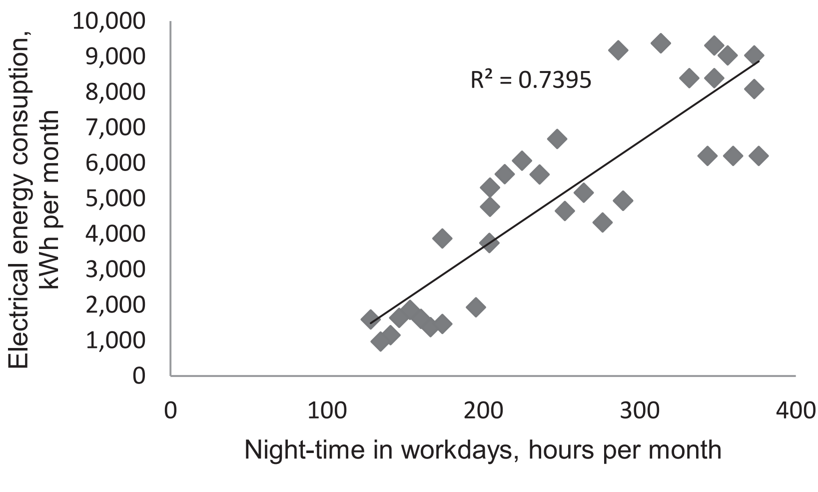

Figure 3. Energy consumption trend line of school.

Lights take 67% of all energy consumption and correlation between energy consumption and night-time in workdays is $R^2 = 0.7395$ in this building that is why necessary to draw a biggest attention to this part to save energy (Fig. 3). The first suggestion is to change all light bulbs to more energy efficient ones. The second suggestion is to buy desk lamps for class rooms, because part of the time when all lamps are on in the class room, teacher is there alone, without students. There is no need to turn on all lights in room, only to be comfortable around working place. The third suggestion is to inform students, teachers and administrative staff about the energy efficiency and plans in DSM.

CONCLUSIONS AND DISCUSSION

Results after testing methodology shows, that following given methodology student is able to choose an object, collect data, analyze them and give useful suggestions to increase energy efficiency. Practical duties allow to forecast the usefulness of the energy efficiency activities and to define the possible acquisitions, not only to analyze the existing situation. The methodology of the established course can be used by various range of municipality and industrial companies' specialists and engineering.

Looking to advantages of this methodology, going through all modules gives broad knowledge. This methodology doesn't require very deep knowledge in mathematics, but it is based on data analyze.

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