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ENERGY CONSUMPTION OF SOVIET TYPE BUILDINGS IN DAUGAVPILS

DAUGAVPILS DZĪVOJAMO ĒKU ENERĢIJAS PATĒRIŅŠ

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Introduction

Daugavpils city is the second biggest city in Latvia. The major part of Daugavpils city building sector consists of dwellings built in Soviet period and is described with big energy consumption. Only one dwelling renovation project has been implemented last year. Daugavpils building sector is an important energy consumer and an important SEG emission source. Building sector in Daugavpils has a high potential for energy efficient measure implementation. During the work 50 dwellings were audited and interviews with housing Management Company and owners were provided to understand potential for energy savings and barriers.
Energy audits were conducted in buildings in order to understand potential for energy savings. For each building a simulation method was used to evaluate the performance of energy consumption and potential for energy savings. This means that theoretical energy consumption is calculated. It is easy to compare calculated (modelled) energy consumption with historical data if buildings have heat meter installed. It is possible to continue with evaluation of energy savings in case if simulated results describe the real energy consumption. In case if historical data is not available it is hard to understand if simulation describes energy consumption correctly and it is hard to evaluate energy savings precisely. In Daugavpils case there is no historical energy consumption data available for the buildings and empirical regression model was developed to validate simulated energy consumptions of buildings without heat meters.

Methods

Empirical regression model for energy consumption will allow us to verify obtained results form energy consumptions simulations for buildings without historical data.
Besides data analyses interviews with flat owners were made during energy audits in buildings. Interviews and data collection were provided in 2007/2008 heating season. Interviews have been conducted in order to understand social barriers that bother implementation of energy saving measures.
At the beginning the data form 50 different dwellings was collected, and randomly selected samples of 35 was analysed after that. Dwellings are of different type and size that represent building stock in Daugavpils city.
Dwellings represent not only different construction types but also different constructions years from 1940 till 1994.

To develop an empirical regression model for energy consumption we used the statistical data from the buildings. In this case we chose to use data that is obtainable easily and that did not require special measurement equipment and measurements. It's enough to collect basic data about building.

At the beginning we assumed that final regression model could be presented in form of equation 1:

$$y = b + a_1x_1 + \ldots + a_nx_n \qquad (1)$$

where,

y – climate corrected energy consumption;

b - intercept;

$a_1 \ldots a_n$ – regression coefficient;

$x_1 \ldots x_n$ – factors.

Seven factors (variables) were selected for development of a multiple regression model - temperature in rooms, number of flats in a dwelling, heated area, dwelling type, number of storeys, number of entrances and construction year. We observed t criteria for each factor and from analyses we concluded that in this practical case construction year and dwelling type is not statistically important factors. In further analyses five independent factors was used in predicting the energy consumption of buildings. These factors are shown in Table 1. We observed t criteria for each factor for determination whether each selected factor is useful in regression model (see equation 1) for estimating the energy consumption.

Form statistics manual table we found that t-critical, two tailed, with 29 degrees of freedom and Alpha = 0,1 is 1,699. The following are the t-observed values for each of the factors see Table 1.

Table 1.

Variables of energy consumption

Variables	Factors	t-observed value
x_1	Temperature in rooms, ^oC	2,936
x_2	Number of flats in a dwelling	2,940
x_3	Heated area, m^2	2,607
x_4	Storeys	3,842
x_5	Entrances	2,914

After we used five independent factors we found that t-observed value values all have an absolute value greater than 1,699. Therefore, all five factors used in the regression equation are useful in predicting the energy consumption. With these selected criteria we obtained the following regression model with R^2=0,6 for the dwellings in Daugavpils (see equation 2):

$$y = 89{,}03 + 6{,}8x_1 - 0{,}75x_2 + 0{,}02x_3 - 12{,}23\,x_4 - 12{,}26\,x_5 \qquad (2)$$

Data form 35 different randomly selected buildings were used. Summary of the survey is presented in Table 2.

Table 2.

Statistics of survey result

x_i	Min	Max
x_1	18,5	22,5
x_2	13	126
x_3	660,1	6439,09
x_5	3	10
x_5	1	9

After building regression model we used the F statistic to determine whether the observed relationship between the dependent and independent variables occurs by chance. Assuming an Alpha value of 0,1 we found form statistical manual tables the critical level of F is 3,173. In our case F=8,33 and it is grater that 3,173 so regression model is adequate and could be used for date analyses.
To compared simulated values against measured we represented measured values and simulated values on the same plot Fig. 1.

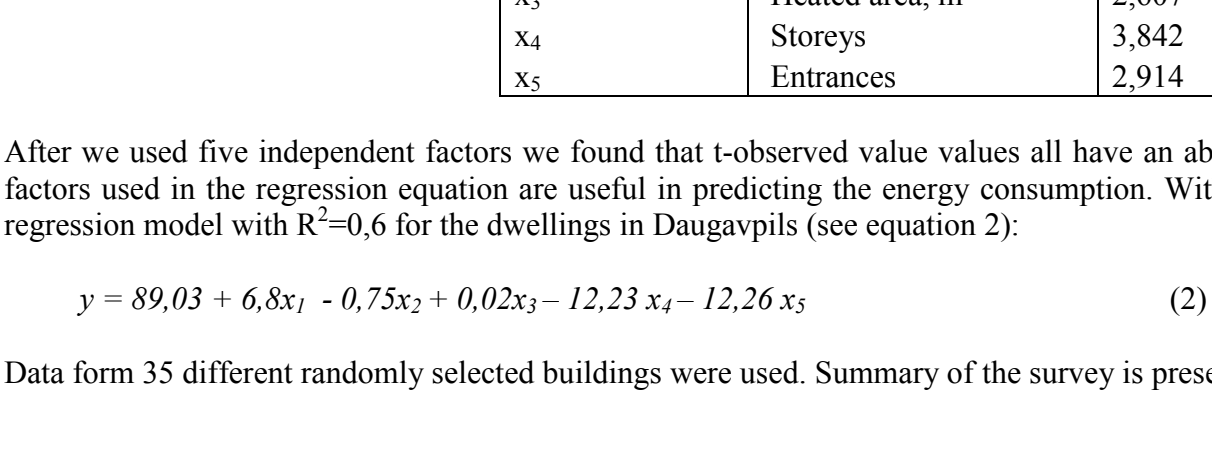

Figure 1. Measured and simulated values

We can see from Fig.1. simulated values keep the same trend as measured values. In Fig.2. simulated values are plotted on the y-axis against measured values on the x-axes.

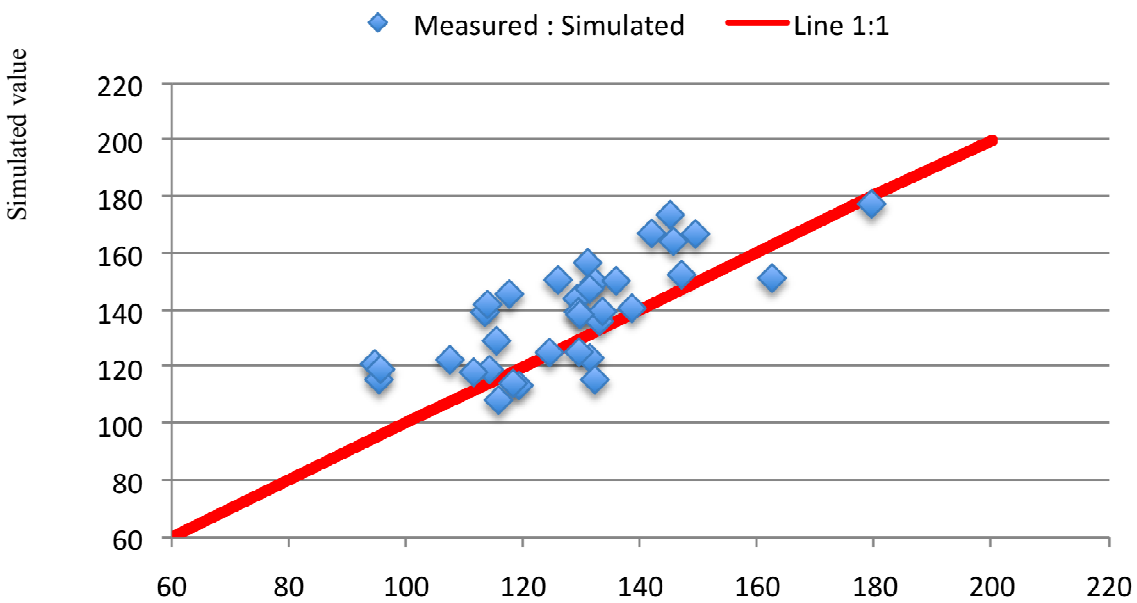

Figure 2. Measured and simulated values

Results

Specialists of housing management companies and energy auditors can use this empirical multiple regression model for making forecasts of energy consumption. Research on possibilities to use multiple-regression analyses for prediction energy consumption should be continued with broaden data set (number of buildings and factors analysed). It's hard to build precise empirical regression model that's allows very precisely predict energy consumption using only statistical information about buildings. To improve regression model other factors like construction thermal properties etc. should be used.
After energy audits and interviews with flat owners and housing management company representative the main barriers for energy efficiency measure implementation were defined. Pprice for heating energy has been low until now and heat meters were not installed in the buildings until this season. The main factors that did not allow continuing comprehensive renovation of buildings in Daugavpils were:

- Lack of knowledge about possibilities to save energy;
- Lack of experience to come up with common decision;
- Distrust to banks, neighbours and housing management company;
- Low energy price;

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Kamenders A., Žogla G., Blumberga A. Daugavpils dzīvojamo ēku enerģijas patēriņš
Daugavpils ir otra lielākā Latvijas pilsēta, kuras dzīvojamo fondu veido energoneefektīva padomju laika tipveida dzīvojamo ēku apbūve. Energoefektivitātes potenciāls ir augsts, bet, lai precīzi novērtētu iespējamo enerģijas patēriņa samazinājumu, ēkās ir jāveic energoaudits. Pēc energoaudita veikšanas tiek modelēts ēkas enerģijas patēriņš. Balstoties uz modelēto enerģijas patēriņu, tiek aprēķināti iespējamie enerģijas patēriņa samazinājumi un ieteikti atbilstoši energoefektivitātes pasākumi. Lai pārliecinātos, ka izveidotais ēkas modelis korekti raksturo ēkas enerģijas patēriņu, tas tiek salīdzināts ar citos gados reālo (uzskaitīto) enerģijas patēriņu. Tas iespējams, ja iepriekšējos gadus ēkai ir veikta siltumenerģijas uzskaite. Ja tas nav darīts, energoauditoram ir grūti spriest par to, vai izveidotais ēkas modelis korekti raksturo ēkas enerģijas patēriņu. Lai to būtu iespējams izdarīt, balstoties uz 35 ēku enerģijas patēriņa rādījumiem un statistikas datiem par šīm ēkām, tika izveidots empīrisks vairākfaktoru matemātisks vienādojums. Šajā rakstā veikta Daugavpils 35 tipveida dzīvojamo daudzdzīvokļu ēku datu analīze, kas ļāva izveidot vairākfaktoru regresijas vienādojumu, lai noteiktu enerģijas patēriņu ēkā.

Kamenders A., Žogla G., Blumberga A. Energy consumption of soviet type buildings in Daugavpils
Daugavpils city is the second biggest city in Latvia. The major part of Daugavpils city building sector consists of soviet time type dwellings with large energy consumption. Energy audits were conducted in the buildings in order to understand potential for energy savings. For each building a simulation method was used to evaluate the performance of energy consumption and the potential for energy savings. This means that theoretical energy consumption is calculated. It is easy to compare calculated (modelled) energy consumption with historical data if buildings have heat meters installed. It is possible to continue with the evaluation of energy savings if the simulated results describe the real energy consumption. In the case when historical data is not available, it is hard to understand if simulation describes energy consumption correctly and it is hard to evaluate energy savings precisely. In case of Daugavpils, there is no historical energy consumption data available for the buildings and the empirical regression model was developed to validate simulated energy consumptions of buildings without heat meters.

Камендерс А., Жогла Г., Блумберга А. Потребление энергии жилых зданий в Даугавпилсе
Даугавпилс второй по величине город в Латвии, чей жилой фонд состоит из застроек типичных жилых зданий советского времени. Потенциал энергоэффективности высок, но чтобы точно оценить возможное уменьшение потребления энергии в здании, необходимо проведение энергоаудита. После проведения энергоаудита моделируется потребление энергии в здании. Основываясь на смоделированном потреблении энергии рассчитывается возможное уменьшение потребления энергии и рекомендуются соответствующие энергоэффективные мероприятия. Чтобы убедиться, что созданная модель здания описывает корректно потребление энергии, эта модель сравнивается с реальным потреблением энергии в другие годы. Это возможно, если в предыдущие годы в здании велся учет потребления теплоэнергии. Если это не было сделано, то энергоаудитору трудно судить от том, корректно ли описывает созданная модель здания потребление энергии. Чтобы это было возможно сделать, было разработано эмпирическое многофакторное математическое уравнение, основываясь на показатели и статистические данные 35 зданий. В данной статье проведен анализ данных 35 типовых жилых многоквартирных домов в Даугавпилсе, что позволяет составить многофакторное регрессионное уравнение для установления потребления энергии в здании.