DZĪVOJAMO ĒKU ENERGOSERTIFIKĀCIJA PĒC PILNĀ ENERGOPATĒRIŅA

Dwelling buildings' energy certification by total energy consumption

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Keywords: energy certification, building energy consumption

Introduction

According to the Directive 2002/91/EC [2] on the energy performance of buildings all member states of the European Union have to introduce the energy performance certification of buildings until 4 January 2006. The Directive does not forbid member states to implement their own buildings' energy certification schemes as no common methodology can be developed in so short time.

The energy certification scheme for dwelling buildings in Latvia was developed by Riga Technical University in 2000 [3], taking into the consideration two main assumptions:

- first, the scheme has to evaluate thermal performance of buildings, and
- second, it has to stimulate the behaviour of the inhabitants in order to make them use energy more rationally.

The existing buildings' energy certification scheme is based on unique rating criteria – standardized annual specific heat consumption, which is calculated on the basis of real measured heat consumption for space heating and hot water supply.

This system of buildings' energy certification was successfully implemented with the support of EU LIFE programme in Ogre town during the ENERLAB project, which lasted from 2002 until 2004. In the framework of this project the heat consumption of 139 multi-storey apartment buildings with total area of 354 265 m^2 was analysed. During the project time energy certification of the analysed buildings was done twice for years 2002/2003 and 2003/2004. The results of this project had proved that energy certification of buildings that was done on the basis of corrected measured consumption is an effective factor of the reduction of building energy consumption. Comparison of buildings' heat consumption before and after energy certification [1] had shown that reduction of buildings' energy consumption was 9,4% after correction for the differences of climatic conditions of heating seasons.

Taking into account the positive results achieved in Ogre town it was decided to continue work in this direction and to modify existing scheme. The modified energy certification scheme should take into consideration full buildings' energy consumption including also gas and electricity consumption. The new scheme will give possibility to create full image of buildings' energy performance and to reach further reduction of energy consumption. In addition, the modified energy certification scheme will be in conformity with the requirements of the Directive 2002/91/EC. It is planned to implement the modified energy certification scheme during ENCERB project that has started in 2004 and will continue until 2006.

The paper gives theoretical basis and methodology for incorporation of electricity and gas consumption in the standardized annual specific energy consumption that is used as criterion in the existing buildings' energy certification scheme.

The analysis of the buildings' full energy consumption in year 2003/2004

The analysis of buildings' full energy consumption for year 2003/2004 was done for the same 139 multi-storey apartment buildings, the heat consumption of which was already studied during ENERLAB project. The great majority of the analysed buildings were built during the period of time from 1950-s up to the 1990-s by serial Soviet projects that were commonly used also in other towns of Latvia.

The buildings' heat consumption for space heating and hot water supply for the period of June 01, 2003 – May 31, 2004 was already monitored during the previous project. The additional data on buildings' gas and electricity consumption for the same period of time was gathered in the scope of new ENCERB project.

Electricity consumption is measured every month separately for household and communal needs. Household electricity consumption is measured separately for each apartment. Communal electricity consumption includes the lighting of landings and cellar as well as electricity consumption of circulation pumps. The gas consumption is measured for each apartment annually. Gas supply is provided for 128 buildings out of 139. In the remaining 11 buildings the gas is not provided and that is why electricity is used for cooking.

The analysis of buildings' heat consumption [1] had shown that the mean total annual specific heat consumption of buildings in Ogre town in year 2003/2004 was 176,16 kWh/m^2, mean annual specific heat consumption for space heating was 102,78 kWh/m^2 and the part of space heating in total heat consumption was 0,59. In order to get more precise results showing buildings' full energy consumption, the new analysis of heat consumption was done only for those buildings, which have all three parts of energy consumption – heat, gas and electricity consumption. The adjusted calculation showed that annual specific heat consumption for space heating is 104,39 kWh/m^2 and for hot water supply – 73,30 kWh/m^2.

Distribution of annual gas consumption per inhabitant is shown in Figure 1.

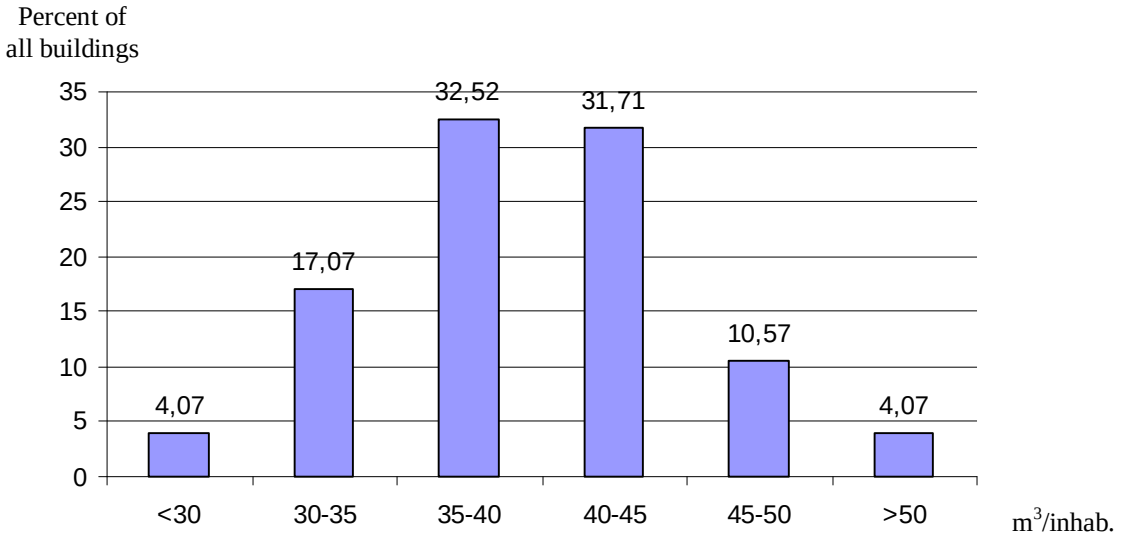

Figure 1. Distribution of annual gas consumption, m^3/inhab.

It can be seen from the Figure 1 that only 4,07% of buildings consume less than 30 m^3 of gas per inhabitant and the same number of buildings consume more than 50 m^3 of gas per inhabitant. The vast majority of buildings have gas consumption that ranges between 35 m^3 and 45 m^3 per inhabitant.

In order to incorporate the gas consumption in the standardized annual specific energy consumption, gas consumption should be expressed in kWh per square meters. The gas consumption can be recalculated into the kWh/m^2 using the following formula:

$$q_g = \frac{Q * 9.33}{A}, \quad \text{kWh/m}^2, \tag{1}$$

where: Q – gas consumption, m^3 per building;
9,33 –heat of gas combustion, kWh/m^3;
A – floor area, m^2.

The average recalculated annual gas consumption for cooking is 13,61 kWh/m^2. Generally gas consumption varies from 8,38 kWh/m^2 up to 21,87 kWh/m^2.

The analysis of buildings' household electricity consumption had shown that the mean total annual electricity consumption for buildings, which are connected to the gas supply, was 470 kWh per inhabitant or 17,88 kWh/m^2. The average electricity consumption for buildings without gas supply was 580,78 kWh per inhabitant or 22,87 kWh/m^2.

Buildings' electricity consumption for household needs in MWh per inhabitant is shown in Figure 2.

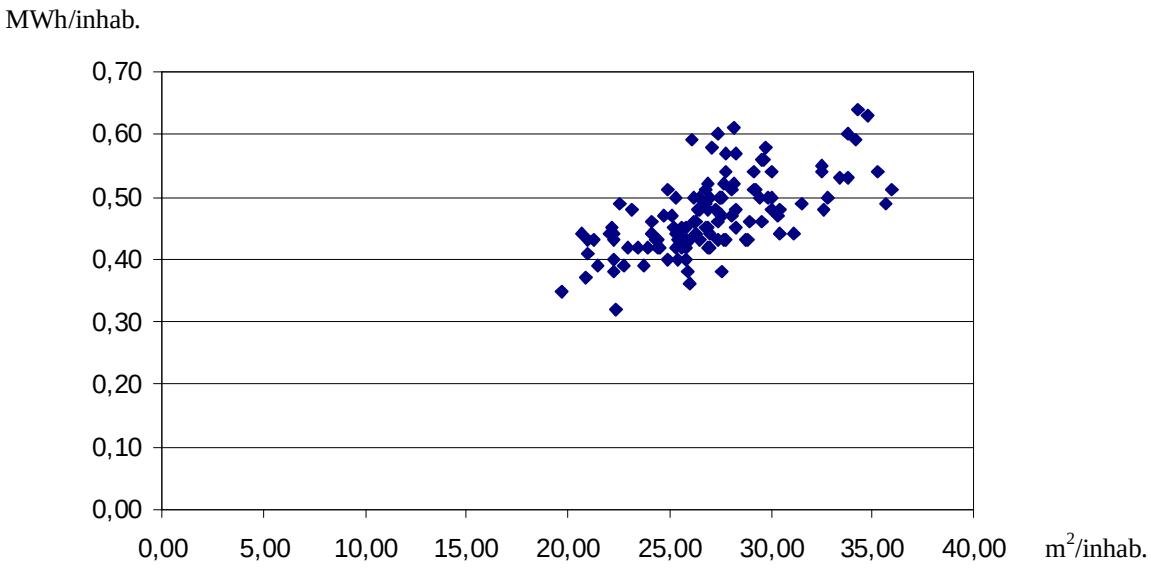

Figure 2. Buildings' electricity consumption for household needs, MWh/inhab.

It can be seen from Figure 2 that with decreasing of occupancy level the household electricity consumption per inhabitant is growing up.

The average annual electricity consumption for communal needs is 2,21 kWh/m^2.

Mean measured annual specific energy consumption, which includes heat, gas and electricity consumptions, and their share in total energy consumption for the period from June 01, 2003 till May 31, 2004 is given in Table 1.

Table 1

Mean annual specific energy consumptions for the period of June 01, 2003-May 31, 2004

Type of energy consumption	Space heating	Hot water	Gas for cooking	Electricity for house-hold needs	Electricity for communal needs	Total
Mean measured annual specific energy consumptions, kWh/m^2	104,39	73,30	13,61	17,88	2,21	211,39
Percent of total	49,38	34,68	6,44	8,46	1,04	100,00

It can be seen from this table that average mean annual specific energy consumption is 211,39 kWh/m^2. Space heating and hot water supply take significant part in full buildings' energy consumption, which amounts to 84,06 percent of total energy consumption. The share of gas for cooking and electricity for household and communal needs is 15,94% out of total energy consumption of the studied buildings. Gas and electricity consumptions' share in total energy consumption is shown in Figure 3.

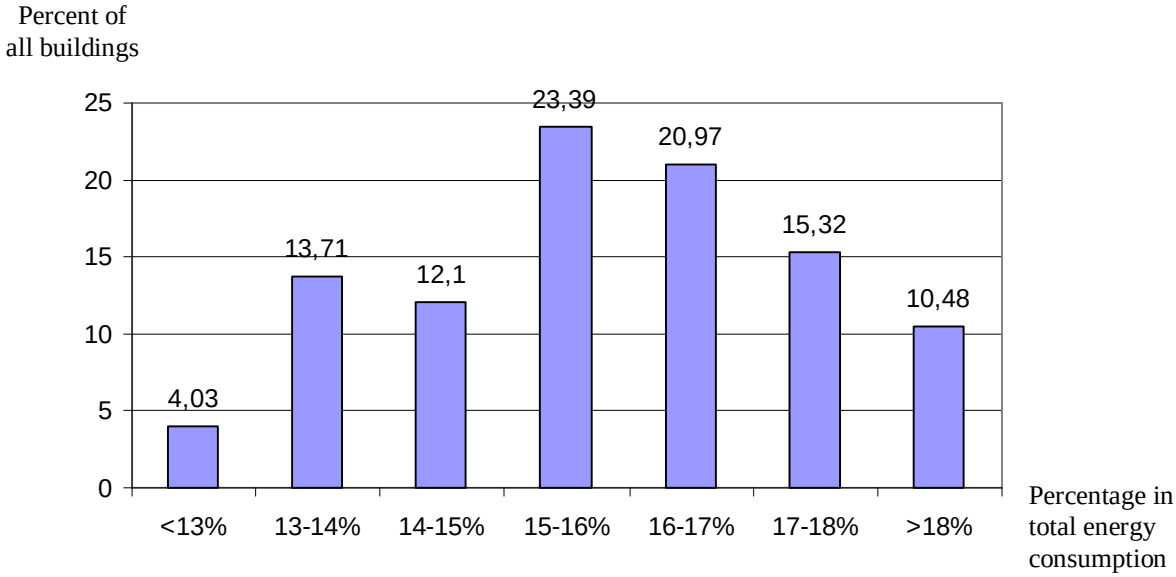

Figure 3. Gas and electricity consumption share in total energy consumption

It can be seen from the abovementioned chart that only in 10,48% of analysed buildings energy consumption of gas and electricity formed more than 18% of total energy consumption, and the maximum share of these consumptions was 21,33%. In 44,36% of buildings share of gas and electricity consumption in total energy consumption was 15-17%.

Figure 4 shows distribution of Ogre buildings' mean annual specific energy consumption versus buildings heated area in year 2003/2004.

It can be seen from the Figure 4 that mean annual specific energy consumption varies from 162,62 kWh/m^2 up to 277,79 kWh/m^2 in different buildings.

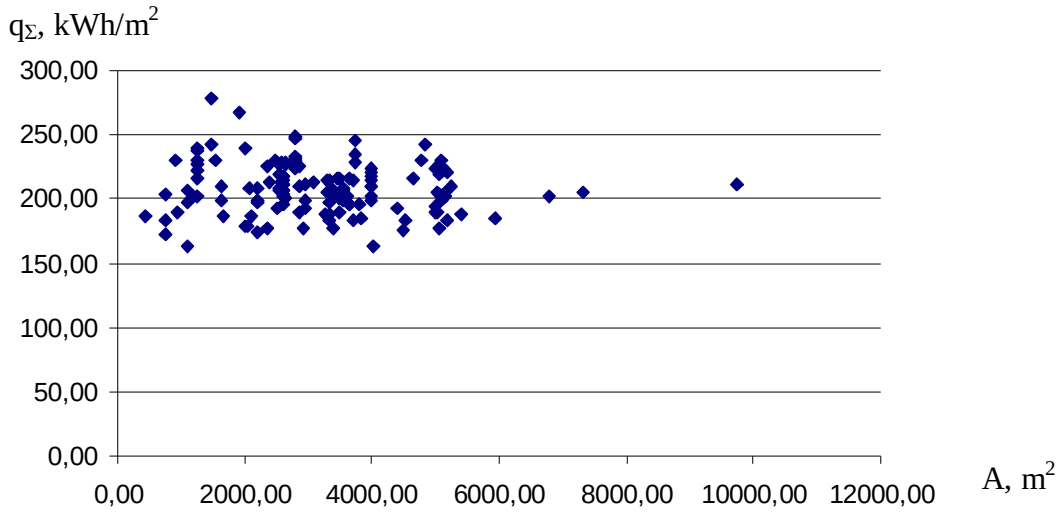

Figure 4. Mean annual specific energy consumption in Ogre town in 2003/2004

Modification of buildings' energy certification scheme

The existing buildings' energy certification scheme is based on unique rating criteria – standardized annual specific heat consumption, which is calculated on the basis of real measured heat consumption for space heating and hot water supply.
Standardized annual specific heat consumption [3]:

$$q_{st} = \frac{q_{s.h.} DD_{st}}{DD} + \frac{q_{d.w.} A}{30n} \text{ kWh/m}^2 \text{ year}, \quad (2)$$

where: *30* - standard occupancy level, m^2 per person; *A* - heated built-in area, m^2; *DD* - degree-days of heating period in rating year; DD_{st} - degree-days of standard year in favourable economical conditions; *n* - number of inhabitants, persons; q_{st} - rating specific heat consumption, kWh/m^2 year ; $q_{s.h.}$ - measured specific consumption for space heating in rating year, kWh/m^2 year; $q_{d.w.}$ - measured consumption for domestic hot water in rating year, kWh/m^2 year.

The standardized annual specific heat consumption for analysed buildings in 2003/2004 was 198,96 kWh/m^2.

For the modification of existing energy certification scheme the same criterion of standardized annual specific energy consumption can be used, expanding it by electricity and gas consumptions. These consumptions alike to hot water consumption mainly depend on the number of inhabitants and so have to be corrected by the occupancy level:

$$q_{st} = \frac{q_{s.h.} DD_{st}}{DD} + \frac{\left(q_{d.w.} + q_{el.h} + q_g\right) A}{30n} + q_{el.c} \text{ , kWh/m}^2 \text{ year}, \quad (3)$$

where: q_{st} - rating specific energy consumption; $q_{el.h.}$ - electricity consumption for household needs, kWh/m^2; $q_{el.c.}$ - electricity consumption for communal needs, kWh/m^2; $q_{el.c}$ - gas consumption, kWh/m^2.

The calculation of standardized annual specific energy consumption had shown that the average standardized specific energy consumption for analysed buildings was 229,44 kWh/m^2, i.e. by 15,32% higher than standardized annual specific *heat c*onsumption of 2003/2004.

Figure 5 shows the standardized annual specific energy consumption for different series of buildings in year 2003/2004.

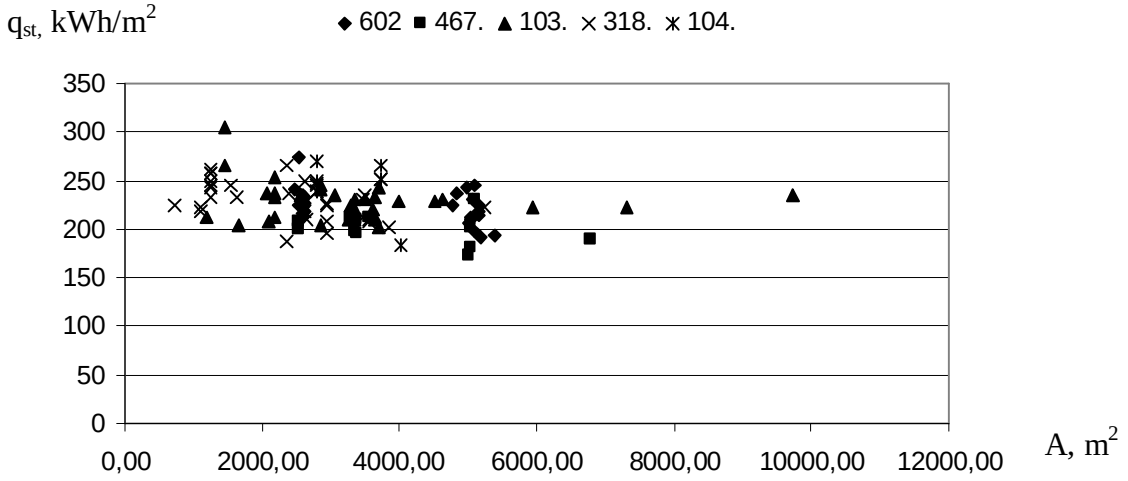

Figure 5. Standardized annual specific energy consumption in Ogre town in 2003/2004

The acquired average standardized annual specific energy consumption for different series of buildings is shown in the Table 2.

Table 2

Annual specific energy consumption for different series of buildings

Buildings' series	Standardized annual specific energy consumption
602nd	223,30, kWh/m^2
467th	202,32 kWh/m^2
103rd	228,35 kWh/m^2
318th	228,35 kWh/m^2
104th	243,56 kWh/m^2

The structure of rating scale proposed to evaluate buildings' full energy consumption is based on the similar rating scale as in the study [3]. In order to modify the existing scale the standardized gas and electricity consumptions were calculated (Table 3).

Table 3

Standardized gas and electricity consumptions for the period of June 01, 2003-May 31, 2004

	Gas consumption, kWh/m^2	Electricity consumption, kWh/m^2	Total consumption, kWh/m^2
Minimum	8.29	12.55	20.84
Average	12.12	17.59	29.71
Maximum	19.34	24.24	43.58

The rating scale for gas consumption is based on the real measured gas consumption for analysed buildings, which is recalculated to the standard occupancy level. The common gas consumption in the rating scale was assumed as equal to average standardized gas consumption, i.e. 12.12 kWh/m^2 . The best present gas consumption was assumed as equal to minimum standardized gas consumption, which is 8.29 kWh/m^2. The worst consumption was taken as maximum standardized gas consumption, which is equal to 20 kWh/m^2. The remaining levels of the rating scale and their calculation methods are shown in the Table 4.

In order to find out the numerical values of the scale for electricity consumption the theoretical electricity consumption for household needs was estimated. The theoretical calculations of electricity consumption were done for typical apartments equipped with the same electrical appliances, belonging to different energy consumption rating classes. The results of calculations had shown that standardized electricity consumption for apartment equipped with "A" class electrical appliances was 11,33 kWh/m^2. The energy consumption of the apartment equipped with "A" class electrical appliances was taken as the best present consumption. Electricity consumption for communal needs adds 2,21 kWh/m^2 to the household electricity consumption and, consequently, total electricity consumption, assumed as the best present consumption, is equal to 13,54 kWh/m^2. Similarly to the gas consumption's ratings common electricity consumption in the rating scale was assumed as equal to average standardized electricity consumption, which amounts to 17,59 kWh/m^2. The worst electricity consumption was taken as maximum standardized electricity consumption, which is 24,24 kWh/m^2. Other levels of the electricity consumption rating scale and their calculation methods are shown in the Table 4.

Table 4

Levels' values for standardized gas and electricity consumptions

Level		Standardized consumptions, kWh/m^2		
Nr.	Description	Gas	Electricity	Total
5	25% better than 3 level	6	10	16
4	10% better than 3 level	7	12	19
3	Best present consumption	8	13	21
2	3 level +1/3(0 lev.-3 lev.)	9	15	24
1	3 level +2/3(0 lev.-3 lev.)	11	16	27
0	Common consumption	12	18	30
-1	0 level +1/2(-2 lev.-0 lev.)	16	21	37
-2	Worst consumption	20	24	44

On the basis of before mentioned calculations the new buildings' energy certification scheme by total energy consumption can be developed. The numerical values of the proposed new scheme of buildings' energy certification are presented in Table 5.

Table 5

The numerical values of the proposed new scheme of buildings' energy certification by total energy consumption

Level			Rating Category		
Nr.	Description	Value, kWh/m^{2}year	Nr.	Description	Values, kWh/m^{2}year
5	25% better than 3 level	125		Gold certificate	=125
4	10% better than 3 level	149		Silver certificate	=149
3	Best present consumption	166	A	Excellent	149.01-166
2	3 level +1/3(0 level-3 level)	201	B	Very good	166.01-201
1	3 level +2/3(0 level-3 level)	235	C	Good	201.01-235
0	Common consumption	270	D	Fair	235.01-270
-1	0 level +1/2(-2 lev.-0 lev.)	313	E	Bad	270.01-313
-2	Worst consumption	356	F	Very bad	>313.01

The results of trial implementation of proposed buildings' energy certification scheme by total energy consumption are shown in Figure 6 below. The trial implementation of the before mentioned scheme was done in Ogre town for 139 multi-storey apartment buildings with total area of 354 265 m^2 for the period of time from June 01, 2003 till May 31, 2004.

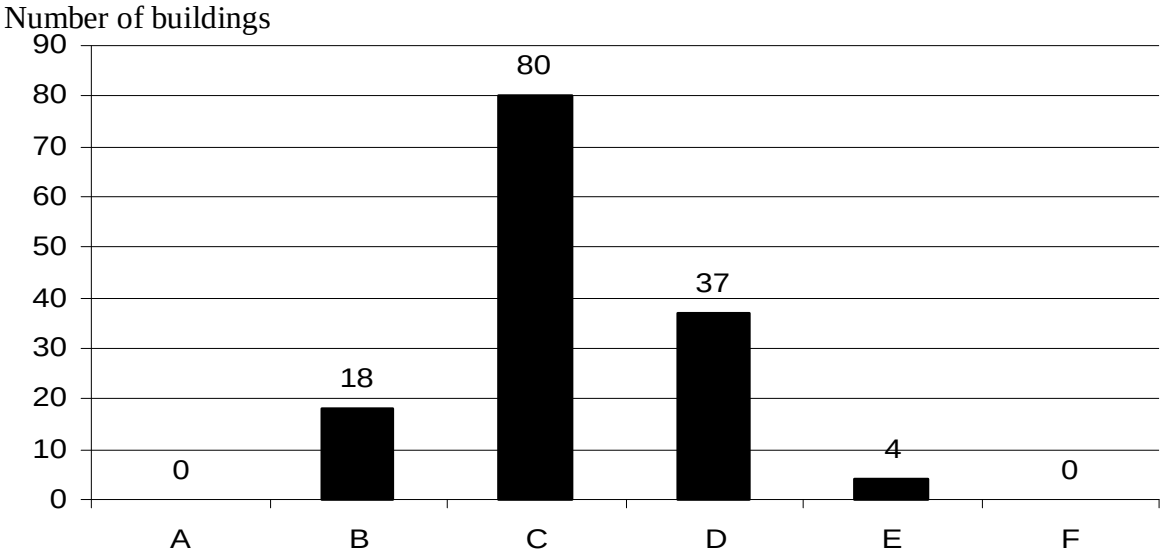

Figure 6. The results of trial implementation of proposed buildings' energy certification scheme by total energy consumption

The results of trial implementation of proposed buildings' energy certification scheme by total energy consumption during the rating year of 2003/2004 had shown that the majority of analysed buildings according to common level of consumption belonged to C and D ratings: 57,55% of all analysed buildings belonged to rating C and 26,62% - to rating D.

Conclusions

§ The existing in Latvia buildings' energy certification scheme is based on unique rating criteria standardized annual specific heat consumption, which is calculated on the basis of real measured heat consumption for space heating and hot water supply. In order to fulfill

requirements of the Directive 2002/91/EC on Energy Performance of Buildings Latvian buildings' energy certification scheme has to be modified to include in the rating also electricity and gas consumption of households.

§ In order to develop new energy certification scheme by total energy consumption the data about heat, gas and electricity consumption for 139 multi-storey apartment buildings for the period of June 01, 2003 – May 31, 2004 was collected and analyzed during the ENCERB project.

§ The results of the assessments done during the project had shown that the share of gas for cooking and electricity for household and communal needs was 15,94% out of total energy consumption of the studied buildings;

§ The analysis of gas consumption had shown that average annual gas consumption for cooking was 41,2m^3 per inhabitant and in different buildings it varied from 26,65 m^3 up to 64,73 m^3 per inhabitant.

§ The analysis of buildings' household electricity consumption had shown that the mean total annual electricity consumption for buildings, which were connected to the gas supply, was 470 kWh per inhabitant or 17,88 kWh/m^2. The average electricity consumption for buildings without gas supply was 580,78 kWh per inhabitant or 22,87 kWh/m^2.

§ In order to modify the existing energy certification scale the standardized gas and electricity consumptions were calculated. The standardized gas consumption varies from 8,29 kWh/m^2 up to 19,34 kWh/m^2. The standardized electricity consumption varies from 12,55 kWh/m^2 up to 24,24 kWh/m^2.

§ Taking into account the results of the buildings' full energy consumption analysis and modifying the existing Latvian buildings' energy certification scheme the authors propose the new buildings' energy certification scheme by total energy consumption with the following rating scale:

Gold certificate	<125 kWh/m^2year;	
Silver	< 149 kWh/m^2year;	
Excellent	149.01-166 kWh/m^2year	- rating A
Very good	166.01-201-kWh/m^2year	- rating B
Good	201.01-235 kWh/m^2year	- rating C
Fair	235.01-270 kWh/m^2year	- rating D
Bad	270.01-313-kWh/m^2year	- rating E
Very bad	>313.01 kWh/m^2yea	- rating F

§ The results of trial implementation of proposed buildings' energy certification scheme by total energy consumption during the rating year of 2003/2004 had shown that 57,55% of all analysed buildings according to common level of consumption belonged to rating C and 26,62% - to rating D.

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Belindževa-Korkla O., Krēsliņš A., Borodiņecs A. Dzīvojamo ēku energosertifikācija pēc pilnā energopatēriņa
Viena no Direktīvas 2002/91/EC prasībām ir ieviest visās ES dalībvalstīs ēku enerģijas sertifikāciju. Šo direktīvu dalībvalstīm ir jāpārņem līdz 2006. gadam. Latvijā dzīvojamo ēku energosertifikācijas shēma tika izstrādāta RTU 2000. gadā un veiksmīgi izmēģināta Ogrē 2002.-2004. gadā. Esošā ēku energosertifikācijas shēma ietver sevī tikai enerģijas patēriņu apkurei un karstā ūdens apgādei. Lai atbilstu energosertifikācijai pēc pilnā energopatēriņa ēku energosertifikācijas shēmā ir jāiekļauj arī gāzes un elektrības patēriņš. Dati par ēku pilno energopatēriņu tika savākti Ogres ēkām 2004./2005. gadā.Rakstā pirmo reizi Latvijā tiek apkopoti un analizēti iegūtie dati par ēku pilno energopatēriņu. Autori sniedz teorētisko pamatojumu un metodoloģiju elektrības un gāzes patēriņu ievēršanai standartizētajā gada īpatnējā energopatēriņā, kas ir izmantots kā kritērijs esošajā ēku energosertifikācijas shēmā.

Belindževa-Korkla O., Krēsliņš A., Borodiņecs A. Dwelling buildings' energy certification by total energy consumption
One of the requirements of the **Directive 2002/91/EC on the energy performance of buildings** is introduction in the EU member countries of energy certification of buildings. It has to be implemented starting from 2006. In Latvia the energy certification scheme for dwelling buildings was developed in RTU in 2000 and successfully implemented in Ogre in 2002-2004. The existing buildings' energy certification scheme takes into account only energy consumption of space heating and hot water supply. In order to comply with the requirements of the certification by total energy consumption the building energy certification scheme has to consider also gas and electricity consumption. The data on buildings total energy consumption were gathered for Ogre buildings in 2004/2005.The paper for the first time presents and analyses measured data on total building energy consumption in Latvia. The paper gives theoretical basis and methodology for incorporation of electricity and gas consumption in the standardized annual specific energy consumption used as criterion in the existing building energy certification scheme.

Белинджева-Коркла О., Креслинь А., Бородинец А. Энергосертификация жилых зданий на основе полного энергопотребления
Одним из требований Директивы 2002/91/ЕС является внедрение схемы энергосертификации зданий во всех странах Европейского Союза начиная с 2006 года. Сейчас в Латвии существует система энергосертификации жилых зданий, которую разработали в РТУ в 2000 году и успешно опробовали в городе Огре в 2002-2004 годах. Существующая схема энергосертификации учитывает только энергопотребление для отопления и горячего водоснабжения. Для того чтобы выполнить требования энергосертификации по полному энергопотреблению, схема энергосертификации должна включать также потребление электричества и газа. Данные о полном энергопотреблении жилых зданий города Огре были собранны в 2004/2005 году.В статье впервые в Латвии собраны и проанализированы фактические данные о полном энергопотреблении жилых зданий. В статье дается теоретическое обоснование и методология для объединения потребления электричества и газа в стандартизированном годовом удельном энергопотреблении, который используется в существующей схеме энергосертификации зданий.