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Energy efficiency assessment problems for buildings in Latvia

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Abstract

Research problem: Buildings in Latvia are being renovated with a goal to decrease CO2 emissions, but after performing final energy audit, they are not being monitored afterwards. Aim of research: To establish connections between increase in buildings energy efficiency and CO2 emissions decrease in Liepaja. Research objectives: Research connections between increase in buildings energy efficiency and decrease in CO2 emissions in Liepaja. Various data was obtained about renovated buildings in Liepaja and amount changes in produced heat energy. To get the data, a complete buildings inspection was done in Liepaja to count renovated buildings and determine their condition. The data was insufficient, to make conclusions about decrease in CO2 emissions, so it was necessary to get data about the company which provides city with thermal energy „Liepaja's Energy" and the amount of produced thermal energy and the amount of CO2 emission changes, separating their own consumption, losses and sold thermal energy. Research methods: literature analysis, observation, statistical data analysis, statistical data processing. Result of the research: suggestions for building energy efficiency evaluation in Liepaja

Keywords: *production of heat energy, home consumption, losses, CO2 monitoring*

1. Introduction

Nowadays the increasing energy efficiency is becoming increasingly important. There are multiple criteria: decreases heating payment, it decreases CO_2 emissions, building becomes more visually attractive and it increases its market value. Fundamental reason for increasing energy efficiency in Latvia is increasing heating costs. From environmental protection point of view it's important to preserve our resources and to create different gas emissions as less as possible, where most of the attention now focuses on CO_2 (or its equal), which is mainly created in burning processes which happens in heating plants. Increasing building's energy efficiency is

one of the most effective ways how to reduce industrialisation's negative impact on environment by reducing energy consumption on the user side and reducing heat losses on supplier side as well as in heat transfer and distribution. It gives us a way to reduce impact that has been created by greenhouse gases, by limiting emissions that are harmful for human health[1]. Energy efficiency plays especially significant role in Liepaja, due to its geographical position – it is situated near the Baltic Sea and cold wind from it decreases air temperature in non-renovated buildings, where, if you want to increase the temperature to a more comfortable level, you have to spend more resources than anywhere else in Latvia. During the heating season, people in Liepaja have higher heating costs.

2. Building's energy efficiency's indicators

Latvia's living apartment fund consists of 36,6 thousand buildings, with overall area of 46,52 million m^2, where, most of them (98% from overall count and 95,5% after area) were built till 1933., before any significant energy efficiency policies were implemented, energy efficiency levels there are quite low. Taking into account our climate, need for heating in Latvia (4035 heating degree days) is significantly higher than it is overall in Europe (3067 heating degree days)[2].

Degree Days – is very significant parameter when analyzing building and public housing energy consumption for heating and air conditioning. Generally, degree day is a degree variance between inside and outside temperatures in day, week and month or in year. Degree day sum in year provides information about how "cold" or maybe "warm" it has been, from heating system point of view[3].

Building's energy efficiency is a relative amount, which describes specific type of building's energy consumption amount during it's exploitation for heating, ventilation, lightning and hot water supply[4]. Building's energy efficiency is measured by kilowatt hours (kWh) per one square meter.

There are multiple technological solutions to save up on heating[5]:

1) By insulating outer walls (15 - 20%)
2) By insulating basement area above ground (2 - 3%)
3) By insulating basement ceiling (2 - 3%)
4) By insulating top storey covering (2 - 3%)
5) By changing windows (7 - 10%)
6) By changing windows in shared spaces (2 - 3%)

[1] http://www.energoefektivitate.com/energoefektivit%C4%81te/
[2] http://www.energodata.lv/lv/sections/skaidrojosa-vardnica
[3] http://likumi.lv/doc.php?id=173237
[4] http://www.lvportals.lv/skaidrojumi.php?id=253546
[5] http://www.slideshare.net/siltinam/ku-energoefektivittes-uzlaboana-daudzdzvoku-mjs-un-kopjs-siltuma-enerijas-ietaupjuma-prognoze

7) By changing outer doors (1 - 2%)
8) By increasing air density (changing hatches, compacting) (2 - 3%)
9) By repairing heating system (2 -3%)
10) By isolating heat system pipes, pipe siding and heat element exchange, mounting individual heat counters (3 - 5%)
11) By repairing hot water supply (2 - 3%)
12) By renovating or reconstructing ventilation system (can be utilised heat recovery ventilation, by individual or centralised heat recovery units) (0 - 9%)

Total (min.) from 40% => up till (max.) 67%

These energy saving solutions can be applied to temperate zone countries, including Latvia. When build a new house and by knowing these options, bio-climatic criteria has to be accounted, making this house self-sufficient, from energy consumption point of view. Although, such occasions are quite rare and they cannot be applied to majority realised projects in Latvia. Building's energy standard is usually measured by amount of energy (kWh) per square meter (m^2) that is required to heat up or cool down a specific building. Table 1 shows renovated building's energy consumption, compared to non- renovated building's. As it can be seen, up to 67% savings can be attained[6].

Table 1. Theoretical energy consumption comparision between renovated and non renovated buildings

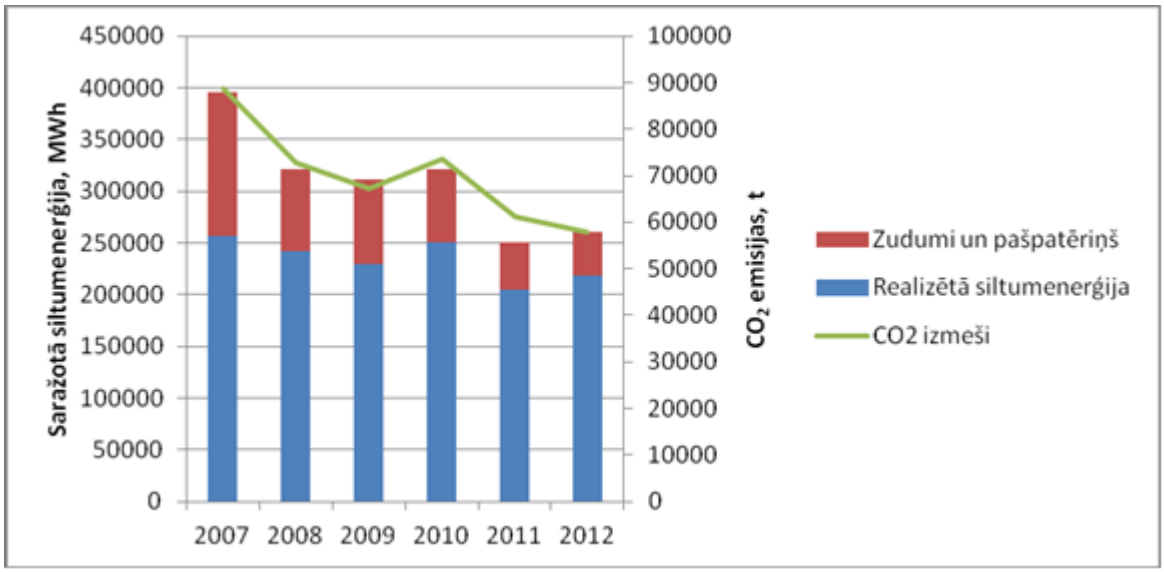
	Non renovated (kWh/m^2)	**Renovated (kWh/m^2)**
Hot water	20	20
Sun energy gain	-24	-57
Inner gain	-28	-28
Gas emission	13	10
Roof	32	10
Walls	51	20
Windows	30	37
Ventilation	47	31
Floor	28	13
Total	**169**	**56**

[6] http://www.rea.riga.lv/files/eku_energoefektivitate_skolenu_rokasgramata_IUSES.pdf

3. Situation in Liepaja.

To determine actual heat energy savings from renovation, author, as the most suitable research basis, chose Liepaja, since heat is produced by a single company and building renovation in this city is very rapid. The only heat energy provider in Liepaja is Ltd "Liepajas energija", founded in 2005. Their main focus is heat production and distribution, as well as realisation and electric energy production and realisation[7]. In year 2007, Ltd "Liepajas energija" produced 396'000 MWh heat energy. Produced heat amount decreases with every year and in year 2012 it was nearly 260'000 MWh. A part from this produced heat didn't even meet its designated consumers, due to old, leaky pipes and broken heating units. To decrease these loses, company has invested significant resources and 99% of city's main heating pipe lines already have been renewed. As a result, these renovation actions have led to significant heat loss decrease and personal heat consumption by half and therefore, achieving more significant CO_2 decrease, as if we would renovate every single household in Liepaja. Therefore, before realizing any other household's energy efficiency projects elsewhere in Latvia, heat system renovation comes first, because it contributes the most in heat production and CO_2 emission decrease. Picture 1 shows the difference between produced heat consumption and CO_2 emission amount from year 2007 till year 2012.

Figure 1 Produced heat energy and CO2 emission amount in ltd. "Liepajas energija" (2007-2012)



[7] http://www.delfi.lv/bizness/uznemumi/fotoreportaza-liepajas-energija-buve-slegto-skeldas-noliktavu-un-biomasas-katlumaju.d?id=43412895#!/3637984/foto.delfi.lv

When Ltd. “Liepajas siltums” was taken over by Ltd. “Liepajas energija” in 2007, began improvements in company’s infrastructure. One of the main priorities at that time was currently existing heat pipe renovation, since most of the heat loss came directly from there. In this year, local government’s 10-30% co-founding program was approved. 10% support will be provided, if partial energy effectiveness actions were taken, for example: changed only windows or renovated only walls. 30% support can be achieved, if complex energy efficiency actions were taken. 40 buildings participated in this project and during two years, about 500’00 LVL were spent. Together with increased energy efficiency, produced heat amount in next year severely decreased. Although, that can be explained with that, that this year had less degree days that it was in previous year.

The average temperature in 2009 was +6,45°C, which is lower than temperature in 2008. +7,69°C, but heat production decrease can be seen, which can be explained with gain from heating pipe renovation, 12,9 km were renewed, as well as local government renovated 54 of its buildings. Since demand for heat production decreased and burning material was consumed as much, CO_2 emissions amount decreased by 15’000 tons, compared to 2008.

The average air temperature in year 2010 was +5,63°C, hence, it was lower than previous year’s +6,54°C, accordingly, a small heat production increase can be observed. Next year’s winter was warm (degree days), therefore, lower degree days and new co-generation plant opening in Tukuma street, created significant energy savings in that year, 50,8 thousand MWh.

Previous year was the second coldest year in this decade, after year 2010, therefore increased heat production can be seen, although, comparing it to year 2010, it is significantly lower. Another co-regeneration plant project was realised in previous year and CO_2 decrease can be seen, compared to year 2011, even though, produced heat amount is bigger. As CO_2 emissions decreased by 35%, produced heat amount was reduced accordingly by 35% as well. Since Ltd. “Liepaja energy” established itself, till this year, produced heat amount as well as CO_2 emission amount has been decreased, without decreasing realized heat energy.

Since 99% of main heating pipe lines are already renovated, next step to achieve higher energy efficiency would be building renovation, which is already rapidly happening in the last few years. To determine current situation, author used G.Kreinata and E.Malovka complete building monitoring data in Liepaja, since author couldn’t find precise data in local government or in ltd. “Liepajas energija”. This data determined completely renovated buildings, partially renovated buildings and those that are currently being renovated. Table 2 illustrates building breakdown by renovation status.

Table 2 Renovated building breakdown and amount in Liepaja, during may 2013.[8]

Completely renovated	End walls	Partially renovated	Being renovated	**Total**
108	21	7	26	**162**

As a positive thing, completely renovated buildings in Liepaja are 80% from currently all renovated buildings. Completely renovated buildings create bigger energy savings than partially renovated ones. Partially renovating buildings, work and material expenses are being decreased, which is more acceptable for some residents, although, it is not a very effective long term investment, investment return time on such projects is even greater than if it would be fully renovated, since energy savings are not on par. Author forecasts, that in this year there will be even less produced heat amount, thankfully to heat providing company's modernisation and new co-generation plant construction, therefore decreasing CO_2 emissions.

4. Energy efficiency assessment on household renovation

To show how important are complete building renovation and what kind of an impact it leaves on energy saving and CO_2 emission decrease in Liepaja, author carried out a comparison on two buildings in Liepaja, which are next to each other, therefore, theoretically speaking, they have very similar conditions. Ed.Tise street 79 (non-renovated, 1 MWh) and Ed.Tise street 81 (renovated, 2MWh). Both buildings are being heated by category A heating plant, which gives heat into general heating system and precise calculation for each single building's heat consumption is not possible[9]. Although, judging by the changes in heat consumption from 2008-2012 and excluding outside air temperature's influence, it can be seen that heat consumption in renovated building has been cut in half, which cites with Ltd's "Liepaja energija" produced MWh. This change is not that significant, since these two buildings don't even make up a percent from current heat production plant's serviced buildings, although differences between these two buildings are quite significant.

[8] Gatis Kreinats, Eriks Malovka an observation 2013, Liepaja

[9] Zaldeniece G., Ltd. „Liepajas energija" Environmental and work safety specialist, personal communication 16.04.2013.

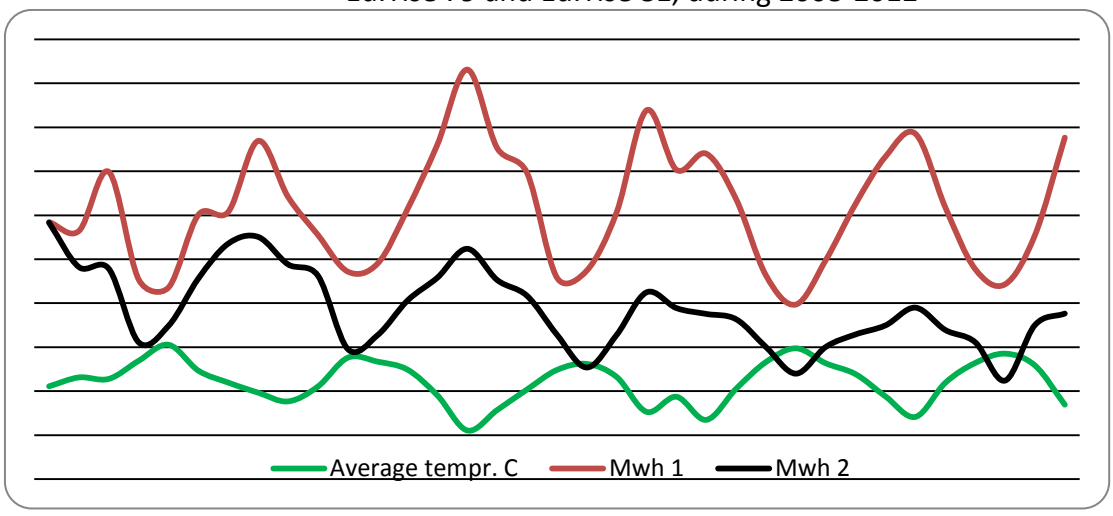
Table 3 Heat consumption in Ed.Tise 79 and Ed.Tise 81 MWh/m^2 and outside temperature in 2008-2012 heating seasons[10]

	2008			2009			2010			2011			2012		
	Average tempr. C	Mhw 1	MWh 2	Average tempr. C	Mhw 1	MWh 2	Average tempr. C	Mhw 1	MWh 2	Average tempr. C	Mhw 1	MWh 2	Average tempr. C	Mhw 1	MWh 2
January	*1,1*	38,5	38,3	*-0,3*	56,9	35,1	*-8,9*	73,1	32,4	*-1,3*	50,3	18,9	*-1,2*	53,3	15,0
February	*3,1*	36,4	28,2	*-2,3*	44,2	28,8	*-4,3*	55,3	25,3	*-6,5*	54,0	17,6	*-5,8*	58,5	19,0
March	*2,8*	49,9	27,8	*1,1*	35,5	26,3	*0,4*	49,6	21,7	*0,6*	43,6	16,3	*1,9*	41,8	13,9
April	*6,9*	25,4	11,1	*7,6*	27,2	9,6	*4,8*	25,8	12,8	*6,6*	26,3	10,0	*6,4*	27,8	11,1
October	*10,6*	23,6	14,9	*6,7*	29,0	12,8	*6,2*	27,4	5,4	*9,7*	19,7	4,0	*8,5*	24,3	2,4
November	*4,7*	40,1	25,6	*4,9*	41,4	20,6	*3,2*	40,7	12,8	*6,3*	29,8	10,1	*5,9*	35,5	15,0
December	*1,9*	40,8	33,6	*-1,0*	56,1	25,8	*-4,7*	63,9	22,5	*3,9*	42,6	12,9	*-3,1*	57,6	17,6

As it can be seen in Table 3, renovated building consumes less heating at equal outside temperature. Dependence from outside temperature is far more important in non-renovated building. Pearson correlation coefficient between outside temperature °C and non-renovated building (Ed.Tise 79) heat consumption MWh (P=0.95) equals **–0,925**, relevance in quite tight and negative, between outside temperature °C and renovated building (Ed.Tise 81) heat consumption MWh (P=0.95) equals **–0,5893**, relevance is average and negative as well, as it can be seen in figure 2.

Figure 1

Correlation between outside temperature and heat consumption in Liepaja, Ed.Tise 79 and Ed.Tise 81, during 2008-2012



[10] Ltd. „Liepaja Energija" unpublished materials, L.Abele

As it can be seen, correlation between renovated and non-renovated building heat consumption with validity interval (P=0,95) is tight and positive **0,6043**. That indicates that both households heat consumption is related to outside temperature variances, although, in non-renovated building, these variances are more significant. Overall, in these five years, renovated building conserved 790,8 MWh heat energy, which is directly linked to renovation results.

Table 4 Savings from the building renovation of the 2008 – 2012

	2008 – 2012 Mwh
Ed.Tise street 79 (Mwh 1)	1445,9
Ed.Tise street 81 (Mwh 2)	655,1
Margin	**790,8**

790,8 Mwh heat energy production in Liepaja, on average, creates 174 tons CO_2 emissions, therefore one building in five years' time can decrease CO_2 emissions for 174 tons, emission amount depends on used fuel, therefore it won't be the same for every building in Liepaja.

5. Conclusions

1. Building renovation for Liepaja is very important due to its geographical position.
2. There are multiple technological options for building heat preservation although, multiple options combined, gives the best result. About 40 – 67 % heat energy can be preserved in total.
3. Main reason for such saving comes from general heat pipe renewal. About 99% from general heat pipes in Liepaja have been renewed and 162 buildings have been renovated till May of 2013.
4. By comparing two buildings heat consumption in Liepaja, which are next to each other, therefore, criteria for both of them is very similar. One household was renovated while second wasn't. In five years time, renovated household consumed 790,8 Mwh less.
5. 790,8 Mwh heat energy production in Liepaja, on average, creates 174 tons CO_2 emissions.

Suggestions:

1. Continue monitoring preserved heat energy and decreased CO_2 emissions in Liepaja from building renovation.
2. By getting newer data, show more accurately the correlation between heat energy preservation, used fuel and CO_2 emission decrease in Liepaja by increasing observation basis to 16 buildings.
3. Develop suggestions for buildings managers in choosing proper renovation project in order to achieve best possible results in Mwh consumption as well as monetary savings.

Used resources:

1. Gatis Kreinats, Eriks Malovka an observation 2013, Liepaja
2. http://likumi.lv/doc.php?id=173237
3. http://www.delfi.lv/bizness/uznemumi/fotoreportaza-liepajas-energija-buve-slegto-skeldas-noliktavu-un-biomasas-katlumaju.d?id=43412895#!/3637984/foto.delfi.lv
4. http://www.energodata.lv/lv/sections/skaidrojosa-vardnica
5. http://www.energoefektivitate.com/energoefektivit%C4%81te/
6. http://www.lvportals.lv/skaidrojumi.php?id=253546
7. http://www.rea.riga.lv/files/eku_energoefektivitate_skolenu_rokasgramata_IUSES.pdf
8. http://www.slideshare.net/siltinam/ku-energoefektivittes-uzlaboana-daudzdzvoku-mjs-un-kopjs-siltuma-enerijas-ietaupjuma-prognoze
9. Ltd. "Liepājas Enerģija" unpublished materials, G.Kreinats, E.Malovka
10. Ltd. „Liepaja Energija” unpublished materials, L.Abele.
11. Zaldeniece G., Ltd. „Liepajas Energija” Environmental and safety at work specialist, personal communication, 04/16/2013.