Heat Consumption Analysis in Public Buildings Managed by Riga City Municipality

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Abstract

The aim of the present study was to analyse heat energy consumption in public buildings (managed by Riga City Municipality) in the year 2008. Our data contained information about more than 400 public buildings, including data on heat energy consumption depending on buildings use, electric energy consumption and data on the quantity and quality of windows in these buildings. Data were analysed by dividing all public buildings into 12 subgroups: schools, special status educational institutions, day-care centres, hospitals, libraries, religious buildings, recreation centres, local government buildings, museums, sports centres, music academies and shelters. The largest groups are schools (158 analysed units) and day-care centres /kindergartens/ (143 analysed units).

Our analysis focused on heat energy consumption in buildings with new double-pane windows and polyvinylchloride (PVC) frames with a heat transmittance $U \leq 1.8$ (W/m²·K), and in buildings with simple windows divided into two-panes with two separate wooden frames with a heat transmittance $U \geq 2.5$ (W/m²·K). We also compared heat energy consumption in each building group with windows covering more than 20 % of the building facades against those with windows covering less than 20 % of the building facades. We analysed data for each group separately. Our analysis showed that partial renovation – the heat insulation of buildings with windows, doors, etc. change – does not provide the heat energy consumption economy required and in of the majority of cases even increases consumption.

Keywords: heat consumption, schools, day-care centres, renovation

1 Introduction

The economic and efficient use of energy is a current issue around the entire world. The economisation and optimisation of energy consumption results is decreased carbon dioxide emissions. Significant decisions of the European Parliament and of the Council are: Directive (2002/91/EC) of 16 December 2002 on the energy performance of buildings, Directive (2004/8/EC) of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market and Directive (2006/32/EC) of 5 April 2006 on energy end-use efficiency and energy services and the repeal of Council Directive 93/76/EEC. On basis of these documents, the Republic of Latvia Cabinet of Ministers created laws for local use. The main ministry that deals with energy issues is the Ministry of Economics.

We are also somewhat aware of these issues through the experience of engineers from other countries and scientist research, such as that described by Fromme et al. (2007) and Santamouris et al. (2008), and Latvian scientists Gendelis and Jakovics (2006), (2006). Buildings that have extremely large heat energy demands are part of the Latvia's heritage from the Soviet era. The majority of public buildings does not have mechanical ventilation systems.

Heat energy consumption in public buildings has been explored very minimally in Latvian scientific research. We did not find similar studies in Latvian scientific publications.

Building renovations were carried out based on inadequate information rather than based on scientific studies. Indoor air quality (IAQ) starts to worsen after a certain period of time. This

unpleasant fact is omitted. Outdoor air infiltration has stopped and people need opening windows to make IAQ better.

Partial renovation does not include the creation of new energy efficiency ventilation systems. The aim of our research is to decrease and optimise the overall final consumption of heat energy in public buildings. We hope to find the right solution to help us to develop an algorithm of optimisation for the renovation of public buildings.

2 Materials

We have analysed heat energy consumption in unrenovated public buildings and in buildings after partial renovation managed by Riga City Municipality in the year 2008. Our aggregate information contained data on 422 public buildings. We divided all buildings in 12 subgroups: schools, special status educational institutions, music academies, day-care centres, hospitals, libraries, religious buildings, recreation centres, local government buildings, museums, sports centres and shelters. The largest groups are: schools (158 units analysed) and day-care centres (143 units analysed). Our analysis focused on heat energy consumption in buildings that are:

a) unrenovated and with simple windows divided into two panes, with two separate wooden frames with a heat transmittance $U \geq 2.5$ (W/m²·K),
b) partially renovated with energy-efficient double-pane windows made with or without gas insulation between the glass and polyvinylchloride (PVC) frames with a heat transmittance $U \leq 1.8$ (W/m²·K).

Latvian Construction Standards define: if windows cover more than 20 % of the floor area, it is necessary to make special calculations for building heat loss. We compared heat energy consumption in building groups with windows covering more than 20 % and less than 20 % of the building facades, such as the example described by Bokel (2007). For this reason we formed two groups from each public building subgroup. We initially analysed the data for each group separately.

Our research overall included data on floor areas: special status educational institutions – 43,060 m²; shelters – 9,993 m²; local government buildings – 44,077 m²; recreation centres – 59,994 m²; museums – 369 m²; hospitals – 15,232 m²; sport centres – 18,435 m²; libraries – 8,324 m²; music academies – 5,368 m²; day-care centres – 248,923 m²; schools – 866,769 m²; religious buildings – 6,067 m².

3 Methods

We obtained our research data after the heating season in the spring and summer of the year 2009. We prepared a special inquiry form and sent it to the chief of every public building managed by Riga City Municipality. After receiving completed forms we sorted them and gathered information. Forms with incomplete information were considered unusable and were discarded. After we finished gathering data we conducted a statistical analysis.

Our data analysis was based on building mathematics, meaning parameters were compared in each of the 12 subgroups separately. We calculated each building group's floor area and heat consumption for the year. Then we calculated how much heat energy each type of building required per one square metre of floor area. After that we compared findings in unrenovated buildings and buildings after partial renovation as described by Krūmiņš et al. (2010).

4 Results

We analysed data on heat energy consumption in unrenovated public buildings and in public buildings after partial renovation for each of the 12 subgroups separately, as well as in two common

groups – buildings with windows covering more than 20 % and buildings with windows covering less than 20 % of the building facades – and prepared Table 1. Our analysed data do not contain information on IAQ parameters.

Table 1*: Average heat energy consumption (kWh/m²) in public buildings managed by Riga City Municipality in the year 2008*

Building Groups	Windows covering ≤ 20 % of building facades		Windows covering >20 % of building facades	
	Unrenovated	Partially renovated	Unrenovated	Partially renovated
1. Special status educational institutions	140	90	170	200
2. Shelters	------	150	------	150
3. Local government buildings	130	120	200	990
4. Recreation centres	140	100	90	20
5. Museums	200	------	------	6,000
6. Hospitals	------	110	------	------
7. Sport centres	------	190	10	100
8. Libraries	60	90	20	90
9. Academies of music	------	170	140	130
10. Day-care centres	190	310	180	220
11. Schools	110	130	120	120
12.Religious buildings	------	------	70	------

------- – No representative data

Table 2: *Heat and electric energy consumption in day-care centres and schools*

	Day-care centres	Schools
Total number of units a) unrenovated b) partially renovated	143 32 111	158 56 102
Total floor area (m^2)	248,923	866,769
Average unit area (m^2)	1,741	5,486
Total heat energy consumption (kWh) in this group of buildings per annum	53,102,920	103,783,050
Average heat energy consumption (kWh/m^2) in this group of buildings per annum	213	120
Average heat energy consumption (kWh/m^2) in unrenovated buildings per annum	184	124
Average heat energy consumption (kWh/m^2) in partially renovated buildings per annum	224	118
Total electric energy consumption (kWh) in this group of buildings per annum/average – (kWh/m^2)	7,010,729 /28	20,207,679 /23
Total electric energy consumption (kWh) in unrenovated buildings per annum/average – (kWh/m^2)	1,685,457 /25	6,254,041 /20
Total electric energy consumption (kWh) in partially renovated buildings per annum/average – (kWh/m^2)	5,325,272 /29	13,953,638 /25

Ventilation with and without air conditioning systems in buildings		
1. Total number of units	79	106
2. Total power (kW)	262	1,515
3. Total power to building one square metre (kW/m^2)	$1 \cdot 10^{-3}$	$2 \cdot 10^{-3}$

Table 3: *Proportion of total floor area and total heat consumption per annum in unrenovated and partially renovated day-care centres, percentage comparison*

Building groups	Windows covering ≤20 % of building facades		Windows covering >20 % of building facades	
	Total floor area (8,262 m²)	Heat consumption per annum (1,933 MWh)	Total floor area (240,661 m²)	Heat consumption per annum (51,169 MWh)
Unrenovated	64	52	27	23
Partially renovated	36	48	73	77

Table 4: *Proportion of total floor area and total heat consumption per annum in unrenovated and partially renovated schools, percentage comparison*

Building groups	Windows covering ≤20 % of building facades		Windows covering >20 % of building facades	
	Total floor area (48,816 m²)	Heat consumption per annum (6,231 MWh)	Total floor area (817,953 m²)	Heat consumption per annum (97,552 MWh)
Unrenovated	13	12	37	38
Partially renovated	87	88	63	62

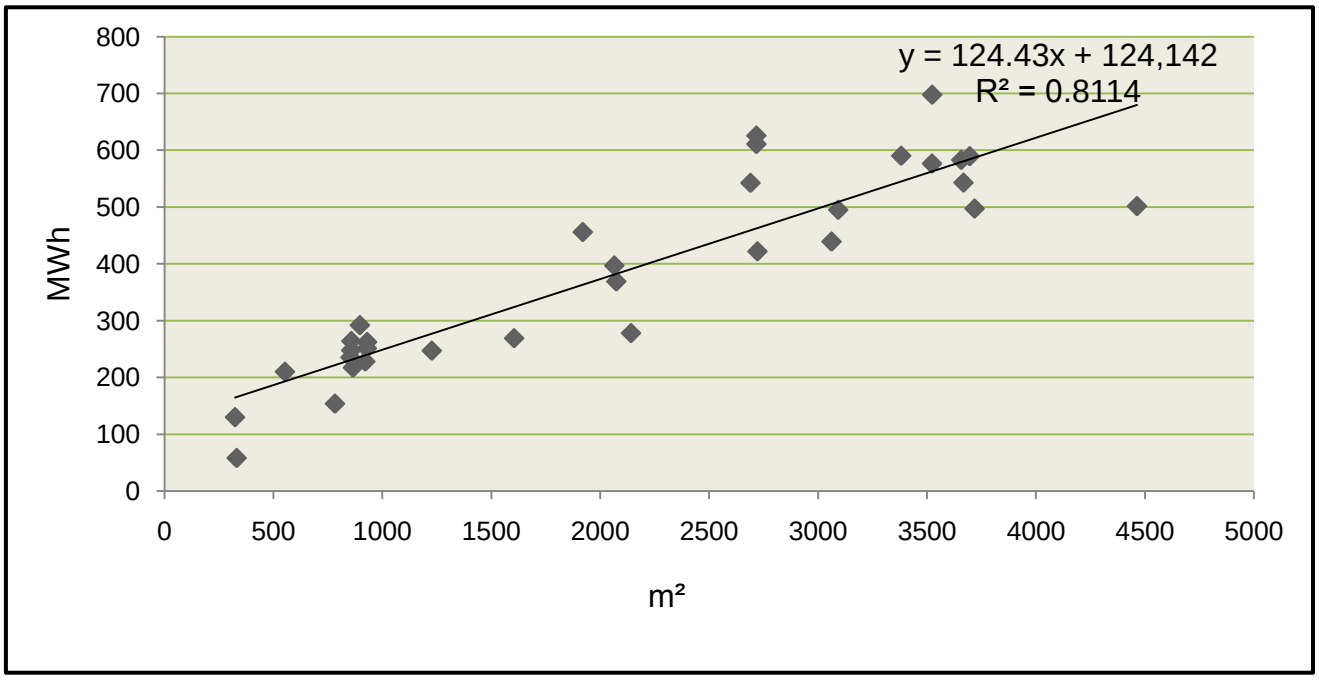

Figure 1. *Unrenovated day-care centre* buildings. Correlation of total heat energy consumption (MWh) per annum to building floor area (m^2) [* - 32units]*

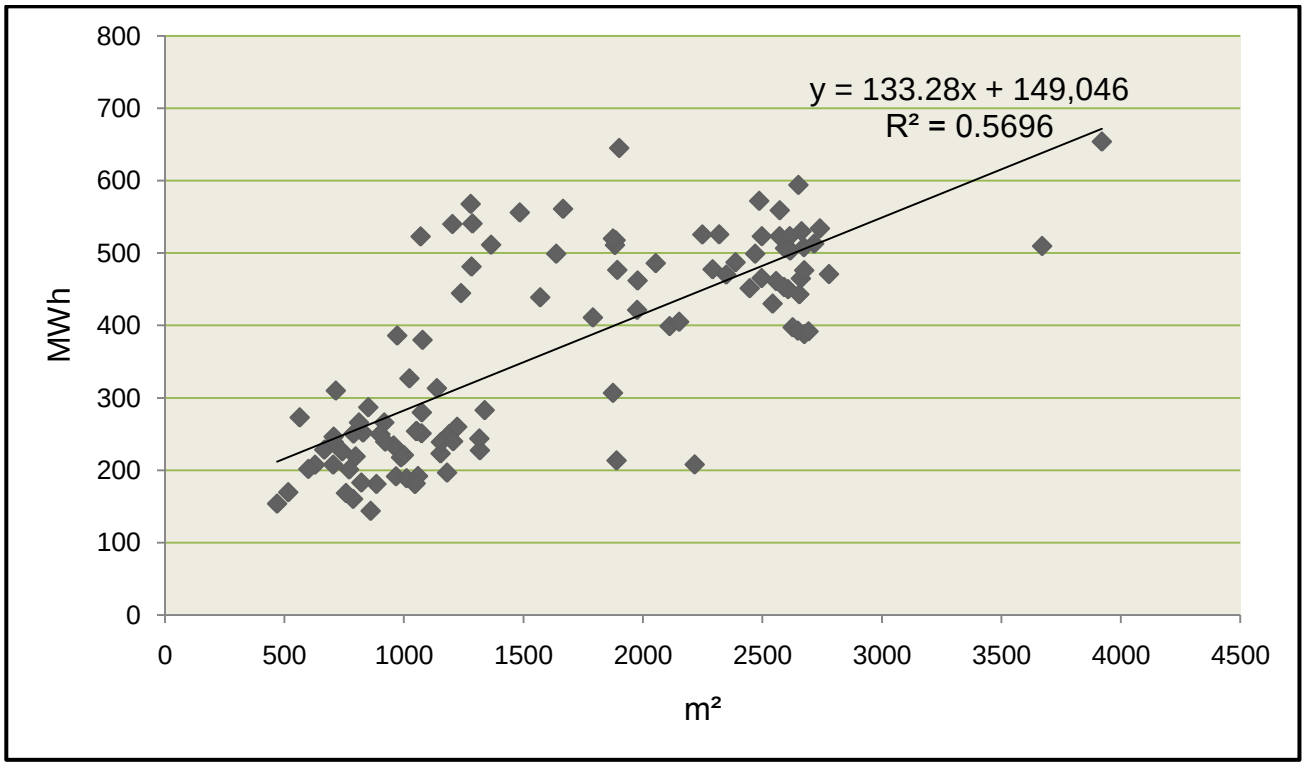

Figure 2. *Partially renovated day-care centre* buildings. Correlation of total heat energy consumption (MWh) per annum to buildings floor area (m^2) [*-111units]*

5 Discussion

We have presented a summary of our investigation results in Figure 3, without dividing day-care centres and schools into the two groups with windows covering ≤20% and >20 % of the building facades.

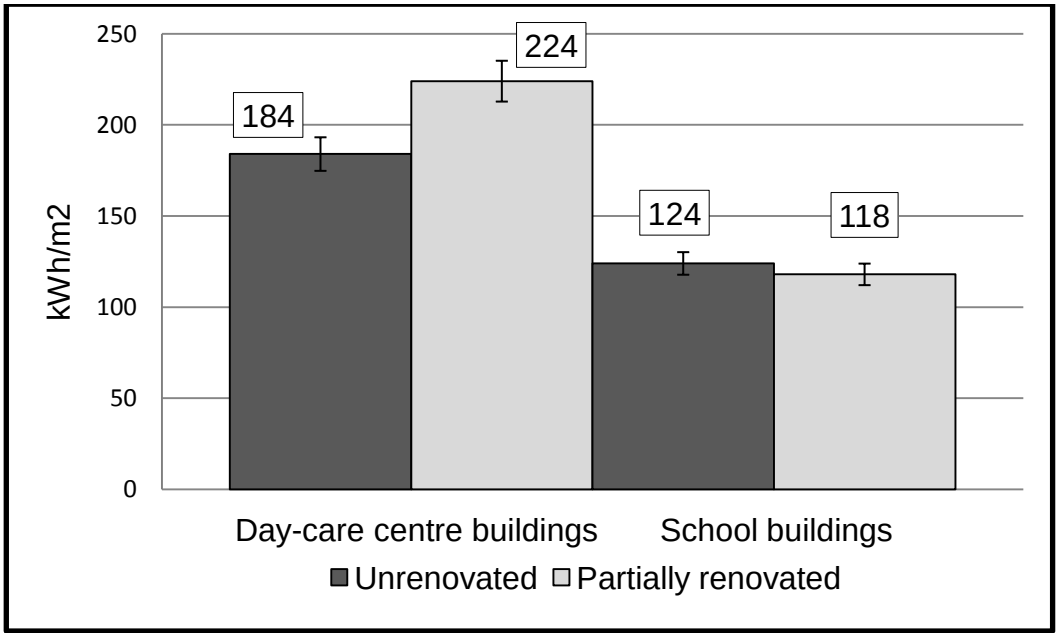

Figure 3. *Average heat energy consumption per annum to one square metre in unrenovated buildings and in partially renovated buildings with error bars with 5% value*

The average heat energy consumption per annum to one square metre in unrenovated buildings and in partially renovated buildings as shown in Fig.1 indicates that partial renovation in day-care centres has been done incorrectly. The average heat consumption after a partial renovation increased by 22 % in day-care centre buildings and decreased by 5 % in school buildings. The Latvian Energy Development Guidelines for the years 2007-2016 stipulate that heat energy consumption must decrease by approximately 28 %. In the time period until the year 2020, heat energy consumption must decrease by 40 %. If the current heat energy consumption is 250 (kWh/m²) per annum, then in the year 2020 heat energy consumption must decrease by 150 (kWh/m²) per annum.

Results of heat energy consumption in unrenovated day-care centre buildings and in partially renovated buildings clearly show that partial renovation did not result in the reported heat energy economy. We can see that the objective of partial renovation in both public building groups was not reached.

At this time we have no representative information on IAQ in either building group.

Some IAQ parameters are taking a turn for the worst, and unpleasant facts such as the increase of both relative air humidity and the level of carbon dioxide in buildings after partial renovation are being glossed over. The IAQ parameters are necessary to obtain to analyse and compare with scientific investigation results from other countries.

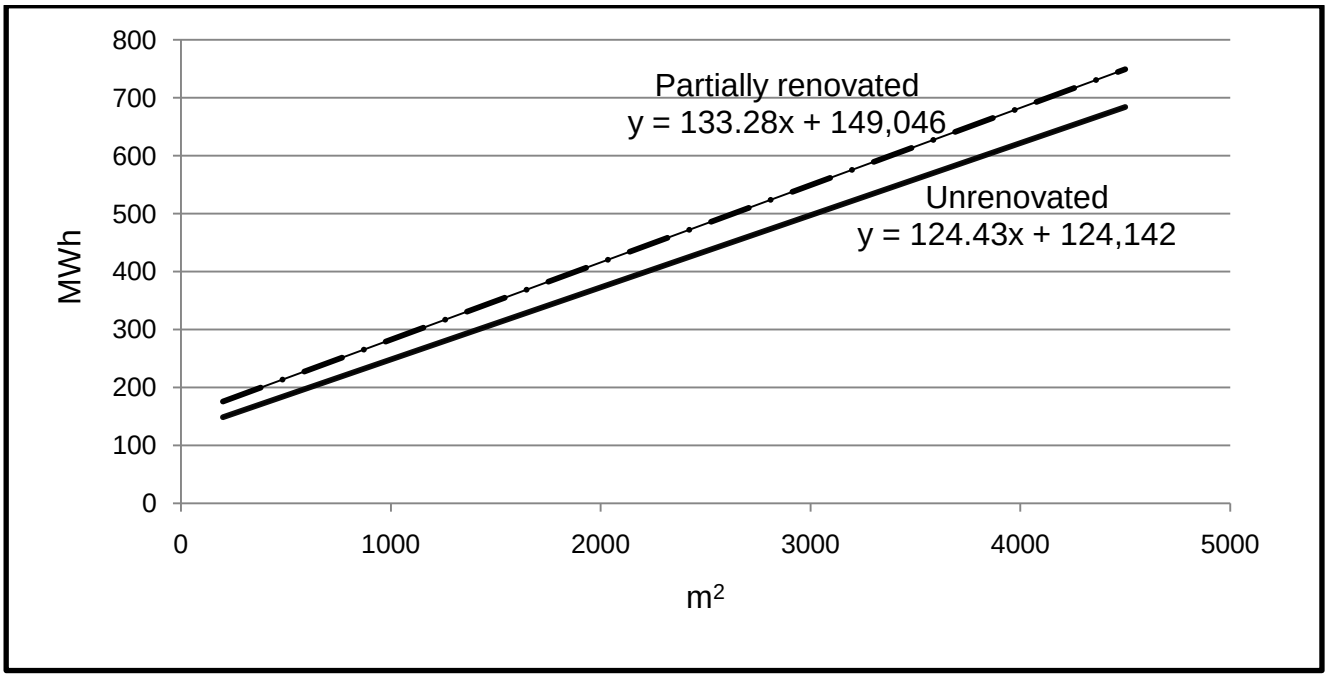

Figure 4. *Regression lines of the day-care centres* from unrenovated buildings and partially renovated buildings [*143units - (unrenovated -32 units; partially renovated – 111units)].*

Fig. 4 shows the integrated regression lines from Fig. 1 and Fig. 2. If partial renovation of buildings was done with adequate information and based on scientific investigations, the regression line from partially renovated buildings would be located under the regression line of unrenovated buildings. Fig. 4 clearly shows that partial renovations in buildings was done incorrectly, but not in all cases (see Fig.2).

6 Conclusions

- Almost all analysed data indicate that partial renovation does not lead to a decrease in heat energy consumption.

- Increased heat energy consumption in day-care centre buildings indicates that partial renovation was done with inadequate project solutions and with a knowledge level below the average.
- This direction has been explored very little in Latvian scientific research.
- Our next task is to research IAQ public building groups to obtain and analyse data.

7 Acknowledgment

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