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Heat Energy Consumption and Indoor Environment in the Three Different Conditions of Day-care Centre Buildings

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Abstract

Our current research has been based on heat energy consumption analysis in the year 2008 and indoor environment - indoor air quality (IAQ) data analysis in day-care centre buildings in the year 2011. We have been analysed more than 420 public buildings heat energy consumption in the Riga city. All public buildings divided into 12 groups depending on these using. Our attention was focused on heat consumption in unrenovated, partially renovated and newly erected day-care centre buildings. Data of heat consumption in this group of public buildings we has analysed and modelled trend line under the Latvian Energy Development Guidelines for the years 2007-2016 and by the year 2020. It can be a main direction for Latvian civil engineering for current public building group. Obtained data indicated another, incorrect tendency in Latvian building sector.

In the year 2011 we will be continued our research and obtained data of IAQ in six different conditions day-care centre buildings. IAQ measurements in three day care-centre buildings we would like to present in this article.

Key words: energy, heat consumption, public buildings, indoor environment, indoor air quality, day-care centre, renovation, civil engineering

Introduction

Latvian Cabinet of Ministers made laws for local use on basis of significant decisions of the European Parliament and of the Council on energy consumption economy and optimisation. The main documents are: Latvian Construction Standard (LBN 002-01) “Building Envelope Calorific”, Latvian Law on The Energy Performance of Buildings, Latvian Construction Standard (LBN 208-08) “Public Buildings and Structures”.

The main ministry for energy issue in Latvia is the Ministry of Economics. Latvian Energy Development Guidelines for the years 2007- 2016 define that heat energy consumption should decrease by approximately 28%. In time period up the year 2020 heat energy consumption should decrease by 40%. Is it possible to achieve this with previous renovation methods? We researched it and give an answer in this study.

Buildings that have very high heat energy demands are part of Latvia’s heritage from the Soviet era. The great majority of public buildings do not have mechanical ventilation systems.

Heat energy consumption in public buildings has been explored in very few Latvian scientific researches. We did not find a similar study in Latvian scientific publications.

Heat Energy Consumption in Public Buildings

Aggregate information contained data about more than 420 public buildings heat energy consumption in the year 2008. All public buildings divided into 12 groups depending on these using: special status educational institutions; shelters; local government buildings; recreation centres; museums; hospitals; sport centres; libraries; academies of music; day-care centres; schools; religious buildings.

Our analysis focused on heat energy consumption in unrenovated day-care centre buildings (32 analysed units) and in day-care centre buildings after a partial renovation and newly erected (111 analysed units), such as that described by Krūmiņš et al. (2010, pp.217-223), (2011, pp. 348-353).

Day-care Centre Buildings Indoor Environment

In winter season (from 11 February to 16 March) 2011 we continued research in the six day-care centre buildings with the aim to attain data from IAQ parameters. Aggregated information total containing more than 60 000 data indication from air relative humidity, temperature and indoor concentration of carbon dioxide as for example described Minnesota Department of Health (2010). IAQ parameters have been definite in The Cabinet of Ministers of the Republic of Latvia in Regulation No. 359, adopted 28 April 2009 as shown in table 1.

These Regulations contain legal norms arising from Council Directive 89/654/EEC of 30 November 1989 concerning the minimum health and safety requirements for the workplace.

IAQ parameters for day-care centre buildings also have been definite in The Cabinet of Ministers of the Republic of Latvia in Regulation No. 596 “Hygiene requirements for educational institutions, implementing preschool program”. There have been written, that for children younger than three years air temperature minimum is +20^{0}C and older than three years air temperature is +18^{0}C. This requirement does not indicate boundary of indoor environment two parameters: relative air humidity and carbon dioxide concentration (last amendments of regulations in 18 August, 2009.

In this research, we used: in unrenovated day-care centre building – MINILOG GSOFT 40K V7.80 (air temperature logger), EASYLOG 40RF GSOFT 40K V7.80 (air relative humidity logger) from 11 February to 17 March. Two units Wöhler CDL 210 version 1.1.6.(air temperature, relative humidity and carbon dioxide quantity) loggers in partially renovated and newly erected day-care centre buildings with a different time of building.

Table 1. **Requirements for the Microclimate of Work Premises Depending on Physical Load**

No.	Time of the year	Work category	Air temperature (C°)	Relative air humidity (%)	Air movement rate (m/s)
1.	Cold time of the year (average air temperature outside work premises + 10°C or lower)	I[1]	19,0–25,0	30–70	0,05–0,15
		II[2]	16,0–23,0	30–70	0,1–0,3
		III[3]	13,0–21,0	30–70	0,2–0,4
2.	Warm time of the year (average air temperature outside work premises exceeding + 10°C)	I[1]	20,0–28,0	30–70	0,05–0,15
		II[2]	16,0–27,0	30–70	0,1–0,4
		III[3]	15,0–26,0	30–70	0,2–0,5

Figure1. **IAQ parameters loggers: Wöhler CDL 210 version 1.1.6, EASYLOG 40RF GSOFT 40K V7.80 and MINILOG GSOFT 40K V7.80**

Loggers have been located in day-care centre rooms approximately 1,5m over floor in the place unaffected from children. After attaining the measurement data, we analysed and compared this data as for example described Dimdina et al. (2010, pp. 33-40).

Results of Heat Energy Consumption in Public Buildings

We analysed data on heat energy consumption in unrenovated public buildings and in public buildings after renovation, also newly erected buildings for each of the 12 groups separately, as well as in two common subgroups: buildings with windows covering more than 20% and buildings with windows covering less than 20% of the building facades and prepared Table 2.

In Table 2 we clearly see that public buildings partially renovation in great majority of groups does not lead to decrease in heat energy consumption. Table 2 also indicated that partially renovation does not affect from windows covering of buildings facades. Our heed has been focused in heat energy consumption in one of 12 public buildings group. It was one of two more representative groups – day-care centre buildings. This public building group consists of 143 analysed units: unrenovated buildings – 32 units, partially renovated and newly erected buildings – 111units.

We compared both buildings condition cases and results disclosed in Figure 2.

The average heat energy consumption per annum in unrenovated buildings and in partially renovated buildings as shown in Fig.2 indicates that partial renovation in day-care centres has been done incorrectly. 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 % (Ministry of Economics of Republic of Latvia). In Fig.2 we can clearly see that in this like manner made partial renovation in not rich. We do not disclose newly erected buildings as scattered instances because these conditions buildings take up very small part from all cases.

Table 2. **Average heat energy consumption (kWh/m²) in public buildings 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. 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	------

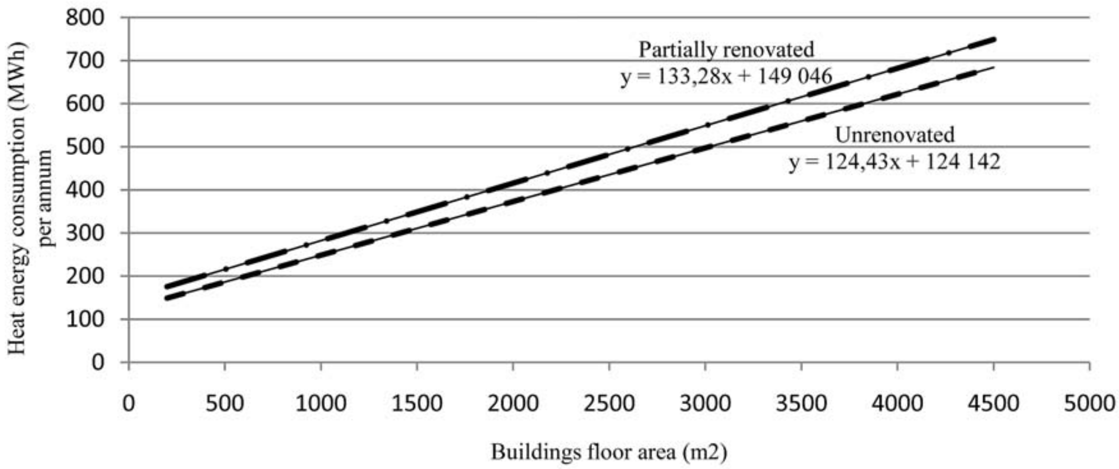

Figure 2. **Regression lines of the day-care centres from unrenovated and partially renovated (also newly erected) buildings**

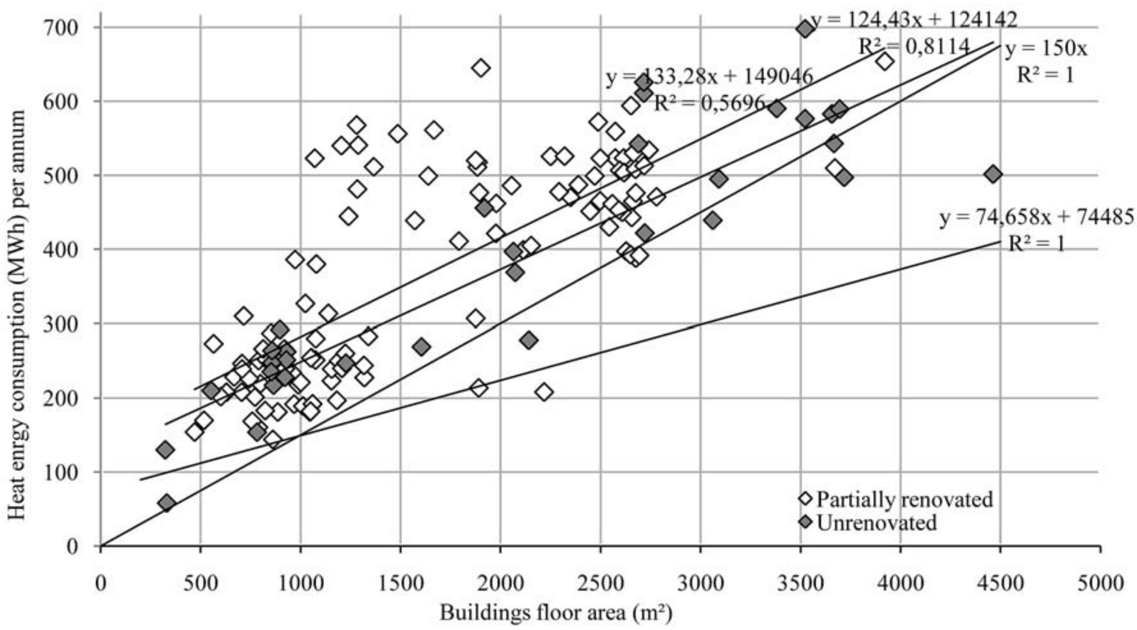

Figure 3. **Unrenovated and partially renovated day-care centre buildings.** Total heat energy consumption (MWh) per annum correlation with building floor areas (m2) with trendlines

In Fig.3 we disclosed:

1. Partially renovated (trendline y=133,28x +149046) and unrenovated (trendline y=124,43x+124142) day-care centre buildings heat energy consumption (MWh) per annum correlation with building total floor area (m^2).

2. Abstract trendline (y=150x), made under Latvian Energy Development Guidelines for the years 2007- 2016 and by the year 2020 heat energy consumption must be decreased by 40% (from 250kWh/m^2 per annum to 150kWh/m^2 per annum on average in Latvia).

We can found a part of algorythm from right building model and made Normative trendline (y=74,658+74485), which was made under Latvian Energy Development Guidelines for the years 2007- 2016 and by the year 2020 heat energy consumption must be decreased by 40% in this public building group. Newly erected day-care centre buildings and buildings after renovation must be located on or below this trendline. This is a right way to decrease heat energy consumption under this Guideline.

Results of Day-care Centre Buildings Indoor Environment

Following Fig.4, Fig.5 and Fig.6 presents outdoor air and indoor air temperature, relative humidity and CO_2 concentration level in day-care centre buildings.

Horizontal axis presents data of times and date. Minor gridlines disclose time:

- first 2:00;
- second 5:00;
- third 8:00;
- fourth 11:00 etc..

Major gridlines, for example from:

- zero to eight is the first data, achieved on 21February;
- nine to sixteen is the second data achieved on 22February
- seventeen to twenty four is the third data achieved on 23 February, etc..

(26 February - Saturday and 27 February- Sunday)

The highest indoor air temperature was in the newley erected building (was built in the year 2007, heat consumption 339 kWh/m^2 in the year 2008) day-care centre building, medium indoorair temperature was in the unrenovated building (heat consumption 130kWh/m^2 in the year 2008) and the lowest was in the partially renovated building. Air temperature in the newly erected and unrenovated buildings was higher and just 1-2 degres lower than +25°C. This temperature is the maximum from recomended optimum in Labour Protection Requirements in Workplaces as prescribed in regulation no. 359 from 28 April 2009 of The Cabinet of Ministers of the Republic of Latvia. Recommended air temperature is from +19 to +25°C if outdoor average air temperature is +10°C or lower. In our case a better and more economical indoor air temperature from +22 to +25°C was in the unrenovated day-care centre building. Air temperature in partially renovated day-care building (renovated in the year 2004, heat consumption 237kWh/m^2 in the year 2008) was under the recommended indoor air temperature very often in our case.

As we see in Fig.4 outdoor air temperature was from minus 16 degrees to minus 4 degrees Celsius. Indoor air temperature in all conditions of building changed in accordance with outdoor air temperature changes. This indicates that in thermal energy consumption is possible to realize optimization. The first step is to change the established heat demand for each other day-care centre building. It is necessary to make day-night conditions and workday and holyday conditions with a temperature difference. In the night hours and holydays is not necessary to maintance, as for example, +25^{0}C. Our study justified this.

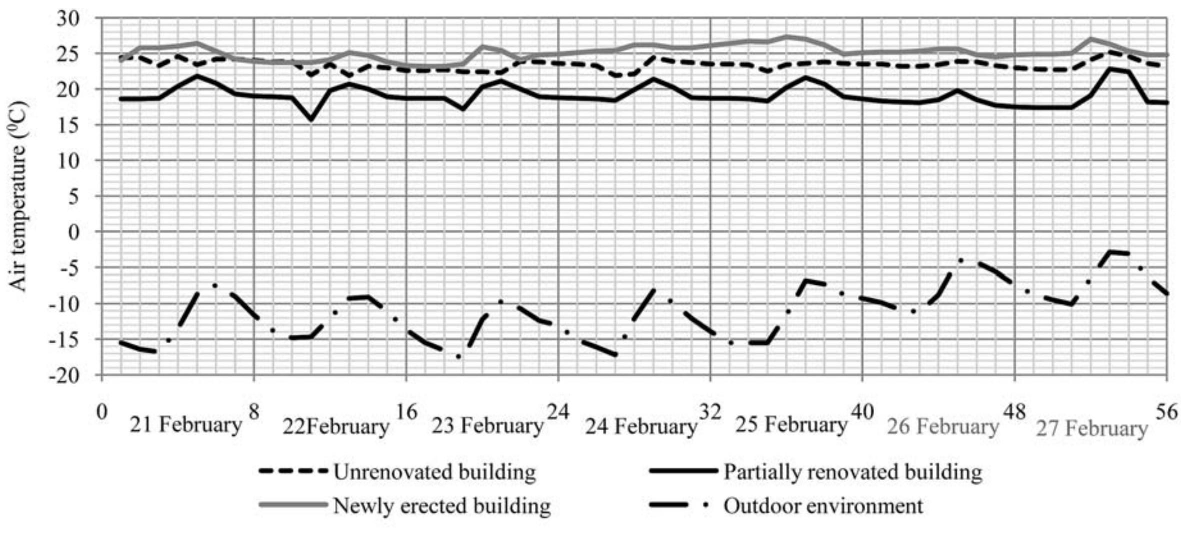

Figure 4. **Air temperature in the different conditions of day-care centre buildings and outdoor environment in the year 2011**

The following Fig.5 clearly shows that indoor air relative humidity is very low. The recommended IAQ minimum is 30% (maximum is 70%) as was written in Labour Protection Requirements in Workplaces as prescribed in regulation no. 359 from 28 April, 2009 of The Cabinet of Ministers of the Republic of Latvia.

In our case in the indoor environment of day-care centre buildings did not guarantee this requirement. Very critical relative air humidity has been obtained in unrenovated and newly erected buildings.

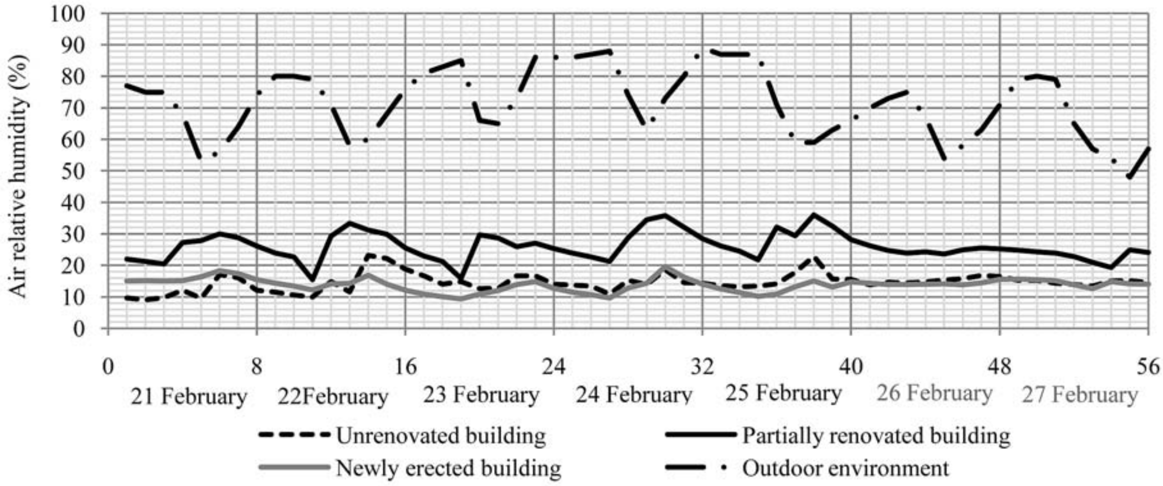

Figure 5. **Air relative humidity in the different conditions of day-care centre buildings and outdoor environment in the year 2011**

Fig. 6 presents the change in carbon dioxide level in the indoor environment in our study period in two day-care centre buildings. They are a partially renovated and newly erected. In Latvia we did not find an institution or structure which had a fixed CO_2 level outdoors. State limited liability company "Latvian Environment, Geology and Meteorology Centre" has information about air outdoor quality, but not included information about CO_2 in the outdoor environment.

We find a similar study in Minnesota Department of Health Fact Sheet (Minnesota Department of Health Fact Sheet, 2010): "Carbon dioxide is a colourless, odourless gas. It is produced both naturally and through human activities, such as burning gasoline, coal, oil, and wood. In the indoor environment, people exhale CO_2, which contributes to CO_2 levels in the air. The outdoor concentration of carbon dioxide can vary from 350-400 ppm or higher in areas with high traffic or industrial activity." Our fixed CO_2 level varied from 410 till 440 ppm in February and March 2011.

The Minnesota Department of Health had written: "the level of CO_2 indoors depends upon:

1. the number of people present;
2. how long an area has been occupied;
3. the amount of outdoor fresh air entering the area;
4. the size of the room or area;
5. whether combustion by-products are contaminating the indoor air (e.g., idling vehicles near air intakes, leaky furnaces, tobacco smoke) ,the outdoor concentration.

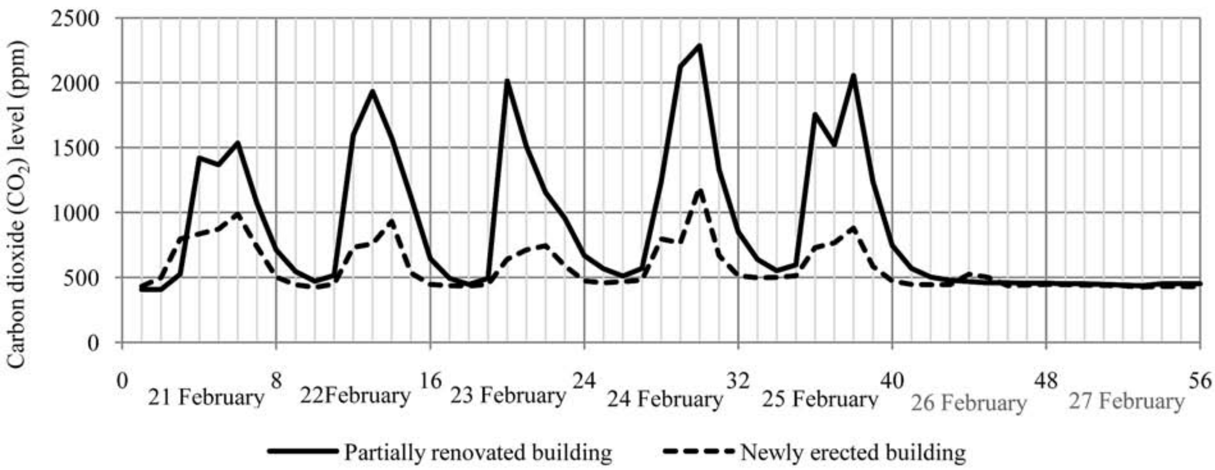

Figure 6. **Carbon dioxide level in the indoor environment in a partially renovated and newly erected day-care centre building**

Carbon dioxide concentrations indoors can vary from several hundred ppm to over 1000 ppm in areas with many occupants present for an extended period of time and where outdoor air ventilation is limited."

Our fixed occupancies (floor area and existence of ventilation system) are:

1. in a partially renovated day-care centre building (3 – 4 years old childrens/adults), floor area 60m^2, there is no mechanical ventilation system:
- 21 February – 12/2
- 22 February – 14/2
- 23 February – 13/2
- 24 February – 12/2
- 25 February – 11/2
- 26 February – 0/0
- 27 February – 0/0

2. in the newly erected day-care building (3-4 years old childrens/adults), floor area 88m^2, there is a mechanical ventilation system:
- 21 February – 16/2
- 22 February – 12/2
- 23 February – 11/2
- 24 February – 13/2
- 25 February – 13/2
- 26 February – 0/0
- 27 February – 0/0

Fig.6 displays that in the newly erected day-care centre building with a mechanical ventilation system, CO_2 concentration level in indoor environment is lower than in a partially renovated day-care building without a mechanical ventilation system. In a partially renovated day-care building in big majority of cases has been exceeded CO_2 advised maximum – 1500ppm..

Conclusions

Our presented study of heat consumption and IAQ measurements in the different types (unrenovated, partially renovated and the newly erected building) of existent day-care centre buildings has affirmed:

1. Partial renovation does not decrease heat energy in most cases. Buildings with similar total floor areas after a partial renovation had big heat consumption differences.
2. Partial renovation was done incorrectly in the majority of cases. This confirmed IAQ measurements in day-care centre buildings and heat consumption analysis on building per one square metre per annum.
3. After a partial renovation in day-care centre buildings and finished building is necessary to set correct heat demand on the control panel in each heat exchanger into initiallyof the heating season.
5. In each day-care centre building and renovation project it is necessary to include a mechanical ventilation system which can attain the building's requirements for correct IAQ as defined in the Latvian Building Laws.

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