RESEARCH ON POSSIBILITIES FOR DECREASING HEAT LOSSES IN BUILDINGS

Edmunds Visockis, Peteris Vucenlazdans, Vita Ansone, Ilga Morozova
Rezekne Higher Education Institution;
Latgale sustainable development research institute
ems@inbox.lv

Abstract. Possibilities for promotion of heat insulation in buildings are the most important factors to decrease heat losses through delimitation constructions (roofs, walls, floors, windows, doors, ventilation, etc.). The publication will describe advisement of traditional energy audits and offer innovative solutions to save heat and good living conditions in buildings. Experts of the energy auditor companies inspect buildings in winter time. Measurements of temperature are made inside and outside of building walls. Information is received on fuel and electricity consumption, ventilation condition, and a lot of other information to be dealt with in special programs. Finally information has to be got with regard to the existing situation of buildings and optimal solutions to decrease the heat energy losses. Increase of the heating system efficiency is also very important. The strategic aim of the EU is increased use of renewable energy resources. In Latvia that mostly concerns different wood products, while wind power, solar energy, heat pumps, etc. are used less. One of the most important preconditions for proper use of wood burning boilers is careful preparation of wood fuel. It must be of the right size for different heating methods and very dry, to receive the maximum amount of heat energy and to use it properly with low heat losses via exhaust to ambient air. The paper will provide theoretical and experimental research to reach the most optimal solutions.

Keywords: heat insulation, microclimate of buildings, energy efficiency, wood fuel.

Introduction

This article discusses the possibilities to decrease heat losses in a kindergarten built in Latvia during the Soviet period in 1976. Economic and energy policy of that time accepted buildings with high energy losses, because the price of heat energy was very low. Now the situation is opposite – the price of heat energy is rising very fast and each year is reaching new records. The buildings received as legacy from the Soviet period should be rebuilt, covered by heat insulation materials, old, non-hermetic windows and doors replaced by solutions of up-to-date generation to save heat. The renovation activities must be performed closely involving adequate ventilation and heat recuperation systems that guarantee the necessary air exchange to avoid optimal inside humidity to be exceeded. If these important conditions are implemented improperly, that can cause condensate to develop on windows, sills, walls, etc. That usually results in mould; inhabitants can feel bad and frequently fall ill.

The Energy Audit Company "Smart Energy" and the "Terma" company in 2010 have carried out the energy audit of the kindergarten. It was aimed at inspection of the overall situation of the building – condition of ground foundation, walls, windows, garret insulation, roof, ventilation system, heating system, etc. The documents about renovation work of last years, fuel and electricity consumption are examined. Other information was collected to precisely define the existing situation to help in careful elaboration of the action plan for proper work to reduce the heat loss. The initial information is displayed in Tables 1-3 [1].

Table 1

Classified energy consumption of experimental object

Energy consumption	MWh·year^{-1}*	kWh·m^{-2}year^{-1}*	% of total energy consumption**
I Heating	250	285	92
II Electricity consumption***	21.8	25	8
III Total	271.8	310	100

* Energy consumption corrected in accordance with climatic conditions.
** Total amount must be 100%.
*** Electricity consumption is counted complexly

Summary of the energy audit statement in the experimental object

The energy audit in the kindergarten was carried out in cooperation between the companies SIA "Smart Energy" and SIA "Terma" in accordance with the Cabinet Regulation No.39 "Energy efficiency accounting methods". The project was implemented and partly paid-up by the EU funding: Financial instrument open competition of climate exchange financed projects "Increase of energy efficiency in education establishment buildings".

Fig.1. **Front view of kindergarten**

Fig. 2. **Top view of kindergarten**

In figures 1 and 2 we can see, that the kindergarten is one-storey cottage type with a big surface of external walls. The building material is thin (250 mm) mostly aerocrete panels without any heat insulation. In some places there are cracks, large ones are filled by foam, but not the small. The concrete foundation in many places is broken, filled up by rain water and destroyed by frost. In cold winter time the concrete foundation and walls become through-frost. Around the entire perimeter there are windows (glass packages and glass blocks). The roof and rainwater downspouts are renovated, but must be repaired. During renovation works in recent years, to save heat inside the building, ventilation airshafts are closed by foam. That was done because the previous old ventilation system was worse, with high heat losses, but for modern recuperative ventilation system there is no money for investment. Finally heat is saved, but inside the building air moisture increases, with condensation on windows, sills, inside angles of external walls and ceiling. That causes arising of mustiness.

The heating system of the building is also in a bad condition. Fuel – firewood logs partly have been stored under the roof, but partly outside. Therefore, in average firewood the content the moisture exceeds normal volume of moisture. That unfavorably affects using of that fuel. With wet firewood it is difficult to light the fire. That is burning down badly and produces a small amount of heat energy (see Fig. 3.) [2; 3].To ensure the burning process major amount of heat energy must be used to dry out moisture from firewood. The burning process is inferior, that clogs the central heating boiler, flue pipes, flue-pump and chimney. Water condensate is extracted, which aggressive components have rusty influence on metal surfaces of heating systems and rapidly reducing their lifetime. Finally, low amount of heat energy is produced, that via clogs insufficiently transfers heat to the water heat exchanger of the central heating boiler. Flue gases of the inferior burning contain a lot of carbon black and harmful emissions.

The operator of the boiler must exercise control over the non-stop burning process, fill up the furnace by firewood logs and control the temperature of the heating system, not to let that dropping down. If that happens anyway, the heating system must be disconnected from the building and let the heating fluid to circulate just via the boiler to keep the temperature and avoid the boiler burn out. In that situation the efficiency of the boiler is 0 %, the heating system is running at a loss, using firewood and producing harmful emissions. After each firing the operator must work hard to clear the boiler inside from carbon black and ashes. The measured consumption of the kindergarten heat energy is 301 $kWh \cdot m^{-2}$ per annum and accounted consumption is 309 $kWh \cdot m^{-2}$ per annum (Table 5). That many times exceeds normal heat energy consumption. The heating system of the building is equipped by new convectors, and on each a thermoregulatory valve is mounted [1].

Hot water for washing needs is provided by electrical boilers since this is a more effective solution in the situation of an ineffective heating system. Water heating by electricity is consuming a considerable amount of the total consumption of electricity in the kindergarten.

Table 2

Information about heat energy consumption

Year		Months												Average	Total
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII		
2007	Total energy consumption, MWh	42	48	33	25	4	0	0	0	3	30	48	51	24	284
	Specific energy consumption, $kWh \cdot m^{-2}$	48	55	38	28	5	0	0	0	3	34	55	58	27	-
	CO_2 emission amount, t*	11	13	9	7	1	0	0	0	1	8	13	13	6	75
2008	Total energy consumption, MWh	44	42	31	21	2	0	0	0	0	25	45	48	22	258
	Specific energy consumption, $kWh \cdot m^{-2}$	50	48	35	24	2	0	0	0	0	28	51	55	24	-
	CO_2 emission amount, t*	12	11	8	6	1	0	0	0	0	7	12	13	6	68
2009	Total energy consumption, MWh	43	39	31	22	5	0	0	0	2	22	42	44	21	250
	Specific energy consumption, $kWh \cdot m^{-2}$	49	44	35	25	6	0	0	0	2	25	48	50	24	-
	CO_2 emission amount, t*	11	10	8	6	1	0	0	0	1	6	11	12	6	66

*Calculated: total energy consumption to multiple by CO_2 emission factor ($t_{CO2} \cdot MWh^{-1}$).

Table 3

Information about electricity consumption

Year		Months												Average	Total
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII		
2007	Total electricity consumption, MWh	3.2	3.1	2.2	1.5	1.0	0.5	0.4	0.2	1.1	2.2	3.1	3.1	1.8	21.2
	Specific electricity consumption, $kWh \cdot m^{-2}$	3.6	3.5	2.5	1.7	1.1	0.6	0.5	0.2	1.3	2.5	3.1	3.5	2.0	-
	CO_2 emission amount, t*	0.8	0.8	0.6	0.4	0.3	0.1	0.1	0.1	0.3	0.6	0.7	0.8	0.5	5.6
2008	Total electricity consumption, MWh	3.2	3.8	2.5	1.6	0.8	0.7	0.5	0.2	0.9	2.2	2.8	3.3	1.9	22.5
	Specific electricity consumption, $kWh \cdot m^{-2}$	3.6	4.3	2.8	1.8	0.9	0.8	0.6	0.2	1.0	2.5	3.2	3.8	2.1	-
	CO_2 emission amount, t*	0.8	1.0	0.7	0.4	0.2	0.2	0.1	0.1	0.2	0.6	0.7	0.9	0.5	5.9
2009	Total electricity consumption, MWh	3.2	3.2	2.2	1.6	1.0	0.6	0.3	0.3	1.1	2.3	2.8	3.2	1.8	21.8
	Specific electricity consumption, $kWh \cdot m^{-2}$	3.6	3.6	2.5	1.8	1.1	0.7	0.3	0.3	1.3	2.6	3.2	3.6	2.1	-
	CO_2 emission amount, t*	0.8	0.8	0.6	0.4	0.3	0.2	0.1	0.1	0.3	0.6	0.7	0.8	0.5	5.8

*Calculated: total energy consumption to multiple by CO_2 emission factor ($t_{CO2} \cdot MWh^{-1}$).

Results and discussion

In the course of the information collection process, the information was aggregated about the necessary heat insulation material, its thickness, kind of ventilation, measured and accounted energy efficiency, emissions of CO_2, etc., see Tables 4., 5. [1].

Table 4

Saved up carbon dioxide and heat energy

Action*	Specific save of supplied energy		Specific save of primary energy		% of measured energy efficiency valuation**	Decrease*** of CO_2
	$kWh \cdot m^{-2} year^{-1}$	$MWh \cdot year^{-1}$	$kWh \cdot m^{-2} year^{-1}$	$MWh \cdot year^{-1}$	%	$kg \cdot m^{-2} \cdot year^{-1}$
Garret heat insulation by rock wool 300mm (sufficient heat transfer $\lambda \leq 0.039\ W \cdot (m^2 \cdot K)^{-1}$)	48	42	69	60	15.95	12.672
External wall heat insulation by hard rock wool 150mm (sufficient heat transfer $\lambda \leq 0.039\ W \cdot (m^2 \cdot K)^{-1}$)	71	62	101	89	23.59	18.744
Ventilation system by heat recuperation	26	62	101	89	23.59	18.744
Replacement of wood framed windows and glass blocks with PVC package blocks with selective coverage $U \leq 1.3\ (W \cdot (m^2 \cdot K)^{-1})$	11	10	16	14	3.65	2.904
Replacement of wood doors with PVC $U \leq 1.3\ (W \cdot (m^2 \cdot K)^{-1})$	2	2	3	3	0.66	0.528

* In accordance with 6th addition to the Cabinet Regulation of 5.01.2010. "Energy efficiency accounting methods".

** Measured valuation of the building energy efficiency - evaluation of energy efficiency, which is done on basis of measurements of the supplied and exported energy amount.

*** Carbon dioxide (CO_2) of fossil fuel burning, required to produce energy for heat in the building, air-conditioner, hot water, ventilation, and lighting. Accounted of supplied energy specific save.

Table 5

Energy rating and prognoses of exchanges

Valuation	Unit	Existing situation	Forecasting information after impact of energy efficiency implementation
Measured valuation of building energy efficiency	$kWh \cdot m^{-2} \cdot year^{-1}$	301	143
Accounted valuation of building energy efficiency	$kWh \cdot m^{-2} \cdot year^{-1}$	309	-
Measured CO_2 emission valuation	year (kg_{CO2})*	78032	41408
Accounted CO_2 emission valuation	year (kg_{CO2})*	79886	-

* Measured and accounted emission of CO_2 valuation per year (kg_{CO2}) received to sum valuation of building emissions.

Energy resources saving prognosis is in accordance with advisement of the energy audit. That is determined as the measured energy consumption after realization of arrangements.

Innovative advisement to increase energy efficiency of buildings

In Fig. 2 we can see, that the kindergarten is made in a shape having very long external walls. That causes high heating energy losses. It would be reasonable to consider possibilities to increase useful inside place of kindergartens by reconstructing and include unused territory. By one new additional heat insulated external wall and roof the heat losses will be reduced, which at the time being are taking place through three external walls without heat insulation. Consequently, the kindergarten will considerably increase the capacity of effective interior, to be able to take on more children and to cover rebuilding expenses from additional income.

The microclimate of the building interior depends on heat insulation, heating system, ventilation and other factors. In a future perspective, it is reasonable to cover the cellar, external wools and garret with a thicker layer of heat insulation materials as recommended by existing regulatory provisions. In combination with an efficient ventilation recuperation system, it is possible to ensure optimum inside climate by a very small amount of additional automatic heat energy. The traditional heating system and operator are not needed any more.

An innovative solution is using double pack windows. Outside package of that kind of windows should be put in the external wall near the wall surface, and inside package near the inside surface of the wall. Between window packages is recommended filling up of room with a moisture absorbing material in dark color on the sunny side. This solution results in decreased heat losses via the window glass. Also bridge of cold is more prevented. It was experimentally determined that double package solution decreases heat loses via windows because the inside glass surface is warmer, but the outside glass surface is colder. On average possible decrease of heat losses are amounting to 20…30 % through windows (experiments done in the experimental object of the company SIA "Terma"). Air between two window packages will stay the same and contain the same moisture. Therefore, windows are not dimmed; also the inside window package will be warmer and will not draw condensate on the room side surface. Dark color of moisture absorbing material in sunny time absorbs heat energy. The experimental tests show that the temperature between the window packages can increase about 10…20 ºC over outside and rooms inside, keeping heat for few hours after sunny time. Also the comfort zone inside the buildings is increasing. That solution is highly recommended for buildings, were windows are taking a big amount of the external wall surface [4].

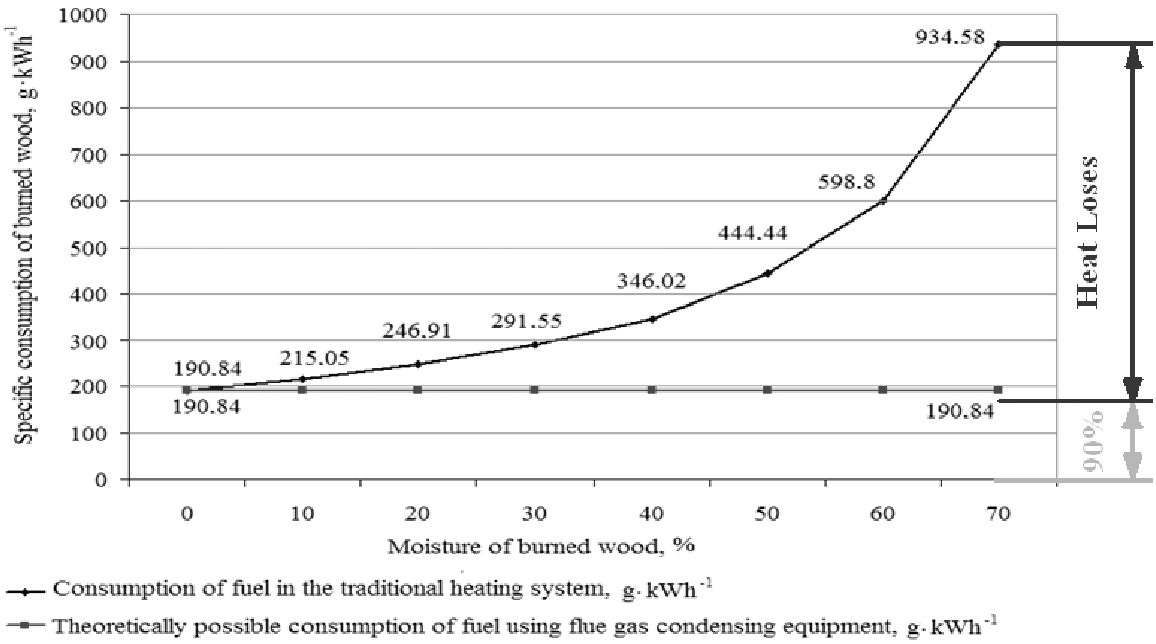

Fig. 3. **Dependence of heat energy losses from wood fuel moisture** [2; 3]

If the kindergarten also in future will be heated by firewood logs, care has to be taken to properly prepare fuel for cold seasons. Usually there are two types of heating. The first is operating by small capacity during the heating time without the heat accumulator. The second is operating with considerably higher capacity, heating up the heat accumulator and stops. The accumulated heat energy heats up interior of the building. Implementation of the first system is cheaper than the second system. But the exploitation costs of the second system are more profitable. Preparation of firewood bricks in the right size is very important. For the first kind of heating rough size logs are recommended, because they must burn long time and give heat. Unfortunately, also heat losses via flue gases are high. For the second kind of heating thin size logs are recommended, because they must burn fast and heat up the accumulator. In short burning time with high temperature and capacity it is possible to produce more heat and decrease heat losses by flue gas.

Wet firewood logs are considerably cheaper than dried logs. Therefore, drying of firewood logs on one's own is favourable. An innovative solution will be the logs stock built of transparent glass or long life plastic as a green house with ventilation on top and open of both ends to be possible to ensure draught wind to let out moisture. In spring fill up stock with piles of logs in south – north direction. Leaving small space between the piles is recommended. In sunny days the sun will heat up the stock till temperature above +40 ºC and dry out moisture. That is way it will be possible to prepare dry firewood in six months, what is faster in comparison with the traditional woodshed solution.

Considerable improvement of the working conditions of the heating system is possible by additional drying and pre-heating of firewood. The firewood prepared in such way was tested in the experimental object of SIA "Terma". That is easy to set on fire, it is burning by high temperature, increases the capacity of the boiler for 10…15 %. The regulations of fire safety must be kept carefully and the olution has to be find to suitable use of heat energy of the boiler surface what usually produces losses [2; 3].

Conclusions

1. The measured heat energy consumption of the experimental object is 301 $kWh \cdot m^{-2}$ per year and the accounted consumption is 309 $kWh \cdot m^{-2}$ per year.
2. The heat energy consumption of the experimental object after implementation of energy saving works in accordance with the energy audit will be 143 $kWh \cdot m^{-2}$ per year.
3. The innovative double pack window solution on average can decrease heat losses of the experimental object for 20…30 %.
4. The temperature between the innovative window packages in sunny time can increase by 10…20 C° above the outside and room temperature, keeping heat for few hours after sunny time and heating up the interior of the building.
5. An innovative solution is a logs stock built of transparent material as a green house, in sunny days the sun can heat up the stock till temperature over +40 C° and dry out moisture. That way it will be possible to prepare dry firewood in six months, what is faster in comparison with the traditional solution by a woodshed.
6. Additional drying and pre-heating of firewood logs can increase the capacity of the heating boiler by 10…15 %.

Acknowledgements

The work has been supported by ESF project, agreement Nr. 2010/0267/2DP/2.1.1.1.0./ 10/APIA/VIAA/169.

ERAF
EIROPAS REĢIONĀLĀS ATTĪSTĪBAS FONDS

References

1. Garkajis E., Dreimane E., SIA "Smart energy"., Ēkas energoaudita pārskats. Pēc ēku energoefektivitātes likuma MK noteikumiem Nr.39 "Ēkas energoefektivitātes aprēķina metode". 2010, Riga, Latvia, 21 p. (In Latvian).
2. Visockis E. Grīdas apsilde ar dūmgāzēm. Promotion labor. Latvia University of Agriculture, 2008, Jelgava, 130 p. (In Latvian).
3. Visockis E. Effectiveness of thermal energy consumption. Proceedings of International project Joint European-Latin American Universities Renewable Energy Project (JELARE). 2010, Rezekne, Latvia, 20 p.
4. Visockis E. Ēku energoefektivitātes paaugstināšanas risinājumi. "Vides tehnoloģiju pārnese: Rēzeknes Augstskola–komercsabiedrības". Rēzeknes augstskola, 2010, Rezekne, Latvia, 20 p. (In Latvian).