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ENERGY EFFICIENT ONE FAMILY HOUSE DEVELOPMENT IN LATVIA

ENERGOEFEKTĪVAS VIENĢIMENES ĒKAS KONCEPCIJAS IZSTRĀDE LATVIJĀ

Agris Kamenders, M.Sc.,
Riga Technical University, Institute of Energy Systems and Environment;
Address: Kronvalda Boulevard 1, LV1010, Riga, Latvia
Phone: 371+7089923, Fax 371+70 89 908
e-mail: agrisagris@inbox.lv

Andra Blumberga, Dr.Sc.Ing, Associated professor,
Riga Technical University, Institute of Energy Systems and Environment;
Address: Kronvalda Boulevard 1, LV1010, Riga, Latvia
Phone: 371+7089923, Fax 371+70 89 908
e-mail: andrab@delfi.lv

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Introduction

The aim of the work was to develop a one family house that could be called an environmentally friendly house. The paper considers the possibilities to build the so-called passive houses in Latvia. For modeling a passive building to be adapted to the Latvian climate, a computer program TRNSYS was used, which made it possible to obtain the thermally-technical parameters necessary for designing private houses in Latvia that would meet the passive building criteria. It should be emphasized that the passive building concept is of vital importance not only for Latvia but for all other countries as well. The service life of buildings is long, while the renovation of available housing proceeds slowly. Up to the present time the energy consumption has not become one of the most important factors determining the building quality and does not affect the choice of buyers. In the work a private house design is sought for that would meet the passive building standards defined in Germany and Austria. In the research for the best design widely spread building methods as well as building construction elements and materials available on the market have been used.

Studied object

So far in Latvia no projects of passive house criteria have been implemented. The reasons for this are as follows: scant information on the subject, insufficient number of such projects implemented in Latvia, lack of research and detailed analysis devoted to the possibilities of implementing such projects in Latvia.

In the beginning it was suspect that it would be a one storey family house of 160 m^2. The geometrical layout of a building is made in such a way that the energy consumption there be the least, taking into account a possible arrangement of the rooms and the day light be used optimally, thus allowing for reducing the energy consumption for lighting. The building compactness in this case will be characterized with the ratio of the total area of limiting constructions to the heated space. In the given research an optimal design was sought for a one-storey private house with a definite living space, therefore the parameter that influences the compactness of a building is its geometrical layout.

Based on the chosen geometry of a building and the placement of windows there, the planning of the building is made up (shown in Fig.1).

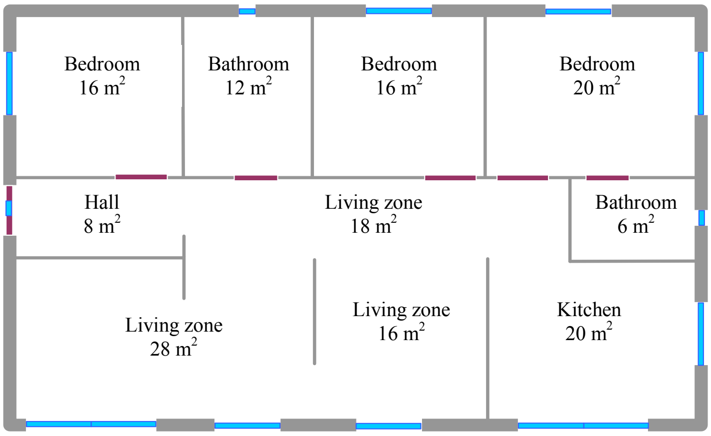

Figure.1. Schematic planning of a building

After the planning of a feasible building has been made, its simulation model in the environment of TRNSYS program is formed. The modeling of a building has been performed for two different regimes, with the heat release of 4 W/m^2 and 2,1 W/m^2. In both cases, the boundary values are used that allow to perform the calculations in such a manner that the technical parameters of the design do not outperform the parameters of the available materials.

Energy for heating is consumed and the total yearly consumption makes up 2107 kWh/year, which means that the energy consumed for heating does not exceed 15 kWh/m^2/year. The specific energy consumption for a heated 1 m^2 of the building is calculated according to the equation number (1).

$$E_{spec} = \frac{E_{year}}{A} = \frac{2107}{160} = 13{,}17 \text{ kWh/m}^2\text{/year} \qquad (1)$$

where

E_{spec} is the specific energy consumption for the heated area of the building per year, kWh/m^2 /year;

E_{year} is the energy consumption per year, kWh;

A is the heated area of the building.

Good results have been achieved (the heat consumption is 13,17 kWh/m^2/year). The simulation model of this designed building does not give the maximum heat capacity lower than 10 W/m^2 per year. As can be seen, also in other cities with a cool climate this value is difficult to achieve, although it is close to the desirable. If we assume that the heat release is noticeably reduced and that we use the best household appliances and lighting devices available on the market, we should consider the case when the heat release is 2,1 W/m^2. At the average heat release of 2,1 W/m^2 and the above defined thermally-technical indices of the building it is difficult to achieve the indices of passive building. Table 1 shows the results of the modelling carried out in Riga and the results achieved for the buildings of other cities (see Table 1) [1].

Table 1

Comparative results for a conceived passive house in Riga and buildings from different countries at various heat release

	2.1 W/m^2	4 W/m^2
Oslo	15,1 kWh/m^2 year, (10,9 W/m^2)	9 kWh/m^2 year , (8,9 W/m^2)
Lillehammer	20 kWh/m^2 year , (14,2 W/m^2)	13.1 kWh/m^2 year , (12,3 W/m^2)
Karasjok	37,9 kWh/m^2 year , (21,5 W/m^2)	29 kWh/m^2 year , (19,6 W/m^2)
Zurich	7,1 kWh/m^2 year , (7,5 W/m^2)	2,4 kWh/m^2 year , (3,5 W/m^2)
Rīga	20,33 kWh/m^2 year , (19,31 W/m^2)	13,17 kWh/m^2 year , (19 W/m^2)

As Table 1 shows, the design with the heat release of 2,1 W/m^2, does not ensure the necessary indices, and the building is therefore to be improved. To achieve the indices ensuring heat energy consumption less than 15 kWh/m^2 per year it is necessary to improve the thermally-technical properties of the limiting constructions up to the following as seen in table 2.

Table 2

Thermally-technical properties

Walls	**Roof**	**Floor**	**Windows**	**Infiltration**
U, W/(m^2*K)	U, W/(m^2*K)	U, W/(m^2*K)	U, W/(m^2*K) and g	h^{-1}
0,096	0,082	0,077	0,59 and 0,584	0,03

These parameters allow for achieving the heat energy consumption of 14,46 kWh/m^2 a year, however, the sought-for result is not achieved, and the maximum heat capacity is shown to be 17 W/m^2. From the analysis it follows that, if high thermally-technical parameters are achieved for a one-storey private house with a heated area of 160m^2 it is possible to obtain the result when the energy consumption for heating does not exceed 15 kWh/m^2 a year, the heat load lower than 10 W/m^2 is, however, difficult to ensure, and it reaches 17 W/m^2. The passive building standard existing in Germany and Austria defines that its energy consumption for heating should not exceed 15kWh/m^2 and that the heat load should be limited by 10W/m^2. Using the simulation model of a passive building, different heating conditions – the heat gains of 2,1 W/m^2 and 4 W/m^2– have been considered. In the former case (improvement of a building's design up to reaching very high thermally-technical indices) the energy consumption for heating is 14,46 kWh/m^2 per year and the maximum heat load – 17 W/m^2. In the latter case (the heat release of 4 W/m^2) these parameters are 13,17 kWh/m^2 and 19 W/m^2, respectively. The analyses show that it is possible to reach energy conception below 15 kWh/m^2, but it was hard to achieve parameter heat load below 10 W/m^2 for a one storey family house. Therefore it was chosen that a two storey one family house should be analyzed. In case for a two story one family house it is possible to ensure the house is more compact. The schematic house plan is shown below in figure 2.

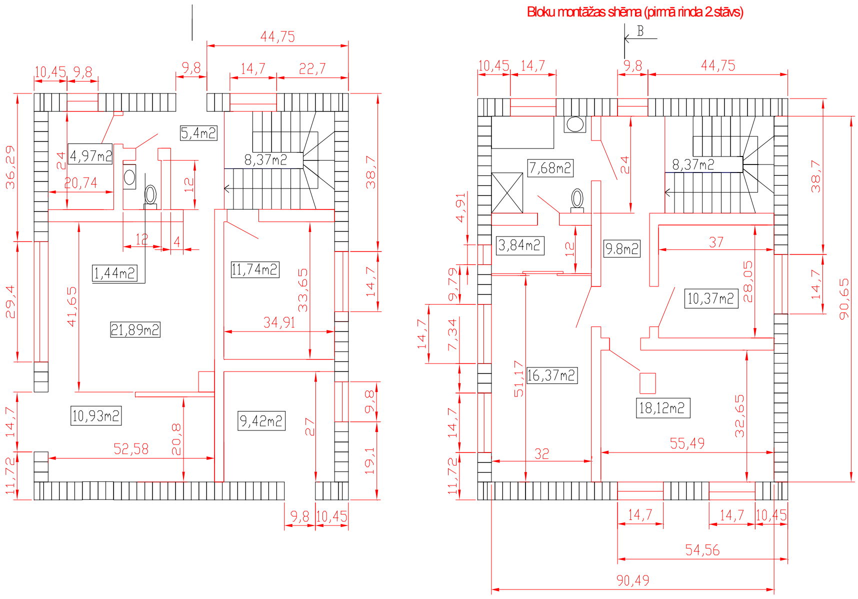

Figure.2. Schematic planning of a building (first and second floor).

It was offered to use thermally-technical properties as seen in table 3.

Table 3

Thermally-technical properties

Walls	Roof	Floor	Windows	Infiltration
U, W/(m^2*K)	U, W/(m^2*K)	U, W/(m^2*K)	U, W/(m^2*K) and g	h^{-1}
0,087	0,074	0,086	0,8 and 0,54	0,05

In this case worse windows were used and bigger infiltration allowed, but wall and roof constructions were improved. The simulation was performed for one regime with heat gains 4W/m^2. During the analyses energy conception 15,3 kWh/m^2 per year was achieved.

Energy consumption reduction

The saved energy if the passive conception is used is defined by comparing the proposed passive one story house parameters with those for a building of the same planning but designed according to the LBN 002-01 standard. The comparison is performed taking a building of the same size in which the same indoor microclimate is maintained. To bring about marked improvements, two versions of building were compared: one of them designed according to the above mentioned standard and another - according to the requirements imposed on passive buildings. In the former version (a building designed based on the LBN 002-01 standard) the best quality windows (U = 1,43 W/(m^{2}K)) are used that are available on the Latvian market and comply with building standards. When analyzing the data obtained in this work the energy consumption for such a building is 13340 kWh per year, which gives the figure of 83,3 kWh/m^2 per year, compared with the energy consumption for the latter version (a passive building) this is 4-5 times greater (see Fig.3).

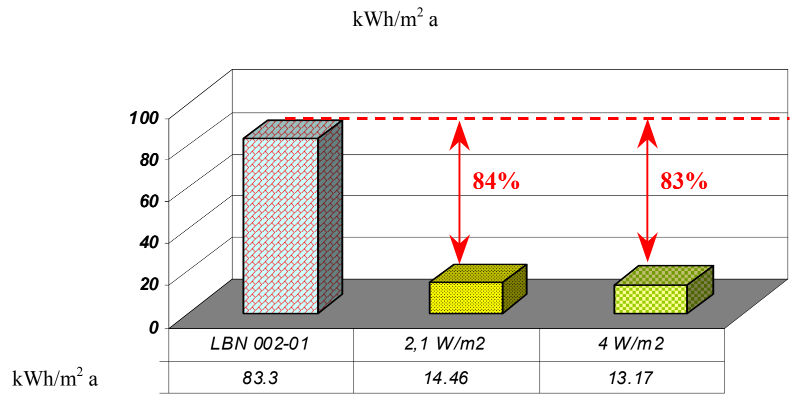

Figure.3. Energy consumption for heating for a building based on LBN 002-01 standard and a proposed passive building.

For proposed two story house savings are around 70% compared with building if it would be designed according to the LBN 002-01 standard. As can be seen, there is a marked decrease in the energy consumption for a building designed according to the passive building conception as compared to that based on the LBN 002-01 standard.

Conclusions

The passive building standard existing in Germany and Austria defines that its energy consumption for heating should not exceed 15kWh/m^2 and that the heat load should be limited by 10W/m^2. Using the simulation model of one story passive building, different heating conditions – the heat release of 2,1 W/m^2 and 4 W/m^2– have been considered. For two story building heat gains 4W/m^2 was used. In the former case (improvement of a building's design up to reaching very high thermally-technical indices) the energy consumption for heating is 14,46 kWh/m^2 per year and the maximum heat load – 17 W/m^2. In the latter case (the heat release of 4 W/m^2) these parameters are 13,17 kWh/m^2 and 19 W/m^2, respectively. For two story house with worse windows and bigger infiltration, but better walls the heat consumption 15,3 kWh/m^2 per year was achieved.
Using the passive building conception, we can achieve a considerable reduction in its energy consumption. Compared with a new building of the same size and planning erected in compliance with the LBN 002-01 standard it is possible to save up to 85% of energy for heating.

Acknowledgements

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Kamenders A., Blumberga A. Energoefektīvas vienģimenes ēkas koncepcijas izstrāde Latvijā.
Dzīvojamais fonds Latvijā ir nolietojies un energoneefektīvs. Augsts enerģijas patēriņš ēkās ir viens no vides degradācijas, vispārējas valsts atkarības no energoresursu importa un to cenām iemesliem. Rodot veidus efektīvai ēku energoefektivitātes paaugstināšanai, būs iespējams būtiski samazināt fosilā kurināmā izmantošanu, energoresursu importu un uzlabot vides aizsardzību valstī. Darbā tiek meklētas iespējas paaugstināt vienģimenes ēkas energoefektivitāti, izmantojot pasīvās ēkas koncepciju. Ar simulācijas programmas TRNSYS palīdzību tika noteikti ēkas konstrukciju siltumtehniskie raksturlielumi, lai ēka sasniegtu pasīvās ēkas rādītājus, kādi ir noteikti Vācijā un Austrijā. Darba gaitā izstrādāti ieteikumi viena un divu stāvu vienģimenes ēkai, lai tā sasniegtu pasīvās ēkas rādītājus. Ar izstrādātā simulācijas modeļa palīdzību tika noteikts, ka ēkās iespējams sasniegt enerģijas patēriņu, kas raksturīgs pasīvajai ēkai, kur enerģijas patēriņš apkurei ir līdz 15kWh/m^2 gadā. Izmantojot ēkās pasīvās ēkas koncepciju, iespējams sasniegt ievērojamus enerģijas ietaupījumus, salīdzinot, ja ēka tiktu konstruēta atbilstoši LBN 002-01, kas nosaka prasības ēku energoefektivitātei. Noteiktais enerģijas ietaupījums konkrētajām darbā piedāvātajām ēkām ir no 75% līdz 85%.

Kamenders A., Blumberga A., Energy efficient one family house development in Latvia.
Existing building stock in Latvia is energy inefficient and that why should be changed with energy efficient and environmentally friendly buildings. Excessive and non-adequate energy consumption in buildings leads to the environmental degradation, dependence form energy resource import and energy resource costs. The building sector is one of the most fast growing sectors in Latvia and ability to develop energy efficient and environmentally friendly building concept can help to solve this problems. Possibilities of developing passive buildings in Latvia are discussed in this paper. Simulation software TRNSYS has been used to create a model of passive building in Latvia's climate. The created simulation model is used to determine technical parameters that should be achieved for the building to conform to passive building indicators and ensure good climate inside the building in Latvia's conditions. With help of simulation model it was possible to clarify that it's possible to reach heat consumption less than 15kWh/m^2 per year for heating. Using the passive building conception, we can achieve a considerable reduction in energy consumption. Compared with a new building of the same size and planning erected in compliance with the LBN 002-01 standard it is possible to save from 75% to 85% of energy for heating.

Камендерс А., Блумберга А., Разработка концепции энергоэффективного односемейного дома.
Жилой фонд в Латвии изношен и энергонеэффективен. Высокое потребление энергии в зданиях-это одна из причин деградации среды, всеобще зависимости государства от импорта энергоресурсов и от их цен. Создавая возможности повысить энергоэффективность в зданиях будет возможно значительно снизить использование фоссильного топлива, импорт энергоресурсов и улучшить вклад в защиту окружающей среды в Латвии. С помощью симуляционной программы TRNSYS определены теплотехнические характеристики для конструкций здания, чтобы здание достигнуло показателей пассивных зданий, которые определены в Германии и Австрии. В ходе работы разработаны рекомендации для одно и дву-семейных домов, чтобы здание достигнуло показателей пассивного здания. С помощью разработанной симуляционной модели было констатированно, что в зданиях можно достичь такого потребления энергии, которая характерна для пассивного здания, энергопотребления для отопления составлял 15 кВт/$м^2$ в год. Применяя концепцию пассивных домов возможно достичь значительной экономии энергии, сравнивая с тем, если бы здание было бы построено в соответствии со стандартом LBN 002-01, который определяют требования к энергоэффективности здания. Определённая экономия для предложенных зданий составляет от 75 до 85 %..