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"Sustainable house" concept: Possibilities and limits of adaptation

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Publised: CESB13 - Central Europe towards Sustainable Building 2013. Konferencia kiadványa pp. 115-118. (ISBN:978-80-247-5015-6)

Summary:

The first version of the "sustainable house" concept, a design method based on local natural resources, was introduced in 2009. In this paper the latest version of the criteria system and its adaptability is discussed.

Keywords: sustainability; low energy consumption; zero-fossil energy consumption; cost-efficiency; feasibility of energetic criteria

1 Problem statement

The reduction of CO_2 emission and the energy consumption has become one of the major topics in building industry. There is a lot of discussion about the life-cycle cost analysis of possible energy conversation measures but there is not enough discussion about the limits of local renewable energy sources and the security of energy supply.

The "sustainable house" concept shows a method for the definition of the energy requirements of buildings based on the sustainable consumption of renewable energy sources.

2 Definition of the "sustainable house" concept

The keystone of the definition is that buildings and the operation of buildings have strategic importance. Namely satisfaction of some needs have priority over some others. Regarding the Maslow motivation theory the "safety needs" (security for self and possessions, etc.) are our most important things after the basic needs (hunger, thirst, sexuality, etc.). Buildings are one of the most important elements which can satisfy these needs as they can provide a frame to working, living, relaxation, etc.

The fundamental assumption of the "sustainable house" concept is that because of the strategic importance of buildings, all amount of "securely available energy sources" at present and in the close future, are consumed to satisfy the needs of buildings and food-production.

"Securely available energy sources" are the non-exhaustible renewable energy sources (solar, wind energy) and the exhaustible, but sustainably used renewable energy sources (biomass, geothermal). The fossil and nuclear energy sources are not securely available, as in 30-300 years the different sources will run out.

Although other human activities need energy (industry, traffic, etc.), but the present form of these activities are based on non-renewable energy sources. The volume of consumption is so high, that even by radically increasing the energy efficiency, there is no realistic chance to completely replace fossil fuels with renewable energies. Therefore it is a rational aim to solve the energy problem of buildings and agriculture, as strategically important fields, and separate them from the other types of consumption.

It is clear, that when phrasing the definition, we have to take care with the natural resources and the rate of resource consumption. We can define the "sustainable house" in the following way:

"Sustainable house" is a building the resource consumption of which throughout its life-cycle is not more than the resources available for that building in the examined area. [1]

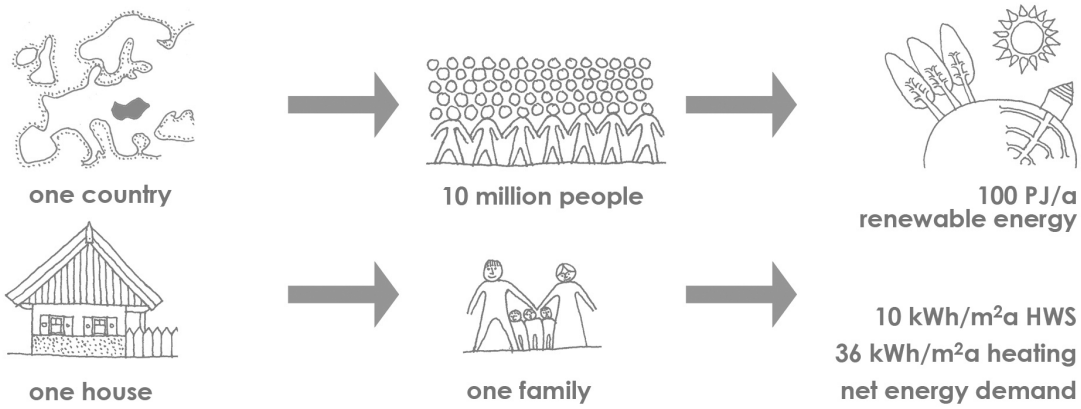

Fig. 1 *Energy system of "sustainable house" use the available energy sources in proportional way*

By taking into account the broader aspects of sustainable building activity to define the energetic criteria system, at least two important complementary notes must be made:

- Also the local environmental load must be studied in addition to the consumption of regional resources.
- When erecting buildings, efforts must be made for cost-effective optimization – instead of minimization of the environmental load (in this case energy use) -, subject to the regional conditions.

3 The energetic criteria system for "sustainable houses" in Hungary (version 3.0)

In the following, we examine the idea and criteria of the "sustainable house" only from the point of view of energy. The reason why we restrict our topic is that building energetic is nowadays the most important field of sustainable building, and we have reliable data on the energy consumption of buildings.

3.1 What does “sustainable consumption” of renewable energy resources mean?

3.1.1 Heating, domestic hot water production, cooking (thermal energy demand)

The solar energy available within the territory of the country is 1800 PJ, but the realistically utilizable energy is much more less because of the energy storage, as well as the initial cost of the equipment required for utilization does represent a problem.

The theoretical biomass potential of the country that can be utilized for energetic purposes is 203-328 PJ, of which 67-200 PJ energy can be utilized according to different calculations. We assume that at least 90 PJ biomass is consumed for space heating of buildings and for domestic hot water production.

A further possibility is the consumption of thermal water energy, primarily for larger-scale usage. According to the Subcommittee of Renewable Energy Technologies at the Hungarian Academy of Science, 10 PJ energy of the theoretical 63 PJ potential is realistically utilizable. [2]

3.1.2 Electric energy

In Hungary, renewable energy resources such as solar energy, wind energy and biomass energy can be harvested and converted into electric energy. The theoretical potential is considerable; according to the calculations of the Hungarian Academy of Science the theoretical photoelectric utilization potential of solar energy is 1800 PJ/year and that of the wind energy is 530 PJ/year, however, without biomass utilization the realistically recoverable potential is low, only approx. 15-25 PJ/year. [2]

3.2 What energetic standards the “sustainable house” has to comply with?

The available primary energy can be divided differently from the method described below it is subject to political decision which energy should be used for which purpose!

3.2.1 Thermal energy: domestic hot water demand

In Hungary the average hot water consumption is about 40-50 l/day/person in the residential and approx. 0-10 l/day/person in the communal sector. Renewable energy resources (60% solar energy, 40% biomass or thermal water) can be used to satisfy the domestic hot water demand. Considering the total population of the country, 10,000,000 “unit consumers” need 12,5 PJ net energy. Assuming 85% efficiency of the building service systems, this requires 14,5 PJ gross energy. Considering the typical domestic hot water demand of households and communal buildings (4:1) and with the floor area ratio of residential and communal buildings (2:1), net 10 kWh/m^{2}a biomass or thermal energy is required in case of residential buildings and net 5 kWh/m^{2}a in case of communal buildings.

3.2.2 Thermal energy: heating energy demand

Potentially 90 PJ biomass, 10 PJ geothermal energy and practically unlimited wind and solar energy can be harvested in Hungary. Since we have to use 14.5 PJ energy for domestic hot water production, only 86.5 PJ biomass and geothermal energy can be utilized for heating purposes. Therefore, we can calculate the heating energy demand according to the energy demand per square meter:

The building stock of Hungary represents about 480,000,000 m^2 (4,000,000 flats of average 80 m^2 area, and about half as much office and public buildings). With regard to the heating energy demand of this sector, the gross primary energy demand of the „sustainable

house“ runs up to 43 kWh/m^{2}a biomass or thermal water energy. The benchmark value can be specified as net heating energy demand of 36 kWh/m^{2}a, with reference to the energetic quality of the building and assuming 85% efficiency of building service systems.

3.2.3 Electricity demand: cooling, household appliances

In case of family houses, adequate architectural and structural design can completely eliminate the energy demand for cooling under the present climatic conditions.

If we wish to provide electric power for the „sustainable house“ only from water, wind and solar energy, 25 PJ energy is available. Considering the typical electricity consumption of households and communal buildings (1:1) and the floor area ratio of households and communal buildings (2:1), gross 11 kWh/m^{2}a in case of dwellings and gross 22 kWh/m^{2}a in case of communal buildings must be provided by harvesting water, wind and solar energy to meet the cooling, lighting and other electric energy demand of buildings.

4 Conclusions

The basic aim of the “sustainable house” concept is that the building systems should be designed and realized based on the local, “securely available” energy sources.

Theoretically the energy supply of buildings based on renewable energies is feasible in Hungary. The requirements of the criteria system 3.0 of the “sustainable house” concept for heating (36 kWh/m^{2}a) and DHW (10 kWh/m^{2}a) are higher than that can be achieved by well known construction systems (e.g. passive house). But the electricity supply based on renewable energy sources is critical question in Hungary.

By achieving this goal, an important step can be taken forward in the direction of energy independence and the improvement of external trade balance. The present upset environmental balance can recover by the sustainable consumption of renewable energies, which can reduce the risks caused by human overconsumption (like global climate change).

Further analyses are necessary to clarify

- the economically utilizable renewable potential of the country,
- how to reduce the need for heating and electricity parallel and in a cost effective way, not to overload the volume of “securely available” energy sources,
- how to achieve the “sustainable house” concept considering the obstacles of existing buildings (urban environment with low solar radiation, historical buildings, etc.).

References

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