WAYS FROM PASSIVE TO ZERO-ENERGY HOUSE

Jan Tywoniak
Faculty of Civil Engineering, Czech Technical University in Prague, Czech Republic

Summary

Paper deals with the design of zero energy houses in the climatic and social conditions of Czech Republic. In the first part, the general problem of definitions is discussed: what type of "zero" should be considered as the most effective to reach the overall environmental targets. The second part of the paper shows one built example – family house at passive house level equipped by PV on roof reaching the zero-energy target in yearly balance of primary energy.

Keywords: passive house, zero-energy house, photovoltaics, primary energy

1 Zero energy building – definition problem

There are still several possibilities how to interpret the meaning of net zero energy building (ZEB) [1], even if restricted to yearly balance of use and production and to residential buildings only. The choice of methodology of consideration (see Table 1) and its consequences should be discussed very carefully. An adequate combination of energy savings and energy production respecting the energy origin is highly needed. Usually, photovoltaic (PV) installation plays a crucial role in energy balance of each zero energy building. On the other hand, the PV production supported by public money (feed-in tariff), should not excuse the energy wasting by operation of particular building.

Tab. 1 Types of zero-energy considerations

Short description	Principle of evaluation	Units
Zero energy house (final energy – level 1)	Yearly balance of all energy demands and all production with renewable sources. Expressed in final energy	MWh/a
Zero energy house (final energy – level 2)	As above, in the renewable production no delivered energy. In final energy.	MWh/a
Zero energy house – primary energy	Yearly balance of energy demands and production. In primary energy.	MWh/a
„Zero-carbon"	Yearly balance of all energy demands and production. In equivalent carbon dioxide emissions	t/a
„Zero energy operation costs"	Yearly balance of all operation costs and production related to energy	CZK/a
„Zero energy import house"	No fossil fuels imported	different

2 Case study

2.1 Description

Typical single-family house was analyzed to study the possibility of reaching the zero-energy targets. Passive house for 4 person with the floor area of 150 m^2 needs 3,8 MWh/a for space heating, 2,8 MWh for hot water and 3,6 MWh for electricity (auxiliary + appliances) using the default values from [2]). Energy system is equipped by pellets heating (alternative A) and solar collectors, gas heating and solar collectors (B) and heat pump (C), respectively.

2.2 Assessment

The energy assessment is based on Czech preliminary standard [2], which slightly differ from PHPP [3] model. Basic data (energy for hot water per person, auxiliary energy according to technical equipment used, energy for electrical appliances per person) are fix default values. The heat use for space heating was calculated according to [2]. The final energy, primary energy and equivalent carbon dioxide emission values are expressed in Tab.2. Electricity for appliances is quite high (aprox.1/3 of total operation energy), if the space heating is reduced to passive house level.

Following data for conversion factor of primary energy were used: for electricity in public grid 3,0, for gas 1,1, for solar thermal system and wood 0,05, for PV 0,2 [2]. Independent PV-production replace the conventional electricity in public grid, therefore the conversion used in the calculation corresponds to value: 0,2-3,0 = -2,8.

For alternative A the zero level was reached in all types of considerations, except of final energy. To reach the same quality in alternatives B and C the PV system has to be at least 15% - 25% larger (Tab.3).

Tab. 2 Overall survey for case study, alternative A

Energy values in MWh/a	**Energy use**	**Energy sources for house operation**			**PV**	**Evaluation**
		electricity	**wooden pellets**	**solar thermie**		
Space heating	3,8	0	3,4 (90 %)	0,4 (10 %)		
Hot water	2,8	0,3 (10 %)	0,8 (30 %)	1,7 (60 %)		
Auxiliary energy	0,4	0,4	0	0		
Appliances	3,2	3,2	0	0		
Total	10,1	3,9	4,2	2,0	4,8	
Final energy (level 2)		use: 10,1, production RES: 2,0 + 4,8 = 6,8				Difference: 3,3 NO
Primary energy		11,6	0,2	0,1	-13,4	-1,5 YES
Equiv.carbon dioxide emission [t/a]		2,7			-3,1	-0,4 YES
Yearly energy costs [thousands CZK]		8	4		-50	-38 YES

Tab. 3 Comparisons of alternative solutions A, B, C

	A	B	C
Specific heat demand for space heating (TNI) [2] (limit 20 kWh/(m^{2}a))	20 kWh/(m^{2}a) required in the case study		
Primary energy (TNI) [2] (limit 60 kWh/(m^{2}a))	16 kWh/(m^{2}a)	39 kWh/(m^{2}a)	50 kWh/(m^{2}a)
Primary energy (PHPP) [3] (limit 120 kWh/(m^{2}a))	80 kWh/(m^{2}a)	103 kWh/(m^{2}a)	114 kWh/(m^{2}a)
Final energy (level 2)	3,3 MWh/a	2,6 MWh/a	0,9 MWh/a
Total primary energy	-1,5 MWh/a	2,0 MWh/a	3,6 MWh/a
Equivalent emissions	-0,4 t/a	0,5 t/a	0,8 t/a

3 Built example

The single-family house corresponding to case study described above (House T, overall heated floor area 150 m^2) was built in Prague in 2009-2010. The load-bearing structure consists of prefabricated concrete skeleton with concrete floor. The building envelope is created by wooden elements, close to 2 x 4 traditional structural principles.

Passive house level according to [2] was reached using usual means: highly insulated building envelope with mean U-value not exceeding 0,16 W/(m^{2}K), mechanical ventilation with very efficient heat recovery, partially working in circulation mode, wooden pellets-heating, solar thermal system. There is a PV-system on the roof (5,8 kWp). The electric current of maximum 20 A allows the cost effective single-phase supply to public grid (with one DC/AC invertor only).

4 Concluding remarks

The overall energy assessment confirmed the possibility to reach a zero energy level by small family house using tools, which are already known and in some extend practically used. The total primary energy balance shall be used for assessments preferably.

Necessarily, the energy concept should start by passive house strategy. In such case is it possible to use relatively small PV-system, which fits to the un-shaded and free part of a roof, by acceptable investment costs.

Additionally, financial incentives for passive house level (carbon trading fund in the Czech Republic) and motivating feed-in tariff can be used very effectively.

The key question for overall design concepts of larger apartment buildings is the availability of un-shaded areas on roofs and facades in needed extend. The symbiotic effect of PVT systems (common production electricity and heat in one element) can be of advantage here.

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Fig. 1 House T – passive single-family house with combined structure (prefabricated concrete + wooden elements) can be also described as a zero-energy house. The house is equipped by solar thermal system (4 m^2) and photovoltaic system (5,77 kWp) on the south part of the roof. (Design: Tywoniak et al., 2008).

References

[1] Documents of European Council for an Energy Efficient Economy (www.eceee.org) and U.S. Department of Energy

[2] TNI 73 0329, Simplified calculation method of assessment and classification of residential building with very low energy demand for space heating – Family houses. ÚNMZ 2009 (In Czech)

[3] Passive House Planing Package 2007. (PHPP 2007). Requirements for Quality Approved Passive Houses. Passivhaus Institut Darmstadt, 2007