Zero Energy Residential Buildings in Czech Conditions

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Abstract

Paper brings basic remarks on possibilities of reaching zero-energy level by residential buildings in Czech Republic. In the first part, one built example of family passive house equipped with PV-system of appropriate size is presented. Its energy performance (operation energy demand and energy sources together with independent PV-production) on the yearly basis is explained. Proposed criteria combine the primary energy balance of the building on with the declaration of reaching best available level in minimizing energy for space heating. Existing incentives for passive house (offered from carbon trading fund) and motivating feed-in tariff can be exploited very effectively to reach such ambitionus targets.

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 consideration level (see Table 1) and its consequences should be discussed very carefully. Usually, photovoltaic (PV) installation plays a crucial role in energy balance of each zero energy building. On the other hand, the PV electricity production supported by public money (feed-in tariff), should not excuse the energy wasting by operation of particular building. Therefore an adequate combination of energy savings and energy production respecting the energy origin is highly needed. For residential buildings, the energy concept should start by passive house level. New European Directive of Energy Performance of Buildings (EPBD) [2] is written in a very general way. It uses terms like "nearly zero energy building" without giving an exact definition. This should be set later on EU or national level.

Table 1 Possible 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. Iin final energy	MWh/a
Zero energy house (final energy – level 2)	As above, in the renewable production no delivered energy considered. 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 House T – built example of ZEB

2.1 Description

The family house (called House T) with overall heated floor area 150 m^2 was built in Prague in 2009-2010 (Fig. 1). The load-bearing structure consists of optimized prefabricated concrete skeleton with concrete floor. This increases the useful thermal inertia of the house effectively.The building envelope is created by wooden elements, close to 2 x 4 traditional structural principles. Passive house level according to [3] was reached using quite usual means: highly insulated building envelope with mean U-value not exceeding 0,16 W/(m^2K), wooden pellets-heating, solar thermal system, mechanical ventilation with efficient heat recovery, partially operating in circulation mode, etc. There is a PV-system on roof (5,77 kWp) with expected on-grid production 4,8 MWh/year. The electric current of maximum 20 A allows the cost effective single-phase supply to public grid (with one DC/AC invertor only).

2.2 Overall energy assessment

The energy assessment is based on Czech preliminary standard (TNI) [3]. Basic data (energy for preparing hot water per person, auxiliary energy according to technical equipment used, and energy for electrical appliances per person) are default values here. The calculation procedure for space heating is based on monthly method. The primary energy and equivalent carbon dioxide emission values are presented in Table 2. Following data were used for conversion factor primary/final energy: electricity in public grid 3,0, gas 1,1, solar thermal system 0,05, wood combustion 0,05, PV 0,2 [3]. Independent PV-production replace the conventional electricity, therefore the conversion used in the calculation corresponds to value: 0,2-3,0 = -2,8. The ZEB-level was reached in all types of considerations, except of final energy. Electricity for appliances is quite high here (aprox.1/3 of total operation energy), if the space heating is reduced to passive house level.

Table 2 Overall survey for house T

Energy values in MWh/a	Energy demand	Energy sources for house operation			PV	Evaluation (YES, NO)
		Electro	wooden pellets	solar thermal		
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)		demand: 10,1, production RES: 2,0 + 4,8 = 6,8				Difference: 3,3 NO!
Primary energy		11,63	0,21	0,10	-13,4	-1,5 YES
Equiv.carbon dioxide emission [t/a]		2,7			-3,1	-0,4 YES
Yearly costs [k.CZK]		8	4		-50	-38 YES

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

3 Discussion

Table 3 brings comparison of alternative solution of the family house described above. Energy system is equipped with wooden pellets heating and solar collectors (alternative A – as built), gas heating and solar collectors (alternative B) and heat pump (alternative C), respectively. 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 (Table 3). In such case the single phase feed-in to public grid would not be possible. Similar result brings the comparison of equivalent carbon dioxide values.

The total final energy is substantialy reduced to approx. 5 % to 20 % in comparison to business-as-usual solutions (effect of passive house concept and use of solar thermal system). Table 4 shows energy demand for building operation expressed in final energy values with significant large part for electricity for household appliances.

Table 3 Comparison of alternative solutions A, B, C

	A	B	C
Specific heat demand for space heating (TNI) [3] (limit 20 kWh/(m^2a))	20 kWh/(m^2a) as required		
Primary energy (TNI) [3] (limit 60 kWh/(m^2a))	16 kWh/(m^2a)	39 kWh/(m^2a)	50 kWh/(m^2a)
Primary energy (PHPP) [4] (limit 120 kWh/(m^2a))	80 kWh/(m^2a)	103 kWh/(m^2a)	114 kWh/(m^2a)
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

Table 4 Final energy in family house (yearly balance)

Use	%
Space heating	38
Hot water preparation (default value per capita)	28
Auxiliary energy (default according to technical system)	4
Household appliances (default value)	32

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. Nowadays in the Czech Republic, the passive house solution is supported by Green Investment Scheme effectively. The feed-in tarif for PV is motivating as well. Hopefully, both incentives remain, at least for some period of time. In our case, the needed size of PV allows the single-phase supply to public grid (electric current max. 20 A with one DC/AC invertor only). Based on further studies it can be stated that the balance of final energy (use and production on site) is not an optimal expression of the design quality. The challenging task for the best and cost-effective ZEB is to minimize the size of PV installation related to building by keeping the primary energy in balance on yearly basis. The key question for overall design concepts of larger apartment building in ZEB-quality is the availability of un-shaded areas on roofs and facades in needed extend. The symbiotical offect of PVT systems (common production electricity + heat in one element) can be of advantage here.

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References

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

[2] EU: Directive on Energy Peformance of Buildings, 2010

[3] 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)

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