COSTS OF REDUCTION OF ENERGY DEMAND IN CONSTRUCTION

Nataliya Anisimova
Czech Technical University in Prague, Faculty of Civil Engineering
Thakurova 7, 166 29 Prague 6, Czech Republic, nataliya.anisimova@fsv.cvut.cz

Summary

Demand for the non-renewable resources is in many cases can be expressed through energy consumption. The EU spring summit 2007 has adopted the target of a 20% share of renewable energies in overall EU energy consumption by 2020 and 20% reduction of greenhouse-gas emissions by 2020. The goal was affirmed in October 2008. "20-20-20" promise can be also expressed in 20%-reduction of primary energy demand. In the article was made an attempt to find the way of estimation of the costs of the achievement of this goal in the sphere of construction. The practicability will be first of all determined by the costs of energy demand reduction. The article describes a way of definition of primary energy demand and several variants of its reduction with their costs at the example of a timber frame two-storied dwelling house. The value of primary energy per one square meter of usable floor area is defined with the help of German software ROWA. After that several ways of a 20%-reduction in primary energy demand are evaluated.

Keywords: final energy, primary energy, energy demand reduction, costs.

1 Estimation of energy demand of a building

For the calculation of energy demand in our task it was necessary to choose a reference building. As the greatest part of energy is consumed for the heating of buildings it is quite reasonable to estimate first of all an energy demand of a typical dwelling house. Our reference building is a timber frame two-storied dwelling house. Main characteristics of the building necessary for our evaluation are:

- gross cubic content V_{ae}= 757.1 m^3;
- covering area of the building A = 500.8 m^2,
- usable floor area A_n= 242.3 m^2;
- ratio of covering area to cubic content A/V_{ae} = 0.66 1/m;
- windows area A_w = 52.8 m^2;
- percentage of windows area in total covering area f = 19.1 %.

Heating system of the reference building is a gas combustion boiler with hot water accumulator inside heating area.

1.1 Final energy demand

For our study we need to estimate *primary energy* demand and its reduction costs for the reference building first. Primary energy value is derived from the final energy amount.

Final energy demand for a dwelling house is formed by heating energy, hot water heat energy and energy loss of heating system.

Heating energy demand is the amount of energy which is transferred to a room through heating system. Hot water heat energy is the amount of energy needed to heat domestic water. It means that *final energy demand* Q_E is calculated as follows:

$$Q_E = e_H Q_H \cdot e_W Q_W \quad (1) \quad [2]$$

where Q_H is heating energy demand, e_H is energy loss of heating system, Q_W is a demand for domestic water heat energy and e_W is energy loss of domestic water heat system. We don't take into consideration e_W in our calculation. Hot water energy demand standardly equals Q_W = 12,5 kWh/m²a for our calculation. [2]

1.2 Primary energy demand

Demand for *primary energy* for a dwelling building is formed by energy demand for heating and hot water, and energy loss during generation, preparation and transportation of energy carrier to the building. It takes into account the source of the energy we use to cover our energy loss and possibility of renovation of the energy. Primary energy demand Q_P equals to:

$$Q_P = (Q_H + Q_W) \cdot e_P \quad (2) \quad [2]$$

where e_P is energy loss coefficient for the heating system. It means that primary energy demand is in the great part determined by the heating system of building. Energy loss coefficient describes energy loss of heating system and energy benefits from environment and expresses total energy efficiency of technical system of the building.

Energy loss coefficient for different heating systems equals to:

- 0,5 – 0,6 – wood-pellet heating,
- 0,7 – 0,9 – heat pump,
- 1,3 – 1,4 – combustion heating,
- 1,5 and more – old heating system.

2 Energy demand evaluation for the reference building

Final energy demand for the reference building is calculated on the base of constructional heat balance. Figure 1 demonstrates the initial data for the energy demand evaluation. The calculation is performed by means of construction physics software ROWA. Main results of the calculation are *transmission heat loss* H'_T of total building covering which characterizes quality of the constructional parts of the building and air tightness of the construction and *primary energy demand* Q_P which shows the efficiency of energy loss covering and takes into account environmental aspects of energy consumption. [1]

Tab. 1 Main characteristics of the reference building.

Indicator	Value	Unit
Annual heating energy demand Q''_H	58.19	kWh/m^2·a
Transmission heat loss H'_T through building covering	0.373	W/m^2 K
Annual final energy demand Q_E	70.67	kWh/m^2·a
Annual primary energy demand Q_P	**91.0**	**kWh/m^2 ·a**
CO_2 emissions per m^2 of usable floor area	20.62	kg/ m^2·a

For the calculation of CO_2-emissions, the values of Global Emission Model for Integrated Systems (GEMIS) 4.13 were used, see [3]. CO_2-emission value is derived from the amount of primary energy needed to cover energy losses. Results of the calculation are showed in Table 1.

	Bauteil	Bez.	Ri.	Fläche [m²]	U-Wert [W/m²K]	Fak.	% Gewinn	% Verlust
1.1	WH AW Oevonatur Putz	AwWest	W	38.38	0.153	1.00	0.304	3.662
1.2	WH AW Oevonatur Putz	AwNord	N	38.91	0.153	1.00	0.308	3.713
1.3	WH AW Oevonatur Putz	AwOst	O	39.01	0.153	1.00	0.309	3.722
1.4	WH AW Oevonatur Putz	AwSud	S	22.41	0.153	1.00	0.177	2.138
1.5	Weberith AW 10-035 g. Erde	KwWest	W	12.38	0.377	0.60	----	1.478
1.6	Weberith AW 10-035 g. Luft	KwaWest	W	9.99	0.320	1.00	0.165	1.990
1.7	Weberith AW 10-035 g. Erde	KwNord	N	26.50	0.377	0.60	----	3.164
1.8	Weberith AW 10-035 g. Luft	KwNord	N	3.06	0.320	1.00	0.051	0.610
1.9	Weberith AW 10-035 g. Erde	KwOst	O	21.50	0.377	0.60	----	2.566
1.10	Weberith AW 10-035 g. Luft	KwaOst	O	2.50	0.320	1.00	0.041	0.498
1.11	Weberith AW 10-035 g. Erde	KwSud	S	27.26	0.377	0.60	----	3.254
1.12	Weberith AW 10-035 g. Luft	KwaSued	S	3.06	0.320	1.00	0.051	0.610
1.13								
2	**Fenster, Fenstertüren**							
2.1	zertifiziertes Fenster 1,4	AwWest	W	15.02	1.400	1.00	12.179	13.086
2.2	zertifiziertes Fenster 1,4	AwNord	N	4.11	1.400	1.00	3.332	3.580
2.3	zertifiziertes Fenster 1,4	AwOst	O	10.98	1.400	1.00	8.904	9.568
2.4	Haustür mit Fenster 1,2	AwOst	O	3.41	1.200	1.00	0.715	2.548
2.5	zertifiziertes Fenster 1,4	AwSud	S	14.57	1.400	1.00	11.815	12.696
2.6	zertifiziertes Fenster 1,4	KwaWest	W	2.39	1.400	1.00	1.935	2.079
2.7	zertifiziertes Fenster 1,4	KwNord	N	0.76	1.400	1.00	----	0.659
2.8	zertifiziertes Fenster 1,4	KwOst	O	0.76	1.400	1.00	----	0.659
2.9	zertifiziertes Dachfenster 1,4	DaNord	N	2.27	1.400	1.00	2.623	1.974
2.10	Luke gg. Dach	De g. DG	-	0.77	2.000	0.80	----	0.767
2.11								
3	**Decke zum Dachgeschoß, Dach**							
3.1	WH Dach Sp-Abstand 80cm	DaNord	N	26.47	0.190	1.00	0.214	3.124
3.2	WH Dach Sp-Abstand 80cm	DaSud	S	39.90	0.190	1.00	0.322	4.709
3.3	WH Decke geg. unb. DG 6cm	De g. DG	-	40.54	0.188	0.80	----	3.796
3.4								
4	**Grundfläche, Kellerdecke**							
4.1	WH BP ZE19A o.FLH	Bodenpl.	-	85.10	0.300	0.75=	----	12.946

Fig. 1 Primary energy demand calculation for the reference building.

3 Variants of reduction of primary energy demand

For the evaluation of costs connected with reduction in primary energy demand in a dwelling house there were chosen several examples most popular by investors nowadays. In each example some measure leading to primary energy reduction by approximately 20% as against reference building is proposed. The following three samples are evaluated in our study:

Sample 1. Additional solar domestic hot water system.

Sample 2. Additional mechanical ventilation system with 80% heat recovery. In this case it is necessary to perform a Blower-Door-Test to proof air tightness of the building.

Sample 3. Installation of air-to-water heat pump for heating and hot water supply instead of gas combustion boiler (reference building).

Tab. 2 Evaluation of primary energy demand reduction.

Indicator	Unit	Sample 1	Sample 2	Sample 3
Annual final energy demand Q_E per m^2	kWh/m^2·a	66.08	63.14	70.67
Annual primary energy demand Q_P per m^2	kWh/m^2·a	72.60	72.50	68.80
Reduction in primary energy demand	**%**	**20.22**	**20.33**	**24.39**
CO_2 emissions per m^2 of usable floor area	kg/ m^2·a	16.51	16.66	17.39
Costs of reduction in energy demand	**EUR**	**4 711**	**12 525**	**9 890**

For each sample was performed the calculation of energy demand, transmission heat loss, CO_2-emissions and was made the evaluation of the amount of additional investment needed for the proposed measure realization. Samples' evaluation is demonstrated in Table 2.

It's obvious that every investor will choose different variant of energy efficiency for his house. By combination of such a measures it can be estimated what amount of money should be invested in the primary energy demand reduction corresponding to the stated goals in EU-countries. State authorities then should stimulate a sufficient motivation of investments in energy demand reduction. This could be made by means of bonuses, subsidies or tax discounts. If we take an average value of money which is needed to be additionally invested by new-built house in our study we receive 9 921 €, it means 40.95€/m^2.

4 Conclusions

The main indicators of energy performance of a dwelling house in our study are transmission heat loss and primary energy demand. There was made an attempt to evaluate possibilities of reduction in primary energy demand, which characterises an environmental efficiency of energy loss covering in the building. By such a method we can choose necessary measures for 20% energy demand reduction and their combination.

By further research with the help of additional tools it is possible to estimate the amount of funds in different support programs motivating energy demand reduction in dwelling houses needed on a national scale for different EU-countries.

This paper is originated as a part of a CTU in Prague, Faculty of Civil Engineering research project on Management of sustainable development of the life cycle of buildings, building enterprises and territories (MSM: 6840770006), financed by the Ministry of Education, Youth and Sports of the Czech Republic.

References

[1] EN ISO 13789: Thermal performance of Buildings – Transmission heat loss coefficient. Calculation method.

[2] Verordnung über energetischen Wärmeschutz und energiesparende Anlagentechnik bei Gebäuden (Energieeinsparverordnung - EnEV) vom 24. Juli 2007. Bundesgesetzblatt Jahrgang 2007 Teil I, pp. 3085 – 3102. (*in German*)

[3] Gesamt–Emissions-Modell integrierter Systeme (GEMIS), Version 4.13, Öko-Institut Darmstadt, Freiburg, Berlin, Kassel: Herausgeber: Hessisches Ministerium für Umwelt, Energie und Bundesangelegenheiten, Wiesbaden, 2002. (*in German*) WWW: www.gemis.de.