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KEY NUMBER PARAMETERS FOR EVALUATION OF BUILDINGS ENERGY EFFICIENCY*

Key Number Method for quick evaluation of energy conservation measures worked out by Norwegian Company ENSI is presented. For further development and usage of this method in Russia parameters for main types of buildings in 10 different regions were calculated and collected.

Key words: Energy conservation, key number method, reference buildings, climatic data

INTRODUCTION

To develop energy efficiency of buildings several alternative solutions should be compared, and the corresponding energy consumption should be calculated. For detailed energy calculations several computer programs are available, however, they usually require large quantities of input data. To carry out all necessary calculations and to conduct results' evaluation from the point of an optimal solution require a lot of time.

The Norwegian company ENSI has developed the "Key Number Method" for quick energy calculations, dealing with design of new buildings, buildings' renovation, and implementation of energy conservation measures in existing buildings.

Based on the Key Number Method, the company has developed the user-friendly Key Number Software to assist engineers and technicians in quick calculations of the energy profile of new and existing buildings. The Key Number Software is partly based on results from advanced computer simulations and partly on experience and measurements from real projects. ENSI has essentially reduced the number of input values and focuses on the most important parameters dependent on major, alternative, energy efficient solutions/measures.

KEY NUMBERS

The key numbers are presented in both standard energy and power demand budgets, as well as in a more detailed form in the software.

The following energy and power demand budget comprise the key numbers for office buildings in Oslo (table 1).

The annual energy consumption [kWh/year] and specific, annual energy consumption, [kWh/m^{2}year] (per m^2 heated area) are given for each budget item, as well as total and specific power demand (kW and W/m^2). In this way, different buildings can be compared, and the energy efficiency of a building can undergo a preliminary evaluation comparing its energy consumption with the key numbers.

The key numbers based on specific energy consumption provide a direct expression of the energy efficiency of the building, similar to the expenditure of petrol per km indicative of vehicles' energy efficiency.

Table 1

Office building data for Oslo (Norway) according to different codes

Budget item	«Older» buildings		Building codes 1987		Building codes 1997	
	[kWh/ m² yr]	[W/ m²]	[kWh/ m² yr]	[W/ m²]	[kWh/ m² yr]	[W/ m²]
1. Heating	94	52	62	39	44	31
2. Ventilation	32	42	35	48	24	33
3. Domestic Hot Water	10	6	10	6	10	5
4. Fans and pumps	17	6	21	8	17	5
5. Lighting	32	16	32	16	26	13
6. Various	24	14	24	14	24	14
7. Cooling	4	15	4	15	4	15
Total	213		188		149	

Key Numbers for new buildings provide guideline values for buildings under construction according to the latest building codes and standards, including energy efficient solutions.

DETAILED KEY NUMBERS

For quick calculations of energy consumption by an individual building, the detailed Key Number Method is used in design of new buildings, buildings' renovation, and implementation of energy conservation measures in existing buildings.

Key Number Method focuses on the most important parameters influencing energy consumption. Based on a set of the countries' unique input values such as reference values, guideline values for energy consumption, and power demand, the energy consumption can be determined. These input values are given for different types of buildings and climatic zones.

According to Table 1, the key number for heating an office building, according to the building codes of 1987, is 62 kWh/m^{2}year. This corresponds with line "1. Heating" in Table 2 for comprehensive key numbers.

Table 2

Key numbers for an office building in Oslo (Norway)

Parameter	Reference	Condition	Before ENCON	Sensitivity [kWh/m^2 yr]	ENCON measure	After ENCON
1. HEATING			62 kWh/m^{2}yr			
U-wall	0,30 W/m^{2}K	0,3	0	+ 0,1 W/m^{2}K = + 6,6	0,3	0
U-window	2,40 W/m^{2}K	3,0	8,9	+ 0,1 W/m^{2}K = + 1,5	1,3	-25,3
U-roof	0,20 W/m^{2}K	0,6	6,8	+ 0,1 W/m^{2}K = + 1,7	0,6	0
U-floor	0,30 W/m^{2}K	0,3	0	+ 0,1 W/m^{2}K = + 1,7	0,3	0
Form-factor	0,36	0,36	0	+ 0,1 = + 9,0	0,36	0
Window area	15 %	15 %	0	+ 1 % = + 1,7	15 %	0
Total solar gain	0,55	0,55	0	+ 0,1 = - 1,5	0,55	0
Infiltration	0,25 h^{-1}	0,3	5,7	+ 0,1 h^{-1} = + 11,3	0,3	0
Lighting	16 W/m^2	16	0	+ 1 W/m^2 = - 0,7	16	0
Various equipment	11 W/m^2	11	0	+ 1 W/m^2 = - 0,7	11	0
Sum 1			83,4			
Net room height	3,2 m	3,2 m	0	+ 10 % = + 7 % of sum 1		
Sum 2			83,4			
Indoor temperature	21 ºC	24	17,8	+ 1 ºC = + 7 % of sum 2	21	-17,8
Distribution system	98 %	98 %	0	+ 1 % = - 1 % of sum 2	98 %	0
Automatic control	Modern	Modern	0	Poor = + 3 % of sum 2 Manual = + 5 % of sum 2	Modern	0
Temperature set back	Yes	No	5,8	No = + 7 % of sum 2	Yes	-5,8
Sum 3			107,0			
O&M / Energy management	98 %	93	5,4	+ 1 % = - 1 % of sum 3	98	-5,4
Sum 4			112,4			58,1
Energy supply efficiency	100 %	100 %	0	+ 1 %= - 1 % of sum 4	100 %	0
1. Heating corrected			112,4			58,1

The most important "Parameters" influencing the energy demand for heating are listed in the first column. For each parameter "Reference" values are given. In this example the reference values are presented for office buildings according to the Norwegian building codes of 1987. With these reference values and climatic data for Oslo, the energy demand for heating is 62 kWh/m^{2}year.

Existing "Conditions" for the building to be calculated are shown in the next column. If the existing condition is different from the reference value, the changes in energy consumption are calculated by the "Sensitivity", and results are listed in the column "Before ENCON" (ENCON – ENergy CONservation).

By describing alternative solutions or energy conservation measures in the column "ENCON measure," corresponding savings are calculated by the sensitivity, and results are listed in the column "After ENCON". The Key Number Software is a suitable tool to make these calculations quick and easy.

There are similar tables for each budget item in the total energy budget (Heating, Ventilation, Domestic hot water, etc.) presented in the software. Also detailed worksheets for each type of buildings are presented in the software.

Key numbers are based on some given conditions, or reference values (i.e. u-values, ventilation rates, operating periods, internal heat loads, efficiency factors, etc.). The reference values are partly based on national building codes and standards, partly on experience data from various projects, and partly on evaluations of what should be considered as profitable energy efficient solutions for the actual type of a building.

The Key Number Method is useful in the following cases:

- Establishing energy and power demand budgets;
- Performing energy evaluations of new or existing buildings;
- Calculating savings from alternative solutions/ ENCON measures.

The standard input values for all parameters (reference values) are included as default in the software, therefore energy calculations can be performed very quickly with the Key Number Software. The energy

calculations are made by changing only those values which are different from the standard input values.

The software can be used at various stages of a project. At the beginning preliminary calculations based on changes of the most important parameters provide engineers with the energy profile of the building. As the project develops, and information on the other parameters is defined, the software can also aid the user in more detailed calculations.

The key numbers do not replace advanced computer-based energy evaluations during detailed energy simulations and studies of alternative solutions. However, they can be used as an important tool at various stages of the project.

COUNTRIES' UNIQUE KEY NUMBERS

The philosophy behind the Key Number Method is that each building category has an energy signature or profile – based on the type of construction, technical installations, user patterns, etc. – described by reference values built into the software.

While determining key numbers for different countries, the decision must be made about the number of different types of buildings available in the software, as well as the reference values for each of them.

Usually they are calculated for the following types of buildings according to the algorithm worked out by ENSI Company:

- Office buildings;
- Hospitals;
- Schools;
- Universities;
- Kindergartens;
- Apartments;
- Single family houses;
- Multi-family houses;
- Warehouses (indoor temperature 15 °C).

According to the period of construction in Norway three levels of key numbers for each mentioned above types of buildings have been developed:

- Old buildings (designed before the year of 1987);
- Buildings designed according to codes of the year 1987;
- Buildings designed according to codes of the year 1997.

In addition to national reference values, local weather data are used to create country unique key numbers. In the Norwegian version 45 climatic zones are included in the software based on monthly climatic data.

The Norwegian authorities have selected the Key Number Method and the Key Number Software as the official tools to be used by Norwegian energy advisors, engineers, regional energy efficiency centres, etc.

RUSSIAN VERSION OF KEY NUMBERS

The author of this paper worked with the Company ENSI in order to prepare the Russian version of key numbers for the types of buildings mentioned above. Ten regions in different parts of Russia were selected for such kinds of buildings: Arkhangelsk, Belgorod, Moscow, Murmansk, Nizhniy Novgorod, Petrozavodsk, Saratov, St. Petersburg, Vladivostok, Volgograd. For all these cities and types of buildings mentioned above parameters were calculated and climatic data were collected. Using these data and a special algorithm the ENSI Company generated key numbers for the Russian version of the software. Table 3 presents the fact data for an office building in Petrozavodsk (Russia) considered as reference values for a building of this type.

Table 3

Office building data for key number parameters in Petrozavodsk

Parameter	Older	1996	2000
Heating			
U-wall W/m²K	1,3	0,66	0,55
U-window W/m²K	2,6	2,5	2,3
U-roof W/m²K	1,0	0,45	0,40
U-floor W/m²K	1,0	0,45	0,40
Window area %	18	18	18
Total solar gain %	0,60	0,60	0,55
Infiltration h-1	0,30	0,30	0,30
Lighting W/m²	10	10	10
Various equip. W/m²	5	5	5
People W/m²	4	4	4
Indoor temp. °C	18	18	18
Distribution syst. %	97	97	97
Automatic control	97	97	97
Temp. set back %	-7	-7	-7
Common Parameters			
O&M / EM %	98	98	98
Energy supply efficiency %	98	98	98

Parameter	Older	1996	2000
Ventilation			
Operating per. h/week	55	55	55
Ventilation rate m³/hm²	8	8	8
Design indoor temp. °C	18	18	18
Heat exchanger %	50	50	50
Automatic control %	98	98	98
Hot water			
Sanitary install. l/m²	150	150	150
Kitchen l/m²	250	250	250
Distribution system %	98	98	98
Automatic control %	98	98	98
Fans and pumps			
Operating per. h/week	55	55	55
Fans W/m²	6	6	6
Pumps, h & v W/m²	0,2	0,2	0,2
Pumps, cooling W/m²	0	0	0
Lighting			
Utilisation per. h/week	40	40	40
Simultaneous power W/m²	10	10	10
Various			
Utilisation per. h/week	35	35	35
Simultaneous power W/m²	5	5	5

Table 3 is just an example of different data calculated and collected for one city and one type of buildings. Additional information includes design temperature and solar radiation of the building at that place. Such data has been prepared for all types of the buildings mentioned above for every city under consideration.

Actually, we have prepared research results for reference buildings of different types – the problem has been set for the state members of the European Union in the following documents:

- Directive 2002/91/EU of the European Parliament and of the Council [1];
- Directive 2010/31/EU of the European Parliament and of the Council [2];
- Regulations No 244/2012 on the energy performance of buildings [3].

In these documents a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements were established.

It reads: "Member States shall establish reference buildings for the following building categories:

1. Single-family buildings;
2. Apartment blocks and multifamily buildings;
3. Office buildings.

In addition to office buildings, Member States shall establish reference buildings for other non-residential building categories listed in Annex I paragraph (5) from (d) up to (i), to Directive 2010/31/EU for which specific energy performance requirements exist".

CONCLUSIONS

Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of Eco design requirements for energy-related products provides for the establishment of minimum energy performance requirements for such products. And Commission Delegated Regulations (EU) No 244/2012 of 16 January 2012 establishes a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for new and existing buildings and building elements. To use this methodology it is necessary to establish reference buildings for different building categories and fix average and economic data from energy conservation point of view. This task is not obligatory for our country because Russia is not a member of EU. But we made an attempt to solve this problem for some regions of the Russian Federation with the help of Key Number Method aimed to use advanced methods in energy conservation suggested by the European Union.

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