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Research Article

EVALUATIONS ON THE ENERGY IDENTITY CERTIFICATE AND THE USABILITY OF CALCULATION METHOD OF BUILDING ENERGY PERFORMANCE (BEP)

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ABSTRACT

In this study, the energy performances for the insulated and uninsulated statuses of a building located in Selcuklu district of Konya were determined and compared. The energy efficiency of the insulated and uninsulated building was examined using the Building Energy Performance Program (BEP-TR 2). In addition, the results obtained from this program was compared with the results obtained from TS-825 and was interpreted. Within the scope of the study, the project information of the building (geometry of building and heating, lighting, mechanical and ventilation system information) was entered into the BEP-TR Program, and clear energy amounts for the heating and cooling needs of the building were determined. Besides, the need of lighting energy, the amount of consumption and the emission amounts of carbon dioxide (CO_2) were determined in the days when the daylight was not utilized and in the areas that had no effect on daylight. Heat loss and heat gain calculations of the building have been made, according to TS-825. In consequence of the data obtained, the annual heating energy need of the insulated building was determined as 92 kWh/m² and the energy class was determined as C class, with the BEP –TR program. However, the annual heating energy need of the uninsulated building was 134 kWh/m² and the energy class was determined E class.
Keywords: Energy efficiency, building energy performance (BEP-TR), energy identity certificate.

1. INTRODUCTION

With the rapid population growth and developing technology all over the world and in our country, energy needs are increasing day by day. Therefore, energy efficiency gains important. Most of the available energy is spent on buildings. Especially, it is expected that there will be a decrease in fossil fuels and accordingly an energy shortage in the coming years. This reveals the importance of energy efficiency.

In order to use energy more efficiently and effectively, countries continue to work on energy efficiency. Especially the European Union, most of the energy produced in our country is consumed in buildings, and therefore energy efficiency studies are among the most current topics.

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In a study conducted in the literature on the Energy Performance of Buildings - Turkey Program (BEP) and the implementation of Energy Identity Certificate (EIC), the energy identity of the Building of Gaziantep Acceptance and Housing Center, which has European Union standards, has been determined in the province of Gaziantep, and the energy performance of the building was examined using the BEP program. Within this scope, using the mechanical, heating and geometry information of the building, energy consumption values were determined with the BEP-TR program, and evaluations have been made on how annual energy consumption values will affect the national budget and on the energy efficiency of a building with international standards [1]. In addition, the energy rate and CO_2 emission amounts consumed for the annual illumination of a building were evaluated. As a result of the study, program-borne errors were identified and solutions were proposed for these errors [2]. The Ministry of Environment and Urbanization developed a new version of the BEP-TR program (BEP) and launched it in 2014. By using this program, more comprehensive and sensitive results are obtained today [3].

In a master's thesis study, methods that increase energy efficiency and the international energy certification systems in residences were examined. Also, the BEP-TR program has been examined and shown its usage; and the BEP-TR program has been compared with other systems that provide certification [4]. In another study, in four different provinces in different regions of Turkey, energy performance class and energy identity of the same building were determined using BEP-TR program. Energy identity class of the buildings was calculated as C class for Istanbul, Ankara, Erzurum; and D class for Antalya. Comparisons were made on the energy performance results of the buildings depending on the provinces [5].

In another study, it examined and was compared the international energy certification systems and the energy certification systems applied in Turkey. Within this scope, the Directive on the Energy Performance of Buildings in Turkey was examined and evaluated [6]. In another study, energy performance classes of the buildings located in 6 different neighborhoods in Korkuteli district of Antalya were determined with the BEP-TR program and it was found that the energy performance class of these buildings were C class. For buildings with different locations and topologies, comparisons were made in terms of the energy efficiency [7]. In a different study where situation analyzes were made according to the architectural settlement location, the researchers emphasized that the energy efficiency should be revised with results obtained according to the settlement location. In this context, it was emphasized that the energy efficiency is the same as the results obtained from the Relux and Carrier-HAP programs and the results from the BEP-TR program. Comparisons were made between different operating modules, heating, ventilation, cooling and lighting conditions, and more comprehensive information was obtained. Values for lighting were compared using the Relux Module [8].

The BEP-TR has been a program which is used in the energy class implementation in buildings in our country as well as in the world, and provides more accurate results within the scope of improvements made for buildings. With the EIC (Energy Identity Certificate) implementation, the building energy class in Turkey has been correctly identified and uncovered significant results on behalf of energy efficiency [9].

2. MATERIAL AND METHOD

In this study, an energy efficiency analysis was made with the BEP-TR program for a sample building belonging to Selcuklu district of Konya and energy class was determined. This building consists of a block including 10 apartments in Selcuklu district of Konya. In addition, it consists of 6 floors including the basement and there are 2 apartments on each floor. In this study, TS-825 calculation method and BEP-TR method were used for the conditions of the building before and after insulation, and the results obtained from both methods were compared. Building heat loss and heat gain calculations were made for TS 825 method and energy performance in buildings was obtained by entering building mechanical system information in BEP program.

According to TS 825, the annual heating energy calculation of the building is calculated as follows [10]

$$Q_{year} = \sum Q_{month} = \sum (Q_{heat\ loss} - \eta . Q_{gain})_{month} \quad (1)$$

$$O_{month} = [H(T_i - T_d) - \eta_{month}(\phi_{i,month} + \phi_{s,month}].t \quad (2)$$

Here:

Q_{year}, Q_{month}: Monthly and annual heating energy need for building, respectively (J)
$O_{heat\ loss}$: Heat loss of building calculated according to TS 825 of the building (W/m^2)
H: Specific heat loss per unit temperature difference of the building (W / K)
$\phi_{i,month}$: Monthly average internal heat gain for building (W)
$\phi_{s,month}$: Monthly average heat gain from sun (W)
t: time of a month (s)

The specific heat loss (H) of the building is equal to the sum of the specific heat loss through conduction and convection (Hi) and the specific heat losses through the ventilation (Hh) of the building,

$$H = H_i + H_h \quad (3)$$

Specific heat loss through conduction and convection is the calculated heat loss when there is a temperature difference of 1°C from these structural elements Specific heat loss through conduction and convection,

$$H_i = \sum AU + IU_I \quad (4)$$

$$\sum AU = U_D.A_D + U_P.A_P + U_K.A_K + 0,8\ U_T.A_T + 0,5\ U_t.At + U_d.A_d + 0,5.U_{ds\imath c}.A_{ds\imath c} \quad (5)$$

Here;

$\sum AU$: Heat loss calculated from external walls, windows and doors, ceiling and floor covering, at 1°C temperature difference (W/K),
U: Overall heat transfer coefficient (W/m^2K),
A: Heat transfer surface area (m^2)
IU_I: In the event that there is a heat bridge on the outer surface of the building elements, the heat loss that is for 1°C temperature difference,

The subscripts used here, *D*: outer wall, *P*: window, *K*: door, *T*: ceiling, t: floor, *dsıc*: adjacent room temperature

2.1. Structure of the Building

The general information of the building examined within the scope of this study is as follows;

- The building consists of a total of 6 floors, including the basement, and the floor height is 3m.
- The exterior wall and roof building components of the building specified in the study are given in Table 2.1.
- For the building, where insulation is made, 0.1 m thick rock wool is used for the roof ceiling and 0.05 m thick for external walls, in the purpose of the insulation.

Table 2.1. Roof and wall component thicknesses of the building

Exterior Wall and Roof Components of the Building and Their Thicknesses			
Wall components	Thickness (m)	Roof structure	Thickness (m)
Gypsum mortar, lime-gypsum mortar	0.015	Mortar screed having cement	0.03
Walls made with a horizontal perforated brick	0.185	Reinforced concrete	0.12
Thermal insulation material (glass wool, rock wool)	0.05	Thermal insulation material (glass wool, rock wool)	0.01
Plaster made from inorganic lightweight aggregates	0.015	Plaster made from inorganic lightweight aggregates	0.02

2.2. Building Energy Management Program

The BEP-TR program is a national building energy performance program approved by the Ministry of Environment and Urbanization and used by users. The first version of BEP-TR, the national certification program, was launched in 2010. This BEP-TR program is in the form of a document containing information on the energy need, energy consumption classification, insulation properties and efficiency of heating and/or cooling systems of the minimal building. It is also a software program that issues an energy identity certificate (EIC) and is accessed through the Ministry's internet address by users.

Within the scope of the Directive on the Energy Performance of Buildings published in our country in 2008, BEP, the first program of the national building energy performance software created 3 years after the publication of the directive, contains many shortcomings. Some of these shortcomings are;

The questions on the mechanical systems tab are difficult to understand by the users

When determining the general energy class of the building; heating, cooling and lighting are given as a single result by taking the average of the mechanical system classes. Consequently, the energy inefficiency in the heating system has raised doubts that the shortcomings of another system has been overcome and the certificate does not reflect the truth.

Since all alternative energy sources (led lighting, geothermal energy, etc.) are not defined in the system, there is a lack of accuracy in the certificate.

There is no software part in the program where CAD-based building geometry can be transferred to the program

Introducing building structure geometry to the program using only similar shapes (U, H, L, square, rectangle, etc.)

The fact that any information exchange on the Mechanical Systems tab directly affects the building energy class has reduced the reliability of its program.

Not all renewable energy sources are defined in the system, so there is no issuing of class A energy identity certificate in particular. In other words, it defines a Class A building and a Class B building as the same, and does not show any difference between them.

The first version of this program was launched as BEP-TR 1 and after these shortcomings were eliminated in the program, it was updated as BEP-TR 2. In this study, building performances related to energy efficiency were examined by using BEP-TR 2 program. The BEP program can evaluate the building to include heating, sanitary hot water, cooling, ventilation, lighting, cogeneration and photovoltaic systems. The BEP-TR-2 program classifies building energy performances into energy performance classes such as A, B, C, D, E, F, G. It is classified as Class A with the highest energy performance and Class G with the lowest. After the building information is entered in the BEP-TR program, the energy class of the building is determined; and it must be at least C class in order for the building in question to be an acceptable building in terms of energy efficiency and to get an energy identity certificate. These different energy classes and energy performances are given in Table 2.2.

Table 2.2. The changes of energy performance level according to the energy class index in BEP program

Energy Performance Level	Energy Class Index
A	0-39
B	40-79
C	80-99
D	100-119
E	120-139
F	140-174
G	175-…

The issuance process of the energy identity certificate, which specifies the energy performance class, is carried out as follows: The expert of the energy identification certificate (EIC) authorized by the Ministry of Environment and Urbanization provides the building information to be entered to the program by logging in the BEP-TR program with the user name and password defined by the ministry. Then the calculation is made by using this information entered into the central database with the internet-based BEP-TR program, and as a result, the program creates the energy performance form of the building. After this form is approved by the ministry, the Energy Identity Certificate (EIC) is issued and the process is terminated. The issuance process of the Energy Identity Certificate is shown in Figure 2.1.

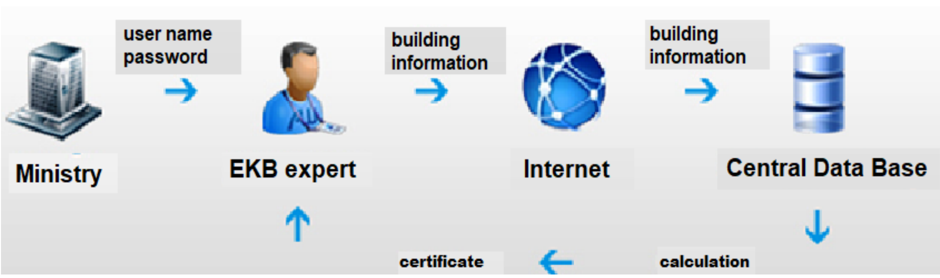

Figure 2.1. The issuance process of energy identity document [11, 12]

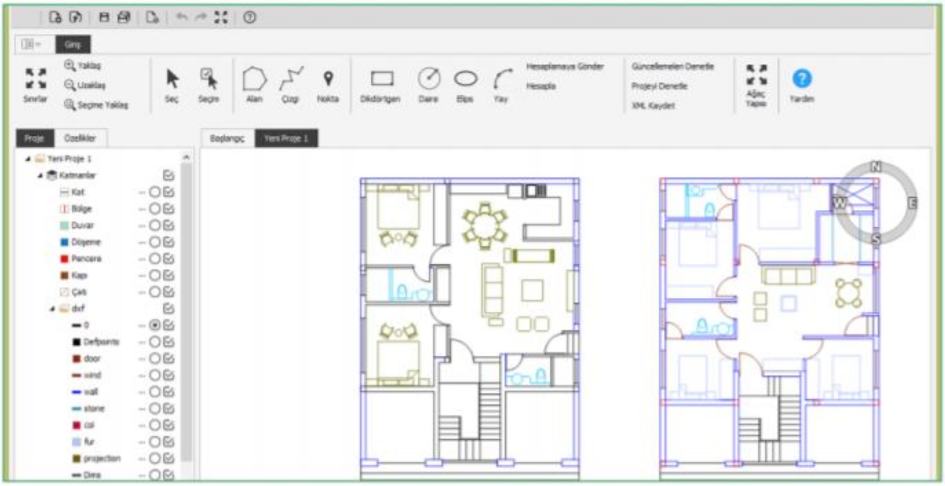

Figure 2.2 Screen shot of the BEP process schema (structure model and information entry) [13]

2.3. Process Steps Of BEP-TR Program

BEP-TR methodology is a program that works under four titles by the Ministry of Environment and Urbanization.

These applications are as follows.

BEP-BUY: The desktop application creates the data file in XML format and it is the part that works offline and online to transmit to BEP-MY and that belongs to the Ministry.
BEP-IS: It is the Operating System of BEP.
BEP-MY: It is the application that makes calculations according to the National Calculation Methodology.
BEP-ONAY: It is the approval application part of the EIC (Energy Identity Certificate).

Among these applications, BEP-IS is fully works as web-based and is administrative control mechanism of the Ministry in terms of the authorization, user information, reports, etc.

BEP-BUY is a part of information entry developed for the end user, defined as a user interface, that can work online and offline (Figure 2.2).

BEP-MY provides results by transferring data to the calculation algorithm from the user interface. The calculation is carried out in the web-based online system under the control of the Ministry. The results obtained after the calculation are used to provide an Energy Identity Certificate for the relevant building. This application is also included in the online system [12].

3. EXPERIMENTAL STUDIES

In this study, the information required for the determination of the building energy performance was taken from the previous static, architectural and mechanical projects of the building and calculations were made. The annual amount of energy needed by the building for heating and cooling of buildings has been determined by entering the information of the building of which energy performance is calculated and consists of a block including 10 apartments into the BEP-TR (Building Energy Performance) Program, and the lighting energy need and consumption amount have been determined for the times when the daylight is not used and the areas where daylight is not effective, considering daylight effects on the building, and the carbon dioxide (CO_2) emission amounts of the building were calculated.

3.1. Analysis

In this study the building energy performance evaluation has been done for the insulated and uninsulated form of a building located in Selcuklu district of Konya. The results obtained from the BEP-TR program are shown in the tables below. In the study, heating, cooling, hot water, lighting and carbon dioxide gas emission amounts for the insulated and uninsulated building were evaluated in terms of energy efficiency. In the Table 3.1-3.2, an energy identity certificate was issued for the uninsulated and insulated building, respectively, and the building's heating, cooling, ventilation, lighting system and carbon dioxide gas emission values are shown.

Table 3.1. Results of the energy identity certificate for the uninsulated building

Systems	Total Consumption (kWh/yıl)	Primary Consumption (kWh/yıl)	Consumption per unit area (m^2)	Class
Heating	215 959.0	218 205.9	228.81	F
Hot water	17 725.5	18 046.1	18.92	D
Air conditioning	4 86.8	1 008,7	1.06	C
Air ventilation	0,0	0.0	0.0	D
lighting	1 435,8	2 974,9	3.12	B
Greenhouse Gas Emission			59.55	E
Total	235 607.0	240 235.6	251.91	E

When the energy results calculated for hot water systems are analyzed, values between 17 811.1 – 18 046.1 kWh/year were obtained for both buildings. Hot water systems have been approximately the same. However, greenhouse gas emission values are different since total energy changes. Thus, greenhouse gas emission values also decreased due to the decrease in heating energy need in the uninsulated condition. Results obtained according to TS-825 for the uninsulated and insulated building are shown in Table 3.3. In case the building is insulated, the heat lost from the external wall has decreased from 955.20 W/K to 439.69 W/K and the heat lost from the ceiling has decreased from 532.53 W/K to 62.43 W/K. This also changed the heat loss occurred through total conduction from the structure elements.

For the uninsulated building, the total heat lost through the conduction from the building structure components was 4 354 W/K, while it decreased by 35% to 2 820 W/K for the insulated building.

Table 3.2. Results of the energy identity certificate for the insulated building

Systems	Total Consumption	Primary Consumption	Consumption per unit area	Class
Heating	141 151.7	142 800.1	149.74	C
Hot water	17 811.1	17 811.1	18.68	D
Air conditioning	771.61	1 598.9	1.68	E
Air ventilation	0.0	0.0	0.00	D
Lighting	1 434.27	2 971.8	3.12	B
Greenhouse Gas Emission			41.09	C
Total	160 832.24	165 181.8	173.21	E

As a result of the calculations, it is an important situation in terms of showing that the insulation application reduces heat loss and shows that less energy will be used for heating energy. When total energy consumption (Q) calculated per unit usage area for this building was compared to the value (Q') in TS-825, the calculated annual heating energy need has been higher than the maximum value specified in TS-825 since the Q> Q ' (120> 92.28 kW/m^2) for the non-insulated building as seen in Table 3.1. For this reason, this building was not found to comply with the standards.

Table 3.3. Specific heat results obtained for insulated and uninsulated building according to TS-825

Results obtained according to TS 825	For uninsulated building	For insulated building
Heat loss from the external walls	995.20 W/K	439.69 W/K
Heat loss from the roof	532.5 W/K	62.4 W/K
Total heat loss from building structure elements	4 354 W/K	2 820 W/K
The max. heat loss required according to TS 825 (Q')	92.2 kW/m²	92.2 kW/m²
Annual heating energy need per unit area	120 kW/m^2	80 kW/m^2

When a similar comparison is made within the uninsulated building, the calculated annual heating energy need has been higher than the maximum value specified in TS-825 since Q> Q' (120 > 92.28 kW/m^2) as seen in Table 3.1. For this reason, this building was not found to comply with the standards. When a similar comparison is made in the insulated building, since Q> Q '(80 <92.28 kW/m^2) as seen in Table 3.2, the insulated building has been found compliant with the standards because annual heating energy need calculated for the insulated building is below the maximum required value. Note: In this calculation, the total heat transfer surface area was calculated from the sum of heat transfer surface areas.

In Table 3.4, in the calculations made according to TS-825, the total heat transfer coefficient (U) values of each structure element for the uninsulated building were compared. As can be seen from this table, all total heat transfer coefficients were higher than the TS-825 max references. This is the biggest indicator that the building needs improvement in terms of energy efficiency.

Here, $U_{D:}$ total heat transfer coefficient of the external wall U_T: total heat transfer coefficient of the ceiling U_t: total heat transfer coefficient of the floor, U_P: it was expressed as total heat transfer coefficient of the window. In Table 3.5, in the calculations made according to TS 825, the total heat transfer coefficient (U) values of each structure element for the insulated building were compared. As can be seen in this table, the results calculated according to TS-825 are almost close to each other with the results obtained from the BEP program.

Table 3.4. The comparison of values of the total heat transfer coefficient (U) for the uninsulated building (Konya, the 3rd Region of Turkey)

For uninsulated building	U_D (W/m².K)	U_T (W/m².K)	U_t (W/m².K)	U_P (W/m².K)
Max reference values given in TS-825	0,5	0,3	0,45	2,4
Values calculated for uninsulated building according to TS-825 and increase percentage compared to the max reference values of TS-825	1.95 (% 290)	1.26 (% 320)	1.80 (% 300)	3.30 (% 38)
Values calculated with BEP-TR 2 program and the increase percentage compared to the max reference values of TS-825	1.26 (% 152)	1.95 (% 550)	1.83 (% 307)	3.30 (% 38)

Table 3.5. The comparison of values of the total heat transfer coefficient (U) for the insulated building (Konya, the 3rd Region of Turkey)

For uninsulated building	U_D (W/m².K)	U_T (W/m².K)	U_t (W/m².K)	U_P (W/m².K)
Max reference values given in TS-825	0.5	0.3	0.45	2.4
Values calculated for uninsulated building according to TS-825 and increase percentage compared to the max reference values of TS-825	0.56 (% 12)	0.35 (% 17)	1.88 (% 318)	3.30 (% 38)
Values calculated with BEP-TR 2 program and the increase percentage compared to the max reference values of TS-825	0.56 (% 12)	0.35 (% 17)	1.93 (% 329)	3.30 (% 38)

As seen in Table 3.5, the results calculated according to TS-825 and the results obtained from the energy identity certificate (BEP) were close to each other.

4. EVALUATIONS AND DISCUSSIONS

In this study, the energy performance for the building consisting of a block including 10 apartments belonging to Selcuklu district of Konya was obtained with the BEP-TR program and the results and the suggestions are given below,

Within the scope of this study, energy certificate results were calculated for the insulated and uninsulated states of a building in Konya and in the comparison, it was seen that the results directly affect the energy certificate class.

In line with the study, different results were obtained in terms of energy efficiency in insulated and uninsulated states of the same building. The building insulation feature was considered as the main factor in being different these results from each other. Especially in heating and cooling values, considering that Konya province is located in the 3rd Region and has a continental climate, it has been observed that the insulation application for the sample building positively affects the energy efficiency results [13].

5. RESULTS

After building energy performance evaluations for a building consisting of a block containing 10 apartments in Konya province, the energy class for the insulated form of the building has been determined *as "Class C"* whereas the energy class for the uninsulated form of the same building has been determined *as "Class E".* This result indicates that the Energy Identity Certificate class of the insulated building is Class C, that is, it is included in the scope of an acceptable building in energy classification, and that the Energy Identity Certificate class of the uninsulated building is Class E, that is, it is included in the scope of an unacceptable building in the energy classification.

There are also significant differences in the energy performance results for the insulated and uninsulated states of the building. This result is an indication of how insulation changes directly the building energy class in buildings.

In accordance with the obtained results, the energy identity of the building was determined and thus, after determining the energy identity of the building, it was showed how the insulation of the building contributes in terms of energy saving and energy efficiency.

For the uninsulated state of the building, the total heat transfer coefficient (U) of the structure elements of the building using BEP-TR 2 was higher 152% on the external walls, 550% on the ceiling, 307% on the floor and 38% on the windows than the max value that should be and that specified in TS-825.

In the insulated state, the total heat transfer coefficient (U) of the structure elements of the building using BEP-TR 2 was higher 12% on the external walls, 17% on the ceiling, 329% on the floor and 38% on the windows than the max value that should be and that specified in TS-825. These values are relatively close to the specified values.

In case of insulation to the building, the total heat loss has decreased from 4 354 W/K to 2 850 W/K compared to the uninsulated one, thereby resulting in a 32.2% reduction.

It has been seen how the insulation has an important effect in determining the energy identity certificate. However, during the analysis evaluation of the building for the BEP-TR program, it showed how appropriate the results of the program would be to TS-825 and the accuracy of the results obtained from the program.

The results obtained from the BEP-TR program showed that approximately similar results were obtained with the results calculated from TS 825, which it is an indication of how accurate the program predicts.

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