ASSESSING THE ACCURACY OF NATIONAL CALCULATION METHODOLOGY OF TURKIYE (BEP-TR) BY USING BESTEST

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ABSTRACT

Energy performance in buildings issue has become one of the most important subject matters in Turkiye, especially regarding the procedure of accreditation within European Union. There are many studies conducted in the context varying from developing standards and regulations to inventory of buildings in the frame of energy performance parameters.
In this paper, it is aimed to evaluate building energy performance regulation that became mandatory since 2010 and its calculation methodology called BEP-tr. There are several problems announced by the users of BEP-tr many of whom are mechanical engineers. Based on the critics related with national calculation methodology, it is necessary to reveal the capacity of the software by testing accuracy.
The content of the paper includes a deep review of Turkish Building Energy Performance Regulation and its calculation methodology regarding the importance of regulations as a big step forward to high performance buildings.
The evaluation of national calculation methodology (BEP-tr) has been performed in order to reveal substantial problems. An internationally recognised validation and diagnostic procedure, BESTEST was applied to test the accuracy of calculation methodology.
The first part of the paper is dedicated to a discussion related with the current status of the regulation. Then, the results of BESTEST cases were interpreted in order to find out whether the national calculation methodology is inside the confidence interval. The results highlighted the basic errors of calculation methodology and project a vision for further improvements of the software.

Key words: Regulations, BESTEST, BEP-tr

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1. INTRODUCTION

It is well known that in most industrialized countries approximately one third of primary energy supply is consumed in buildings. As a consequence the building sector is essential to realization of energy savings and reduction of carbon emissions. From this point of view, improvement of the energy performance of buildings has a great potential towards the realization of total energy efficiency strategies. In Turkiye, there have been many studies executed on energy efficiency measures over the last decade. First of all, revision of the Thermal Insulation Requirements for Buildings Standard (TS825) was finalised in April 1998 and issued by the Turkish Standards Institute. Yet this only applies to new buildings, although Turkiye has a huge existing building stock. The goal is to decrease total energy consumption in buildings with roughly one half, but so far has not met that expectancy. Furthermore, the "Law on Renewable Energy Sources" was effectuated in 2005 and the government released a new "Law on Energy Efficiency" in the first half of 2007.

In the light of the introduction of the Energy Performance of Building Directive of the European Union, a big step was taken in Turkiye with releasing "Building Energy Performance (BEP) Regulation" in 2009. Moreover, the related national calculation methodology and its tool (BEP-tr) became mandatory in 2010.

This paper aims to evaluate the scope of BEP regulation and the ability of national calculation methodology (BEP-tr) towards performance-based approach. A deep review of calculation methodology has been performed and several inadequacies have been listed. As an evaluation methodology, BESTEST is going to be applied to test the accuracy of calculation methodology. The results are discussed and several suggestions are listed towards the improvement of the methodology.

2. CURRENT STATUS IN TURKIYE

Energy performance in buildings has become one of the most important subject matters in Turkiye, especially regarding the procedure of accreditation within European Union. There are many studies conducted in the context varying from developing standards and regulations to making inventory of buildings in the frame of energy performance parameters.

The most recent and the important one of those regulations is "Building Energy Performance Regulation" which released in 05 December 2008 and became effective in 05 December 2009. The aim of the regulation is stated as follows:" to manage [a] the rules of calculations which is going to evaluate whole energy consumption of the buildings considering climatic conditions, indoor space requirements, local conditions and cost efficiency; [b] classification of buildings regarding primary energy and carbon emissions; [c] defining minimum energy requirements for new construction and major renovations; [d] assessing the possibility of renewable energy source applications; [e] control of heating and cooling systems; [f] reducing greenhouse gas emissions; [g] defining the criteria of building performance and the rules of its applications; [h] executing environmental saving." [BEP, 2010].

Here, the primary energy is defined as the sum of heating energy consumption, cooling energy consumption, ventilation energy consumption, lighting energy consumption and domestic hot water.

One of the requirements of this regulation is to prepare an "Energy Performance Certificate". In order to use during preparation of the certificate, building energy performance calculation methodology has been developed. The aim of the calculation methodology is to evaluate the effect of each parameter that has a role on energy consumption of the building on energy efficiency. Besides the objective includes assessing energy performance of all types of current and new constructed buildings that is covered by the regulation as residences, commercial buildings, educational buildings, health buildings, hotels, malls.

Building Energy performance calculation methodology includes;

- Calculation of net energy amount that building needs during heating and cooling,
- Definition of total heating and cooling energy consumption considering system performances and loss from the systems which is foreseen to meet heating and cooling energy needs,
- Definition of ventilation energy consumption,
- Calculation of lighting needs and consumption during the period that day lighting not available and where no day lighting effective,
- Calculation of energy consumption for domestic hot water. [Bayram, 2011]

Depending on the requirements of calculation methodology, new software was developed based on local conditions called BEP-tr. In the regulation it is stated that the only mandatory tool to implement national calculation methodology is BEP-tr software. Besides, the software must be used by the experts who are licensed by Ministry approved courses.

As a base standard, TS EN ISO 13790 is accepted for energy calculation methodology of heating and cooling needs of buildings.

3. EVALUATION OF BEP-tr BY BESTEST

BEP-tr is internet based software of national calculation methodology. It is aimed to collect all the data under the control of Ministry and develop a detailed tracking system and a database related with whole the buildings in Turkiye. Since 01 January 2011, using BEP-tr software is mandatory for preparation of building energy certificate. As this is defined clearly in the regulation, it is not possible to use any other tools that code the underlying calculation methodology.

Early researches executed with BEP-tr stated that the software needs to validate and should be tested. [Yılmaz, 2011]. One of the well known methodology to test energy performance evaluation tools is BESTEST. It was developed in IEA SHC Tasks 8, 12 and 22. Recently, it is accepted as a valid Standard called "Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs" as ANSI/ASHRAE Standard 140-2001 [Judkoff, 1995].

Within BESTEST it is possible to compare tools by analysing box models in different detail levels. The capacity of the tested tool can be revealed by help of those different box models and different input detail levels. The model defined in BESTEST method is a single zone sized 8x6x2.7 m^3. For several tests, the zone has no window, in some others; there is a 3x2 m^2 opaque window, for the rest a transparent window faced to South (Figure 1).

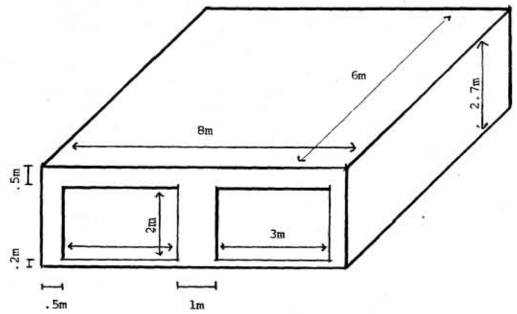

Figure 1. BESTEST test box [Judkoff, 1995].

BESTEST has two different test system. One is diagnostic test, the other is quality test. For each test procedure needs to define different levels of model. In this study, BEP-tr national calculation tool has been tested with the lowest level case box of both diagnostic and quality tests. The input parameters and the values of the model can be found in Judkoff, 1995.

BESTEST 230 and 410 models allow to test infiltration ability. The windows of the model defined as leak proof and only envelope performance based energy demand are evaluated. Different values of infiltration applied to the model and deviation of the results analysed to reveal the infiltration ability. In BESTEST 230 model air change rate value is 1.0 ach; in BESTEST 410 model it is 0.5 ach. Although in BEP-tr national calculation tool it is not possible to change infiltration value, here the table (Table 1) is used for air change rate values advised for different building envelope types. For 0.5 ach infiltration value, BESTEST 410 case is applied and the results for heating and cooling energy demands are shown in figure 2 and 3.

Table 1. BEP-tr national calculation tool air change rate levels.

	Multiple surfaces			Single surface		
	Leak proof			Leak proof		
	low	medium	high	low	medium	high
Non-protected site(Rural area and high rise buildings in urban)	1,2	0,7	0,5	1,0	0,6	0,5
Light-protected (Urban -low density)	0,9	0,6	0,5	0,7	0,5	0,5
High protected (Urban-high density)	0,6	0,5	0,5	0,5	0,5	0,5

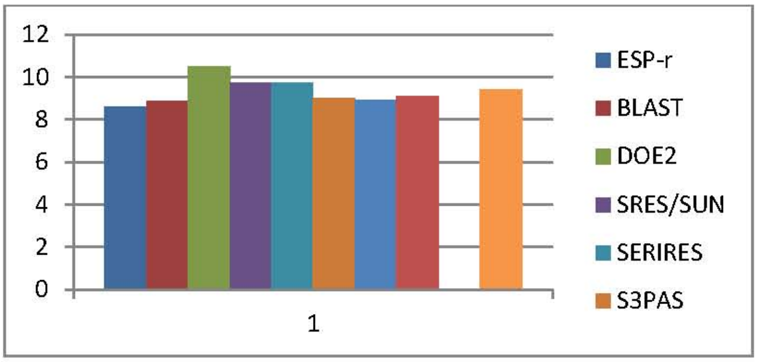

Figure 2. Comparison of annual heating energy demand (case 410).

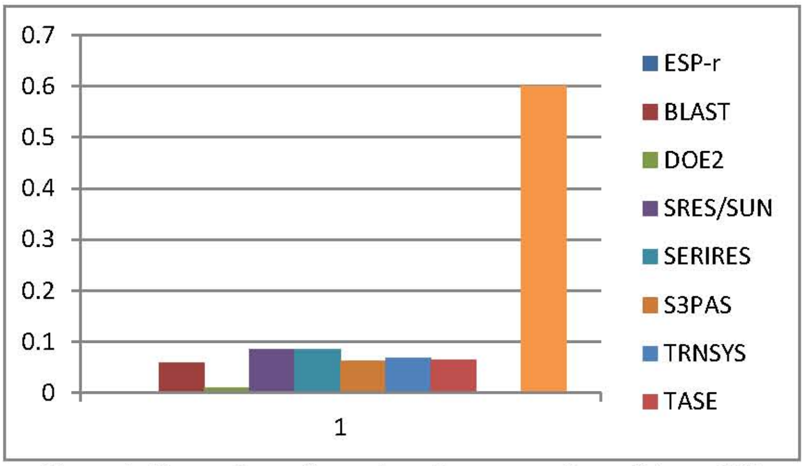

Figure 3. Comparison of annual cooling energy demand (case 410).

In BESTEST 410 model while infiltration value is 0.5 ach, heating energy demand level calculated with BEP-tr is within acceptable range. However, cooling energy demand is calculated so higher than the maximum level of the rest and 86% deviation is detected. During modelling, whole envelope of the box is defined as opaque surface, so the cause of high cooling energy demand should not be the results of direct solar gains. Internal heat gain is the possible reason of this result. If it is possible to change the infiltration level, based on the deviations of results, the critics on the software default values would be more detailed.

Another step of the diagnostic test includes solar transmission. Here, the window of the model defined as transparent. The comparative results of BESTEST 270 case can be seen in Figure 4 and 5. BEP-tr software is within acceptable ranges of calculating both heating energy demand and cooling energy demand. In another words, BEP-tr is successful in calculating solar transmission.

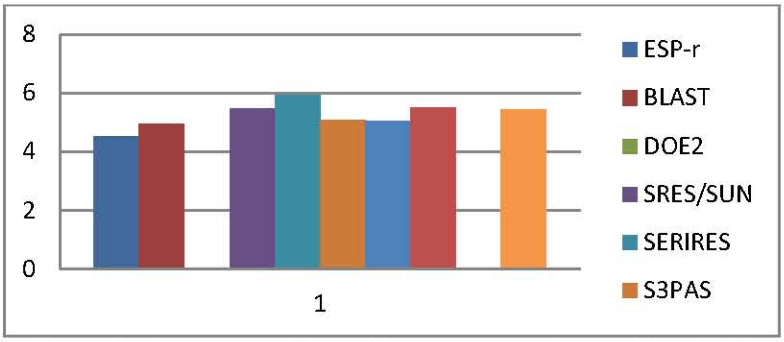

Figure 4. Comparison of annual heating energy demand (case 270).

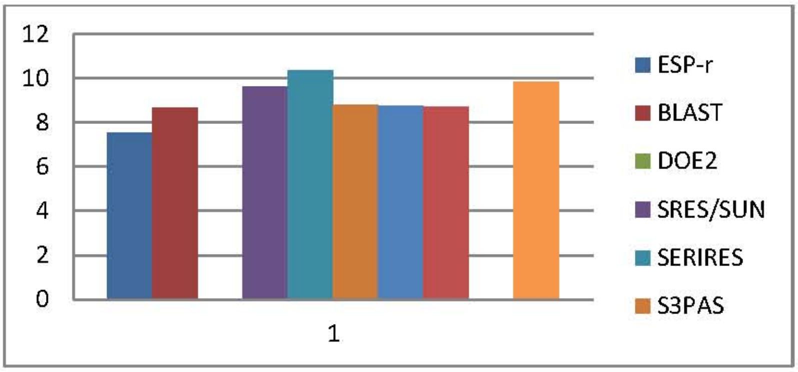

Figure 5. Comparison of annual cooling energy demand (case 270).

The basic model of quality test of BESTEST is case 600. By this case, it is possible to test parameters as windows at different sides, vertical and horizontal shadings, thermostat settings, greenhouse that effect on heating and cooling energy consumption.

The results of the analysis done with BESTEST case 600 can be seen in Figure 6 and 7. Similar to the heating energy demand results of case 410, here BEP-tr has acceptable results, as well.

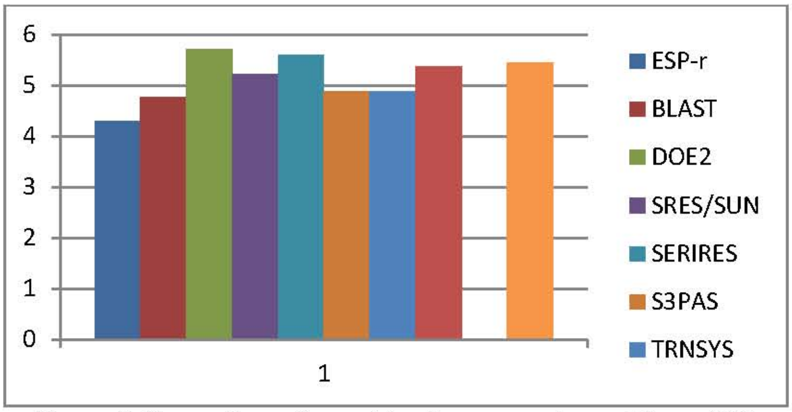

Figure 6. Comparison of annual heating energy demand (case 600).

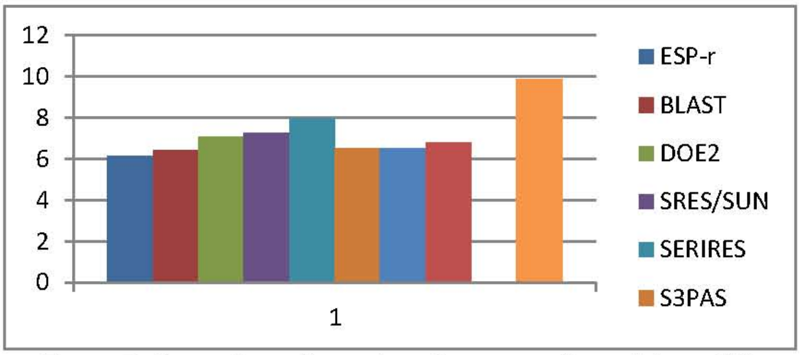

Figure 7. Comparison of annual cooling energy demand (case 600).

On the other hand, annual cooling energy demand calculated with BEP-tr is higher than the rest of the tools. The calculation methodology accepts the basic assumptions of TS825 Heat Insulation Standard which puts heat loss and heating energy consumption forward. However, Turkiye's localisation needs to consider cooling energy demand as much as heating demands. Yılmaz [2011] stated in the research she executed that there is a big potential in reducing cooling energy demand in Turkiye. A deviation occurs in cooling energy demand calculation of BEP-tr. The result is 19.2 % higher than the maximum result of the other tools.

A very simple and superficial analysis shows that the calculation methodology of BEP-tr has several problems. Particularly the calculation of cooling energy demand has deviations. It is necessary to review cooling energy demand calculations and renew the data, defaults and variables of heat transmission of building envelope, internal gains and infiltration.

It should be noted that all the analysis executed here is possible with the input values that BEP-tr software permits. Several necessary data for BESTEST could not be changed and left as assumption of BEP-tr or could not be considered at all. It is *obvious that a deep review of the software should be done by the developers of the software to reveal the real limits of the tool.*

4. DISCUSSION

The results of BEP-tr is compared with the results of validated 8 simulation tools in BESTEST and the deviations are analysed. Although those 8 tools are dynamic, hourly computed-detailed tools, there are two reasons to test monthly, simplified tool-BEP-tr with BESTEST tools. One is to use the opportunity of prepared (ready-to-compare) results of BESTEST cases, the other is to reveal inadequacy of BEP-tr in the means of considering parameters in detail while it is necessary to make an energy analysis.
First of all, there are several difficulties revealed during application of BESTEST method. All alterable data of BEP-tr is considered among input data of BESTEST model, however some of BESTEST data is not included in calculation or cannot be discovered how to included in calculation. For instance, the values of internal heat gains listed in BESTEST model could not be defined in BEP-tr; values of infiltration could not be changed. Moreover, there is no possibility to change indoor thermal comfort ranges in BEP-tr which is also a variable of BESTEST model.
The biggest difficulty during application of BESTEST method is climate definition. BEP-tr analysis allows defining the city of Turkiye to regard climatic conditions. That information is obtained from TS825 standard which defines 4 climatic regions in Turkiye and this climatic definition is not enough for meeting the requirements of Building Energy Performance regulation [Yılmaz, 2007, Yılmaz 2011]. The heating and cooling degree day values of the region that BESTEST used are compared with the same values of the cities in Turkiye [Bulut, vd., 2007] and the closest values are found in Muş. The values are listed in Table 2.

Table 2. Comparison of heating and cooling degree day values

	BESTEST	MUŞ
Heating degree day	3636.2*	3563*
Cooling degree day	487.1*	208**
*reference value 18C **reference value 22C		

Consequently, the difficulties of analysing with BEP-tr are listed below;

a) For modelling, there are only a few basic geometric forms can be defined as building in BEP-tr. Particularly for multi-zone, complex buildings, it is very hard to simplify geometry to basic forms. Besides calculation of simplified forms will deviated the results in high rates.
b) BEP-tr has a library for input data. However it is not possible to insert a new data to library or change a data in the library. For instance, old (for renovation), new or different-innovative material cannot be defined.
c) For solar gains, it is very essential to consider "thermal mass" in calculations. However in TS825 heat insulation Standard, from where the calculation

methodology is obtained, heat transmission coefficient is calculated by only regarding convection and conduction. So for calculations of BEP-tr there is a statement that "*since there is no information related with specific heat values of construction materials in standards, in this calculation methodology, a default value is defined. The value is assumed that building has a medium weight and a medium thermal capacity. If the values of materials related with heat capacity will be available, thermal mass will be considered in calculations in detail.*" Passing over thermal mass effect in calculation is a deficiency for BEP-tr.

d) Definition of internal heat gains is essential for energy calculations. BEP-tr accepts only one default value for all internal gains (lighting, appliances, etc.). This value cannot be changed, or enlarge on. Particularly for cooling energy consumption, internal gains are one of the important parameter and should be defined in detail.
e) In national calculation methodology there is a list for definition of comfort conditions for different building types and for different zones. However, in the software (BEP-tr) there is no possibility to change the values. There is no option to define a comfort band or thermostat setting for heating and cooling.
f) In order to run calculation, it is necessary to define a cooling system. For the buildings with only heating system defined (for instance houses, apartments, etc.) cannot be calculated.
g) For the system definitions (heating, cooling, ventilation) there are very limited and static data is enough for calculation. Although energy performance regulation recommends innovative solutions of systems, there is no possibility to integrate innovative system options to the model in BEP-tr.
h) When several alterations are done at any data value (ie. material of envelope construction) of BEP-tr model, heating and cooling energy demand has been changed. Related with energy consumption, it was expected any change at the value of carbon emission but there is no or very slight change occurs.
i) Another recommendation of BEP regulation is renewable energy system integration where possible. However, the software does not allow identifying renewable energy system.
j) BEP-tr can only be used by internet connection. The tool runs on a web based system. This is another handicap of the tool, since the accessibility of the tool depends on the limits and speed of your connection. The most complaint of the users is the problems occurred during connections.

5. CONCLUSION

Today it is obviously accepted that in order to reach high performance building level, energy performance evaluation from the very beginning of the design process with an interdisciplinary team is a must. Concordantly the expectations from a national calculation tool-BEP-tr are higher. Although the national calculation methodology released by the Ministry includes almost all the parameters (internal gains, solar gains, air change rates, thermal capacity, etc.) in detail, the tool use assumptions or accept most of those parameters as default values.

Basic expectations from BEP-tr as an energy analysis and modelling tool are as follows:

Modelling: Although it is enough to model as simple as possible, parameters like form, size, surface specifications, etc. should not be simplified. It is necessary to reduce assumption requirements and develop an interface that allows user to select the data or to modify it. At this point, an expert knowledge and an expert support are required.

Calculation: superficial definitions in the model-if any-, particularly HVAC system configurations, should be set as default. At that point intelligent defaulting is very essential. The tool user should be sure of the tools reliability. The definition of "intelligent defaulting" is very hard.

Analysis of the results: the results should have an ability to give advice to the further stages of design. The optimization and alternative solutions can be able to guide the designer during design decisions.

In addition to all the requirements listed above; it should be accepted that national calculation tool- BEP-tr is not a "design tool" but a "performance confirmation tool". Therefore the tool cannot be used during early phases of design and all the information related with building should be available by the user. Hence, it should be emphasised that there should be no necessity to "assumption" or "intelligent defaulting" during modelling.

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