PROBLEMS FOR ENERGY CERTIFICATION OF COMPLEX BUILDINGS THROUGH SIMPLIFIED METHODS

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ABSTRACT

Energy certification methods are usually simplified methodologies in national level of certification. When it comes to complex buildings the impact of simplification of the simulation tool is crucial. This study focuses on the differences between 'Simple Hourly Dynamic Calculation Method' and 'Detailed Dynamic Calculation Method'. Complexity level of the building has a significant effect on heating and cooling energy demand of the building. In this study, this effect of the complex buildings is analyzed through hospital buildings. Turkish national energy performance simulation tool (BEP-TR) and internationally recognized simulation tool EnergyPlus are used in the analysis.

INTRODUCTION

Building energy certification is one of the fundemental issues in building and energy sectors. Building energy performance is the amount of energy which is consumed to provide the different needs associated with the standard use of the building, and it consists of heating, cooling, ventilation, domestic hot water, and lighting. At the same time, energy design of buildings is a very important subject to reach the prospective energy consuming rate, but to design in an appropriate way there is a need for a suitable calculation methodology. The energy consuming rate of the buildings can be calculated by appropriate algorithms and according to the energy performance level of an analyzed building, this level can be changed to a better degree (EN15217, 2007).

There are different calculation methodologies in each country, however these methods work the best for residential buildings. Therefore, the most important issue is the way to calculate the energy performance levels of non-residential buildings.

Non-residential buildings also refer to complex buildings. Complex buildings, such as educational buildings, hotels, healthcare buildings, shopping centers have an important complexity in terms of internal gains and thermal zoning. In a complex building the equipment in use, the working schedules, the materials, and comfort conditions can vary from one zone to another. National calculation algorithms are usually simple and when these algorithms are applied to complex buildings the assessor has to face a number of assumptions according to the complexity level of the building. These assumptions may have strong effects on heating and cooling energy demand results. For this reason, each zone should be evaluated individually in a complex building.

In this study, the main focus is the healthcare buildings. In addition to the national, regional and local energy planning, a high rate of energy performance is an important need in hospital buildings to maintain desired comfort requirements for occupants which are mostly patients (Tschudi et al., 2009).

The analysis in this study is followed in two parts. The first part of the study shows the effect of calculation method and the differences between calculation algorithms of simplified and detailed methods. To this aim, Turkish national building performance calcualtion method BEP-TR (Building Energy Performance, Turkey) and internationally recognized building performance simulation tool EnergyPlus are used. As information, BEP-TR bases on Simple Hourly Dynamic Calculation Method and it is a web-based calculation tool. In the second part, following the results of the first part the influence of boundary conditions (temperature set-point values, occupancy, equipment, lighting, ventilation) and the variability of boundary condition data in hospital buildings are examined.

THE EFFECT OF CALCULATION METHOD

The first step of this study is to investigate the energy calculation methodologies of EnergyPlus and BEP-TR. To this aim, a specific hospital building example is chosen from EnergyPlus database (Benne et al. 2011). Since the healthcare buildings are complex buildings, each zone is specified as a different thermal zone and analysed separately.

Internal heat gains from people, lights, and equipment can contribute to the majority of the cooling load in a modern building, since the building envelopes have improved in response to strict codes.

In particular, an Operating Room is used to investigate the calculation methods. The Operating Room is located on the second floor with North and

East external façades. The tests are done by using Istanbul, Turkey climatic conditions.

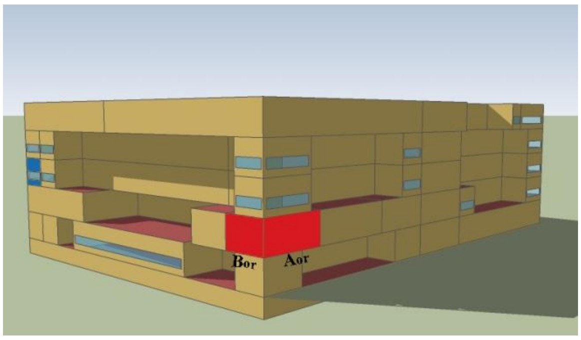

Figure 1 Benchmark Hospital Model Operating Room

In Figure 1; Aor is 9.2m, Bor is 6.1m. The height of the room is 4.3m. The zone area is 56.1m² and the zone volume is 239.6m³.

There are no transparent components on the Operating Room façade for hygienic reasons (Turkish Republic Ministry of Health, 2006).

Table 1
Building components for Operating Room

Layer Name	Material	Thickness (d)-m	Conductivity (λ)-W/m-K
External Wall Layers	1 IN Stucco	0.025	0.69
	8 IN Concrete HW	0.20	1.31
	Mass NonRes Wall Ins.	0.05	0.05
	½ IN Gypsum	0.0127	0.16
Internal Wall Layers	½ IN Gypsum	0.0127	0.16
	½ IN Gypsum	0.0127	0.16
Internal Floor Layers	Carpet Pad		
	MAT-CC05 4 HW CONCRETE	0.10	1.31

Table 1 shows the opaque building components of the Operating Room zone.

It is important to underline that the input data for residential and office buildings are complete in BEP-TR database while there are missing input data for hospital buildings. In addition, according to the related standards, the existing data in BEP-TR database are sometimes not completely coherent to a hospital building; for example, because of the various medical equipment and lighting types, the internal gain amounts should be higher as in EnergyPlus. So, the input data in EnergyPlus database are used for the calculations to have accurate results. BEP-TR uses EN standards, as reference, and EN standards do not have all the specific boundary condition data for healthcare buildings. Energy assessor should obtain these data with a special search, ASHRAE standards and manufacturers could be helpful at this point.

Table 2 shows a comparison between the input data of the selected Operating Room. The input data from EnergyPlus database are different from the input data in BEP-TR database (EnergyPlus Input Output Reference, 2010).

Table 2
Comparison of the data in EnergyPlus and BEP-TR

Boundary Conditions	EnergyPlus Inputs	BEP-TR Inputs	
$Q_{space}=(Q_{TR}+Q_{ventilation})-(Q_{solar}+Q_{internal\ gains})$	Operating Room	Operating Room	unit
Q_{TR} walls $U_{op,stnd}$	0.7	0.7	W/m²K
Q_{TR} windows U_{win}	No win.	No	
Outdoor air flow per zone	0.2		
Outdoor air flow per zone (per person)	240	---	m³/ph
Air Change rate per Hour	3	---	1/h
Internal Gains			
People (sensible heat gain)	91 4.86	10.69	W/p W/m²
People (latent heat gain)	29 1.6	5.35	W/p W/m²
TOT	360	900.16	W
Max number of Person	3	7.5	
Lights (per m²)	23.67	---	W/m²
TOT	1328.36	---	W
Electric Equipment (per m²)	43.04	0.92	W/m²
TOT	2415.40	51.63	W
Temperature set-point			
Heating set-point	18.3	20	°C
Cooling set-point	18.3-22.2	26	°C

Three selected case groups are discussed to compare EnergyPlus and BEP-TR calculation methods. The main characteristics of the investigated cases are shown in Table 3.

Table 3
Case Descriptions

Changing Parameters	Case Name	Case Description
Air Change Rate per Hour= 0 h^{-1}	Case 1	EnergyPlus
	Case 2	BEP-TR
	Case 3	BEP-TR with “0 W” solar gains
Air Change Rate per Hour= 3 h^{-1}	Case 4	EnergyPlus
	Case 5	BEP-TR
	Case 6	BEP-TR with “0 W” solar gains
The BEP-TR equation: $\Phi_m=(A_m/A_{tot})*(0.5*\Phi_{int}+\Phi_{sol})$ has been changed into: $\Phi_m=(A_m/A_{tot})*(0.7*\Phi_{int}+\Phi_{sol})$	Case 7	BEP-TR and ACH=0 1/h
	Case 8	BEP-TR and ACH=3 1/h

In all the cases, possible heat recovery on ventilation air is not considered at this stage of analysis.

In the first investigation group, the effects of boundary conditions and solar gains on Annual Heating and Cooling Demands are evaluated by taking infiltration value “0 1/h” and temperature set-point value 20 °C constant. In this case, it is accepted that there is no ventilation in the zone. In a zone as Operating Room with no transparent components and with high internal gains, medical equipment and characteristic lighting are the most important thermal flux in the energy balance of the zone. In Case 3 of the first investigation group, solar gains are taken “0 W” to examine the effect of heat gain/loss through solar transmission on the results of Operating Room zone. As shown in Table 4, cases 1 and 2 have the same input data but the results are different as in Table 5. However, both methods have the same tendency of heating and cooling.

Table 4
Boundary condition data that used in investigations

Operating Room		**Unit**	**All Cases**
Boundary Conditions	Heating set-point	°C	20
	Cooling set-point	°C	20
	Sensible heat gain from people [16]	W/m^2	4.9
	Latent heat gain from people [16]	W/m^2	1.6
	Internal heat gain from lighting	W/m^2	23.7
	Internal heat gain from equipment	W/m^2	43
	Air change rate per hour	1/h	0 or 3 according to the case

As expected, high cooling demands are evaluated due to high internal gains and low heat losses. Since there is no infiltration value in these cases it is normal to have almost no heating demand and a very high cooling demand. The effect of the thermal behaviour of the envelope is tested with “Case 3” by taking solar gains “0 W”. As a result of “Case 3” a little reduction in Cooling Demand is investigated as in Table 5. In a zone with high internal gains like Operating Room, the heat transfer from the building envelope does not have an important effect on annual heating and cooling demands. It should also be considered that Operating Room does not have any transparent components.

Table 5
First investigations: Operating Room results

		Case 1	**Case 2**	**Case 3**
Annual Heating Demand	kWh/m^{2}a	0	0	0
Annual Cooling Demand	kWh/m^{2}a	571	702	696

Since, the result difference between Case 2 and 3 has a small rate, it is confirmed that the reason of high cooling demands is the high internal gain rates in the Operating Room zone.

As shown in Table 5, there is no heating demand in all cases. While the cooling demand need is 571 kWh/m2a in EnergyPlus tests, it is 702 kWh/m2a in BEP-TR. It is important to show that BEP-TR result changes into 696 kWh/m2a when there is no solar gain, as mentioned above, this numerical results prove that in zones with high internal gains, the most important parameter is internal gain.

In the second investigation group, the air change rate per hour value is fixed at “3 1/h” as suggested in EnergyPlus database for the Operating Room and the tests are done by using the same boundary conditions of the first investigation group as in Table 4, also to investigate the effect of air change rate per hour data on annual heating and cooling demand results. Since there is an infiltration data in this phase of tests a little increase on annual heating demand and a reduction on annual cooling demand are expected in comparison to the first investigation group. As anticipated, in Table 6, it can be observed that there is a little increase in annual heating demand and a reduction in annual cooling demand in EnergyPlus results (Case 4) in comparison to Case 1 results.

Table 6
Second investigations: Operating Room results

		Case 4	**Case 5**	**Case 6**
Annual Heating Demand	kWh/m^{2}a	0.1	3	4
Annual Cooling Demand	kWh/m^{2}a	379	173	167

As expected, infiltration data has a reducing effect on cooling demand. Since it is a specific Operating Room case, internal heat gains are highly effective on the results, and still there is a high cooling need. However, the increase in annual heating demand and the decrease in annual cooling demand are too sharp in BEP-TR results. Even with these high internal heat gain rates, BEP-TR tends to underestimate the cooling load and overestimate the heating load for this case study. In this case, it is observed that the sensitivity to internal gains is not sufficient and the sensitivity to the infiltration coefficient is higher in BEP-TR. For this reason, since internal gains are dominant for the thermal balance of the test zone Operating Room, it is checked that whether internal gains are represented sufficiently in EN 13790 since BEP-TR algorithm is based on this standard (Cases 7 and 8).

Additionally, the tendency of the results is the same with the first investigation group. Results of Case 6 with a little difference in comparison to Case 5 show that the heat gain/loss through the building envelope does not have an important effect on annual heating and cooling demands of Operating Room.

The third investigation group, cases 7 and 8, is formed with the aim of analysing the reason of different results of second investigation group. As mentioned before, the sensitivity to internal gains is not sufficient enough in BEP-TR and for this reason the calculation methodologies of EnergyPlus and BEP-TR are examined in detail. In the second investigation group, despite an infiltration rate value is added, there should be a high cooling demand as in EnergyPlus result (Case 4) according to internal heat loads. Since these results are not supported by BEP-TR results, the third investigation group is prepared to prove the effect of the calculation methodology differences on results.

Since BEP-TR results are in harmony with boundary condition data changes, the algorithm of the method is analysed and compared with the algorithm of EnergyPlus by studying the equations in EN 13790. It is obtained that the annual heating and cooling demand results are different in comparison to EnergyPlus results because of the simplification in BEP-TR's calculation methodology.

As shown in Table 6, annual heating demand results are higher when calculations are done by BEP-TR because the thermal behaviour of the building is calculated by a simplified method which is obtained from EN 13790. In particular, instantaneous loads through the opaque envelope are higher in BEP-TR because BEP-TR tends to underestimate the storage effect in comparison with EnergyPlus (EnergyPlus Engineering Reference, 2010). Therefore, the effect of heat transmission and heat storage through opaque envelope change, and thus EnergyPlus is able to simulate the heat storage dynamics in a better way. Moreover, EnergyPlus considers the radiative and convective gains while calculating the solar gains and to this aim, it uses different coefficients to multiply with the total solar gain and presents the difference in between the radiative and convective heat gains. In addition, in BEP-TR a simplification method suggested by EN standards is adopted to take into account internal and solar gains. In this case, BEP-TR tends to distribute the solar gains Φsol to the space and solar gain is multiplied with A_m/A_{tot} value which is a lower value than "1", thus solar gain is reduced (EN ISO 13790, 2008). In particular, internal and solar gains are treated in BEP-TR as follows:

$$\Phi m = (Am \,/\, Atot) * (0.5 * \Phi int + \Phi sol) \quad (1)$$

In equation 1, Φm represents the heat flow from internal and solar heat sources in Watt. A_m represents the useful surface area in m² and A_{tot} represents the area of all surfaces facing the room in m². Φint represents the heat flow rate due to internal heat sources and Φsol represents the heat flow rate due to solar heat sources (EN ISO 13790, 2008).

The reason of lower annual cooling demand results is while BEP-TR analyses the effects of internal gains, it does not consider the difference of radiative and convective gains and uses equation 1 as a simplification. As in the equation 1, 50 % of the internal gains are instantaneously converted into room loads applying equation 2.

$$Q°ihg\ (t) = 0.5 * Q°ihl \quad (2)$$

These assumptions are typical for "standard buildings" where the amount of internal gain is not as high as the case of an Operating Room where it is the prevalent heat load. This type of assumption draws away the results from being acceptable for complex buildings contain a lot of zones that have high internal gain sources.

The third investigation group tries to test possible variation of the coefficient "0.5" in equation 1 that seems to be inappropriate for the distribution of internal heat gains. In particular, it is increased into "0.7" and new simulations are done by BEP-TR. The results of the third investigation group are shown in Table 7. A decrease in Annual Heating Demand and a significant increase in Annual Cooling Demand are observed when the internal gain assumption is changed.

The different results of the first and second investigations that are affected by the simplification in BEP-TR algorithm become closer to the EnergyPlus results when those simplifications are changed in harmony with the dynamic tools, as shown by the third investigations.

Case 7 has the same input data with Case 2. Annual Heating Demand result does not change since there is no infiltration data for this case. Annual Cooling Demand result is higher than Case 2 because the effect of internal gains is increased. In Case 7 annual cooling demand result is 782 W/m²a, while it is 702 W/m²a in Case 2. In Figure 2, Annual Cooling Demand comparison is shown.

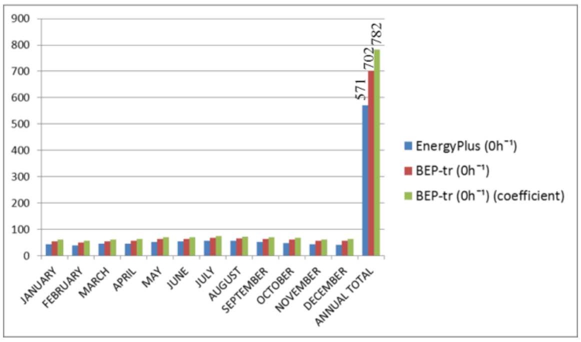

Figure 2 Annual Cooling Demand results comparison for cases 1, 2, and 7

To be closer to the detailed simulation method result additional tests have to be performed on this specific topic. As expected when the tendency to internal heat gains is increased annual cooling demand would also be increased.

Case 8 has the same input data with Case 5. Since the effect of internal gains is increased, Annual Heating

Demand results are decreased in comparison to Case5, in harmony with the new situation and the result gets closer to the one of Case 4, which is the EnergyPlus result. As in Figure 3, annual heating demand is 0 W/m²a in Case 8, 3 W/m²a in Case 5 and 0.1 W/m²a in Case 4.

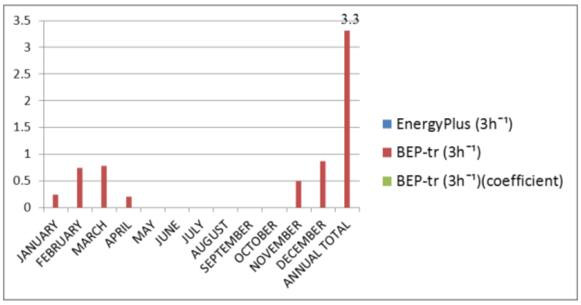

Figure 3 Annual Heating Demand results comparison for cases 4, 5, and 8

Annual Cooling Demand is increased in comparison to Case 5 as expected and it gets closer to the EnergyPlus result in Case 4. As in Figure 4, it is 263 W/m²a in Case 8, 173 W/m²a in Case 5 and 379 W/m²a in Case 4. This is the effect of increasing the sensitivity to internal gains.

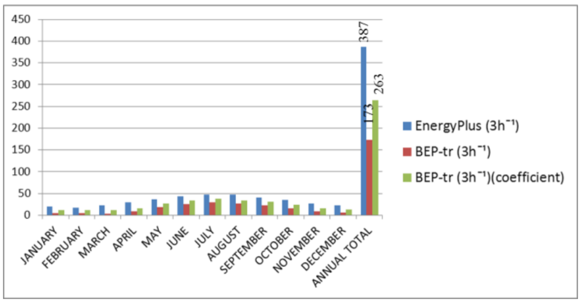

Figure 4 Annual Cooling Demand results comparison for cases 4, 5, and 8

THE INFLUENCE OF BOUNDARY CONDITIONS & VARIABILITY OF BOUNDARY CONDITION DATA

In this phase of comparison, the complexity of the input data selection for complex buildings is investigated through two real hospital building projects.

When we face a real hospital building case in reality, we would have variation in comparison to standard situation. In addition, boundary condition data change from one hospital to another. Each healthcare building could be a different case study and it is hard to generalize them and the data required for them.

The first hospital building project locates in Kosovo and it is an IVF (In Vitro Fertilization) Centre. The second project, CTO Torino locates in Torino, Italy and it is one of the oldest general hospitals in Torino. Kosovo IVF Centre is a branch hospital and CTO Torino is a general hospital. So, the type of the hospitals is different. Kosovo IVF Centre input data are gained from ASHRAE standards. CTO Torino input data are gained by monitoring. Figure 5 shows the selected zones to be tested for the investigations from Kosovo IVF Centre. The green coloured zones are a Delivery Room, a Patient Room and a Consultation Room.

Figure 5 Selected zones from Kosovo IVF Center

Figure 6 shows the selected zones to be tested for investigations from CTO Torino Hospital. The orange coloured zones are an Operating Room, a Patient Room and a Consultation Room.

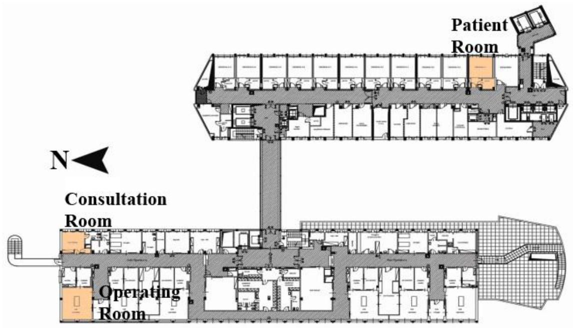

Figure 6 Selected zones from CTO Torino

These selected zones are examined by using EnergyPlus in Istanbul climatic conditions. Heat transfer coefficient (U factor) values of both hospitals' building components are shown in Table 7.

Table 7
U values for IVF Centre and CTO Torino case zones

Layer Name	(IVF) U factor – W/m²K	(CTO) U factor – W/m²K
External Wall	0.65	2.2
Internal Wall	0.54	2.2
Floor	1.2	1.77
Ceiling	2	1.77
Window	3.23	5.78

Delivery Room is an operating area. Therefore, IVF Centre Delivery Room is examined together with CTO Torino Operating Room. They both need a sterilized area and a façade with no transparent component. In addition, both rooms include special medical equipment and lighting. Boundary condition data and EnergyPlus results for Kosovo IVF Centre are shown in Table 8 and for CTO Torino these are shown in Table 9.

Table 8
IVF Centre: Delivery Room boundary condition data and EnergyPlus results

		Values	Unit
Boundary Conditions ASHRAE 2003; ASHRAE 2005 Fundamentals, 2005. (28 m^2)	Heating set-point	20	°C
	Cooling set-point	24	°C
	Heat gain from people	18	W/m^2
	Internal heat gain from lighting	36.5	W/m^2
	Internal heat gain from equipment	35.4	W/m^2
	Air change rate per hour	5	1/h
Annual Energy Demand	Annual Heating Demand	3	kWh/m^2a
	Annual Cooling Demand	273	kWh/m^2a

Table 9
CTO Torino: Operating Room boundary condition data and EnergyPlus results

		Values	Unit
Boundary Conditions Monitoring (45 m^2)	Heating set-point	20	°C
	Cooling set-point	24	°C
	Heat gain from people	11	W/m^2
	Internal heat gain from lighting	15.3	W/m^2
	Internal heat gain from equipment	59.5	W/m^2
	Air change rate per hour	15	1/h
Annual Energy Demand	Annual Heating Demand	823	kWh/m^2a
	Annual Cooling Demand	170	kWh/m^2a

Since Delivery Room and Operating Room zones are both operating areas, similar boundary condition data are expected. Both operating areas have the same temperature set-point values. Internal heat gain from people is also the same when the unit is in Watt. However, in IVF Centre internal gain values from lighting and equipment are from ASHRAE standards (ASHRAE 2005 Fundamentals, 2005; ASHRAE 2003). In the case of CTO Torino, these values are the results of monitoring. In addition, some of the values, especially infiltration values, change according to the country that the building is located. As in this example, ASHRAE standards require "5 1/h" air change rate per hour value for operating rooms, however since CTO Torino is located in Italy, Italian standards are applied on Operating Room zone and these standards require "15 1/h" for operating rooms (ASHRAE 2003; DCR 616-3149-2000, 2000). Thus, it is possible to say that infiltration is highly related to national standards and it cannot be generalized. So, the air change rate per hour value depends on the location of the building.

Boundary condition data values and EnergyPlus annual heating and cooling demand results for Patient Room zones are shown in Table 10 and Table 11.

Table 10
IVF Centre: Patient Room boundary condition data and EnergyPlus results

		Values	Unit
Boundary Conditions ASHRAE 2003; ASHRAE 2005 Fundamentals, 2005. (23.1 m^2)	Heating set-point	21	°C
	Cooling set-point	24	°C
	Heat gain from people	7	W/m^2
	Internal heat gain from lighting	10.6	W/m^2
	Internal heat gain from equipment	25.2	W/m^2
	Air change rate per hour	2	1/h
Annual Energy Demand	Annual Heating Demand	6	kWh/m^2a
	Annual Cooling Demand	119	kWh/m^2a

Table 11
CTO Torino: Patient Room boundary condition data and EnergyPlus results

		Values	Unit
Boundary Conditions Monitoring (35.5 m^2)	Heating set-point	20	°C
	Cooling set-point	24	°C
	Heat gain from people	4.6	W/m^2
	Internal heat gain from lighting	6.7	W/m^2
	Internal heat gain from equipment	5	W/m^2
	Air change rate per hour	2	1/h
Annual Energy Demand	Annual Heating Demand	109	kWh/m^2a
	Annual Cooling Demand	57	kWh/m^2a

Considering patient rooms both of their aim is the same and so, similar boundary condition data are expected for each zone. In both patient rooms, heat gain from people has the same value in Watt units. Also, air change rate per hour data are same both in ASHRAE and Italian standards for Patient Rooms (ASHRAE 2003; DCR 616-3149-2000, 2000). In these zones, the most important difference is internal heat gain from medical equipment. In IVF Centre Patient Room, since this room is for women who gave birth and their babies, there are some other special appliances that increase the internal heat gain value from equipment while CTO Torino Patient Room is a general patient room with almost no medical equipment (only moving/constant oxygen pump).

Consultation Room means examination room where medical doctors work during the day. In general, the utilization of examination rooms is for diagnosis and treatment. Boundary condition data values and EnergyPlus annual heating and cooling demand results for Consultation Room zones are shown in Table 12 and Table 13.

Table 12
IVF Centre: Consultation Room boundary condition data and EnergyPlus results

		Values	Unit
Boundary Conditions ASHRAE 2003; ASHRAE 2005 Fundamentals, 2005. (25.2 m^2)	Heating set-point	21	°C
	Cooling set-point	24	°C
	Heat gain from people	15	W/m^2
	Internal heat gain from lighting	9.1	W/m^2
	Internal heat gain from equipment	51.4	W/m^2
	Air change rate per hour	2	1/h
Annual Energy Demand	Annual Heating Demand	2	kWh/m^2a
	Annual Cooling Demand	238	kWh/m^2a

Table 13
CTO Torino: Consultation Room boundary condition data and EnergyPlus results

		Values	Unit
Boundary Conditions Monitoring (23.3 m^2)	Heating set-point	21	°C
	Cooling set-point	24	°C
	Heat gain from people	16	W/m^2
	Internal heat gain from lighting	9.2	W/m^2
	Internal heat gain from equipment	5.8	W/m^2
	Air change rate per hour	2	1/h
Annual Energy Demand	Annual Heating Demand	184	kWh/m^2a
	Annual Cooling Demand	51	kWh/m^2a

In both consultation rooms, except heat gain from medical equipment, all other data are almost the same. That is because, the meaning of examination changes according to the branch type of the hospital. The Consultation Room in CTO Torino is a general consultation room for usual patients and it only includes a computer as an electrical equipment to register the condition of patients, however the Consultation Room in IVF Centre is for pregnant women and it includes an ultrasound system and hysteroscopy pump in addition to the computer.

DISCUSSION

In the first part of this study, detailed dynamic method and simple hourly method are compared in order to find the most appropriate method for complex buildings energy performance calculations.

The Turkish simulation method for energy certification BEP-TR is a simplified calculation method that has been developed in principle to be used for all building typologies; however, it is more appropriate to be used for residence, education and simple office buildings. A more detailed simulation tool is needed for energy performance assessment of complex buildings or simplified simulation tools have to be improved to match energy simulation of complex buildings.

The first part shows the shortcomings of this method. According to the researches for hospital buildings BEP-TR uses EN standards as reference for boundary condition data. However, EN standards are not enough for hospital buildings and after obtaining this result, ASHRAE standards and manufacturers' help are used to continue the examinations for energy performance assessments of hospital buildings. In a hospital building, as shown in all phases of study there are a lot of thermal zones and each of them has different working, activity, temperature set-point, internal gain, and ventilation schedules. BEP-TR calculates the energy performance of hospital buildings with a simplification that distributes all the parameters of each thermal zone to the whole floor with the area weighted average value. In this case, the different parameters of each thermal zone do not have an effect on each other. This simplification is normal for energy performance calculations of standard buildings and it is also useful for the usage of the software. However, it is a problem for complex building cases as it is analyzed in this study for hospital buildings. Moreover, national simulation methods like BEP-TR are appropriate to evaluate the energy performances of building typologies which has no high "intensity" of internal gains.

The second part of the study is important if national methods are going to be improved and to be able to calculate the energy performance of complex buildings. This part shows all parameters that should be considered in calculations. As it is explained in the first part, in a hospital building there are many different types of zones. However, even the same zones could have different energy demand according to the hospital typology. For example, as in the tests Delivery Room and Operating Room are both operation zones. However, Delivery Room is a zone to give birth. Therefore, there will be different needs in comparison to a general Operating Room. In addition, IVF Centre is a modern building with new construction type while CTO Torino is an old building. Building components do not have an important effect in zones with high internal gains while they have an effect in zones with a small internal gain value like Consultation Room.

In the comparative results of second part CTO zones have more heating and less cooling demand than IVF Centre zones, which is because of both reasons stated above. However, in a hospital building the most important parameter that influences annual heating and cooling demand is internal heat gains. Therefore, envelope components of course should be considered, but it should be kept in mind that because of the high internal gains, building envelope is less effective than internal heat gains on the results.

CONCLUSION

As in the first part, BEP-TR adopts the simplification which is required by EN 13790 for heat gain/loss through solar transmission and internal gains. However, for complex buildings heat gain algorithms should be in harmony with the detailed simulation algorithms to distribute the heat gains with appropriate coefficients as radiative and convective.

Therefore, if national simulation methods are also for calculating the energy performances of complex buildings, these methods have to be improved in accordance with the detailed methods. Moreover, other standards should be used in addition to EN standards or EN standards should be improved.

The second part briefly shows that space heating and cooling demands are affected by; complexity of the building itself as its geometry, complexity of indoor environmental requirements and boundary conditions.

Therefore, as a result of both parts, the investigations should be done not only from the modelling point of view but also it should be clear on envelope, dimensions, and boundary conditions. The definition of what is being analysed should be considered in the case of hypothesis and certification.

Energy assessor should not generalize the boundary condition data of a zone, because this zone could have different boundary condition data according to the activity type of the hospital and it is very important to select the right data. To this aim, a boundary condition library for each branch type of hospital buildings could be useful for the assessments. Moreover, these libraries could be used in national calculation methods' database.

As a result of the selection of calculation methodology, energy performance calculation of complex buildings is a problem in all countries. Nowadays, some of the internationally recognized dynamic simulation tools are considered to be useful to calculate the energy performance of complex buildings in some European countries. However, these kinds of tools require ability of energy modeling with dynamic methods. Even after an education for these tools, there will be a control problem on how the energy assessor uses the tool. Therefore, it is important both to educate and to control the usage of detailed simulation tools and it is crucial to analyze the algorithm of simple hourly simulation methods and improve them in national base.

NOMENCLATURE

Φm,	heat flow from internal and solar heat sources
Am,	useful surface area;
$Atot$,	area of all surfaces facing the room;
Φint,	internal heat gains;
Φsol,	solar heat gain;
$\dot{Q}_{ihg}$,	internal heat gain;
$\dot{Q}_{ihl}$,	internal heat load.

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