Insights into Energy Efficiency of hotels Constructed as Green Buildings

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ABSTRACT

Global climate change has already had observable effects on the environment. Hotel industry has a role to play mitigating climate change by reducing carbon emissions. This article explores the energy saving potentials in hotels by simulating several currently available scenarios at different climates by using methodical and iterative processes to evaluate potential decisions and achieve long-term goals. The information provided in this research work is based on a review of relevant literature and the results of EQUEST simulations for 3 hotels certified with LEED V3 across Turkey. Three locations were selected to represent the three climate zones in Turkey. Green criterias are evaluated according to LEED V3 certification system. Based on the findings presented in this paper, it is suggested there exists significant energy savings potential for the Turkey's hotel industry if hotels are designed and built with sustainability principles. The main finding after compairing the three hotel designs is that it is technically feasible to increase energy efficency more than 60% without compromising guest comfort by using green technologies. Because the number green design and construction of new constructed hotels is low, implementing a new green building code with strict energy requirements is recommended for those developers who do not want to certify their hotels.

Keywords: *green hotels, energy simulation, CO_2 reduction, LEED, DGNB, sustainability*

1. INTRODUCTION

Glaciers have shrunk, ice on rivers and lakes is breaking up earlier, plant and animal ranges have shifted and trees are flowering sooner. Taken as a whole, the range of published evidence indicates that the net damage costs of climate change are likely to be significant and to increase over time. The Second Assessment Report (SAR) of the Intergovernmental Panel on Climate Change (IPCC), published in 1996, is an assessment of the then available scientific and socio-economic information on climate change. Working Group I, dealing with the scientific aspects of climate, stated that carbon dioxide remains the most important contributor to anthropogenic forcing of climate change. According to US Green Building Council, with buildings accounting for up to 30 percent of global emissions, a commitment to the rapid transformation of the global built environment seems to be one solution that the entire world can get behind.

United Nations declared that, emissions generated directly from the tourism sector account today for 5 per cent of global CO_2 emissions but may be higher. Due to similar facts, energy consumption and conservation in hotels received growing attention globally in recent years. Hotel facilities rank among the top five in terms of energy consumption in the tertiary building sector (minor only to food services and sales, health care and certain types of offices). Among non-domestic buildings, hotels belong to one of the highest emitting sector. According to US EPA, for a study that was carried out in the United States for both hotels and motels on their practices and operating costs energy represented roughly six percent of all the operating costs. The CHOSE project estimated that European hotels – which are reported to provide nearly half of the world total hotel rooms – used a total of 39 TWh (terawatt hours) in 2000, half of which is in the form of electricity. Most of this energy is derived from fossil sources, and the hotel sector's contribution to global warming and climate change, is estimated to include annual releases between 160 and 200 kg of CO2 per m2 of room floor area, depending on the fuel mix used to provide energy. Global hotel-based CO2 emissions were assumed to be at the level of 55.7 Mt in 2001, while the estimated annual energy consumption for European hotel of 39 TWh, would result in emissions of more than 10 Mt of CO2 each year.

	COST OF ENERGY/COST OF TOTAL SECTOR
Other services	18,90
Other mining	12,40
Precious Metal Mining	9,80
Road Transport	9,20
Distribution of Water	9,10
Production of other minerals-non metalic	8,90
Air Transportation	8,90
Sale, maintenance and repair of vehicles	7,80
Production of paper	7,00
Production of simple metal	6,80
Transportation of water	6,70
Hotels and restaurants	**5,40**
Rental of equipments without operators	5,30
Wholesale commerce	5,30
Real Estate Activities	4,70
Retail commerce	4,50
Agriculture and Fishery	4,40
Plastic and rubber production	4,40
Wood production	4,20
Textiles production	3,70
Balance	2,40

	COST OF ENERGY/GROSS VALUE ADDED
Air Transportation	27,1
Production of simple metal	26,4
Production of paper	23,9
Production of other minerals-non metalic	21,2
Precious Metal Mining	20,6
Other service actions	19,2
Other mining	16,4
Wood production	14,9
Plastic and rubber production	14,9
Textiles production	12,8
Road Transport	10,5
The sooting and sewing of leather	9,9
Production of chemical products	9,3
Hotels and restaurants	**8,8**
Production of electrical equipments	8,8
Production of metal products	8,3
Sale, maintenance and repair of vehicles	8,1
Water transport	7,5
Production of cars	7,1
Public Governance and defence, mandatory social security	6,1
Balance	3,4

Table1: The ratios of total gross value added (right) and cost of total sector (left) to the cost for total energy. Source: Calculations prepared by Deloitte based on EU Commission Tables on Turkey data

According to Turkey's National Energy Efficiency Plan, energy costs for hotels have a considerable portion among total industry costs. Looking from this framework, as seen from the Table 1 data, the increase of energy efficiency in hotels will not only drop the cost of energy, but will contribute lowering the energy density and increase the competitiveness. The hotels designed and built according to sustainabilility principles and certified with green building certification systems can contribute to this national goal.

According to USGBC rankings, Turkey has made the top 10 Countries for LEED certification list, and was able to make this year's list on the strength of the 258 percent increase in the amount of year over year. Maintaining this form of commitment to transforming Turkey's national built environment holds enormous potential for the country's long term economic and environmental future since 42 percent of Turkey's net electricity consumption comes from the country's building sector.

Rank	Nation	GSM of LEED certified space (million)	Total GSM of LEED-certified and registered space (millions)	Total number of LEED-certified and registered projects
1	Canada	26.63	63.31	4,814
2	China	21.97	118.34	2,022
3	India	13.24	73.51	1,883
4	Brazil	5.22	24.50	991
5	Republic of Korea	4.81	17.47	279
6	Germany	4.01	8.42	431
7	Taiwan	3.84	9.08	149
8	United Arab Emirates	3.13	53.44	910
9	**Turkey**	**2.95**	**23.74**	**477**
10	Sweden	2.54	4.20	197
	United States	276.90	727.34	53,908

Table 2: World rankings for LEED certified and registered projects

2. STATUS OF HOTELS WİTH GREEN BUİLDİNG CERTİFİCATİONS

In US alone, hotels represent more than 5 billion square feet of space, nearly 5 million guest rooms and close to 4$ billion in annual energy use. Hotels and hospitality venues have significant opportunity to reduce negative

environmental impacts associated with guest rooms, event space, an general facility use through measures such as enerfy and water efficiency, waste reduction and management, sustainable and local purchasing, and the use of alternative transport. Hotels can also contribute to human health by providing healthy, comfortable, and productive indoor environments with improved indoor air quality, access to daylight and views, and occupant control of the lighting and thermal environment]. Leadership in Energy and Environmental Design (LEED) is a set of rating systems for the design, construction, operation, and maintenance of green buildings. Developed by the U.S. Green Building Council (USGBC), LEED is intended to help building owners and operators be environmentally responsible and use resources efficiently. Since 1993, it has been a popular system all around the world. In LEED, credits are all organized under the following seven categories: location and transportation, sustainable sites, water efficiency, energy and atmosphere, material and resources, indoor environmental quality, and innovation. Len Foote Hike Inn in Dawsonville, Georgia became the first LEED certified hotel in the world. Since 2004, though practitioners and advocates have been promoting LEED certification, hospitality industry was shy about using LEED. One reason maybe was the LEED criterias were not initially directed specifically at hotels. Since 2004, hotels started seeking green building certification systems.

Available studies seem examine the benefits of LEED from a cost perspective, with a focus on whether certification will reduce energy costs or empirically examine the impact of LEED certification on revenue performance on a substantial sample of hotels. The LEED certification system's new v4 has criterias specifically designed for the hospitality industry and is intended to create incentives for new lodging construction that meets sustainability criteria.

A recent study of 93 LEED certified hotels found that the certified hotels displayed better financial performance than a larger sample of non-certified ones. These researchers analyzed the financial results of hotels that had received the Travelocity eco-friendly hotel designation, which is based on any of a dozen different certifications. They found that the "green" hotels recorded higher resource efficiency for both hotel operations and customer activities, as compared to those that had not earned the designation. Thus, it may be that regardless of the certification, hotels that are involved in sustainability activities are operated more efficiently than typical properties.

DGNB is relatively a new system by German Sustainable Building Council. The DGNB has developed the CORE 14 system for international use. It is based on international standards and requirements and can be adapted to local requirements in different countries. As of August 2015, there are 17 hotels in Germany certified with DGNB and an additional project certified by ÖGNI in Austria with the DGNB System other than the one pre-certified hotel project in Turkey.

2.1 Status of hotels with green building certifications

Turkey's energy demand is increasing so does the number of new hotels built. Out of 477 buildings in Table 2, only 36 of them are hotels registered to be certified at some level of LEED. The author used the three hotel projects in Turkey for this research, aiming to be certified with LEED.

The Fairmont Hotel in Mecidiyeköy, İstanbul received a DGNB-Gold pre-certification but the project has not been completed and received the final certification yet.

Even though BREEAM as well as LEED and DGNB is a widely used green building certification system in Turkey especially for retail projects; there are no BREEAM certified hotels in Turkey as of August 2015.

From 2007 to 2015, the number of hotels aiming to get certification in Turkish market give us an indication that hotel industry has started appreciating the benefits of certification. The hotels aiming for green building certification in Turkey are among top-tier foreign hospitality brands, offering environmentally friendly features and practices including solar panels, green roofs, electric vehicle charging stations, rainwater collecting systems and VIP parking for electric and hybrid vehicles. The hotel buildings themselves incorporate many sustainable design and construction features, while the hotel teams include sustainability professionals to oversee environmental practices throughout the buildings.

3. STATE OF ART

According to USGBC, energy efficiency is a key strategy for reducing building-related pollution and greenhouse gas emissions, which are possibly the most important negative environmental consequence of building operation. Production of electricity from fossil fuels is responsible for air pollution and water pollution. Building systems including electrical, lighting, HVAC, and others can be designed to significantly reduce energy consumption compared to conventional designs and practices. The real estate industry started using green building certification systems to demonstrate that their design and construction since early 1990s. Several Cornell Hospitality Reports have demonstrated the importance of green certification in gaining favorable guest notice, including ISO 14001 and LEED. A study of over 2,000 independent hotels in Spain by Segarra-Oña, Peiró-Signes, and Verma found that hotels that have implemented the ISO 14001 environmental standards displayed stronger sales and earnings before taxes and depreciation than those that were not certified.

Constructing hotels green is one of the great strategies to combat climate change for the hotel industry. Greening the hotels help building managers, investors, owners and occupiers reduce the running costs and improve the environmental performance once the hotels start operation. Independent certification process provides a clear and credible route map for sustainable design and construction. Green design and energy simulation results help to optimize the building envelope and mechanical and electrical systems as well as fullfilling the pre-requisite requirements of green building certification systems.

4. METHODOLOGY

This research is conducted on 3 hotel projects in Turkey. These hotels are: Rixos Bademlik Hotel in Eskişehir (certified with LEED-GOLD) and CARYA Hotel at Belek (certified with LEED-GOLD) and HILTON Güneşli in İstanbul (certified with LEED-GOLD). The author was the LEED Process Manager of the three projects and was involved from the design to end of construction of the every step of the integrated project management process including performing the energy simulations with a team of experts for each hotel. In LEED, energy performance is a key component of sustainable design. Accordingly, in both of these systems it is the energy consumption category EA is the the most influential in terms of its impact on the overall assessment score. The most influential sub-categories in LEED is: EA Credit-1 Optimize Energy Performance (19 available credits). 'EA Credit-1' sub-category grant credits for buildings that demonstrate a performance improvement over a specific target. For LEED this target is associated with ASHRAE performance standards. To enable this, the performance of the 'Designed building' is compared to that of a generated 'Base case' building by using any of the approved simulation tools according to each standard. The 'Base case' building shares some characteristics with the 'Designed building' (shape, size, activities etc.), but includes adjusted specifications for building fabric and service systems. For LEED V3 standard: The 'Base case' building is known as the 'Baseline building' and is defined in accordance with the specifications outlined in ASHRAE 90.1-2007. The LEED 'performance improvement' is a cost savings calculation.

For LEED EA Credit-1 calculations, USGBC approves the qualified simulation program must follow a list of specification that includes requirements that the tool must be able to • Calculate 8760 h of building operation to simulate annual energy use. • Model hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat set points, and HVAC system operation.

Energy modelling was performed for each hotel to predict the annual hotel energy usage and to investigate the energy savings. Performing energy simulation is a prerequiste in order to get most green building certifications but energy modeling predates certification systems like LEED, BREEAM and DGNB. Energy modelling proved to be a powerful tool in all projects since it was part of the integrated design process from the beginning. Energy efficiency measures in each projects are diverse and have different interactions with other components of the building and it was necessary to evaluate their effectiveness using some sort of modelling approach.

There are many energy modelling softwares available in the market. A fundamental issue that has been highlighted in various studies is the predictive variability found between energy simulation tools. For the design and selected HVAC equipment, the research team decided to select eQUEST. eQUEST, used for all 3 projects demonstrates the percentage improvement in the proposed building performance rating compared to the baseline building performance rating as per ASHRAE/IESNA Standard 90.1-2007 for a whole building project simulation using the Building Performance Rating Method in Appendix G of the standard. The proposed design model is based on the actual parameters and actual design considerations and architectural details.

During schematic design phase a simplified model of building is used to test site and basic design features. For the values not available at the pre-design stage, default values are utilized. After several runs, alternative scenarios are compared. During design development stage inputs like, building characteristics, occupant characteristics, system characteristics are used to model. The outputs show us what the monthly consumption by end use will be as well as equipment type. Once the design development is completed the exact location, size and material characteristics for the envelope, windows, doors, roof and foundation are plugged into the model. During the preparation of construction and bid documents the complete energy model outputs are used. Construction management team is asked to install the designed features. Modelling also helped us to examine the life cycle costs.

There are 35 possible points and 3 Prerequisite requirements for energy requirements in LEED V3. The prerequisites are: 1. Fundamental Commissioning of Building Energy Systems 2. Minimum Energy Performance 3. Fundamental Refrigerant Management. The document states that the minimum energy performance in Prerequisite 2 is 10% improvement in the proposed building performance rating for new buildings compared with the baseline building performance rating. Other credits are:

- Credit 1 Optimize Energy Performance 1-19
- Credit 2 On-site Renewable Energy 1-7
- Credit 3 Enhanced Commissioning 2
- Credit 4 Enhanced Refrigerant Management 2
- Credit 5 Measurement and Verification 3
- Credit 6 Green Power 2

New Buildings	Existing Building Renovations	Points (NC & Schools)	Points (CS)
12%	8%	1	3
14%	10%	2	4
16%	12%	3	5
18%	14%	4	6
20%	16%	5	7
22%	18%	6	8
24%	20%	7	9
26%	22%	8	10
28%	24%	9	11
30%	26%	10	12
32%	28%	11	13
34%	30%	12	14
36%	32%	13	15
38%	34%	14	16
40%	36%	15	17
42%	38%	16	18
44%	40%	17	19
46%	42%	18	20
48%	44%	19	21

Table 3: % improvement and corresponding LEED credits

4.1 Case studies

A total number of 36 major hotel developers in Turkey were contacted for the study. 35 of these hotels aimed to receive LEED certification at some level while 1 aimed to receive DGNB. All 3 cases under this study received LEED GOLD certifications.

4.2 Bademlik Rixos Hotel at Eskişehir, Turkey

The Hotel consists of 5 basements, ground floor and 3 Guest Room floors. Boilers are designed to meet the heating energy demand of the building. Principal heating source is natural gas. According to function of the zones different heating systems are used. 4-piped Fan Coil system is used ballroom, back stage retail areas, foyer. Water cooled VRF system is used in guest rooms; café, restaurant and gym are heated by PTACs. Water cooled chillers are installed for cooling; FCU indoor units are used to meet the cooling energy demand of the building. Geothermal water is used as domestic hot water and laundry process demand. In addition to heating and cooling systems;

provided fresh air rates are designed according to ASHRAE 62.1-2007. In order to predict and compare the energy performance of the project with respect to the LEED NC requirements, Energy Analysis is done using eQUEST. This program simulates the energy performance of a building using hourly time steps for all 8760 hours in a year and by using Meteonorm Hourly Interpolated Values for Eskisehir weather file. The analysis and modeling methodology is in line with the LEED requirements. The energy model results show that the actual design for the building performs 30 % better than ASHRAE 90.1-2007 requirements using the LEED performance rating method.

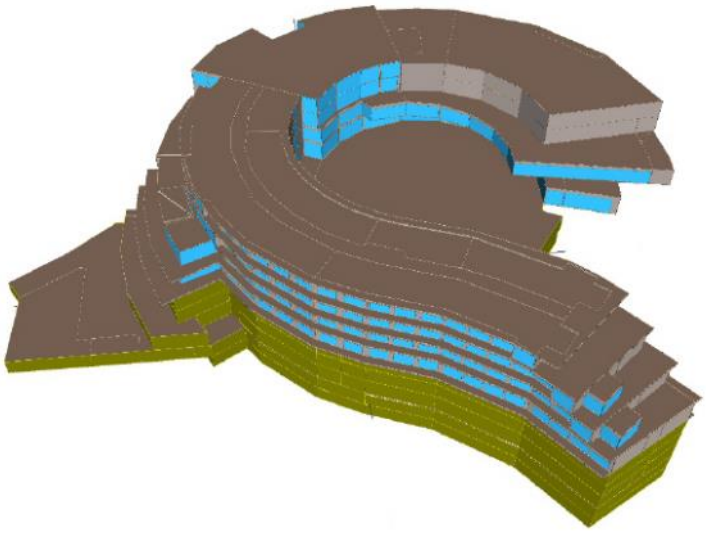

Figure 1: The 3D geometric model output of Bademlik Rixos Hotel for eQuest

4.3 Carya Hotel in Antalya, Turkey

Carya Hotel consists of one basement, Ground floor, one Mechanical Floor, and 4Guest Room floors (including Attic Floor). Boilers are designed to meet the heating energy demand of the building. As a fuel type natural gas is used. According to function of the zones different heating systems are used. 4-piped Fan Coil system is used office, hotel rooms and circulations. Unitary Heaters are used in technical areas; café, restaurant and gym are heated by PTACs. Chillers are installed for cooling; FCU indoor units are used to meet the cooling energy demand of the building. Tri generation unit installation is the most important point for energy efficiency and improvement in the building. In addition to heating and cooling systems; provided fresh air rates are designed according to ASHRAE 62.1-2007.

eQUEST is used to simulate the energy performance of a building using hourly time steps for all 8760 hours in a year and by using TUR_Antalya_MN6.bin weather file. The analysis and modeling methodology is in line with the LEED requirements.

The proposed design model is based on the actual parameters and actual design considerations and architectural details. The key measures of an efficient design are: improving glazing, improving exterior wall Thermal Energy conductivity, using Heat Recovery Wheel; etc. The energy model results show that the actual design for the building performs 20 % better than ASHRAE 90.1-2007 requirements using the LEED performance rating method.

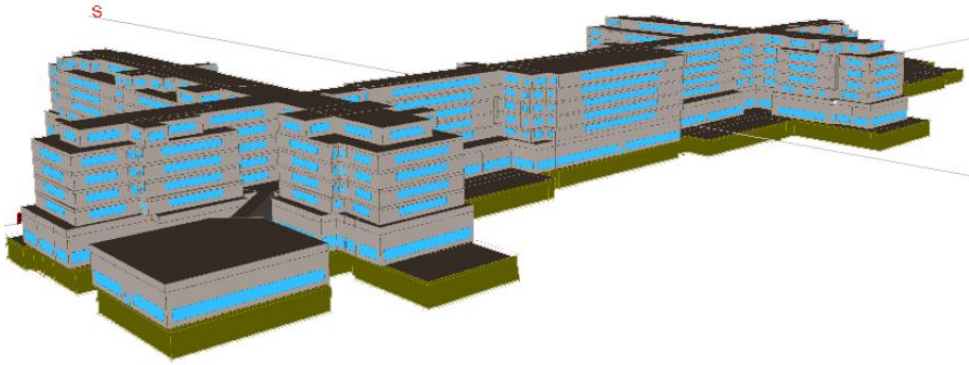

Figure 2: The 3D geometric model output of Carya Hotel for eQuest

4.4 GÜNEŞLİ HILTON, ISTANBUL, Turkey

Güneşli Hilton Hotel consists of 4 basements, ground floor and 22 Guest Room floors. Boilers are designed to meet the heating energy demand of the building. Principal heating source is planned to be natural gas. According to function of the zones different heating systems are used. 4-piped Fan Coil system is used in restrooms, changing rooms, ballroom, boardrooms, offices, fitness room, guest rooms and corridors. Variable air volume with under floor static heating is modelled for the pool area. Air cooled chillers are installed for cooling; FCU indoor units are used to meet the cooling energy demand of the building. In addition to heating and cooling systems; provided fresh air rates are designed according to ASHRAE 62.1-2007. In order to predict and compare the energy performance of the project with respect to the LEED NC requirements, an energy analysis is completed using eQUEST. The proposed design model is based on the actual parameters and actual design considerations and architectural details. The energy model results show that the actual design for the building performs 26,9 % better than ASHRAE 90.1-2007 requirements using the LEED performance rating method.

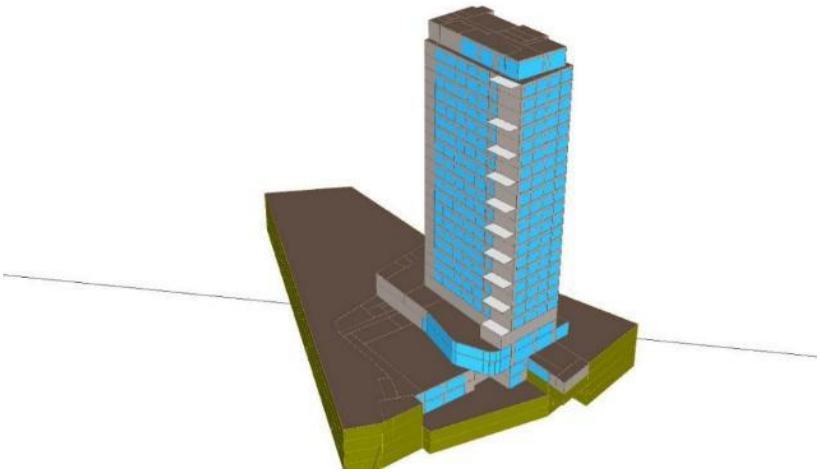

Figure 3: The 3D geometric model output of GUNEŞLİ HILTON hotel for eQuest

5. RESULTS

Green building rating systems like LEED, aims to give benchmark and rank buildings within a specific frame. LEED considers a broad range of categories for reducing the environmental impact. The certification process requires a substantial modelling work. Building Energy Modelling helps determine the most cost effective solutions. Balancing the long-term payback of energy improvements, against critical capital costs, defines the building decisions. It is beneficial for hotel designers to utilize modelling as part of their design plan since modelling helps to optimize the building envelope and mechanical and electrical systems. Based on the findings presented in this paper, it is suggested there exists significant energy savings potential for the Turkey's hotel industry as in the case for the 3 green hotel projects from three different climate zones in Turkey. The main finding was that it is technically feasible to have 67 % energy cost improvement over baseline without compromising guest comfort by using green technologies used in Carya Hotel in Antalya.

Category	DATA	CARYA	BADEMLIK	HILTON
ENERGY	Standard of Simulation	ASHRAE 90.1-2007 App. G	ASHRAE 90.1-2007 App. G	ASHRAE 90.1-2007 App. G
	Actual Design (kWh/m2/year)	166,37	221,56	155,49
	Baseline Design (kWh/m2/year)	208,05	318,14	212,71
	% energy cost improvement over baseline	67	37,89	19,94
	Actual Design (KgCO2/m2/year)	90,1725	120,0855	84,2755
	Baseline Design (KgCO2/m2/year)	112,7631	172,4318	115,2888
	% improvement over baseline	20	30	26,9
	U values of exterior wall (W/m2.K)	0,31	0,42	0,48
	U values of glazing+frame system (W/m2.K)	4,49	2,27	4,31
	% of actual energy cost by renewable/trigen sources connected to the building	56	2	0
WATER	% Water consumption improvoment over baseline	33	43	40
WASTE	Percentage (%) of waste diverted from landfill	89	87	88
AIR QUALITY	%30 Increased Ventilation according to ASHRAE 62.1-2007	YES	NO	YES

Table 4: Comparision of sustainability criterias

6. CONCLUSİONS AND RECOMMENDATİONS

Turkey has a favorable economic environment for foreign direct investment and construction market has a compound annual growth rate (CAGR) of 19%, while investment in the sector is increasing with a CAGR of 10%. Every year 100 thousand construction permits are granted for new buildings and 1,2% of these permits are for hotels. That corresponds to approximately 1200 hotel construction per year where only 3% of these hotels are aiming to receive green building certification systems. Based on the analysis of the three hotels which received LEED-GOLD certification, there exists significant energy savings potential for the Turkey's hotel industry if hotels are designed and built with sustainability principles. The main finding after compairing the three hotel designs is that it is technically feasible to increase energy efficiency over 60% without compromising guest comfort by using green technologies. From the LEED registered hotel list in Turkey, a high percentage of hotels receiving green building certifications are found to be foreign brands. Turkey, in order to develop its local hotel brands in a sustainable way, has to create a green code for the hotels. Turkish NGOs in the real estate sector are on the verge of creating a new national code for buildings. Since the ASHRAE 90.1 Energy Standard is being widely used by international green building certification systems, the new building code to be developed for Turkey can embed the requirements of ASHRAE 90.1 Energy Standart into the new code. Designers can use the building energy modelling to efficiently meet the new building code standard. This way, developers can evaluate energy saving potential of several possible solutions and pick the one suitable to meet the requirements of the code.

CONFLİCTS OF INTEREST

The author declares no conflict of interest.

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