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EVALUATION OF SUSTAINABILITY IN HOSPITALITY SECTOR IN TURKEY AND COMPARATIVE LIFECYCLE ASSESSMENTS OF ACCOMMODATION OPTIONS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

KADRİYE AKDEMİR YILMAZ

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
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IN
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EVALUATION OF SUSTAINABILITY IN HOSPITALITY SECTOR IN TURKEY AND COMPARATIVE LIFECYCLE ASSESSMENTS OF ACCOMMODATION OPTIONS

submitted by **KADRIYE AKDEMIR YILMAZ** in partial fulfillment of the requirements for the degree of **Master of Science** in **Building Science in Architecture, Middle East Technical University** by,

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ABSTRACT

EVALUATION OF SUSTAINABILITY IN HOSPITALITY SECTOR IN TURKEY AND COMPARATIVE LIFECYCLE ASSESSMENTS OF ACCOMMODATION OPTIONS

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Master of Science, Building Science in Architecture
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May 2022, 123 pages

Currently, one of the most important factors influencing the future of the world is tourism, due to its negative effects on the natural environment and consumption of natural resources. The tourism sector, which offers its guests natural and cultural beauties in the region where it is located, will not be able to survive if the potential danger to natural environment and resources is not halted. In other words, sustainable tourism is entirely dependent on the sustainability of the environment and resources.

The Turkish Ministry for Culture and Tourism has awarded the Environmental Friendly Establishment Certificate for promoting and encouraging positive contributions of touristic facilities to the environment, since 1993. However, this research shows that the contribution of investments in the Green Star Certificate System to the success of 'greening' the hotels is insufficient. Although there are many types of research focusing on Green Star Certified Hotels in terms of tourism; there is not enough focus on the evaluation of the hotel buildings and the alternative accommodation options in Turkey.

This study primarily aims to investigate the Green Star Certification System by determining the success of adopting sustainability principles; through a preferability survey based on guests' feedback. The second aim, in view of the transformation in accommodation options, is to determine whether there is a relationship between sustainability measures in hotels, preferability according to guests ratings, and the lifecycle assessment impact.

According to the first aim of the study; both qualitative and quantitative data of Environmentally Sensitive Green Star certified hotels is analyzed via statistical t-tests. The results show that Environmentally Sensitive Green Star Certified Hotels are more successful in terms of guests' satisfaction. However the distribution of the Green Star certified hotels are almost zero value for the three and lower star rating hotels. The statistical results also can encourage these lower class hotel owners.

In line with the second aim of the study; the case study building consisting of residential units, serviced apartments, and guest rooms in the same hotel is selected from Istanbul. The comparison of three accommodation options are done both for the zones and per guests. The LCA results are obtained by assessment with Athena Impact Estimator for Buildings 5.4 software. According to the results; it can be said the product, construction and end of life stage enviromental impacts of the each zones increase respecively hotel rooms, service apartments and residential units. The LCA results show that the alternative accomodation options` design and material selections need improvements comparing with hotels` guest rooms.

Keywords: Green Certified Star Hotels, Sustainable Hotels, Lifecycle, Accommodation Options.

ÖZ

TÜRKİYE`DEKİ TURİZM SEKTÖRÜNÜN SÜRDÜRÜLEBİLİRLİK YÖNÜNDEN GELİŞİMİ VE KONAKLAMA SEÇENEKLERİNİN YAŞAM DÖNGÜSÜ AÇISINDAN DEĞERLENDİRİLMESİ

Akdemir Yilmaz, Kadriye
Yüksek Lisans, Yapı Bilimleri, Mimarlık
Tez Yöneticisi: Prof. Dr. Soofia Tahira Elias Ozkan

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Günümüzde dünyanın geleceğini etkileyen en önemli faktörlerden biri, doğal çevre üzerindeki olumsuz etkileri ve doğal kaynakların tüketimi nedeniyle turizmdir. Bulunduğu bölgede doğal ve kültürel güzellikleri misafirlerine sunan turizm sektörü, doğal çevre ve kaynaklara yönelik potansiyel tehlike durdurulmazsa varlığını sürdüremeyecektir. Bir başka deyişle, sürdürülebilir turizm tamamen çevrenin ve kaynakların sürdürülebilirliğine bağlıdır.

Türkiye Cumhuriyeti Kültür ve Turizm Bakanlığı, turistik tesislerin çevreye olan olumlu katkılarını desteklemek ve teşvik etmek amacıyla 1993 yılından bu yana Çevre Dostu Kuruluş Belgesi ile tesisleri ödüllendirmektedir. Ancak bu araştırmada, Yeşil Yıldız Sertifika Sisteminde yatırımların otellerin “yeşillenmesi” başarısına katkısının yetersiz olduğunu göstermiştir. Yeşil Yıldız Sertifikalı Otellere turizm açısından odaklanan birçok araştırma olmasına rağmen; Türkiye'deki otel binalarının değerlendirilmesi ve alternatif konaklama seçeneklerine yeterince odaklanılmamaktadır.

Bu çalışma öncelikle konukların geri bildirimlerine dayalı bir tercih anketi ile sürdürülebilirlik ilkelerini benimseme başarısını belirleyerek, Yeşil Yıldız Sertifikasyon Sistemini araştırmayı amaçlamaktadır. İkinci amaç, konaklama seçeneklerindeki dönüşüm ışığında, otellerde sürdürülebilirlik ilkeleri ile misafir puanlarına göre tercih edilebilirlik ve yaşam döngüsü değerlendirmesi etkisi arasında ilişki olup olmadığını belirlemektir.

Çalışmanın birinci amacına göre; Çevreye Duyarlı Yeşil Yıldız sertifikalı otellerin hem nitel hem de nicel verileri istatistiksel t-testleri ile analiz edilmiştir. Sonuçlar Çevreye Duyarlı Yeşil Yıldız Sertifikalı Otellerin misafir memnuniyeti açısından daha başarılı olduğunu göstermektedir. Ancak Yeşil Yıldız sertifikalı otellerin dağılımı, üç ve daha düşük yıldızlı oteller için neredeyse sıfır değerindedir. Ayrıca istatistiksel sonuçlar bu alt sınıf otel sahiplerini cesaretlendirebilir.

Çalışmanın ikinci amacı doğrultusunda; İstanbul'dan aynı otel binasında bulunan otel odaları, kiralanabilir daireler ve rezidans birimlerinden oluşan örnek olay binası seçilmiştir. Üç konaklama seçeneğinin karşılaştırması hem bölgeler hem de misafir başına yapılmıştır. Yaşam döngüsü değerlendirmesi sonuçları Athena Impact Estimator for Buildings 5.4 yazılımı ile elde edilmiştir. Sonuçlara göre; her bölgenin ürün, inşaat ve yaşam sonu çevresel etkilerinin sırasıyla otel odaları, kiralanabilir daireler ve konut birimlerinin arttığı söylenebilir. Ayrıca yaşam döngüsü değerlendirmesi sonuçları, alternatif konaklama seçeneklerinin tasarım ve malzeme seçimlerinin, otellerin odalarına kıyasla iyileştirmelere ihtiyaç duyduğunu göstermektedir.

Anahtar Kelimeler: Yeşil Yıldız Sertifikası, Sürdürülebilir Otel, Konaklama Seçenekleri, Yaşam Döngüsü.

.

To my beloved family

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WSSD	World Summit on Sustainable Development
UNWTO	United Nations World Tourism Organization
CSD	Commission for Sustainable Development
WTTC	World Travel & Tourism Council
UNEP	United Nations Environment Programme
TIES	The International Ecotourism Society
EC	Earth Council
BMS	Building Management Systems
BEMS	Building and Energy Management System
HVAC	Heating, Ventilating and Air Conditioning
ISO	International Organisation for Standardization
LCA	Lifecycle Assessment
LCI	Lifecycle Invenory
EUI	Energy Use Intensity

CHAPTER 1

INTRODUCTION

This study focuses on the hospitality sector in Turkey in terms of sustainability and LCA. In this chapter the argument, aim of study, research objectives and methodology, and disposition of content are presented.

1.1 Argument

The construction of buildings and their operation contribute to “one-third of global final energy consumption and nearly 40% of total direct and indirect CO2 emissions” (Internationa Energy Agency, 2020). The International Energy Agency emphasizes that the energy demand of buildings and the construction sector is rising continually (Internationa Energy Agency, 2020).

Global warming trend is threatening the future of the world and the most important contributors to this phenomemon are the building, tourism, and transportation sectors (Canbay, 2011). The tourism sector, which offers its guests natural and cultural beauties in the region where it is located, will not be able to survive in case of potential danger to natural resources. Therefore, tourism can be said to be almost entirely dependent on sustainability as it is directly related to sustainable resources.

According to the World Tourism Organization report; Turkey with its increasing annual growth of tourism investments is one of the most preferred touristic destinations around the world (World Tourism Organisation, 2019). This growth rate is dependent on the support of sustainability policies that ensure success in the tourism industry. Turkey is continuing many initiatives regarding sustainability in the tourism sector, the most prominent one is the Green Star Certificate System. It can be said that this certification system represents the sustainable awareness of tourism in Turkey. However the Green Star Certificate System does not cover the accommodation establishments having investment licence. The accommodations having operation licence which is already designed and built can be awarded by the Green Star Certificate. This situation may cause overlook sustainable design solutions and discourage the investment licenced accommodation establishments. Also this certification system can be said that stipulates the criteria based on the sustainability in general approach. However improving the sistem by the light of lifecycle assesment can be more holistic in terms of evaluation of lifespan of hotel buildings and affects design decisions in more comprehensive manner.

Some researches show that embracing environmentally friendly policies of hotels is gaining importance for guests' choice and has a positive impact on hotels' image. Moreover, with their increasing importance, sustainability-based solutions have started to play a role in the success of hotels as well as ecological gains. The gains from sustainability have a positive effect on other investments in the hospitality sector.

It can be said that despite the legal obligations and incentive systems in Turkey, sufficient awareness of sustainability in hotel investments has not yet been formed. However, it is obvious that the success of hotels that have adopted the principles of sustainability will help other businesses to take steps by encouraging them in this regard. Since the increasing trend of hotel investments continues without sustainable applications; the sustainability of tourism in Turkey may come at a risk.

Also during the literature review, it is realized that many types of research are focusing on the Green Star Certified Hotels in terms of the tourism area. However, there is not enough research focusing on the evaluation of hotel buildings.

It is an important fact that tourism and accommodation options in the world are also undergoing a great transformation. Today, accommodation facilities do not only vary according to hotel classes. A new option has emerged in the tourism sector, as property owners start to rent their furnished flats when they are not using them. With the increase of rentable furnished apartments and flats for short terms, hotel businesses have started to produce alternatives such as short term residences or service apartments and residential units that aim to offer both residential and hotel comfort to their customers; with the concept of ‘home away from home’.

Hotels can be defined as an accommodation option for travelers. The typology of hotels is similar to housing units but differs by combining it's dining and other activities in common areas. For this reason; it can be said that there are three basic options for accommodations for tourists and travellers; which are housing units, service apartments, and hotel rooms. In this regard; it is vital to evaluate and compare these three accommodation options not only in terms of sustainability but also in terms of the accomodation buildings lifecycle.

This study primarily aims to investigate the Green Star Certification System by determining the success of adopting sustainability principles; through a preferability survey based on guests’ feedback. The second aim, in view of the transformation in accommodation options, is to determine whether there is a relationship between sustainability measures in hotels, preferability according to guests ratings, and the lifecycle assessment impact.

1.2 Aim and Objectives

It can be said that; there are 3 systems to evaluate sustainable hotels. These are;

- Adopting sustainable principles categorized by certification systems.
- Life Cycle Assessment of the building.
- Preferability of accommodation options by guests.

The fundamental aim of the study is to reveal the relationship between these three evaluation systems of hotels.

Related to this aim, the following questions will be answered;

- Do the number of sustainable hotels vary according to hotel types?
- Does the investment in sustainability change according to the hotel class and region in Turkey?

- Are the Green Star certified hotels prefered by guests?
- Is the satisfaction of guests the same with green star classified hotels and uncertified ones located in the same region and having the same standards?
- In terms of LCA; is there any difference between the three different accommodation options?

In order to achieve the aim of the study; the following objectives will be fulfilled;

- To determine the success of the Environmentally Sensitive Green Certified Hotels according to guest reviews.
- To assess the environmental impacts of the material used in three different accommodation options.
- To define the relationship between three evaluation systems of hotels; certification, guest review and LCA impacts.

1.3 Procedure

The research focuses on the hospitality sector and accommodation options in Turkey in terms of sustainability and LCA. In order to collect reliable data; the subject is specialized according to national norms and standards, which are Turkey Ministry of Culture and Tourism's requirements and acceptance as Environmentally Sensitive Green Star Certified Hotels.

For the inventory analysis; the Statistical Reports of Green Star Certified Accommodation`s data from 2001 to 2020 were analyzed. And it was noticed that the the rate of certified green star hotels has never exceeded 12% of the total number of hotels.

As a first step of the research, a comprehensive literature review was conducted focusing on Green Star Certification System, sustainability assessment methods, sustainable strategies and practices for hotels, guest satisfaction, and lifecycle assessment.

In the second step; research area is defined as Istanbul and Antalya because of the region, touristic features, and the number of hotels. And qualitative and quantitative data sets are prepared. While the quantitative data consists of the list of Environmentally Sensitive Green Star certified hotels; guests ratings` gathered from an online travel website; Triago.com is used as the qualitative data. The data set combining the both qualitative and quatitative data is analyzed via statistical t-tests.

In the third step; the case study building; which is consisting of residential units, serviced apartments, and guest rooms in the same hotel, is selected from Istanbul. The data derivered from the drawings and bills on quantities (BOQ) of the case studies. The BOQ of the building`s finishing works is also calculated according to the guests` numbers. The comparison of three accommodation options are done both for the zones and per guests. The LCA results are obtained by assessment with Athena Impact Estimator for Buildings 5.4 software.

1.4 Disposition

In the first section of this thesis, arguments, problem statements, and objectives are explained.

The second section is the literature review part, which starts with information about the Green Star Certification System. On the following parts; energy consumption on hotel buildings, sustainable design strategies for hotels, and LCA methodology are justified.

In the third section of the thesis, materials, and methods are presented. As a first step, both quantitive and qualitative research on the Green Star Certified hotels in Turkey was conducted aiming to understand the success of these hotels. Afterward, the case study building is examined in order to reveal the lifecycle assessment of different accommodation options.

Analysis, discussion, and results are explained in the fourth section. The conclusion, the last section, gives brief information about the study and the findings.

CHAPTER 2

LITERATURE REVIEW

In this section, the literature review is presented, starting with sustainable tourism in Turkey, classification of hotels, relationship between hotels` star rating and sustainability, energy consumption in hotels. Afterward, sustainable strategies for energy efficiencies grouped according to the design and operation phases are explained. After sustainable hotel practices and guest satisfaction, sustainable assessment methods are described according to certification, eco-labeling and lifecycle assessment methods. Finally lifecycle assessment of hotel buildings are researched.

2.1 Sustainable Tourism in Turkey

Reducing energy consumption and production of greenhouse gases is essential for sustainability; in order to protect natural resources to pass them on to future generations and cope with the problem of global warming. Sustainable design aims to create a better physical environment according to user needs by prioritizing environmental sustainability.

The tourism sector is estimated to be responsible for 5% of global CO2 emissions while hotels and accommodation are responsible for 20% (Nearly Zero Energy Hotels, 2018). Realizing that natural resources are at risk and raising environmental awareness all over the world; many governments and international organizations have focused on environmental sustainability and energy-efficient systems, policies, incentives, and measures. In order to ensure sustainable implementation to the buildings; many regulations, building codes, and certification systems have been established all around the world. This evaluation according to sustainability has also affected the tourism industry. Figure 1; demonstrates the historical development of sustainable tourism; starting from 1987 to 2016 (Pan, et al., 2018).

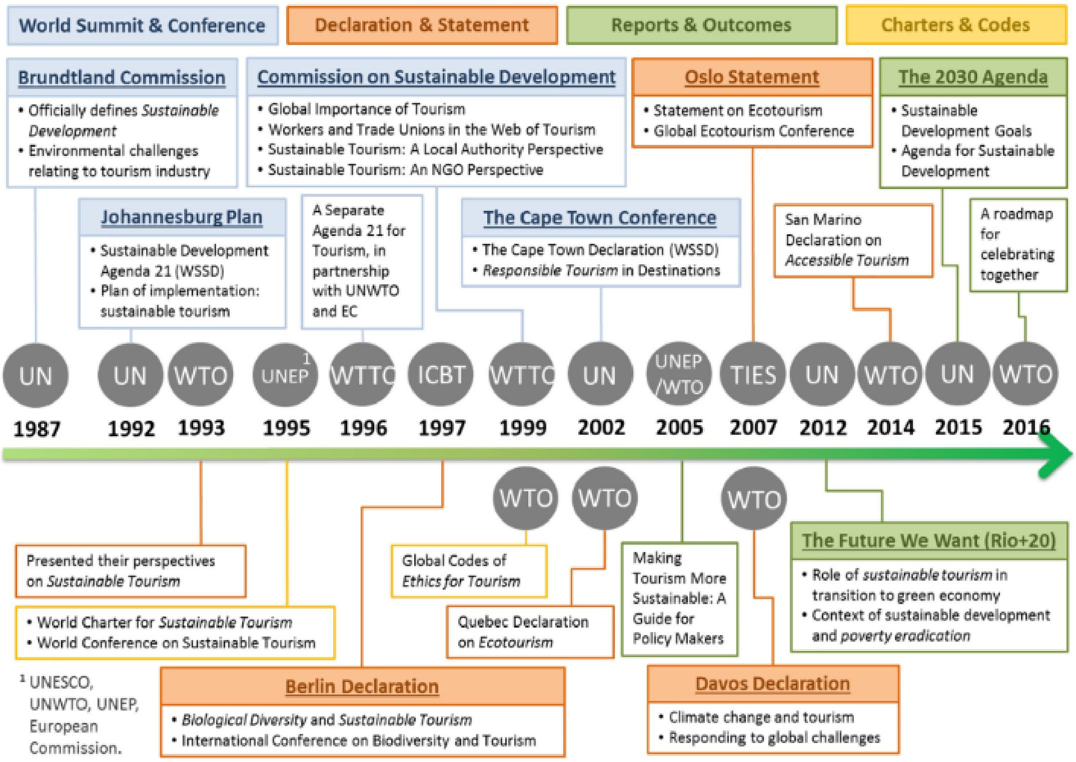


Figure 2.1. Historical development of sustainable tourism (Pan, et al., 2018)

Turkey has become a party to the Kyoto Protocol on 26 August 2009 and has developed and maintained its policies on environmental protection and sustainability. According to the Sustainable Development Tools Evaluation Report of Turkey; “Developing and implementing policies to support sustainable tourism that creates jobs and promotes local cultures and products by 2030” is one of the Sustainable Development Goals of Turkey (Presidency of The Republic of Turkey, 2019). In the last 10 (pre-pandemic) years, Turkey`s tourism income increased by 16.1% and the foreign arrivals increased by 49.1% (Turkish Tourism Investors Association, 2018). Tourism revenues have a growing importance in Turkey`s economy, therefore, touristic facilities and infrastructures in new destinations are supported by the government. However, in line with tourism development goals sustainability requirements should be fulfilled on either new constructions or existing buildings.

International building sustainability assessment and certification methods are being used in Turkey; in addition to the first national system of Environmental Friendly Establishment Certificate for touristic facilities called the Green Star Rating System. The success of the Green Star Certificate System and the sustainability of tourism is crucial for Turkey`s tourism and economy. However; it can be said that the emphasis on the contribution of investments in the Green Star Certificate System to the success of hotels is insufficient.

2.2 Classification of Hotels

Determining the minimum qualifications of touristic facilities, ensuring the standard unity among these facilities, increasing and maintaining the quality are under the responsibility of the Turkish Ministry for Culture and Tourism by regulations.

According to the Turkish Ministry for Culture and Tourism regulations, touristic accommodation facilities are listed under seven titles as; hotels, holiday villages, boutique hotels, special accommodation facilities, motels, pensions, and apart hotels. Since this study focuses on hotels, the classification of hotels is included (Resmi Gazete, 2019).

The Turkish Ministry for Culture and Tourism defines hotels as accommodations which has auxiliary and complementary units for their guests' food-beverage, sports and entertainment needs. And hotels are classified as one, two, three, four and five star hotels. The hotels' classes are determined by the classification commission's evaluation of the Turkish Ministry for Culture and Tourism according to the minimum qualification of hotels such as hotel type, capacity, physical characteristics, standard of materials used, quality of operation and service, qualifications and education level of personnel (Resmi Gazete, 2019).

The hotel classification evaluation is conducted for hotels which accomplished these basic criteria which is based on the collecting points of hotels qualifications in twenty five categories and 202 different subjects such as; management, pools, entertainment units, dining rooms, patisserie and buffets, elevators and outdoors (Resmi Gazete, 2019).

While the regulation of Turkish Ministry for Culture and Tourism dated on 2005/8948 (Resmi Gazete, 2005) ; introduced requirements for 4 and 5 star hotels in areas such as indoor and outdoor pools, restaurants, snack bars, parking lots, these obligations were not included in the regulation dated 2019/1. And the scoring system came to the fore in hotel star classification.

As a prerequisite for hotel classification evaluation, there are requirements in addition to the criteria of a subclass in every class from one star to 5 star. The basic criteria that hotels have to meet are listed according to star are listed following subtitles.

i. **One-Star Hotels**

In addition to the equipment conditions that will meet the basic needs of the guests in the rooms and hotel facilities, having minimum 10 rooms, a reception hall with beverage service are the requirements for one star hotels.

ii. **Two-Star Hotels**

In addition to the qualifications of one-star hotels, these are the hotels that pass the score threshold of classification evaluation, offer a management room, a service office on the bedroom floors, and internet service in common areas to their guests.

iii. **Three-Star Hotels**

In addition to the qualifications of two-star hotels, these are the hotels that pass the score threshold of classification evaluation, offer a breakfast room, air conditioning in common areas, room internet connection and laundry to their guests.

iv. **Four-Star Hotels**

In addition to the qualifications of three-star hotels, these are the hotels that pass the score threshold of classification evaluation, four star hotels must have additional management room, restaurant, luggage room, air conditioning in rooms and common areas, certificated and licenced personel or minimum 5 year-experienced management personel.

v. **Five-Star Hotels**

In addition to the qualifications of four-star hotels, these are the hotels that pass the score threshold of classification evaluation, four star hotels must have additional minimum 60 rooms which are well equipped and decorated according to the standards, service elevator, seperated entrance between guests and equipments, customer relations and consultancy service.

2.3 Relationship Between Hotels` Star Rating and Sustainability

Studies focusing on the hotels` environmental applications emphasize that the sustainability adoption of the hotels is directly related with the hotels` financial performance (Claver-Cortés, Molina-Azorin, & Pereira-Moliner, 2007). As the star rating is the demonsration of the hotels` qualifications, it can be said that the hotels` meeting the the criteria of upper star rating is also related to their financial strength. According to N. Stylos and C. Vassiliadis`s study; hotel star ratings has great importance on the economic viability (Stylos & Vassiliadis, 2015).

A study reveals that four-star and five-star hotels` sustainable impelications has strenghten the hotels image and improve hotels` attibutes; while three-star hotels` sustainability concerns was determined as far behind the price issue (Peiró-Signes, Segarra-Oña, Verma, Mondéjar-Jiménez, & Vargas-Vargas, 2014).

On the other hand; another research comparing the sustainability commitments of green hotels` according to star ratings also proves that the achievement of the sustainability goals is higher for the hotels having higher star ratings (Abdou, Hassan , & El Dief, 2020).

Many studies have drawn attention to the importance of managemental principles in adopting sustainability principles in hotels (López-Gamero, Claver-Cortés, & Molina-Azorín, 2011). As described on the previous section; employment of certificated and licenced personel or minimum 5 year-experienced management personel is basic criteria of four and five star hotels according to the regulation of Turkish Ministry for Culture and Tourism (Resmi Gazete, 2019). It can be shown as one of the important reasons for the four and five star hotels` sustainable implications.

Also sustainability adoption process requires plan and programme defined by the specialists. Most of the financially strong hotels groups and chain hotels develop sustainability strategies in an holistic approach. It can be said that behind the sustainable success of these hotels lies the strategies planned by experts.

2.4 Energy Consumption in Hotels

As tourism gains increasing importance in revenues for the government`s economy around the world; the investments in hotels and the tourism industry are growing. The tourism sector that is developing rapidly should adopt the principles of sustainability and energy-efficient applications in order to reduce the share of carbon emission which nearly accounts for 2% of the world (Global Real Estate Sustainability Benchmark, 2022).

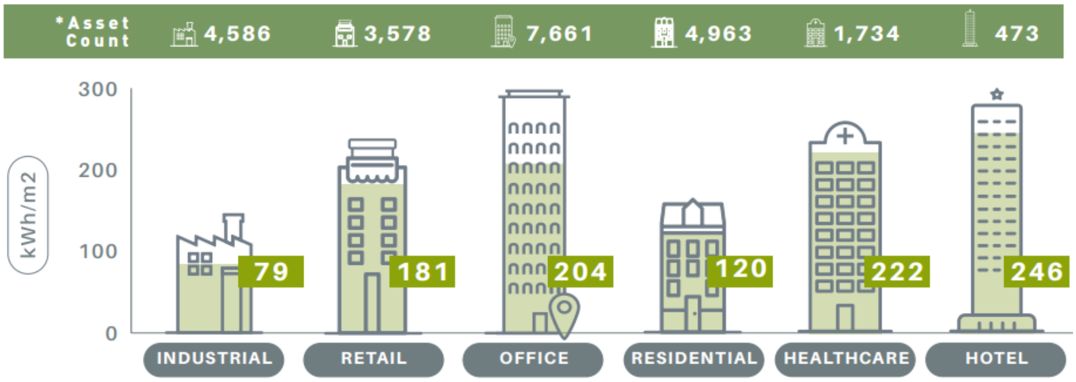


Figure 2.2. Energy use intensities according to building types (Global Real Estate Sustainability Benchmark, 2022)

Figure 2.3 shows hotel energy consumption according to years. It can be assumed that the increasing consciousness and the attention to global warming have had positive effects on hotel buildings by decreasing energy demand.

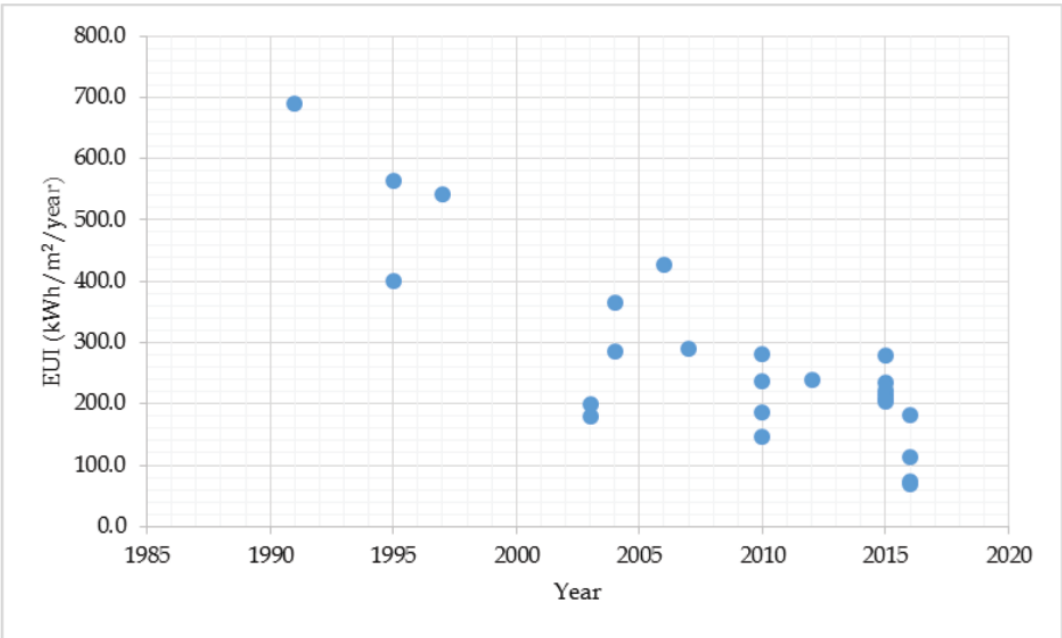
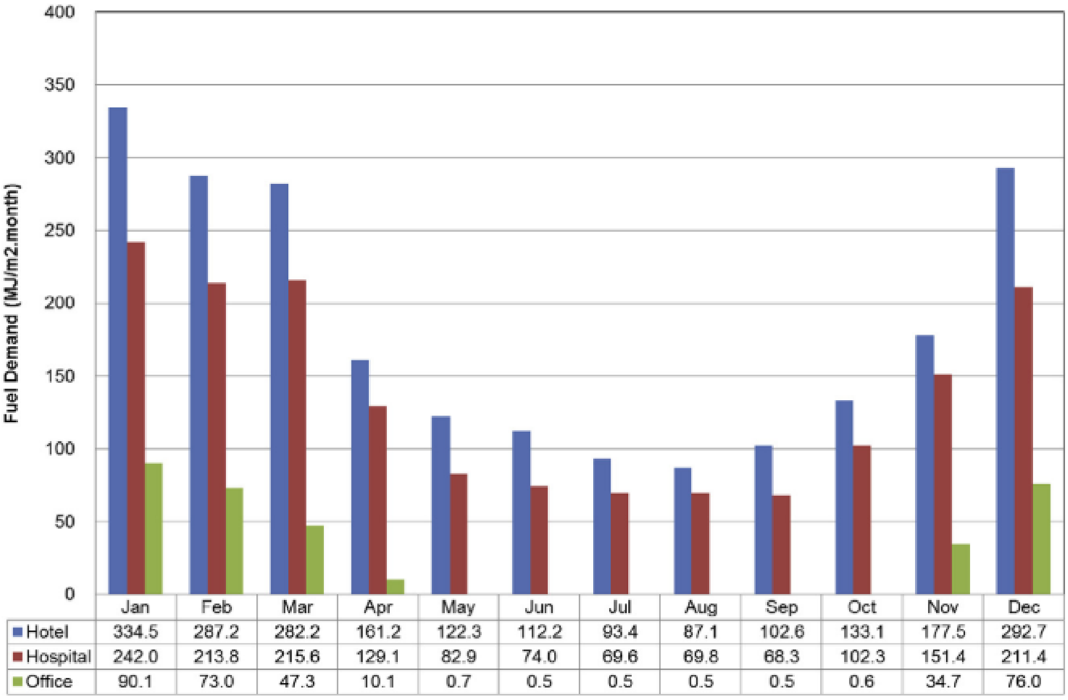


Figure 2.3. Trend of average total EUI of hotels in the world (Amanda & Sanjei, 2019).

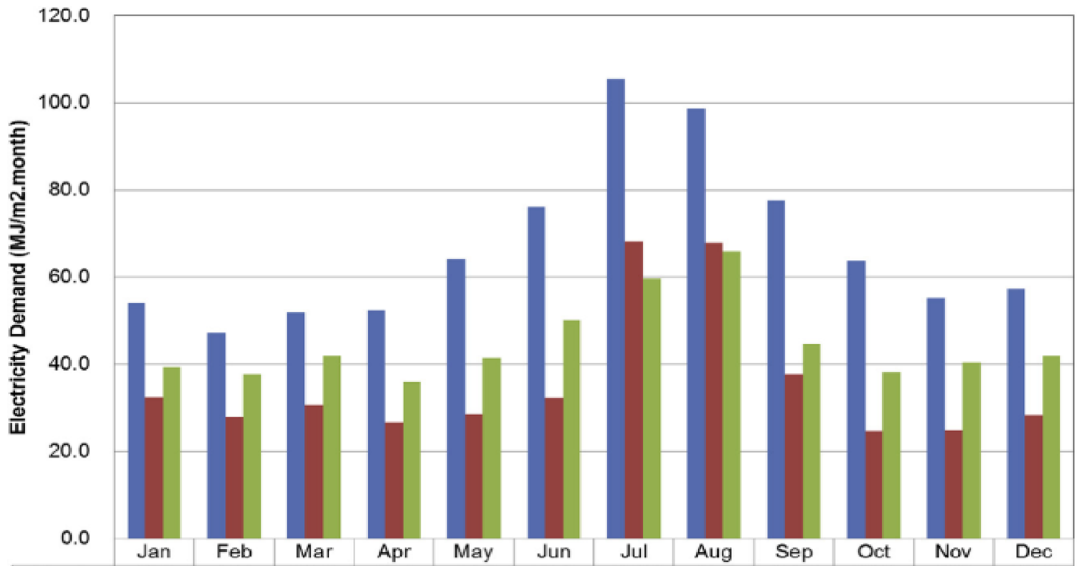
Considering the energy consumption of buildings; many factors like the type of building, design elements, heating cooling systems, maintenance, lighting, equipment, other facilities, and services affect energy demand.

Although hotels can be classified under the title of commercial buildings; their all-day-long activities and highly energy-consuming services differentiate them from other types of commercial buildings. Figure 2.4 and Figure 2.5 demonstrate the comparison of hotel, hospital, and office buildings` annual energy consumption in terms of fuel and electricity.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hotel	334.5	287.2	282.2	161.2	122.3	112.2	93.4	87.1	102.6	133.1	177.5	292.7
Hospital	242.0	213.8	215.6	129.1	82.9	74.0	69.6	69.8	68.3	102.3	151.4	211.4
Office	90.1	73.0	47.3	10.1	0.7	0.5	0.5	0.5	0.5	0.6	34.7	76.0

Figure 2.4. Monthly fuel consumption per unit area (Chung & Park, 2015).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hotel	54.0	47.3	51.9	52.3	64.1	76.2	105.5	98.8	77.5	63.6	55.3	57.4
Hospital	32.3	27.8	30.7	26.7	28.6	32.3	68.2	67.9	37.8	24.7	24.8	28.3
Office	39.4	37.8	41.8	36.0	41.4	50.2	59.6	65.9	44.7	38.2	40.4	41.8

Figure 2.5. Monthly electricity consumption per unit area (Chung & Park, 2015).

Also, the occupant`s attitude and expectation directly affect a hotel's energy performance. Most of the visitor`s tends to consume irresponsibly and unconsciously; in fact they may even spend far beyond their habits and waste energy, as they pay the bill according to time they stay, not their consumption (Santamoris, Balaras, Dascalaki, Argriou, & Gaglia, 1996).

When comparing the numbers of buildings according to their types; it can be easily seen that hotels correspond to a very small proportion of building stock unlike office and residential buildings. However, some researchers point out that hotels are the most energy-consuming buildings due to their operational energy demand and occupants` behavior. Also, hotels' energy sources and types are usually different from other buildings due to their diverse facilities.

Nearly %40 of total energy is used by HVAC systems in hotels. In order to evaluate hotel energy performance; different factors were studied regarding the energy consumption of these buildings. One of the important factors is the location of the hotel due to climate conditions which are directly related to the energy demand of the building. Previous studies demonstrated that outdoor temperature has an important role in the energy consumption of hotels (Figure 2.5). However other factors of climate like humidity and global solar radiation are not found as significant parameters. Another factor can be the class of the hotel. Although there is no significant difference between the four and five-star hotels; three-star hotels differ significantly according to their energy consumption (Priyadarsini, Xuchao, & Eang, 2009).

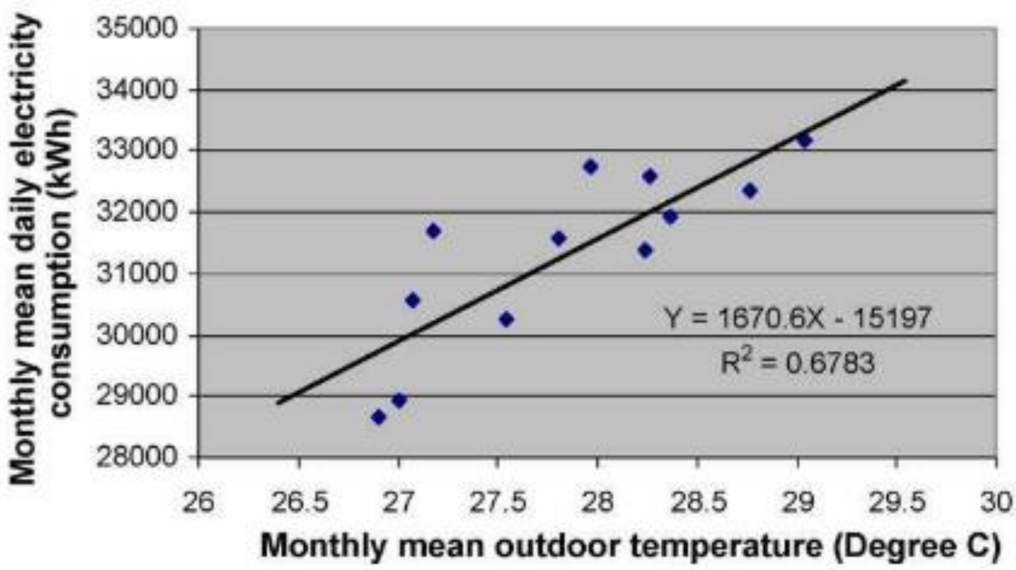


Figure 2.6. The relationship between outdoor temperature and energy consumption (Priyadarsini, Xuchao, & Eang, 2009).

2.5 Sustainable Strategies for Hotels

Although it seems contradictory to implement sustainability approaches in hotel buildings that promise to it`s guests a desirable environment and satisfying services, the right design strategies make it possible.

When it is considered not only for today but also for the future years; due to possible fuel cost rise, electric grid decarbonisation, potential carbon taxes, penalties can push the hotel managements have to find sustainable solutions for hotel buildings (ARUP, Gleeds, IHG, Schneider Electric, 2022).

Also recent studies show that green building certification increases the value of commercial properties as well as reducing the operational costs and risks nearly 15% (Leskinen, Vimpari, & Junnila, 2020). A study suggests that the sustainable improvements has the potential to deliver 38% internal rate of return in five years period (ARUP, Gleeds, IHG, Schneider Electric, 2022).

Heung et al. (2006) defined sustainable hotels as those that “adopt policies that are safe, healthy and environmentally friendly, implement green management practices, advocate green consumption, protect the ecology and use resources properly” (Heung, Fei, & Hu, 2006). Today, with its increasing importance, sustainability-based solutions have started to play a role in the success of hotels as well as ecological gains. A well-designed hotel in line with sustainability; “not only provides a green, luxurious environment but also enhances the hotels' financial strength” (Ahn & Pearce, 2013). The gains from sustainability will have a positive effect on other investments in the hotel revenues. Therefore, the opinions of the visitors should be more positive than the others in hotels with sustainable elements. The success of hotels can be easily observed from the visitor opinions expressed in their feedbacks.

Some researches show that embracing environmentally friendly policies of hotels is gaining importance for guests’ choice and has a positive impact on hotels’ image (Wszendybył-Skulska & Kapera, 2017).

Also studies aiming the net-zero carbon target has also focused on hotel buildings due to their excesessive share of carbon emission. Figure 2.7 represents the schematic guide of net zero methodology for hotels which can be fallowed by all the hotels during the sustainable implications. Table 2.1 listed the milestone categories and descriptions according to the scopes in Figure 2.7, while Table 2.2 shows the relationships between them and role players.

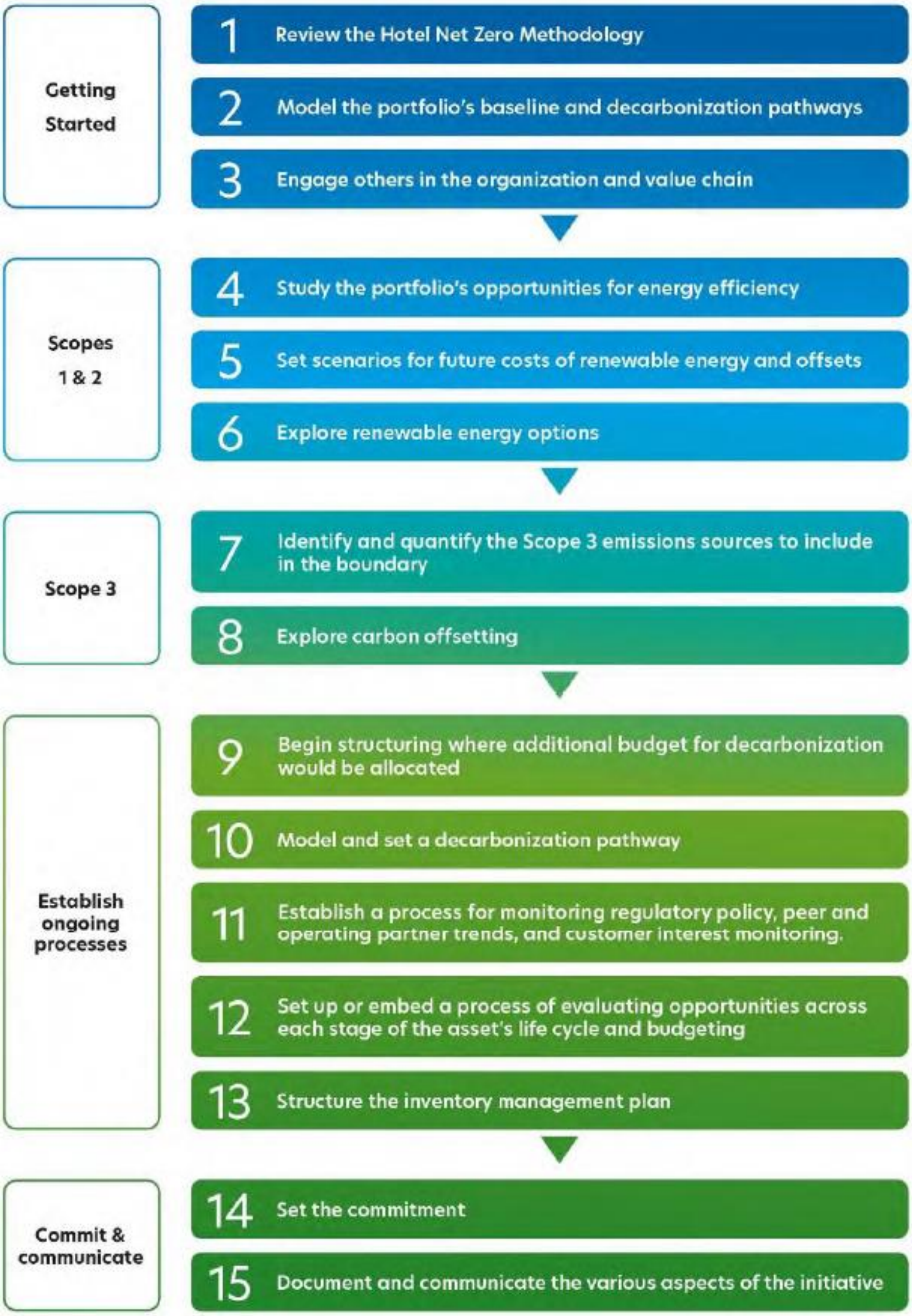


Figure 2.7. Guide of net zero methodology for hotels (Greenview, 2021).

Table 2.1 Milestone categories and descriptions for hotels (Greenview, 2021).

MILESTONE CATEGORY	DESCRIPTION
Facility Emissions Intensity	Covers the emissions from the energy usage of the building itself, and separate from other sources of hotel operation that may be includes such as vehicles or fugitive emissions, to enable performance thresholds and comparability. The primary KPI of Scope 1 & 2 emissions is intensity per square meter, progress against which will be determined by actions in the other Scope 1 & 2 categories. The effects of changes in electric power emission factors - from which emissions from electricity are derived - will be most profound in this category. This category also covers carbon offsetting for the building Scope 1 emissions based on yearly limits.
Energy Efficiency	All activities to reduce the Scope 1 & 2 energy consumption of the facility, including investment in efficient design, equipment, technology, and operating procedures
Energy Sources	The various forms of installing or purchasing energy either as a source of power for the hotel in Scope 1 & 2 emissions, or as a contribution to the electric power grid via market certificate or mechanism for the hotel's Scope 2 emissions. Includes activities to switch to cleaner fuels used by the hotel, and switching to electric power as an energy source for heating and cooling from fuels
Other Scope 1 & 2	Includes any other Scope 1 & 2 emissions sources of the hotel or the company that are not included in the default boundary of performance targets, but should be part of engagement targets, and may be material to the hotel or the company and increase in priority level, including: fugitive Scope 1 emissions from refrigerants, vehicles , additional company facilities, business units or other activities.
Franchised Properties	Reductions of Scope 1 & 2 emissions of franchised properties that form the Scope 3 boundary of the franchisor, if applicable.
Waste	Activities to reduce emissions of waste disposal, in terms of source reduction, reuse, and diversion from landfill or incineration (recycling, composting, upcycling, donation, etc.) which are categorized as Scope 3.
Outsourced Laundry	Scope 3 emissions of laundry wash at a separate offsite facility outside the hotel's ownership or operational control.
Embodied Carbon of Building, land use change, and FF&E	The most significant sources of Scope 3 emissions which are often classified as "Capital Goods" in Scope 3 evaluation, consisting of the construction of a hotel and the upstream lifecycle emissions of the building materials and FF&E, according to a life-of-use allocation of the embodied carbon balance over the lifecycle of the hotel. This category is a catch-all for several sources, which can be further segmented and clarified in future years.
Purchased Ongoing Consumable Goods (F&B, OS&E)	The most significant sources of Scope 3 emissions from the upstream lifecycle emissions of products sourced for ongoing consumption at the hotel.
Employee Commuting	Scope 3 emissions of property staff commuting to and from work via transportation not owned or operated directly by the hotel.
Business Travel	The transportation and lodging for purposes of business travel of property-level and company-level staff employed by the organization.
Transmissions & Distribution Losses	Emissions from location-based losses from delivery of purchased electricity from source (utility) to the hotel
Other Significant Scope 3	Any other Scope 3 emissions sources of the hotel or the company that are not included in the default boundary, but are material to the specific hotel or the company and require a different approach and milestone pathway to net zero, including: a Guest transportation and other activities within the destination b Transportation of fuel for onsite generation of electricity in remote, private island resorts.

Table 2.2 Hotel`s entities, roles and boundries (Greenview, 2021).

ENTITY	RELATION AND ROLE	SCOPE 3 BOUNDARY
HOTEL FRANCHISOR	Provides the brand/flag of the hotel and other support. The franchisor does not staff the hotel or take part in its operation.	Scope 1 and 2 Emissions of the hotel facility and operations
HOTEL ASSET MANAGER	Manages the ongoing strategy and budget of the physical hotel property on behalf of the owner.	
HOTEL COMPANY INVESTOR	Invests capital into the entity that owns, operates, and/or franchises a hotel or a portfolio of hotels.	Scope 1 and 2 Emissions of the hotel facility and operations Note that the proportionate embodied carbon of the building in the case of investing in an owner should be accounted for
HOTEL LENDER	Provides a loan to the entity structured to own the hotel property.	
HOTEL DEVELOPER	An entity that leads the design, financing, permitting, land acquisition, and construction of the hotel or master-planned destination, then sells the real estate to a different owner.	Until exiting the venture, Scope 1 and 2 emissions of the hotel facility and operations Embodied carbon emissions of the building are the entity's Scope 1, 2 and 3 depending on the source
PHYSICAL DESTINATION ENTITY	When a hotel is located within a specific, master-planned mixed use destination where the entity may be a development corporation but plays an ongoing role in the destination's management and ownership.	Scope 1 and 2 Emissions of the hotel facility and operations Other value chain emissions of the hotel to be captured separately via other boundaries of the entity (i.e. entity may own/operate the ground transport or outsourced laundry facilities directly) Note that the proportionate embodied carbon of the building in the case of investing in an owner should be accounted for, which may fall under Scope 1&2 or Scope 3 depending on the structure
GEOGRAPHIC/ POLITICAL DESTINATION ENTITY	The municipal, state/province, designated tourism zone/region, nation, or supranational union or initiative covering several states, nations or economies.	Scope 1 and 2 Emissions of the hotel facility and operations Other value chain emissions of the hotel to be captured separately as related to businesses and activities within the destination
GUEST	The person or persons staying at the hotel or where applicable, attending the meeting or using other amenities or facilities.	Scope 1, 2, and 3 emissions from the hotel stay calculated using the HCMI methodology, apportioning emissions based on facility type and including outsourced laundry
CUSTOMER	The entity on behalf of which the guest is staying, if the guest is part of an organization. Or an entity such as a tour operator.	
TRAVEL BUYER	An entity buying the travel on behalf of a customer or guest, such as a corporate travel management company. This entity is responsible for sourcing the room nights.	Scope 1, 2, and 3 emissions from the total amount of hotel stay and meeting space bookings calculated using the HCMI methodology, apportioning emissions based on facility type and including outsourced laundry
TRAVEL INTERMEDIARY	An entity involved in the marketing, sales, distribution, transaction of the hotel room night or meeting space rental, such as an OTA, software booking engine, destination management company, or backend application.	
EVENT ORGANIZER	The entity organizing an event, MICE, with generates the demand for the travel and hotel stays, but which may not represent the customer or be involved in the purchase of the hotel stay.	
HOTEL AND TRAVEL MEDIA	An entity that provides B2C or B2B media and communications relating to the hotel industry or wider travel sector, but whose business model is not tied directly to a transaction of travel purchases.	Scope 1, 2, and 3 emissions from the entity's business travel, calculated using the HCMI methodology,
TRAVEL CARBON OFFSETTER	An entity that provides or profits from carbon offsetting for consumer or business activities that include hotel stays or wider travel, which may engage consumers for carbon offsetting separately from relation to any other entity in the travel value chain.	Any carbon offsets transacted relating to hotel stays or meeting space usage should be quantified using HCMI
SERVICE SUPPLIER	An entity providing a service to a hotel, such as IT support, offsite server, maintenance, consulting, etc.	To be determined by the entity based on the relationship to the hotel the services provided to the hotel
GOODS SUPPLIER	An entity supplying goods procured by the hotel such as food, soap, etc	
OTHER	Any other entity involved in the value chain that is not specifically categorized within the above.	

2.5.1 Design Phase

Sustainable hotels are sometimes presumed as simple plain and less comfortable areas. However in the aim of architecture; the building well designed and using natural and renewable sources would be not only fulfill sustainability targets but also satisfy the occupants. The right passive design strategies improve the comfort conditions with the aim of minimizing energy needs.

According to sustainability targets; researchers and practitioners tried to develop customized applications based on general practices for hotels. Possible design applications and incomes for luxury hotels are shown in Table 2.4 (Ahn & Pearce, 2013).

Also, the design phase is when decisions are made that directly affect the rate of embodied carbon impacts. As the hotels bedrooms and common areas have hardgoods and softgoods usually refurbished on a period of time; embodied carbon impact becomes predominant contributor to whole life time of hotel buildings (ARUP, Gleeds, IHG, Schneider Electric, 2022). Figure 2.8 demonstrates the estimated shares of embodied carbon of hotel buildings.

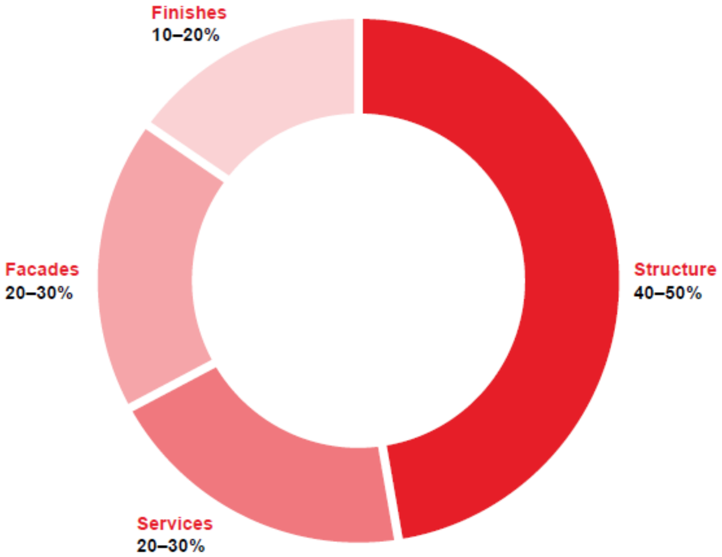


Figure 2.8. Estimated shares of embodied carbon of hotel buildings (ARUP, Gleeds, IHG, Schneider Electric, 2022).

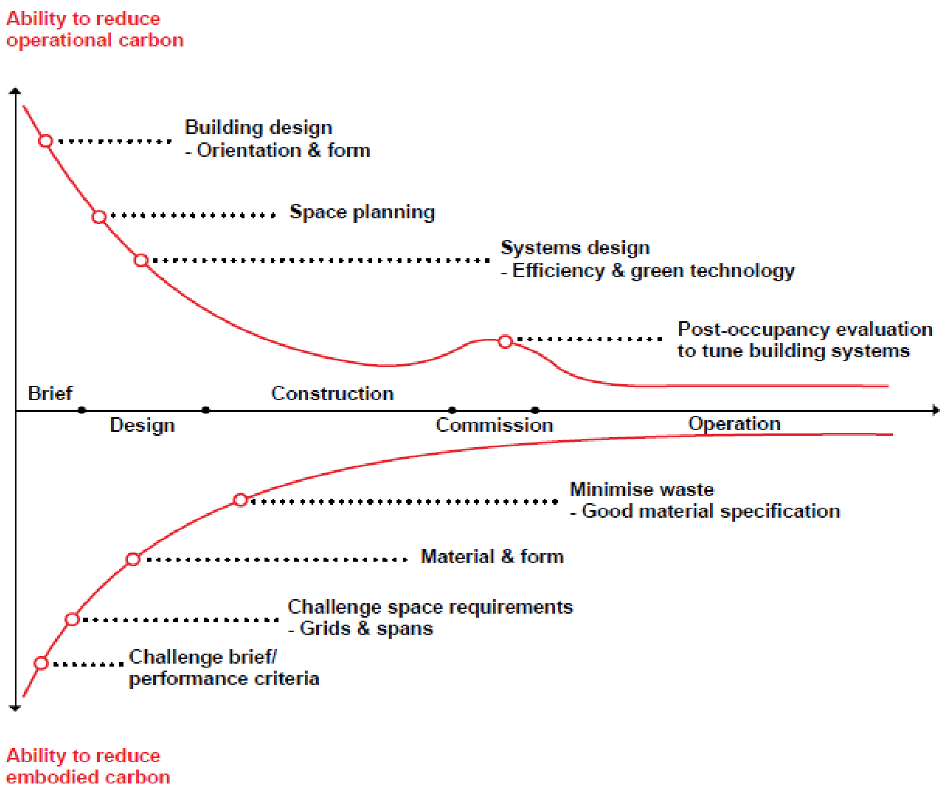


Figure 2.9. Possible carbon reducing implications during the life time of a hotel building (ARUP, Gleeds, IHG, Schneider Electric, 2022).

It can be said that the critical stage is the design phase when considering the whole life carbon impact of a hotel building. During the design phase it is possible to reduce operational carbon as well as the embodied carbon. Figure 2.9 demonstrates the possible carbon reducing implications according the life time of a hotel building.

Table 2.3 Possible design application and incomes for luxury hotels (Ahn & Pearce, 2013).

Categories	Major Practices	Specific Benefits
Sustainable Site	• Sustainable site planning and landscaping • Solar orientation of building • Public transportation • Stormwater management	• Reduce environmental impacts • Efficiency of site use • Heat island effect • Reduction of civil infrastructures
Energy Efficiency	• Solar orientation • High efficiency envelopes (efficient windows and high R-value insulation) • High efficiency HVAC system • Building automation systems • Daylighting and high efficiency lighting • Onsite renewable energy sources (photovoltaics)	• Energy saving • Reduction in greenhouse gases • Lower operating costs
Water Efficiency	• Water saving fixtures and technologies • Rainwater harvesting system	• Water saving • Lower operating costs
Materials & Resources	• Green supplies and materials • Construction waste management • Recycled content materials • Regional materials, locally sourced • Rapidly renewable materials	• Resource saving • Reduce environmental impacts
Indoor Environment Quality	• Daylighting & high efficiency lighting • Adequate air filtration • Low VOC materials • Mold prevention • Enhanced acoustical performance	• Productive and healthy indoor spaces • Provide optimal indoor • environment to building users • Improved occupant health and wellbeing
Building Operation & Maintenance	• Green cleaning supplies • Indoor pest prevention and control • Waste reduction and recycling • Energy and water conservation • Green grounds keeping • Electronic versus paper communication • Guest education/communication program	• Reduced environmental impacts • Reduced operational and maintenance costs
Demolition	• Exposed ceiling • Nylon 6 recycled carpet	• Reduce construction waste

As it can be seen in Table 2.3; there are various categories and options in order to embrace sustainability during the design phase of the hotel. Also, the life cycle of buildings and materials should be evaluated. Different combinations of the sustainable options` performance should be analyzed by the project design team in order to get optimum cost, life cycle impact, sustainability, and luxury in balance. And also it is important to remember that adopting sustainable design strategies increase hotel financial strength by reducing energy consumption and making the hotel image more powerful for the potential guests (Ahn & Pearce, 2013).

2.5.2 Operation Phase

The operation phase corresponds to over 70% of energy use in hotel buildings (Rosselló, Beatriz, Moià Pol, Andreu, Cladera, Antoni, & Martínez Moll, Víctor, 2008). While, this process is totally dependent on design phase decisions. Enclosing the structure with highly efficient envelope, usage of renewable energy sources and the implementation of water and energy reduction systems would decrease total energy and water consumption in hotel buildings as long as these adaptation decisions are made at the design stage.

Electrical, HVAC, and all mechanical systems should be ensured to operate at maximum efficiency by controlling and monitoring all the systems. For this purpose, building automation and service systems would be useful for ongoing measurement and increasing efficiency.

Also room management and planning systems enhanced by guest detection and occupancy sensors integrated with building management can help reducing energy waste. It is important to try to allocate rooms close together in order to minimize energy consumtion on floors as well as allowing heating and cooling to be reduced when the rooms are unoccupied (ARUP, Gleeds, IHG, Schneider Electric, 2022).

As the pools are important energy consumer zones of the hotels; pool water and hall temperature should be set carefully. Setting pool hall temperature above the water temperature would help reducing evaporation and condensation(ARUP, Gleeds, IHG, Schneider Electric, 2022). Also using pool covers and allowing the water temperature drop at nights would save 4% energy savings(ARUP, Gleeds, IHG, Schneider Electric, 2022).

2.6 Sustainable Hotel Practices and Guest Satisfaction

Robert Tooth described customer satisfaction as a three legged stool. These legs are quality, health, hygene, safety and sustinability and each leg is essential to remain steady (Toth, 2002).

Figure 2.10. Customer satisfaction on three legged stool of tourism (Toth, 2002).

Although the guest preferences and satisfaction are substantially related with Robert Tooth’s illustration, another factors like; cost, level of luxury, cultural and environmental elements can be influential on the choice of guests.

Contrary to the belief that only laws, rules and eco-labeling programmes are sufficient in the adoption of sustainability principles, many dynamics of societies such as the age, nationality, education, welfare and sociocultural backgrounds are related with sustainable adoption and affect the sustainable attitudes. Also the significance of sustainable tourism can not be said to be consistent across nations. This difference can be easily noticed both in the investments of the countries in sustainability and in the visitor profile.

As dealt in the first chapter; although Turkey can be defined as a latecomer for the sustainable tourism, due to its regional and climatic advantages, it aims to enlarged the possesion and incomes of tourism. In this regard, guest satisfaction should be prior to choose the application methods of sustainable tourism in order to get success and maintain these adaptation.

A study focusing on the relationship between guest satisfaction and the nationality proves that, although sustainable practices of hotels have positive effect on guest satisfaction, there are differences on satisfaction level of hotel guests according to their nationalities (Berezan, Raab, Yoo, & Love, 2013).

S. Mathur et al. (2017) analysed guest awareness and satisfaction levels of five star hotels adopted sustainable practices in Delhi with an emprical study. The results shows that the level of awareness and satisfaction of guest is extremely low regarding to sustainable practices of hotels.

On the other hand, another survey conducted between American and Mexican respondents in Mexico; asserted the sustainable practices cause significant level of satisfaction regardless of nationality (Berezan, Millar, & Raab, 2014).

The variation of the results of studies conducted on guest satisfaction of the sustainable practices of hotels point out to the discrepancies between the guest expectations and the hotels' sustainable implications. In another word; guest satisfaction depends on the type of the action. For this reason; decisions regarding sustainability practices in hotels should be taken with comprehensive and holistic way by taking into consideration of guest satisfaction and loyalty. Also managemental approach can affect the choosing effective sustainable implications. Experienced, skilled specialists and managers' can have more comprehensive perspective on the decisions of hotels' sustainable applications and carry out a successful results with guests' satisfaction. (Özder & Gül, 2019)

As the relationship of tourism with sustainabilty can not be denied, hotels need to adopt sustainability practices in their business and marketing activities due to competitives. Some of the studies emphesizes the guests' demand for envirenmentally friendly products and services at hotels. According to O. Hossein et al.'s analysis (2021), guests satisfaction affects positively depending on their familiarity with sustainability. Also it is also important how sustainability practices are reflected on the guests. Hotel management should ensure that the guests experience is not impacted negatively by the sustainable applications by increasing service quality and information the positive consequences of environmental actions (Moise, Gil-Saura, & Ruiz-Molina, 2018).

Hotels ensuring their sustainable adaptation with the right sustainable practices that have a holistic approach covering the hotel economy and guest satisfaction, can increase the success of the hotel by increasing the investments in applications aimed at increasing customer satisfaction. However the applications should be selected without sacrificed the guest' comfort. Also; emphesizing the hotel's energy and water usage reduction and waste can make the hotel's image stronger for guests by contribute on sustainability.

2.7 Sustainability Assessment Methods

Buildings can be defined as one of the most complex industrial product considering the life time and the production process (Scheuer & Keoleian, 2002). Therefore; adaptation process and methods for sustainability can not be simplified. In fact; for this very reason each building and relating to constuction process should be evaluated in detail by a specific method. Consequently, various methods both theory and practice that provide sustainable adaptation and control are being developed by building experts and authorities.

Due to the complexity of building production several methods can be integrated for the comprehensive assessment of environmental impact of the building. Although each methods are designed in order to evaluation of buildings environmental impact, they set their own assumptions and limitations. (Scheuer & Keoleian, 2002) Certification and Life Cycle Assesment (LCA) methods are choosen as primary methods are defined under following sections.

2.7.1 Certification and Eco-Labeling Methods

Increasing concerns about constuction sector and sustainability also cause governments and international authorities make legislations and regulations. In order to comply with the sustainability policies; certification and eco-labeling programmes also being promoted by the authorities.

Certification and eco-labeling programmes can be defined as a environmental branding method which can be seen as a prestige symbol for investors and encouraging activities for the authorities. The methodology of these programmes are based on examining the building environmental performance such as water and energy consumption, waste generation and recycling.

Adopting a certification or eco-labeling programme has several advantages like governmental support, tax subsidies as well as the reduced environmental impact.

However the level and the extent of sustainability evaluation can be simplified in terms of certification or eco- labeling methods (Scheuer & Keoleian, 2002). According to the more comprehensive approach, using dual assesment tools to evaluate the buildings both provides certification and accomplish sustainability.

Also, the examination and evaluation process is started by auditing the performance of the building after the building is constructed. This eliminates the possibility of making better decisions during the design phase.

2.7.1.1 Green Star Certification System

The Turkish Ministry of Culture and Tourism has been awarded the Environmental Friendly Establishment Certificate for promoting and encouraging the positive contributions of touristic facilities to the environment since 1993 (General Directorate of Investment and Enterprises, 2020). After some regulations were implemented the certification system has been updated and developed into the Green Star Rating System, which is the latest certification system in use since

2008. The Green Star certificate is awarded to businesses that meet the conditions specified by the Ministry.

According to the Turkish Ministry for Culture and Tourism's report, only 473 of the 4109 licensed hotel establishments have Green Star Certificates (General Directorate of Investment and Enterprises, 2020). The ratio of certified green star hotels has slightly increased from 0% to %12 after 2015. However; the rate of certified green star hotels has never exceeded 12% of the total number of hotels, since 2010. Therefore, it can be said that the emphasis on the contribution of investments in the Green Star Certificate System to the success of hotels is insufficient. (Figure 2)

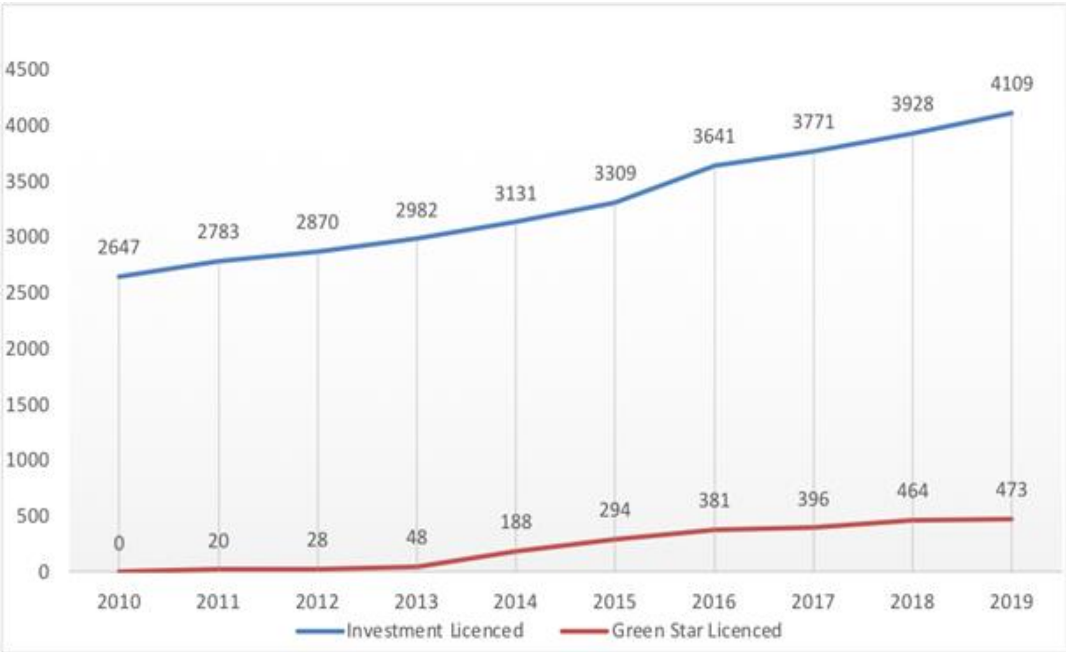


Figure 2.11. Investment Licenced and the Green Star Licenced Accommodation Numbers from 2010 to 2019. Chart drawn by author based on data retrieved from (Ministry of Culture and Tourism, 2017).

Green Star Certificate System qualifications ensure that touristic accommodations are designed, planned, constructed and put into operation in an environmentally friendly manner. The criteria comprise the rules aiming that reducing the amount of energy and water consumption, encouraging the use of renewable energy sources and increasing energy efficiency. Accommodations must meet the basic criteria in order to apply to have Green Certificate. Basic criteria list is shown in Table 2.1. (Ministry of Culture and Tourism, 2017) Afterwards they should collect points by their practices in the ten categories and 122 different subjects comprising both management policies and environmental applications. These categories, subjects and weightings are shown in Table 2.2 (Kılıç & Altun, 2018).

Table 2.1 Basic criteria list of Green Star Certificate System. (Ministry of Culture and Tourism, 2017)

NO	MAIN CRITERIA	POINT
1	Having environmental policy, aim and action plan.	5 points
2	Having an authority to implement the action plan at the facility.	5 points
	Getting support from experts and consultants.	1 Point
3	Collecting and monitoring the data according to water and energy consumption (compiling and preparation of monthly, quarterly and annual reports of water, fuel, and electricity consumption per m^2 of indoor area or per night.)	5 points
4	Providing periodical training to the personnel in order to increase environmental awareness and ensure the implementation of environmental measures and action plan.	5 points
	Collecting and monitoring the data of chemical usage. (compiling and preparation of monthly, quarterly and annual reports of chemical consumption per m^2 of indoor area or per night by volume and/or weight.)	5 points
5	Collecting and monitoring the data of amount of waste. (compiling and preparation of monthly, quarterly and annual reports of amount of waste per m^2 of indoor area or per night by volume and/or weight.)	5 points
6	Having an environmentally friendly waste water plan.	5 points
7	Ensuring that all the installations and equipments maintenance and repair are done periodically by the authorized service or experts and keeping records.	5 points
8	Complying with the environmentally friendly waste water management plan of the municipality.	4 points
	Having environmentally friendly waste water management plan approved by the municipality.	2 points

Table 2.2 Green Star Certificate System categories, subjects and weightings. (Kılıç & Altun, 2018)

Green Star Certificate System Categories	Number of Subject	Category Weights (points)	Percentage
Management	13	72	12.35
Training	6	17	2.92
Arrangements in the Bedrooms	23	70	12.01
Adaptation to the Environment and Environmental Enhancement Activities	6	27	4.63
Ecological Architecture	8	42	7.20
Energy	22	178	30.53
Water	16	57	9.78
Chemical Usage(detergents, disinfectants,	6	16	2.74
Waste	12	53	9.09
Others	10	51	8.75
Total	**122**	**583**	**100**

Energy category is divided according to using renewable energy to supply electricity, heating and cooling systems and heat water. Also energy category points varies according to the ratio of renewable energy use to all energy used for the hotel facility. For instance; using renewable energy of the total amount of electricity used account for 20 points, while using renewable energy source for electicity at the rate of 10% accounts for 2 points. Although the calculation based on using renewable energy ratio of the total is divided into 100%, 50, 20 and 10 percent rates; there is not a ratio for the water saving and waste reduction. However; obtaining drinking or utility water from sea water is accounts for the highest points of water category with 10 points.

According to Table 2.3; the minimum points that the facilities must get in order to have the Green Star Certificate differs according to hotels' classes and star ratings. (Resmi Gazete, 2020) As the hotel class lowers, the policies to be implemented become easier. However, the tendency to comply with environmental rules is considered to be reduced by small business owners.

Table 2.3 The minimum points that the facilities must get in order to have the Green Star Certificate. (Resmi Gazete, 2020)

HOTEL CLASS	MIN. POINT
5 STAR	225
4 STAR	195
3 STAR	135
2 STAR	95
1 STAR	90
OTHERS	90

Turkey Ministry of Culture and Tourism categorized cities according to 6 touristic development regions. Points are added according to their region at the Hotels' Green Star Evaluation report. (Appendix A.1)

This certification system also provides several advantages for business owners as well as the contribution of sustainable tourism in Turkey (Giritlioğlu & Güzel, 2015). Some of the advantages of the Green Star Certificate are;

- In hotel management, costs are reduced and water and energy savings are provided.

- Efficiency is increased by higher employee motivation.

-The consumption of products that can harm the environment is reduced.

- The use of recycled products is encouraged.

- The harmony between the hotel and the environment increases.

- During the investment phase, planning is made in an environmentally friendly manner.

- Environmentally friendly hotel products are advantageous in marketing.

- Environmental awareness of employees and guests is increased.

- Electricity subsidy was also provided to the hotels with Green Star by the Ministry; i.e. a portion of the electricity fee used by enterprises with a certificate of

Green Star was covered by the Ministry (Giritlioğlu & Güzel, 2015). However, this support was ended on 31.12.2018.

2.7.2 Life Cyce Assssment Method

The impact of production activities is one of the reasons for environmental damage. Therefore, the necessity of analyzing each of the production stages of the products in detail and investigating the effect on the environment has emerged. Life cycle assessment is one of the developed techniques to reveal the impact of each production stage, the lifecycle of a product, and the disposal process to the environment.

A common definition of LCA is a 'cradle-to-grave' survey of products. The 'cradle' represents the extraction of raw material, and the 'grave' represents the recycling or disposal process that returns to nature. However according to the purpose and the type of production activity the LCA method and size can change. Figure 2.6 represents possible LCA variants adapted to a building.

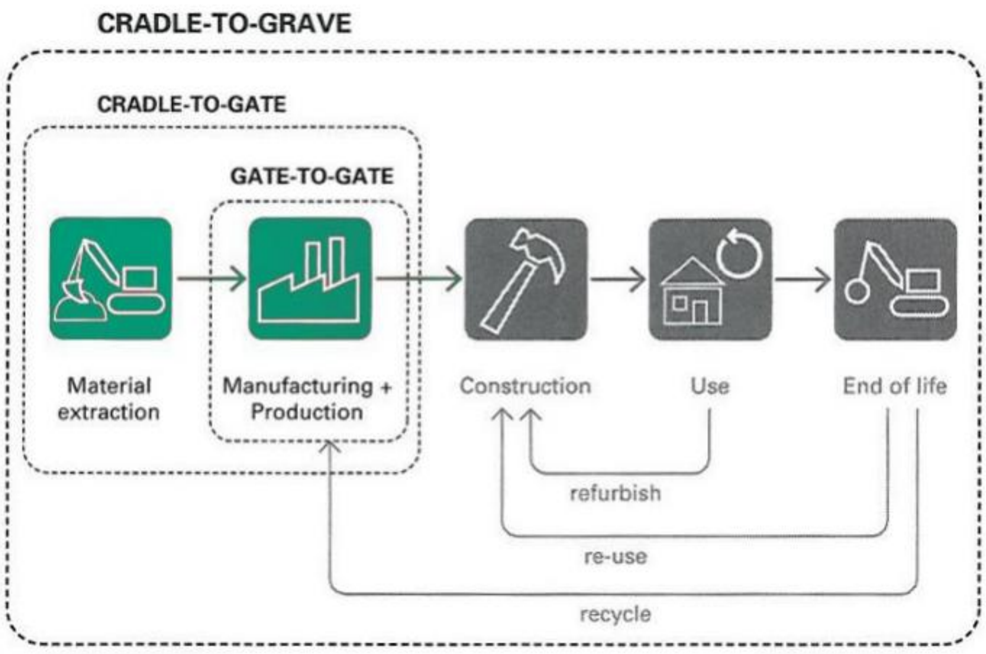


Figure 2.12. Life-cycle variants of a building. (Simonen, 2014)

According to ISO 14040:2006; LCA can assist four main tasks. By means of LCA;

- improvements on products` life cycle stages by identifying the opportunities that can be available.
- Organizations and professionals can get the awareness of the life cycle stages. And the priorities can be defined as planning, production, and design.
- Environmental impact indicators measurement techniques selection can be assisted.
- Environmental certification or ecolabelling processes can be assisted (International Organization for Standardization (ISO), 2006).

2.7.2.1 Life Cyce Assssment Phases

ISO 14040 divided the life-cycle assessment procedure into four interrelated phases which can be seen in Figure 2.7. During the application of LCA to the building according to defined LCA phases, the building becomes the 'product'. However, building differs from other industrial products by its materials and components. Therefore; these phases are handled according to building processes in detail.

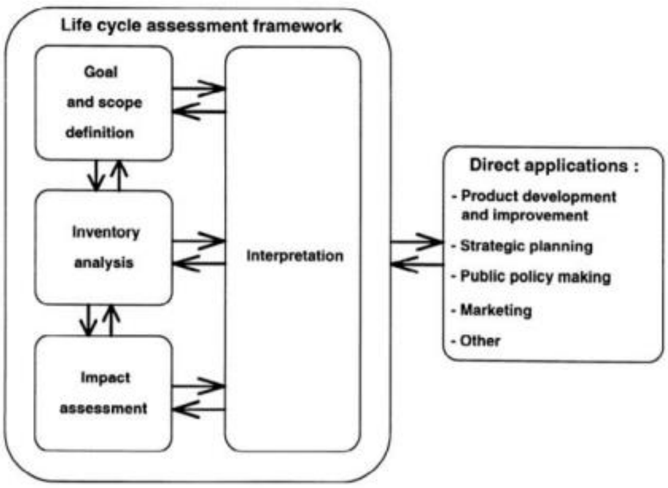


Figure 2.13. LCA phases (International Organization for Standardization (ISO), 2006).

It is important to define the life-cycle stages of buildings. These stages can be divided into four titles; material manufacturing, construction, maintenance, and end of life (Georgia Institute of Technology, 2010). Figure 2.8 demonstrates the common LCA phases of building.

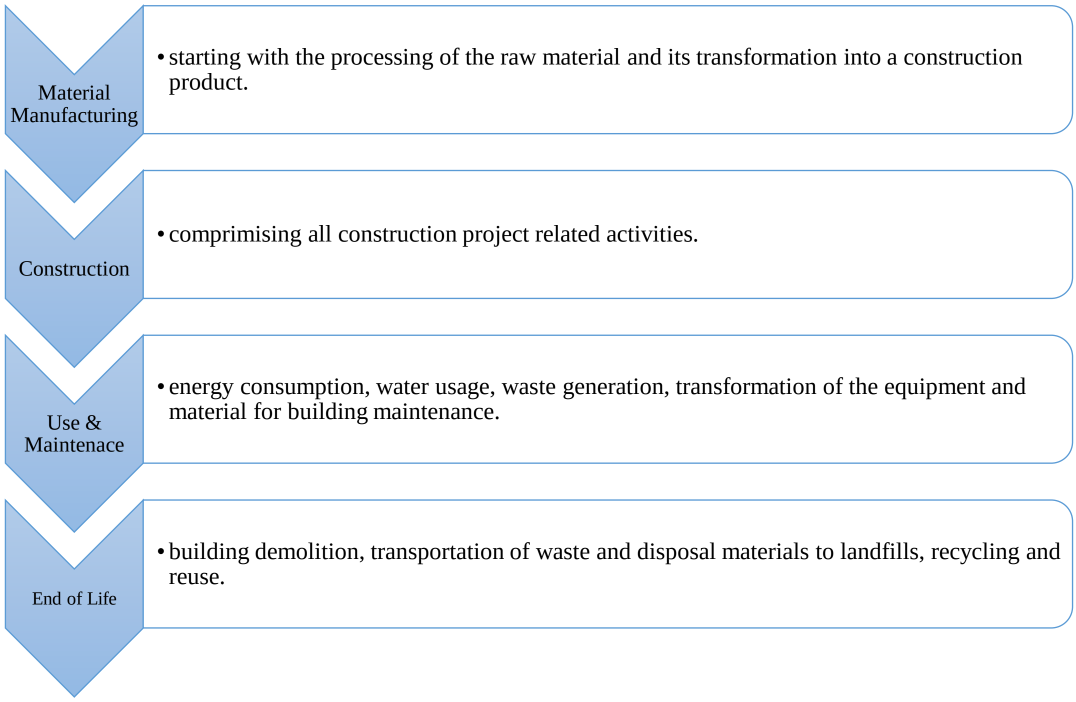


Figure 2.14. LCA phases (Georgia Institute of Technology, 2010).

vi. Goal and Scope Definition Phase

The first step of LCA is identifying the aim and scope which directly affects the results of the LCA. The common goal of the LCA study of a building is reducing the environmental impact of the building. As the construction processes are complicated and the buildings have a long life span, and the possibilities of transformation on building use, all LCA phases can affect the goal and scope phase and arise a necessity to review and modify after each phase (Khasreen, Banfill, & Menzies, 2009). Due to each building's unique features and project`s priorities, the goal and scope should be set according to the case study. Well-defined objectives and setting boundaries, in the beginning, has importance. These boundaries can be various such as; setting up the life span out of assumptions, delimitations, neglecting the impacts of some production activities, or limiting the material selection.

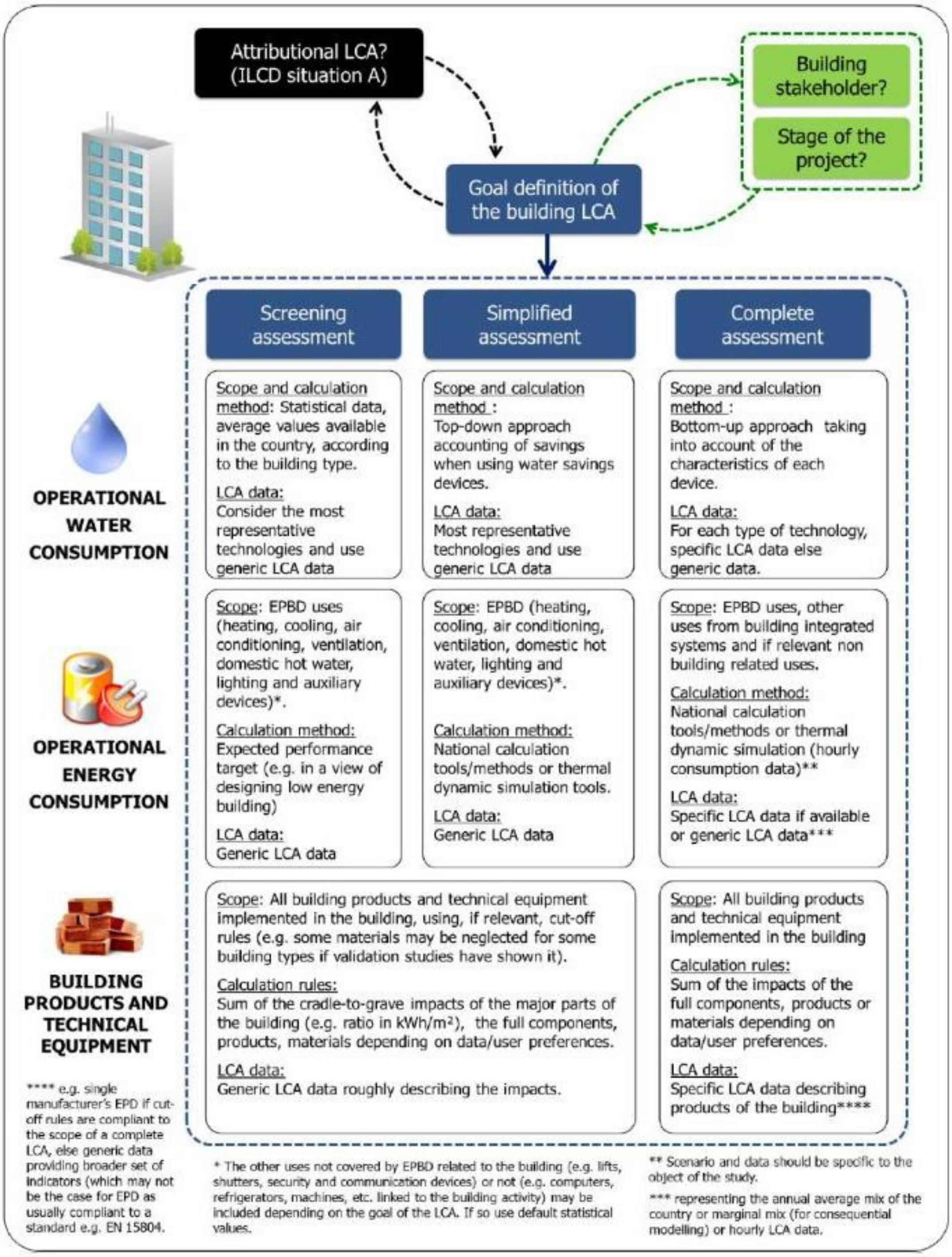


Figure 2.15. Goal definition of the building (Lasvaux, et al., 2013).

vii. Inventory Analysis Phase

The inventory analyses phase is comprising the data collection and analyzing processes.

The collected data should be gathered according to input and output of energy, resources from nature, and emission into nature as well as other parameters related to the building`s comfort and operation (Kaoula & Bouchair, 2018). Figure 2.8 demonstrates energy and mass flow, input, and outputs of building LCA.

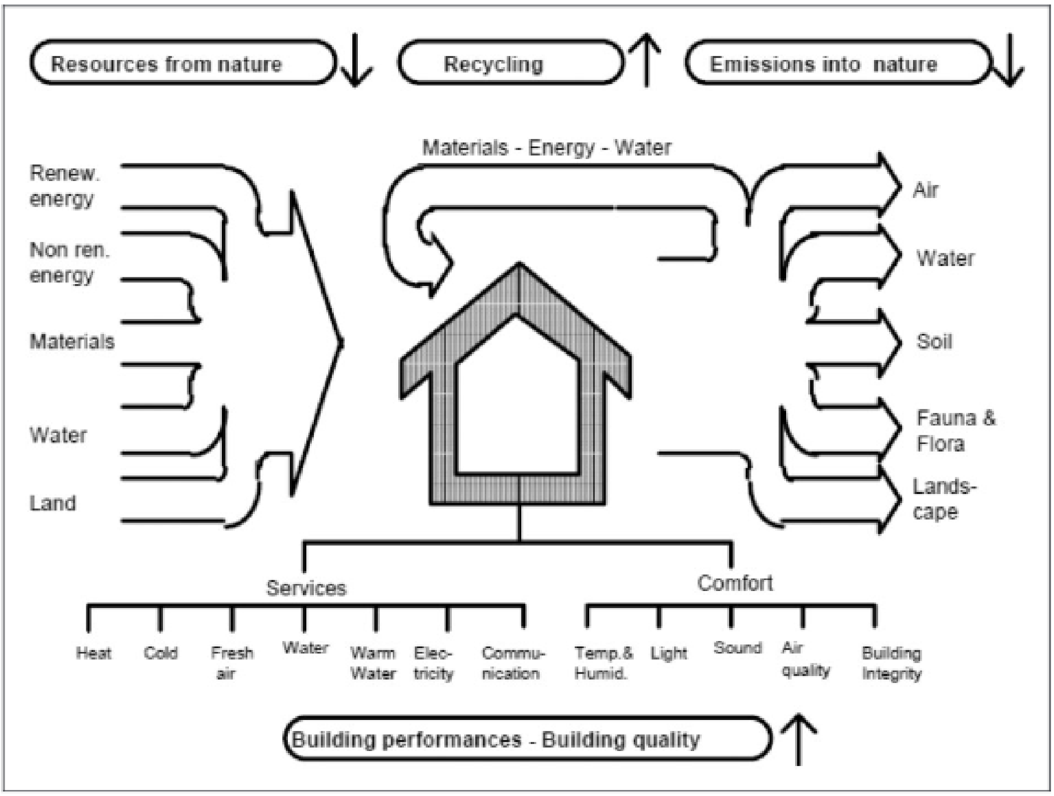


Figure 2.16. Inputs and outputs of building LCA (Trocmé & Peuportier, 2008).

Commonly, building materials and components form the main database which is used for the life-cycle inventory phase(LCI). During the LCA of a building; the embodied energy of materials and building components, transportation processes of materials, energy use of a building, water consumption, maintenance, and demolition are considered. However; equipment transportation, construction waste, and energy usage during the construction can not be considered (Kotaji , Schuurmans, & Edwards , 2003). The data set required according to the goal of the LCA should be collected, measured, or estimated. The goal of the LCA is directly affected by the life-cycle inventory phase. Therefore, data quality and availability can change the goal and scope of the LCA (Khasreen, Banfill, & Menzies, 2009). The data source plays an important role in the accuracy of the LCI. Table 2.5 shows the indicators in a matrix to improve the quality of the database by determining the reliability of data.

Table 2.4 Matrix of data quality evaluation (Weidema & Wesnæs, 1997)

Indicator score	**1** Excellent	**2**	**3**	**4**	**5** Unreliable
Reliability	Verified data based on measurement	Verified data partly based on assumptions or non-verified data based on measurements	Non-verified data partly based on assumptions	Qualified estimate (e.g., by industrial expert)	Non-qualified estimate
Completeness	Representative data from a sufficient sample of sites over an adequate period to even out normal fluctuations	Representative data from a smaller number of sites but for adequate periods	Representative data from an adequate number of sites but from shorter periods	Representative data but from a smaller number of sites and shorter periods or incomplete data from an adequate number of sites and periods	Representativeness unknown or incomplete data from a smaller number of sites and/or from shorter periods
Temporal correlation	Less than three years different from year of study	Less than six years different	Less than 10 years different	Less than 15 years different	Age of data unknown or more than 15 years different from year of study
Geographical correlation	Data from area under study	Average data from larger area in which the area under study is included	Data from area with similar production conditions	Data from area with slightly similar production conditions	Data from unknown area or area with very different production conditions
Technological correlation	Data from enterprises, processes and materials under study	Data from processes and materials under study but from different enterprises	Data from processes and materials under study but from different technology	Data on related processes or materials but same technology	Data on related processes or materials but different technology

viii. Impact Assessment Phase

The impact assessment phase starts with impact categories definition and selection. The building practitioners can choose any of the impact categories which is relevant to the defined goal and scope of the study. The commonly studied whole process construction impacts are shown in Table 2.6. (Khasreen, Banfill, & Menzies, 2009). Classification of LCI results according to impact categories should be done as a second step. Following these steps, optional assessments can be done such as different size and unit-based classifications, changing the scale of the assessment, or making a comparison.

Table 2.5 Whole Process Construction impact categories (Khasreen, Banfill, & Menzies, 2009).

Impact category	Abbreviation	Scale	LCI data i.e., classification	Characterization factor
Global warming	GW	Global	Carbon Dioxide (CO_2) Nitrogen Dioxide (NO_2) Methane (CH_4) Chlorofluorocarbons (CFC_S) 'Hydro chlorofluorocarbons' ($HCFC_S$) Methyl Bromide (CH_3B_r)	Global warming potential
Acidification	A	Regional Local	Sulphur Oxides (SO_X) Nitrogen Oxides (NO_X) Hydrochloric Acid (HCL) Hydrofluoric Acid (HF) Ammonia (NH_4)	Acidification potential
Eutrophication	E	Local	Phosphate (PO_4) Nitrogen Oxide (NO) Nitrogen Dioxide (NO_2) Nitrates, and Ammonia (NH_4)	Eutrophication potential
Ozone depletion	OD	Global	Chlorofluorocarbons (CFC_S) Hydro chlorofluorocarbons ($HCFC_S$) Halons, and Methyl Bromide (CH_3B_r)	Ozone depletion potential

In this study; impact assesment has evaluated in terms of seven impact categories which are described seperately in the fallowing subtitles.

These categories are;

- Total Primary Energy
    - Non-renewable Primary Energy
    - Fossil Fuel Consumption
- Global Warming Potential (GWP)
- Acidification Potential
- Aquatic Eutrophication Potential (EP)
- Human Health (HH) Particulate
- Ozone Depletion Potential(ODP)
- Smog (Photochemical Ozone Formation Potential)

- **Total Primary Energy**

Total primary energy consumption measures all the energy used directly or indirectly beginning from the raw material stage through constuction. Direct energy is associated with the processes of material production stages. In direct energy inputs are calculated according to transportation, convertion, operational energy. The calculation reports are created in mega-joules (MJ) unit. Non-renewable energy and fossil fuel consumption are the subdivisions of total primary energy (Athena Sustainable Materials Institute, 2019).

- **Non-renewable Primary Energy**

The energy obtained from non-renewable energy sources like petroleum, natural gas, coal or uranium are calculated in mega-joules (MJ) unit (Athena Sustainable Materials Institute, 2019).

- **Fossil Fuel Consumption**

The energy coming from the fossil fuels are calculated in mega-joules (MJ) unit. Hydro, non hydro renewable, nuclear and wood energy sources are excluded. (Athena Sustainable Materials Institute, 2019)

- **Global Warming Potential (GWP)**

Global warming potential is associated with greenhouses gases which cause Earth warming by absorbing the energy and blocking the escapes to space (United States Environmental Protection Agency, 2022). Comparisons of the relative impacts of other gases with carbon dioxide is used for the calculation methods because the "heat trapping capability" of carbon dioxide makes it basic reference.

Although one of the main reasons for the greenhouses gases is the energy combustion, raw material processing of some products also causes significant greenhouses gases emissions. During the cement production, limestone calcination stage can be shown as an example with excessed carbon dioxide emissions.

- **Acidification Potential**

Acidification potential refers to concentrations of sulfur dioxide (SO2), nitrogen oxides (NOx) on air or water emission (Athena Sustainable Materials Institute, 2019). The calculation of the acidification potential is based on the SO2 equivalence effect on a mass basis (Athena Sustainable Materials Institute, 2019).

- **Aquatic Eutrophication Potential (EP)**

Increased nutrigents in water can cause excessive development of microorganisms and fertilisation of water surfaces. Over fertilisation, wastewater or polluting emissions can cause the increased plant growth, plankton algea and oxygen consupmtion in water. As a result of proliferation of aquatic photosyntetic plant life, diversity of species can change and perish. The calculation is based on the equivalent mass of nitrogen(N).

- **Human Health (HH) Particulate**

EPA defines particulate as a mixture of solid particles and liquid droplets hanging in the air causes human respiratory system deterioration (United States Environmental Protection Agency, 2022). The size of the particulate matters is various between 2.5 micrometers to 10 micrometer diameter.

- **Ozone Depletion Potential(ODP)**

Stratospheric ozone depletion potential is measured the amount of protective ozone layer of stratosphere destroyed by emission of Trichlorofluoromethane (CFC-11) and similar gases over their entire atmospheric lifetime (Estanislao, Arnau, & Tuñón, 2014). Each of the substance relative to CFC-11 is calculated according to final impact indicator mass in weight unit (kg etc.) of equivalent CFC-11 (Athena Sustainable Materials Institute, 2019).

- **Smog (Photochemical Ozone Formation Potential)**

Due to industrial and transportational activities; air emissions can cause photochemical smog which is the result of the trapped volatile organic compounds(VOCs) and nitrogen oxides (NOx) at the ground level of air (Athena Sustainable Materials Institute, 2019). The smog indicator calculation is based on the equivalentmass of ozone (O_3).

Table 2.6 Impact category indicators. (impact category scores; +++ high reliability; + very low reliability) (Bio Intelligence Service, 2005)

Area of protection	Impact category	Scientific unit for the indicator	Reliability of the calculation methods	Confidence in the inventory data
Consumption of resources	Total energy	MJ	+++	+++
Air pollution	Global warming potential	g eq. CO_2	+++	+++
	Acidification potential	g eq. SO_2	++	++
	Photochemical oxidation	g eq ethylene	+	+
Water pollution	Eutrophication potential	g eq. PO_4	+	+
	Water pollution (critical volume)	m^3	+++	++
Waste	Municipal waste	kg	+++	+++
	Hazardous waste	kg	+(+)	+(+)

BIO Intelligence Service divided the impact categories in terms of reliability. Table 2.7 shows impact categories indicators based on the reliability and calculation methods and confidence in the inventory data.

It is also important that; there are another impact categories like noise, odour, nature conservation, land use and risk of nuclear accidents which cannot be derived from life cycle inventory data.

ix. Interpretation Phase

Interpretation is the final phase of LCA. This phase comprises result analysis, the definition of limits, evaluation, conclusion, and recommendation. Therefore; all these results and analyses acquired should be presented clearly and understandably. Also, the interpretation phase should be compatible with the goal and scope of LCA.

2.8 Life Cycle Assessment of Hotel Buildings

Sustainability concerns are increasing with the growth and transformation in the construction sector. It is aimed to build structures with reduced environmental impacts by developing more detailed evaluation systems. LCA methodology has started to be used in the construction sector since 1990 (Fava, 2006).

Life cycle assessment is one of the most common and used evaluation systems in designing and constructing sustainable buildings. However distinctive features of the construction sector make LCA applications specific. Mohamad Monkiz Khasreen et al. define these distinctive features as listed below (Khasreen, Banfill, & Menzies, 2009).

- The difficulties of the building lifetime prediction also correspond to a long-time period.
- The possibility of renovation, restoration, retrofitting, and refurbishment. (Also these changes can be an opportunity by minimizing the negative effects on the environment during the long life span.)
- The critical period of a building`s life span is using the building. In this period there is a high possibility to increase environmental impact. In order

to prevent negative environmental impacts building, design and material selection should be done properly.

- The organizational structure of the construction industry combines many stakeholders. For example; the designer who is the decision-maker of the project; can not take a role in the material production processes or finishing works. Also, a comprehensive standardization can not be possible, as each building is unique.

According to Ayşem Berrin Çakmaklı`s research (2007); the difficulties listed below are also make building LCA complicated.

- Most of the impacts are local as each building has a specific site.
- Due to the complex composition of buildings and their components, the associated product manufacturing process can vary widely from site to site.
- The behavioral attitude of the users directly affects energy consumption during the use phase of the building.
- Being multi-functional makes a building difficult to select a functional unit.
- Creating an indoor living environment requires comfort and health assessments.
- Omitting the building`s integration with urban infrastructure can cause misleading LCA results.

It can be said that the most valuable contribution to the construction process of LCA is providing an ability to demonstrate the deficiencies of the project and allowing to get sustainable design decisions in a scientific approach during the design phase. LCA can be defined as a tool that enables building professionals to understand the energy use and other environmental impacts associated with all life cycle stages of the building such as; procurement, construction, operation, and commissioning. Figure 2.9 demonstrates the possible contribution of LCA to the design stages (Georgia Institute of Technology, 2010).

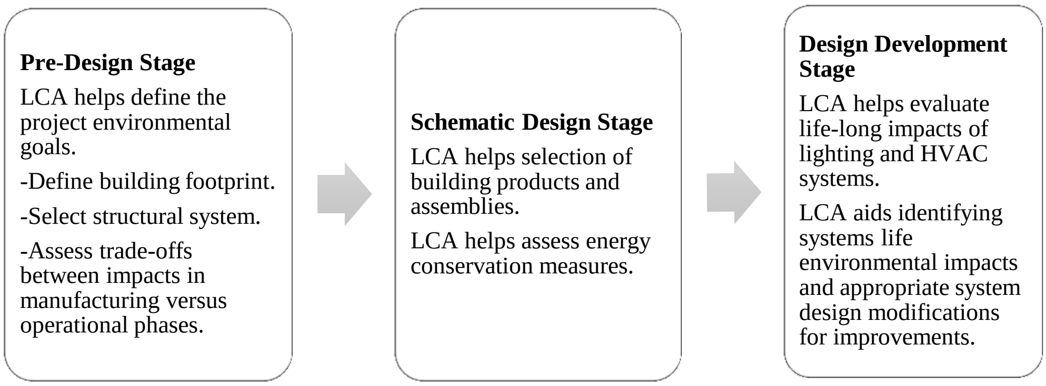


Figure 2.17. Inputs and outputs of building LCA. (Georgia Institute of Technology, 2010)

In order to evaluate hotel buildings, the LCA methodology described in previous parts can be used. However focusing on the specific attributes of hotel buildings are highly energy-consuming operation schemes, day-long activities, and hotel guests' behavioral attitudes which are prone to consumption and resource-intensive. This negative situation can be overcome by choosing environmentally friendly, durable, recycled, and certified materials; as Ayşem Berrin Çakmaklı mention in her study. Also having low embodied energy, being locally produced should be prioritized in material selection (Çakmaklı, 2007).

On the other hand; during the use period of a hotel building which is designed according to sustainability criteria; operational energy, water, and energy consumption can be decreased while comfort and the performance of the building increases.

CHAPTER 3

MATERIALS AND METHOD

In this chapter, the material and methodology of this study are explicated. The study covered two interconnected research questions in order to comprehend the success of sustainability certification systems in Turkey and the lifecycle assessment of recently constructed Green Star and LEED-certified hotel building.

The first part of the research is about hotels that have managed to fulfill the Environmentally Sensitive Criteria of the Green Star Certification System as determined by the Culture and Tourism Ministry of Turkey; and received the certificate.

The second part of the study is conducted on a case study, i.e. a certified green hotel building that is designed to contain three different accommodation zones and different material selections.

3.1 Materials

The materials of the first research were statistical data, reports, and information. Data collected from various sources are explained in detail under Section 3.1.1.

In order to extend the research area the second part of the research was conducted on a case study hotel building, details on which are given in section 3.1.2; and the software are described in section 3.1.3.

3.1.1 Data on Green Star Certified Hotels in Turkey

In order to gather information on Green Star Certified Hotels in Turkey; the following data were obtained.

- The List of Environmentally Sensitive Establishments; (2019) Republic of Turkey Ministry of Culture and Tourism.
- Data collection of guests ratings for hotels' in Istanbul and Antalya (green star certified or not) based on visitors' comments on the travel web site Trivago.com. (Table A.2, Table A.3 in Appendix A)

In order to verify the relationship between the region and the rate of the Environmentally Sensitive Green Star Certified Hotels; the following data were obtained.

- Accommodation and Tourism Statistics Report (2019); Republic of Turkey Ministry of Culture and Tourism.
- Regional list of cities according to Green Star Certification System. (Table A.2 in Appendix A)

In order to verify the relationship between the hotel`s star rating and the rate of the Environmentally Sensitive Green Star Certified Hotels; the following data were obtained.

- The list of Tourism Business Certified Establishments, i.e. hotels; Republic of Turkey Ministry of Culture and Tourism (2019).
- The minimum points that the facilities must get in order to have the Green Star Certificate according to Star rating. (Table 2.3)

3.1.2 Green Star Certified Case Study Hotel Building

The selected case study hotel building located in Istanbul was completed in 2021. The five-star hotel, which was designed to get LEED Gold certification, belongs to an international prestigious hospitality chain. The building with a height of 229.4 m was built with a steel-concrete composite structural system. This high-rise hotel building having 49 floors consists of five main parts. The section key plan is presented in Figure 3.1 below.

- The two basement floors and the ground floor in this hotel are used to house the staff areas, storage, ballroom, retail area, lobby, lounge, entrance, restaurant, and administration offices.
- Two different pools, a spa, and the mechanical spaces are placed on the 11th and 43rd floors.
- Zone A consists of the lower 9 floors and serves as the hotel floors with a total of 182 guest rooms offering four different types of accommodation capacities.
- Zone B consists of 18 floors (12th to 29th) that have furnished rentable service apartments, which make the property owners benefit from the shared revenue by enrolling in the hotel system. 197 apartments ranging from 1 bedroom to 3 bedroom units are offered to the serviced apartment guests.
- Zone C consists of 17 floors (30th to 46th) that have 123 residential units ranging from 1 bedroom to 5 bedroom units, and penthouses.

The three parts of the building (Zones A, B, and C) were divided in order to offer different accommodation choices to the guests. These three parts of the building are described in more detail in the following sections.

The hotel is designed for three different types of users with different materials and planimetric configurationson different floors in accordance with the principles of sustainability. The building's composite facade cladding covers the entire building without any variation; in other words, all 3 zones have the same facade configuration. The Building Information Modelling method (BIM) is used during the management phase of the building as it was used for the design process; and the HVAC and electrical systems are controlled from the same control center.

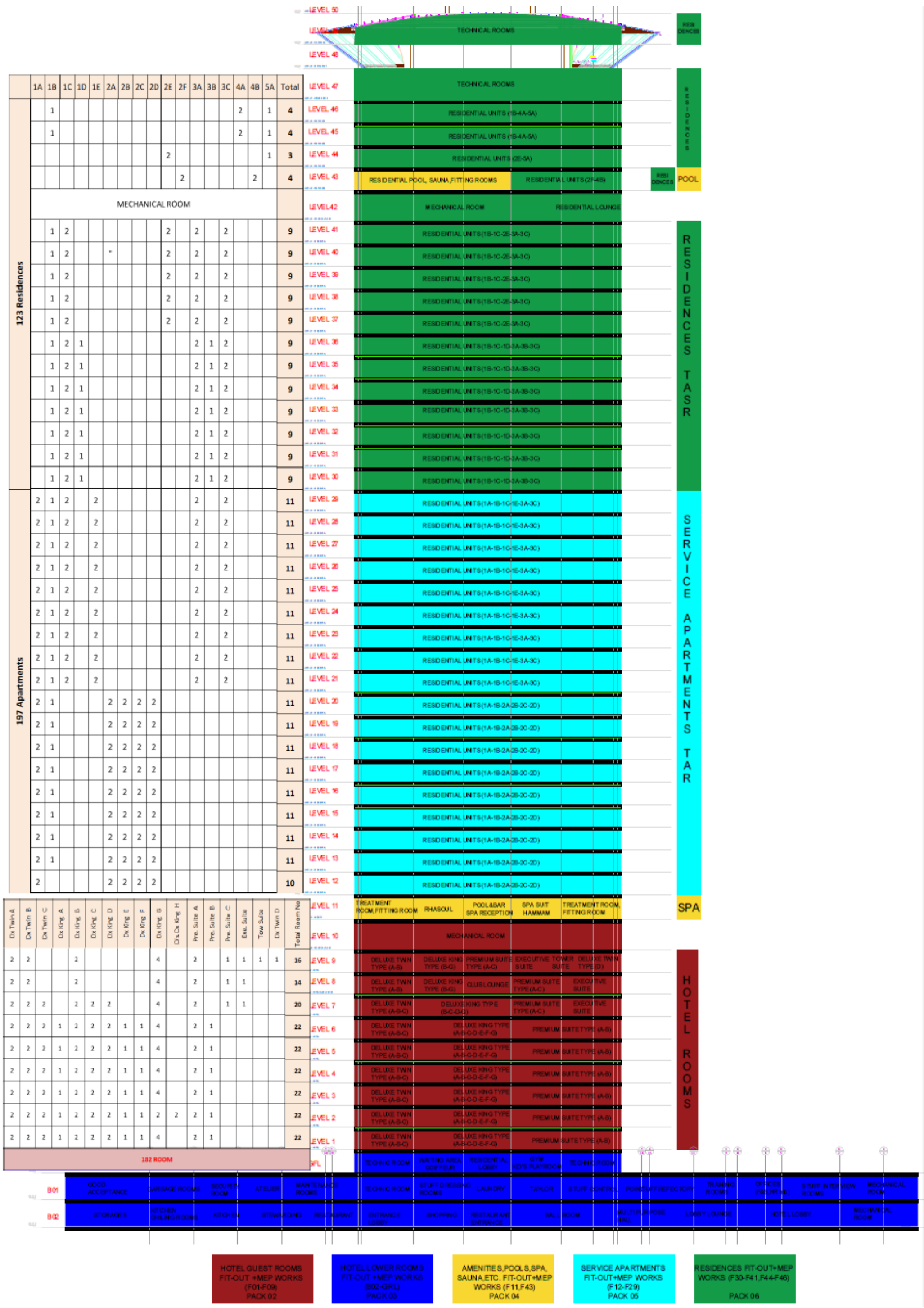


Figure 3.1. The section key plan of the building showing the 5 zones; Zone A (Brown) contains guest rooms, Zone B (cyan) contains serviced apartments, Zone C (green) contains residential units.

3.1.2.1 Hotel Rooms – Zone A

Hotel Rooms, which are in Zone A, are placed on 9 floors of the building. This zone consists of 51 deluxe twin rooms, 100 king-size rooms, 27 premier suites, and 4 executive suits. Each floor has a fixed area of 1598 square meters, and Zone A has a total area is 14,382 square meters. The floor to floor height in this zone is 4.05 m and the floor to ceiling height is 2.80 m. Floor 1 to 6 have 22 rooms on each floor while the 7th floor has 20, the 8th floor has 14 rooms and the 9th floor has 16 rooms.

The architectural layout of a typical hotel floor is presented in Figure 3.2.

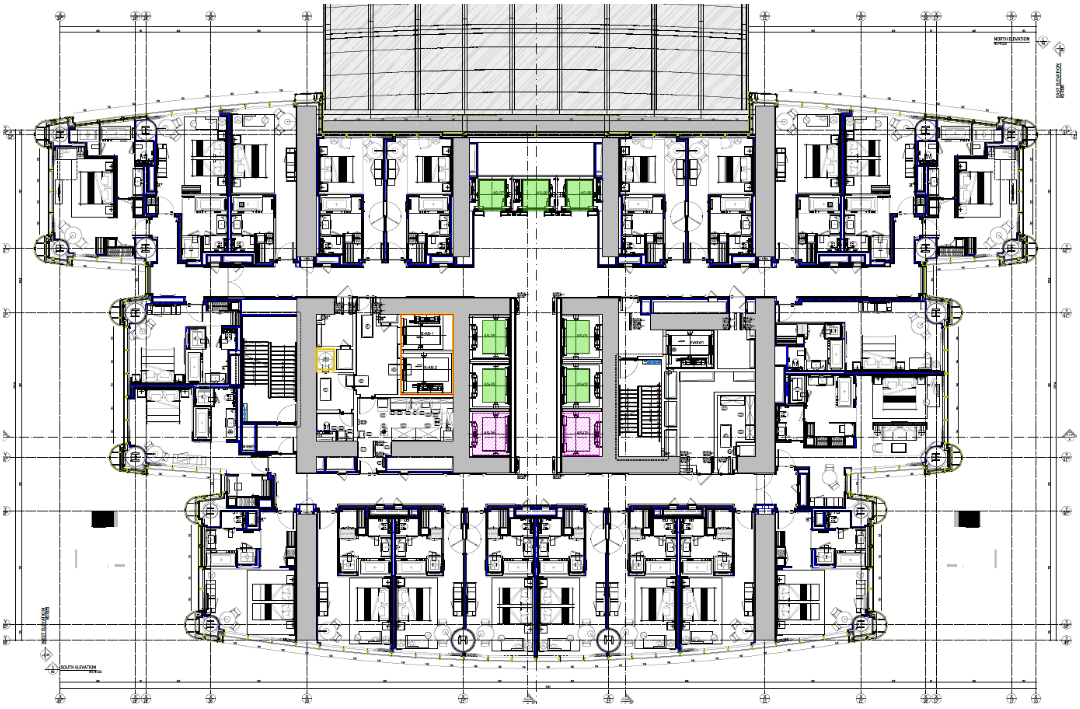


Figure 3.2. Architectural plan of floors 1 to 6 of Zone A.

3.1.2.2 Serviced Apartments – Zone B

Service Apartments in Zone B exist on the 12th to 29th floors of the building. Furnished rentable service apartments provide hotel amenities to the guests while allowing the property owners by renting their flats. In this system, all the apartments are sold fully furnished as hotel rooms and the property owners can enroll their apartments in the hotel system to profit while they are not residing.

Zone B consists of 97 one-bedroom apartments, 72 two-bedroom apartments and 36 three-bedroom apartments. Each floor has the typical area of 1598 square meters, and Zone B has a total apart-hotel area iof 30,362 square meters. The floor to floor height in this zone is 4.05 m and the floor to ceiling height is 3.00 m.

The architectural layout of a typical service apartment floor is presented in Figure 3.3.

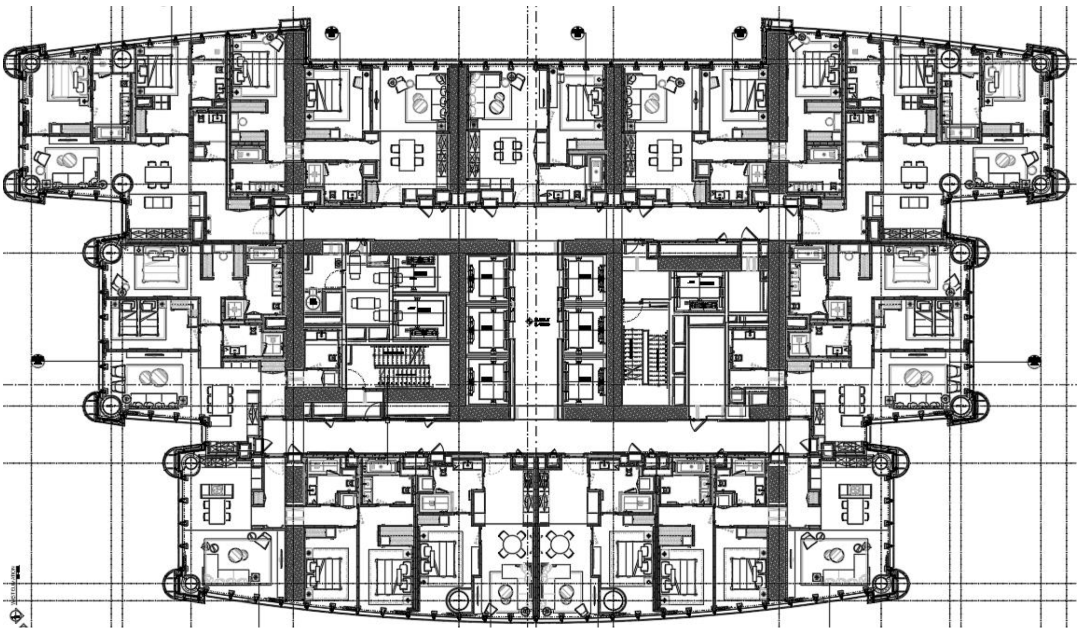


Figure 3.3. Architectural plan of floors13 to 20 of Zone B.

3.1.2.3 Residential Units – Zone C

Zone C is spread from the 30th to 46th floor and contains 123 residential units ranging from 1 bedroom to 5 bedroom apartments, and penthouses, with the concept of an apart hotel.

Of these 41 are one-bedroom residential units, 14 are two-bedroom residential units, 50 are three-bedroom residential units, 6 are four-bedroom residential units and 3 are five-bedroom residential units. Each floor has the typical area of 1598 square meters, and Zone C total floor area is 27,166 square meters. The floor to floor height in this zone is ialso 4.05 m and the floor to ceiling height is 3.00 m.

The architectural layout of a typical residential units floor is presented in Figure 3.4.

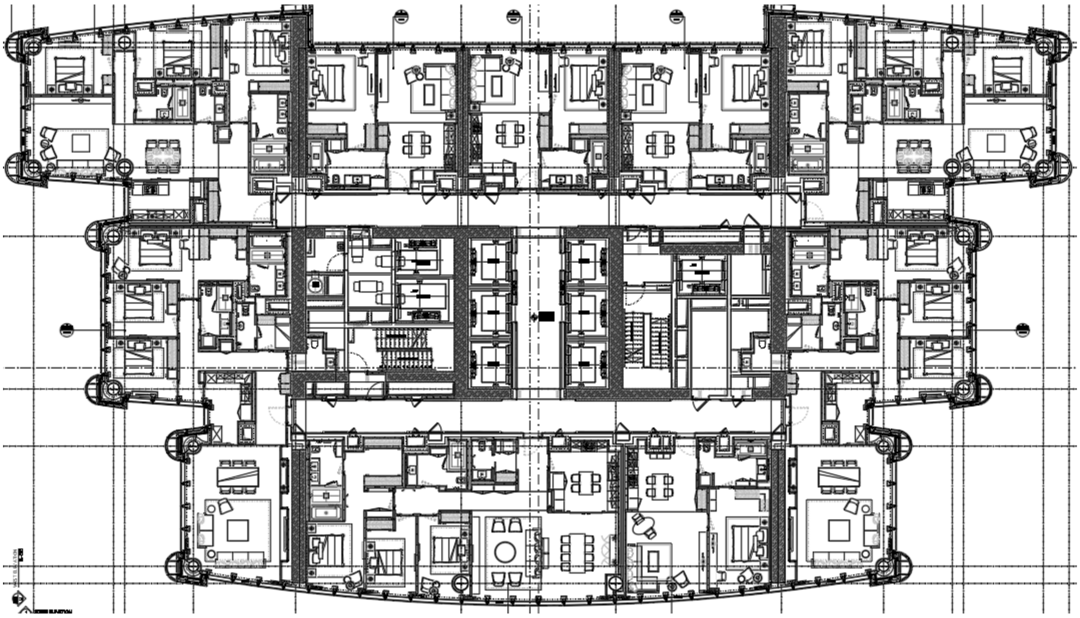


Figure 3.4. Architectural plan of floors 30 to 36 of Zone C.

3.1.3 Bill of Quantities of the Three Accommodation Zones

The data was derived from the BOQ of the building according to finishing works. The building is divided into 5 main zones as mentioned before. However, the mechanical rooms of the pools are included in Zone A and Zone C. For this reason these areas and the floors they belong to were excluded from the calculations. On the other hand, the data used in the comparisons of Zones A, B, and C were derived according to the typical floor plans which are the most repetitive.

Specific data and information about the structural elements and the facade materials was not gathered since the entire building has the same structure and envelope. For the sake of comparison these two components could be ignored in the LCA of the three types of accommodation options.

Table 3.1 is composed according to selected floors and the materials used for finishing works. In the updated BOQ file, information on electrical and mechanical works has been omitted; as well as bathroom utilities, fixtures, bedroom headboards, counter tops.

The most significant difference between Zones A, B, and C based on material selection is the wall materials. In the hotel and Service apartments plasterboards were used for interior walls in order to facilitate possible renovation works in the future; while in the residential units, G4 class autoclaved aerated concrete block were used.

Table 3.1 Bill of quantities of selected floors` finishing works.

Description	Unit	*BOQ Zone A 6th Floor*	*BOQ Zone B 18th Floor*	*BOQ Zone C 36th Floor*
Partition Walls				
Autoclaved Aerated Concrete Block Wall				
AAC Block Wall -15 cm	m²	*5.73*	*1.70*	*21.22*
AAC Block Wall -20 cm	m²	*224.32*	*247.85*	*857.69*
Gypsum Board Wall				
Drywall Construction (U-C channels)				
Single Layer (FX) plasterboard	m²	*3.02*	*15.27*	*54.72*
One-sided box profile stud wall cladding with double-layer (DF) gypsum board and acoustic insulation element	m²		*102.35*	*133.05*
Box profile stud wall with double-sided double layer (FR) gypsum board and rock wool board	m²		*11.03*	*29.38*
Double-faced double-layer FR-DF plasterboard (elevator shafts)	m²	*21.63*	*67.36*	*64.72*
One-sided coating with double-layer (FX) plasterboard and rock wool _DC75	m²	*31.65*	*114.42*	*146.85*
Double-sided double layer (FR) plasterboard and rock wool	m²	*58.57*	*22.15*	*13.90*
Double stud double-sided double layer (FR-DF) gypsum board and rock wool _2*DC50	m²	*258.00*	*125.10*	
Single-sided double-layer (FX) gypsum board with rockwool_DC50_40 cm stud distance	m²	*596.57*	*692.64*	*892.18*
Single-sided double layer (FX) gypsum board with rockwool_DC75 _40 cm stud distance	m²	*44.22*	*23.51*	*54.32*
Single sided cladding with double layer (FR-DF) gypsumboard and rockwool_DC50	m²	*419.00*	*477.48*	*64.57*
Double-sided double layer (FX) gypsum board and rock wool	m²	*80.23*	*571.53*	*500.65*
One-sided coating with double-layer (WR) gypsum board and rock wool _DC50, 40CM stud distance	m²	*613.04*	*750.64*	*698.43*

Table 3.1 Continued.

Double-sided double layer (WR/FX) gypsum board and rock wool (Bathroom sided water-resistant emulsion)_DC75, Marine plywood +box profile reinforcement	m²	*238.38*	*323.97*	*252.50*
Double-sided double layer (WR) gypsum board and rock wool (double-sided water resistant emulsion)_DC50	m²	*15.87*	*19.63*	*23.47*
Double-sided double layer (FX) gypsum board and rock wool	m²	*25.18*		
Single-sided double layer (FR) gypsum board and rock wool _ 50*50*2 Box profile reinforcement	m²	*217.57*	*111.63*	*0.00*
Curvilinear Geometry (U-C Profile) Gypsum Board Wall				
One-sided box profile stud wall with double-layer (Herform) gypsum board and rock wool	m²	*59.29*	*82.96*	*59.63*
Box Profile Supported Wall Applications				
Bathroom- marine plywood	mt	*63.35*	*18.20*	*16.21*
Wall Cladding				
Natural Stone Wall Cladding				
Spider Grey natural stone wall cladding	m²		*44.97*	*119.35*
Crema Unico natural stone wall cladding	m²		*228.08*	
Cool Grey natural stone wall cladding	m²	*542.66*	*236.09*	*265.21*
Cora Beige natural stone wall cladding	m²			*24.60*
New London Grey natural stone wall cladding	m²			*8.91*
ST-TS-05 Calacatta Oro natural stone wall cladding	m²	*48.73*		
Ceramic Wall Cladding				
Ceramic Wall Cladding	m²	*57.62*	*10.00*	*38.38*
Wood Wall Cladding				
Wood Wall Cladding	m²	*180.37*	*107.12*	*97.98*
Mirror				
Mirror flat	m²			*0.96*
Metal- Aluminium Wall Cladding-Skirting-Frame				
Elevator frame	mt	*16.20*	*21.60*	*20.32*
Metal Wall cladding	m²	*1.50*	*1.80*	*1.80*

Table 3.1 Continued.

Elevator push button panel	ad	*2.00*	*2.00*	*2.00*
Metal door frame	mt	*36.86*	*31.39*	*32.00*
Vinyl-Polyester Wallpaper				
Vinly wallpaper (wood panel)	m²	*573.10*	*327.22*	*134.00*
Vinly wallpaper (Gypsiumboard)	m²	*254.04*	*1,372.71*	*31.50*
Repair, Plastering and Painting Works				
Repair and Plaster Works				
Gypsium plaster-1cm	m²	*262.77*	*230.37*	*231.24*
Plaster and Paint Finish				
Stucco (wall)	m²	*297.22*	*228.49*	*302.50*
Plastering (wall)	m²	*822.24*	*568.00*	*1,995.41*
Painting (wall)	m²	*56.51*	*37.74*	*39.64*
Painting (ceiling)	m²	*1,238.67*	*1,462.63*	*1,424.14*
Painting (water-resistant)	m²	*3.40*		
Paint Primer (reinforced concrete surface)	m²	*86.05*	*72.33*	*73.53*
Floor Finish				
Natural Stone Floor Tile				
Natural stone floor tile	m²	*198.49*	*397.93*	*381.22*
Natural stone sill	m	*147.90*	*275.36*	*390.26*
Natural Stone Skirting				
Natural Stone Skirting	mt	*8.96*	*28.54*	*14.34*
Ceramic Floor Tile				
Ceramic Floor Tile	m²	*76.34*	*33.50*	*37.46*
Ceramic Skirting				
Ceramic Skirting	m	*92.85*	*34.75*	*32.90*
Laminated Floor				
Laminated Floor_ BOEN Oak Smoked (Plank)	m²	*552.22*	*551.82*	*573.47*
Hardwood Sill (American Walnut)	mt	*24.64*	*7.00*	
Polyethylene silt 3 mm	m²	*576.86*	*558.82*	*573.47*
Wood Skirting				
Wooden Skirting	m	*401.86*	*516.95*	*515.42*
Floor Strip				
Floor Strip	mt	*232.93*	*338.05*	*277.98*
Reinforced Concrete Steel				
Steel Mesh (Ø188/188)	ton	*1.08*	*0.45*	*0.44*

Table 3.1 Continued.

Screed and Filling Works				
40-45 mm screed	m²	*322.81*	*160.02*	*152.54*
95mm screed	m²	*16.08*	*15.70*	*14.65*
Concrete fiber (30-35mm)	m²	*789.56*	*1,004.90*	*1,003.92*
Shower sill (bathroom)	mt	*19.29*	*20.10*	*21.37*
Modulo raised floor (50mm)	m²	*1,113.00*	*1,161.99*	*1,153.70*
XPE sill (10 mm)	m²	*1,113.00*	*1,164.92*	*1,156.46*
Metal Floor Strip				
Metal Floor Strip	mt	*107.51*	*128.15*	*131.30*
Concrete Flooring				
Cement Mosaic Tile (30mm)	m²	*32.66*	*25.98*	*25.39*
Cement Mosaic Terrazo Precast stair tread and risers (30mm)	mt	*62.50*	*58.34*	*57.60*
Cement Mosaic Skirting (30mm)	mt	*65.20*	*55.09*	*55.50*
Water Proofing				
Cement based waterproofing (Masterseal WP 666)	m²	*486.11*	*457.24*	*360.09*
Ceiling Works				
Gypsum board - Rockwool Suspended Ceiling				
Access Panel (100 * 60 cm)	ad	*22.00*	*36.00*	*30.00*
Single-layer gypsum board suspended ceiling	m²	*622.72*	*851.66*	*870.65*
Single-layer water-resistant gypsum board ceiling	m²	*204.07*	*168.53*	*137.04*
60x60 Rockwool suspended ceiling	m²	*46.83*	*15.06*	*15.49*
Gypsum board Suspended Ceiling				
Gypsum board Suspended Ceiling	m	*465.09*	*577.87*	*565.04*
Vinyl Suspended Ceiling				
Vinyl Suspended Ceiling	m²	*78.00*	*57.56*	*58.46*
Metal Suspended Ceiling				
Metal Suspended Ceiling	mt	*49.75*	*25.80*	*23.33*
Partition Wall and Glass Separation				
Glass Separation	m²	*153.48*	*34.92*	*39.44*

3.1.4 LCA Software

To assess the life cycle environmental impacts of materials used in the case study building; a commonly preferred life cycle assessment software tool called ‘Athena Impact Estimator for Buildings 5.4’ was used.

This free software which is produced by the Athena Sustainable Materials Institute in Ontario, Canada; enables us to assess and compare buildings and assemblies according to the LCA methodology. Consequently, the possible design decisions and material selections can be done with a holistic approach on environmental factors.

At the beginning of the evaluation with ATHENA; the project location, building type, life expectancy, building height, and gross floor area information should be entered into the database. Regional information has importance on the electrical grid, material manufacturing and transportation, energy use, demolishing and disposal process. It is also required to define the building`s estimated annual operating fuel type energy.

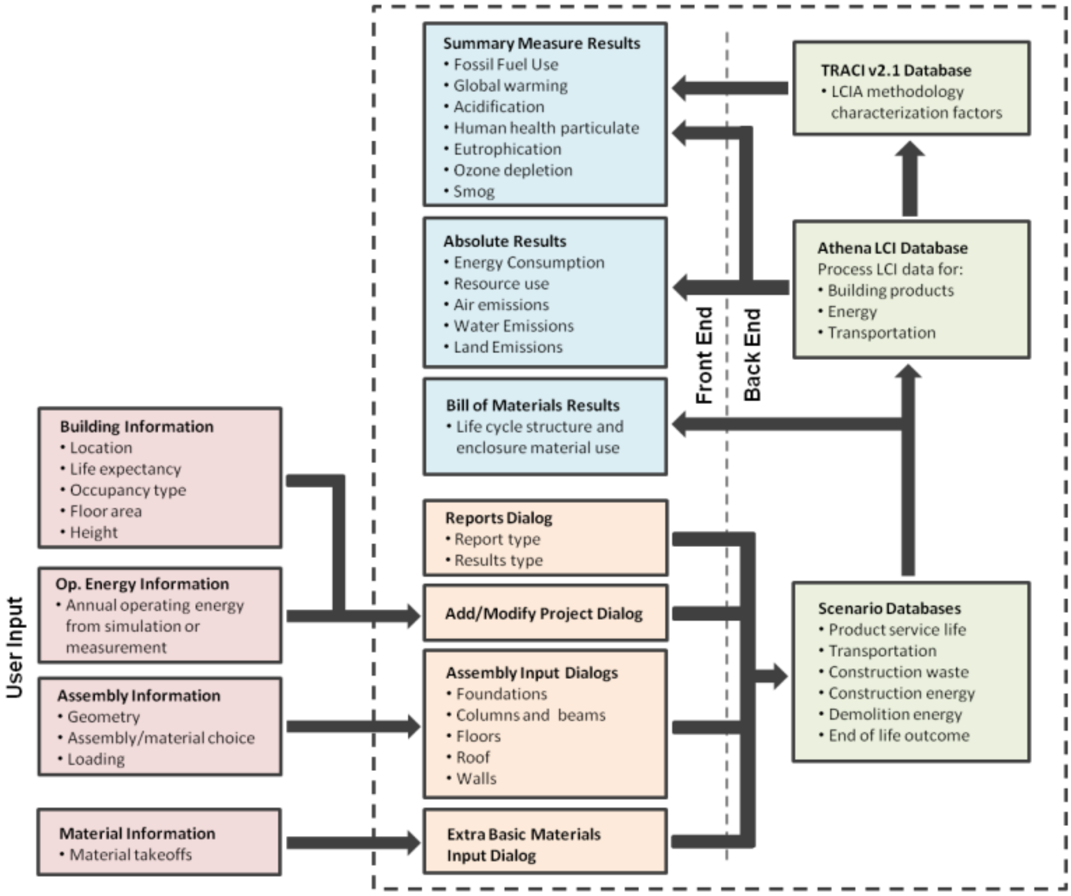


Figure 3.5. Work scheme of Athena Impact Estimator for Buildings. (Athena Sustainable Materials Institute, 2019)

In order to define building elements; the Add Assembly Menu is used in whether imperial or metric units. Foundation, structural elements, additional walls, roof, and floors can be added separately. By adding materials for any of the building units the software also calculates the associated materials in need. For example; after defining length, width, and the attributes (stud type and space, the materials) of a gypsum board wall the number of nails are calculated by the software and added to the bill of materials report (Athena Sustainable Materials Institute, 2013). Also, the ‘modify custom wall’ tool and the ‘add extra material’ tool allow to change wall layers and materials; however, the materials are limited by the software`s library, which covers the common materials used in North America and Canada.

The results can be preduces in terms of the nine impact measures which are described in detail in Section 4.2 fallowing the results of the software.

3.2 Method

After determining and defining the research area; a comprehensive literature review was carried out to find relevant articles regarding sustainability in the hospitality sector in Turkey, by using ScienceDirect, ResearchGate, and Google Scholar. 15 different articles focusing on the subject of green tourism in Turkey were examined. For the inventory analysis; the Statistical Reports of Green Star Certified Accommodation`s data from 2001 to 2020 were analyzed. And it was noticed that the Green Star Application has not become widespread enough as only 473 of the 4109 touristic accommodation establishments have a Green Star certificate in 2020. However, as in the whole world, studies are carried out in the field of sustainable tourism in Turkey, and there are even incentives from the government in this regard. In addition, sustainable tourism certification programs are not recently developed systems that need time to be adapted; their history goes back 30 years.

The gains from sustainability will have a positive effect on other investments in the hotel economy. Therefore, the opinions of the visitors can be more positive than the others in hotels with sustainable elements. As guests' opinions can be accepted as a success rate; it is anticipated that hotels with a stronger financial structure will be more focused on increasing customer satisfaction.

A study shows that the hotel owners' choice and consciousness on sustainability directly affects the actions on sustainable tourism (Sardianou, Kostakis, Roido, & Vaitsa, 2016). Thus; it is believed that proving the success of hotels having the Green Star certificate is crucial for raising awareness. This could be accomplished by finding out how were they rated by the guests as opposed to the green certificate rating.

During the certification process, an overlooked important issue is the lifecycle of buildings and the transformation of the accommodation choices. From this point of view; as a second step of the research a Green Stars and LEED certified hospitality building combining three types of accommodations was selected to understand the impact of its lifecycle; and to see how they matched with respect to its certification.

The research methodology can be defined under the following six steps.

Step 1: Gathering information and data on the Environmentally Sensitive Green Star Certified hotels in Turkey.

Step 2: Determination of the location of hotels that will be evaluated for guests' feedback.

Step 3: Compiling statistical data and combining them with the guests' ratings according to the hotel located in selected cities.

Step 4: Testing hypotheses based on qualitative and quantitative data regarding the success of Green Star Certified hotels

Step 5: Determining the Green Stars and LEED certified case study hospitality building and collecting information, drawings, and BOQ data on its three accommodation zones.

Step 6: Since the floor areas, building envelope, structural system and HVAC systems were the same for all three zones, the BOQ of materials used in the different interior floor plan configurations of the three accomodation zone of the building were calculated.

Step 7: The updated BOQ was used for simulating the LCA impact of the different accommodation zones.

Step 8: Results from the LCA simulation were analyzed to derive meaningful conclusions.

3.2.1 Comparing Hotels` Green Star Certification with Guest Ratings

In order to find answers to research questions, quantitative data and reports were collected from the Ministry of Culture and Tourism of Turkey and categorized in terms of environmentally sensitivity certificate, region, and hotel class.

Before the qualitative data compilation process, the number of hotels was analyzed according to the 6 touristic development regions of the Ministry of Culture and Tourism (Appendix A.1). It was seen that the distribution of the hotel numbers were the highest in region 1 due to comprising the most attractive touristic cities (Appendix A.2). Then the scale of the research was made smaller and focused on the hotel numbers of Antalya and Istanbul provinces were analyzed. In this selection, attention was paid to the fact that the number of hotels is high and that these cities have different touristic features.

According to the categorized qualitative data; quantitative research was carried out in order to obtain success factors depending on having green star certificate or not. Since it is not possible to specifically address the issue by conducting a survey with professionals or hotel guests in the study, an online holiday website; Trivago.com is used in this research to determine the success of the hotels where the guests' ratings are shared.

99 of 442 hotels do not have guests` rating in Istanbul. 2 of these hotels are Green Star cerfied. Since the chance to access information about all hotels in Istanbul was not possible for Antalya province a systematic sampling method was used. The information of 673 hotels in Antalya is listed in alphabetical order and sorted according to the hotel class and certificatation status. Sample size (n) is set to 5. 49 of 138 hotels do not have guests` rating in the sample group 10 of these hotels are Green Star certified.

The research data set was prepared by classifying and combining both qualitative and quantitative inputs (Figure 3.5). Following survey was carried out to gather the data on certified hotels and guest reviews:

- Gathering information and statistical data of the Environmentally Sensitive Green Star Certificated Hotels in Turkey, by years and by regions.
- Compiling statistical data and combining them with the guest review ratings according to the hotel located in selected cities.
    a. Are the Green Star certified hotels preferable by users?
    b. Are the preferability and satisfaction of visitors the same for green star certified hotels and uncertified ones located in the same region and having the same standards?
    c. Do the percentages of green star certified sustainable hotels vary according to hotel types?
    d. Does the investment in sustainability measures change according to the hotel class and region in Turkey?
- Testing hypotheses based on qualitative and quantitative data.

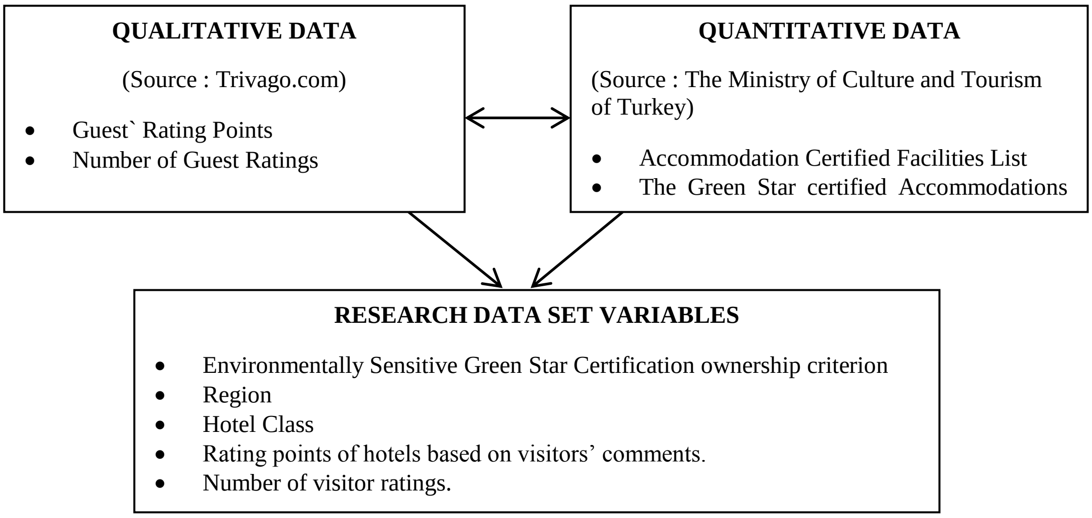


Figure 3.6. The data gathered of the research.

3.2.1 Comparing Green Star and Guests Ratings

The gains from sustainability will have a positive effect on other investments in the hotel economy. Therefore, the opinions of the guests should be more positive than the uncertified hotels with sustainability measures. It is anticipated that hotels with a stronger financial structure will be more focused on increasing customer satisfaction; i.e the more luxurious hotels (5 and 4 stars) had more investment on sustainability features. As guests' opinions can be accepted as a success rate; Hypothesis 1 is developed.

Hypothesis (H_1): Environmentally Sensitive Green Star Certified Hotels are more successful in terms of guests' satisfaction.

Null-Hypothesis (H_0): Adoption of ecological principles does not directly or indirectly affect guests' preferences and satisfaction for hotels in Turkey.

In order to determine the success of Green Star certified hotels regarding to guests` ratings formulated hypothesis was tested via T-test because of the sample size.

3.2.2 Comparing LCA Data for Three Accomodation Options in the Case Study Building

In order to evaluate the lifecycle of different accommodation options the case study building was selected from Istanbul. The reason for choosing this building is its exceptional design which is consisting of residential units, serviced apartments, and guest rooms in the same hotel. Also, the location of the case study was selected in view of the insight gained from data on green certified hotel Buildings in Turkey.

In addition to the drawings of the case study building; the bill of quantities are calculated according to the selected floors and per user. The number of the guests is accepted as equal to the number of beds in the architectural plans.

Table 3.2 Distribution of accomodation types and number of guests per floor according to building zones.

	Zone A	***Zone B***	***Zone C***
Type of accomodation	Guest Rooms	Serviced Apartments	Residential Units
Typical floor	6th Floor	18th Floor	36th Floor
Number of Guests per floor	44	32	28

This part of the study consists of three different accommodation zones' lifecycle assessment via Athena Impact Estimator for Buildings 5.4. This software provides assessing each zone of the building one by one while making it to possible to compare all of them.

Before the assessment process each part of the building information, material selection, and measures are done separately.

The following information for set up files is the same for all case studies.

- Building Height: 4.05 m (floor height)
- Gross Floor Area: 1598 m2

As the location selections are limited with 17 cities in Canada and USA. Toronto is selected as the location due to similarities with the electricity grid in Turkey, as in Cakmakli`s research (Çakmaklı, 2007). Building life expectancy is set for 60 years (Georgia Institute of Technology, 2010).

Under the 'Building Type' menu the three zones were identified as follows:

- Zone A – containing Guest Rooms had a hotel concept for short term stay and was identified as 'Commercial'
- Zone B - containing Serviced Apartments had an apart-hotel concept for midt term stay and was identified as 'Multi-Unit Residential-Rental'
- Zone C – containing Residential Unitshad a home away from home concept for long term stay and was identified as 'Multi-Unit Owner-Occupied'

The building components such as foundations, walls, columns and beams, roofs, floors, and extra materials can be selected from the 'Add Assembly' tool, which is used to define building units and their dimensions. Although the material library was expanded to include roof and insulation components for the 5.4 version, some of the local materials cannot be found in the library. Therefore, equivalent materials having similar components or systems were selected for this study. (Table 3.2). Also carpet material was excluded from the calculation due to lack of equivalent material in material library.

Table 3.3 Equivalent material selections from the ATHENA database for simulation purpose.

CASE STUDY MATERIAL	EQUIVALENT MATERIAL (ATHENA)
Ceramic Tile	Clay Tile
Wooden Wall panelling	Pine Wood tongue and groove siding
Mirror	Glazing Panel
Vinyl-Polyester Wallpaper Covering	Polyprophlene Scrim Kraft Vapour Retarder Cloth
Repair and Plaster Works	Mortar
Metal Floor Strips	Cold Rolled Sheet 0.3 kg/mt
Reinforced Concrete Steel	Rebar,Rod, Light Sctions
Screed Works	Concrete Benchmark CAN 30 Mpa (4 cm)
Terrazzo Tile	Concrete Tile
Water Proofing	Emulsified Asphalt Primer Coat
Plasterboard Access Panel	Regular Gypsium Board
Vinyl Suspended Ceiling Tiles	1/2`` Glass Mat Gypsum Panel

Some of the supplementary materials used is not available in the material selection tool. Also architectural detail projects to calculate BOQ of some material was not provided. Therefore; assumptions made about such material are listed below.

- BOQ of skirting was calculated in m2, assuming a height of 12 cm and the same material with the floor covering.
- It is assumed that 1 liter of paint paints 4 m2 surface. (AkzoNobel Paints, 2021)
- The unit weight of metal floor strip assumed as 0.3 kg/mt.
- The joint compound consumption was calculated as 250 gr for a 10 m2 surface.
- Screed thickness is assumed as 4 cm.
- Width of sill is assumed as 20 cm.

CHAPTER 4

RESULTS AND DISCUSSION

In this chapter, the results of the hypothesis testing and simulations are presented under separate sections.

4.1 Discussion on Statistical Data

It can be said that sustainability investments in hotels are dependent on the economic size of the businesses. As known hotels` star ratings represent the class, quality and facilities of hotels. Therefore sustainability relationship with the hotels` star rating is directly proportional. Figure 4.1 proves that as the star ratings of hotels` increase; the Green Star certified hotel numbers increasing as well.

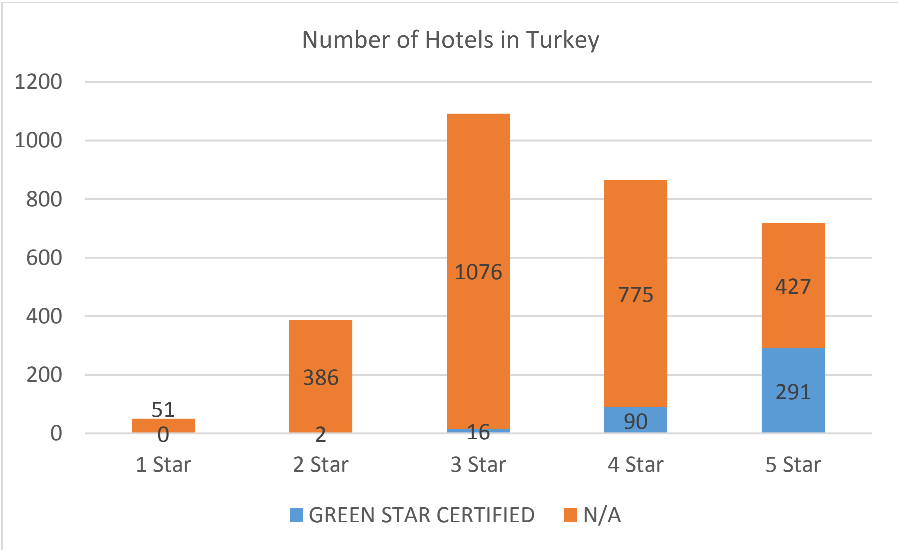


Figure 4.1. Number of Green Star Certified Hotels and Investment Licenced Hotels in Turkey. Chart based on data retrieved from Tourism website (2020).

When the statistical data was analyzed on the scale of Istanbul; it was seen that 12% of the hotels are Green Star certified. And almost all of the certified hotels are

4 star or 5 star hotels. In the statistical analyses made on the Antalya scale, although the distribution of certified hotels according to the stars shows the same features, the share of certified hotels is much higher; i.e. 31%.

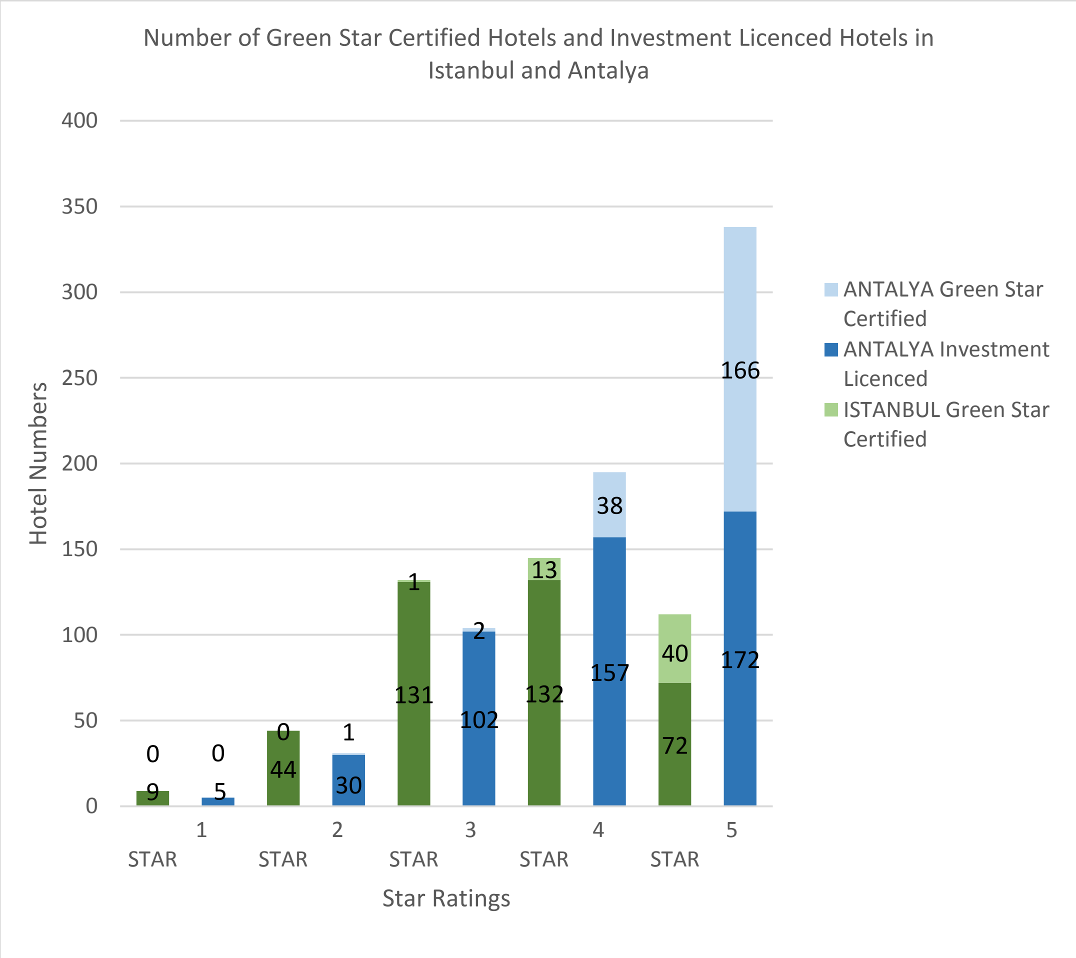


Figure 4.2. Number of Green Star Certified Hotels and Investment Licenced Hotels in Istanbul and Antalya. Chart based on data retrieved from Tourism website (2020).

In order to analyze the qualitative and quantitative data of hotels` the independent samples t-test was used. The survey is conducted firstly according to hotels in Istanbul and Antalya. Due to the fact that Green Star certified hotels are mostly 4 and 5 star; t-tests were also repeated for pairs classified according to their class and province.

Hypothesis (H_1): Environmentally Sensitive Green Star Certified Hotels are more successful in terms of guests' satisfaction.

Null-Hypothesis (H_0): Adoption of ecological principles does not directly or indirectly affect guests' preferences and satisfaction for hotels in Turkey.

Table 4.1 Result of the t-test on guest ratings data for Istanbul hotels.

t-Test: Two-Sample Assuming Unequal Variances

	Green Star Certified	*Investment Licenced*
Mean	8.264	7.773925
Variance	0.228881633	0.509433
Observations	50	293
Hypothesized Mean Difference	0.05	
df	91	
t Stat	5.537261329	
P(T<=t) one-tail	1.47406E-07	
t Critical one-tail	1.661771155	
P(T<=t) two-tail	2.94811E-07	
t Critical two-tail	1.986377154	

As P value is less than alpha value (0.0000002948 < 0.05) null-hypothesis is rejected. And the results show that; there is a significant difference between the green star certified hotels and uncertified investment licenced hotels in Istanbul in terms of guests` ratings.

Table 4.2 Result of the t-test on guest ratings data for Antalya hotels.

t-Test: Two-Sample Assuming Unequal Variances

	Green Star Certified	*Investment Licenced*
Mean	8.689032258	7.897709924
Variance	0.38747633	0.846994715
Observations	155	131
Hypothesized Mean Difference	0	
df	222	
t Stat	8.357323944	
P(T<=t) one-tail	3.50829E-15	
t Critical one-tail	1.651746359	
P(T<=t) two-tail	7.01658E-15	
t Critical two-tail	1.970707395	

As P value is less than alpha value; null-hypothesis is rejected. And the results show that; there is a significant difference between the green star certified hotels and uncertified investment licenced hotels in Antalya in terms of guests` ratings.

T-test results show that Environmentally Sensitive Green Star Certified Hotels are more successful in terms of guests' satisfaction in both Istanbul and Antalya.

4.2 Discussion on Comparison of LCA for the Three Accommodation Options`

This part of the research is divided in to two stage in order to analyze of each zone in detail. First part of the evaluation is based on the simulations of of each zone, (Zone A,B, and C) according to selected LCA measurements.

For the second part of the evaluation reapplied in terms of the guests` numbers per floor.

i. Simulation of Three Accommodation Zones

After entering the BOQ of each zones as the input to the ATHENA, the summary tables, and comparison graphs were obtained as the output.

Since the entire building has the same structure and envelope, the components of the floors and walls assemblies` LCA reports of the each zone are gathered. Summary tables of calculation of each LCA measurement indicator according to zones and assemblies are combined in Table 4.1.

Table 4.3 Combined summary tables of calculation of each LCA measurement indicator according to five main LCA categories.

LCA Measures	Unit	ZONE A - 6th Floor		ZONE B - 18th Floor		ZONE C - 36th Floor	
		Walls	Floors	Walls	Floors	Walls	Floors
Global Warming Potential	kg CO2 eq	1.05E+05	5.47E+04	1.08E+05	5.63E+04	1.84E+05	5.61E+04
Acidification Potential	kg SO2 eq	6.57E+02	2.74E+02	6.56E+02	2.71E+02	9.36E+02	2.71E+02
HH Particulate	kg PM2.5 eq	2.89E+02	7.24E+01	2.85E+02	8.19E+01	4.01E+02	8.21E+01
Eutrophication Potential	kg N eq	6.07E+01	1.22E+02	6.58E+01	7.81E+01	1.45E+02	7.63E+01
Ozone Depletion Potential	kg CFC-11 eq	1.34E-03	1.21E-03	1.06E-03	1.02E-03	2.66E-03	1.00E-03
Smog Potential	kg O3 eq	1.10E+04	5.45E+03	1.14E+04	5.80E+03	1.79E+04	5.79E+03
Total Primary Energy	MJ	1.50E+06	6.30E+05	1.55E+06	6.22E+05	2.25E+06	6.13E+05
Non-Renewable Energy	MJ	1.47E+06	6.10E+05	1.53E+06	6.02E+05	2.20E+06	5.93E+05
Fossil Fuel Consumption	MJ	1.39E+06	5.87E+05	1.44E+06	5.83E+05	2.09E+06	5.74E+05

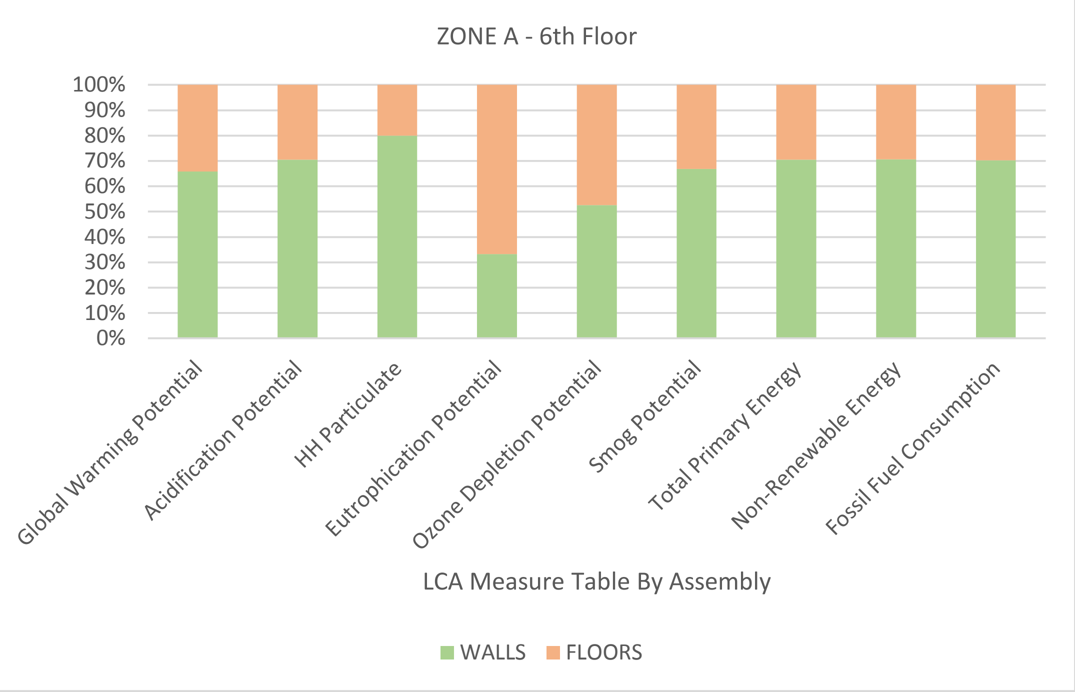


Figure 4.3. Analysis of the contribution of Zone A assemblies according to the LCA measures. Chart drawn by author based on data retrieved from ATHENA.

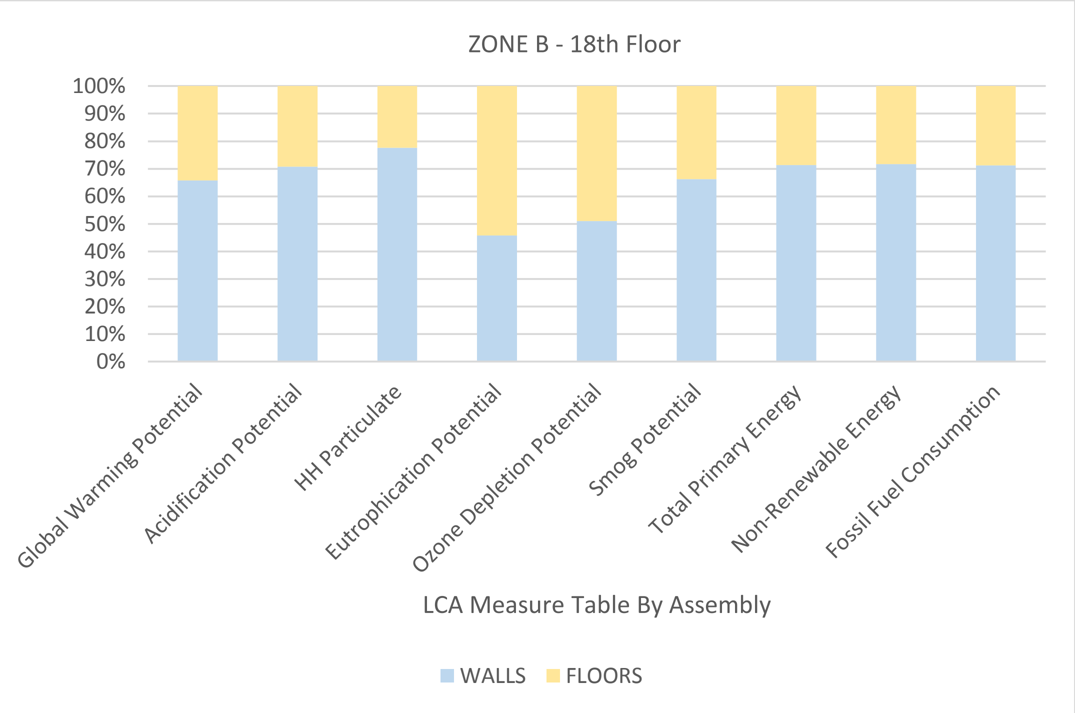


Figure 4.4. Analysis of the contribution of Zone B assemblies according to the LCA measures. Chart drawn by author based on data retrieved from ATHENA.

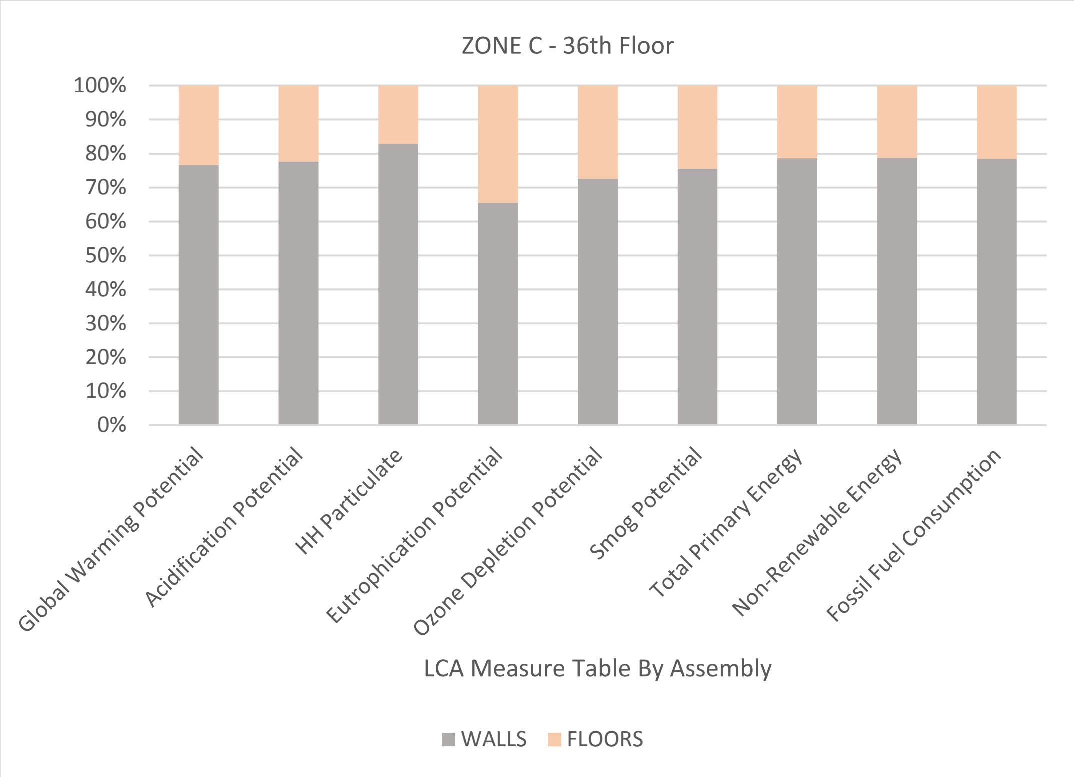


Figure 4.5. Analysis of the contribution of Zone C assemblies according to the LCA measures. Chart drawn by author based on data retrieved from ATHENA.

Figure 4.2, 4.3 and 4.4 demontrates the analysis of the contribution of each zone`s assemblies according to the LCA measures.

Comparing the each bar chart; contribution of wall comes into prominence respectively Zone A to Zone C due to material selection. As described on section 3.1.3; in Zone A and B plasterboards were selected for interior walls; however in Zone A, G4 class autoclaved aerated concrete block were used.

As it can be seen in Table 4.2; it is seen that the environmental impact of autoclaved aerated concrete block is significantly different when compared to plasterboard.

Table 4.4 Combined environmental impact categories of plasterboard and autoclaved aerated concrete block during lifecycle A1 to C4. Table derivered from the LCA reports of plasterboard and autoclaved aerated concrete block in Appendix D.1 and D.2 (British Precast Concrete Federation, 2017) (Knauf Danogips GmbH, 2020).

	TYPE OF MATERIAL	
ENVIRONMENTAL IMPACT CATEGORY	**PLASTERBOARD**	**AAC BLOCK**
	TOTAL(A1-C4)	**TOTAL (A1-C4)**
AP (Acidification potential of land and water)	8,69E-03	2,48E-01
EP (Eutrophication potential)	2,41E-03	2,90E-02
GWP (Global warming potential)	2,39E+00	1,20E+02
POCP (Formation potential of tropospheric ozone photochemical oxidants)	4,42E-04	5,31E-02
ADPE (Abiotic depletion potential for nonfossil resources)	2,72E-06	2,87E-03
ADPF (Abiotic depletion potential for fossil resources)	4,07E+01	1,32E+03
ODP (Ozone depletion potential)	4,10E-07	7,10E-07

In order to make comparison between each zone LCA; calculation reports are created in terms of life cycle stage embodied effects. Total operational energy has the value zero for all indicators. This phase is ignored because operational energy data of the building according to the consumption of electricity and natural gas could not obtained during the data compilation process.

The comparison outputs of the software are divided into five main categories according to life cycle stages. (Table 4.2) These are product, construction process, use, and end of life.

Table 4.5 Life cycle stages of LCA. Table by author based on data retrieved from ATHENA (Athena Sustainable Materials Institute, 2014).

	Product			Construction Installation		Use							End of Life			
Life Cycle Stage	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
Information Module	Raw Material Supply	Transport	Manufacturing	Transport	Construction-installation Process	Use	Maintenance	Repair	Replacement	Refurbishment	Operational Energy Use	Operational Water Use	Deconstruction	Transport	Wate Processing	Disposal

Although it is claimed that the present capacity of the software s in compliance with the LCA requirements and North American green building codes; Table 4.3 summarizes the system boundries and capacities of ATHENA according to the LCA lifecycle stages (Athena Sustainable Materials Institute, 2014).

Table 4.6 System boundries and capacities of ATHENA according to the LCA lifecycle stages (Athena Sustainable Materials Institute, 2014).

Information Module	Supports?	Processes Included
A1 Raw material supply	Y	Primary resource harvesting and mining
A2 Transport	Y	All transportation of materials up to manufacturing plant gate
A3 Manufacturing	Y	Manufacture of raw materials into products
A4 Transport	Y	Transportation of materials from manufacturing plant to site.
A5 Construction-installation process	Y	Construction equipment energy use, and A1-A4, C1, C2, C4 effects of construction waste
B1 Installed product in use	N	n/a (currently insufficient consensus in methodology and data for this module to be addressed)
B2 Maintenance	Partial	Painted surfaces are maintained (i.e. repainted), but no annual maintenance aspects are included
B3 Repair	N	n/a (not currently well-supported with data)
B4 Replacement	Y	A1-A5 effects of replacement materials, and C1, C2, C4 effects of replaced materials
B5 Refurbishment	N	n/a (this module applies to known future refurbishment and needs to be addressed on a case-by-case basis if applicable)
B6 Operational energy use	Y	Energy primary extraction, production, delivery, and use
B7 Operational water use	N	n/a
C1 De-construction demolition	Y	Demolition equipment energy use
C2 Transport	Y	Transportation of materials from site to landfill
C3 Waste Processing	N	Most material data does not include waste processing effects, however, the newer metals "avoided burden" methodology data does include waste processing effects, but it is not separated into its own C3 module (see Metal Recycling on page 28)
C4 Disposal	Y	Disposal facility equipment energy use and landfill site effects
D Benefits and loads beyond the system boundary	Y	Carbon sequestration and metals recycling

The LCA mesurement indicators described in detail in section 2.7.2.1 were set for the seven comparison graphs. These indicators are;

- Total Primary Energy
  - Non-renewable Primary Energy
  - Fossil Fuel Consumption
- Global Warming Potential (GWP)
- Acidification Potential
- Aquatic Eutrophication Potential (EP)
- Human Health (HH) Particulate
- Ozone Depletion Potential(ODP)
- Smog (Photochemical Ozone Formation Potential)

As the total primary energy indicator comprises non-renewable energy and fossil fuel consumption; these two subdivision was not included. The comparison results of LCA according to each measurement indicator are demonstrated in Figure 4.5-Figure 4.11.

Total Primary Energy

Total primary energy consumption is reported in mega-joules (MJ) unit. The energy used all the stages beginning from the raw material to the demolition phase is calculated.

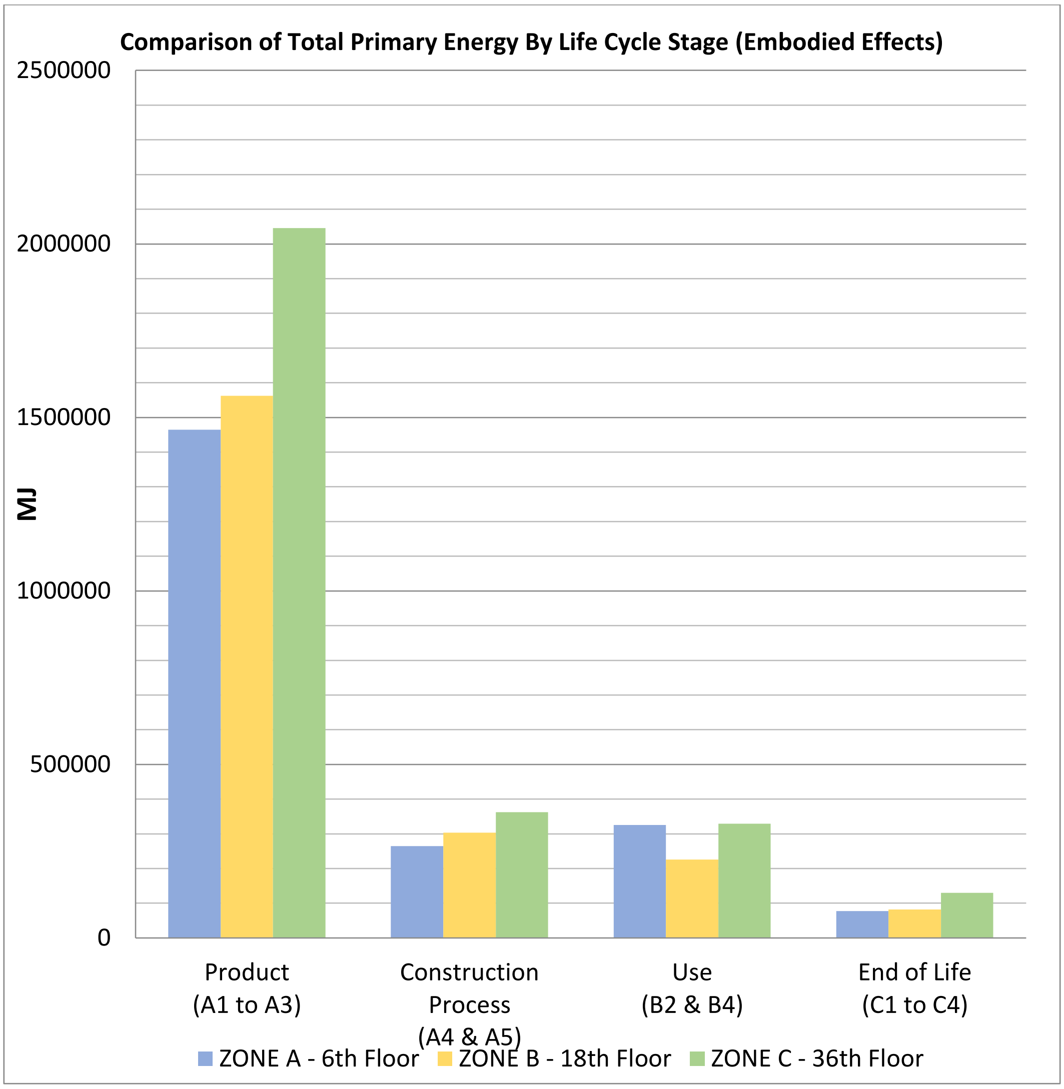


Figure 4.6. Comparison of Total Primary Energy By Life Cycle Stage.

Global Warming Potential (GWP)

Carbon dioxide effect in kg or tonnes unit is the expression of global warming potential. Global warming potential is one of the most accepted LCIA categories (Athena Sustainable Materials Institute, 2019).

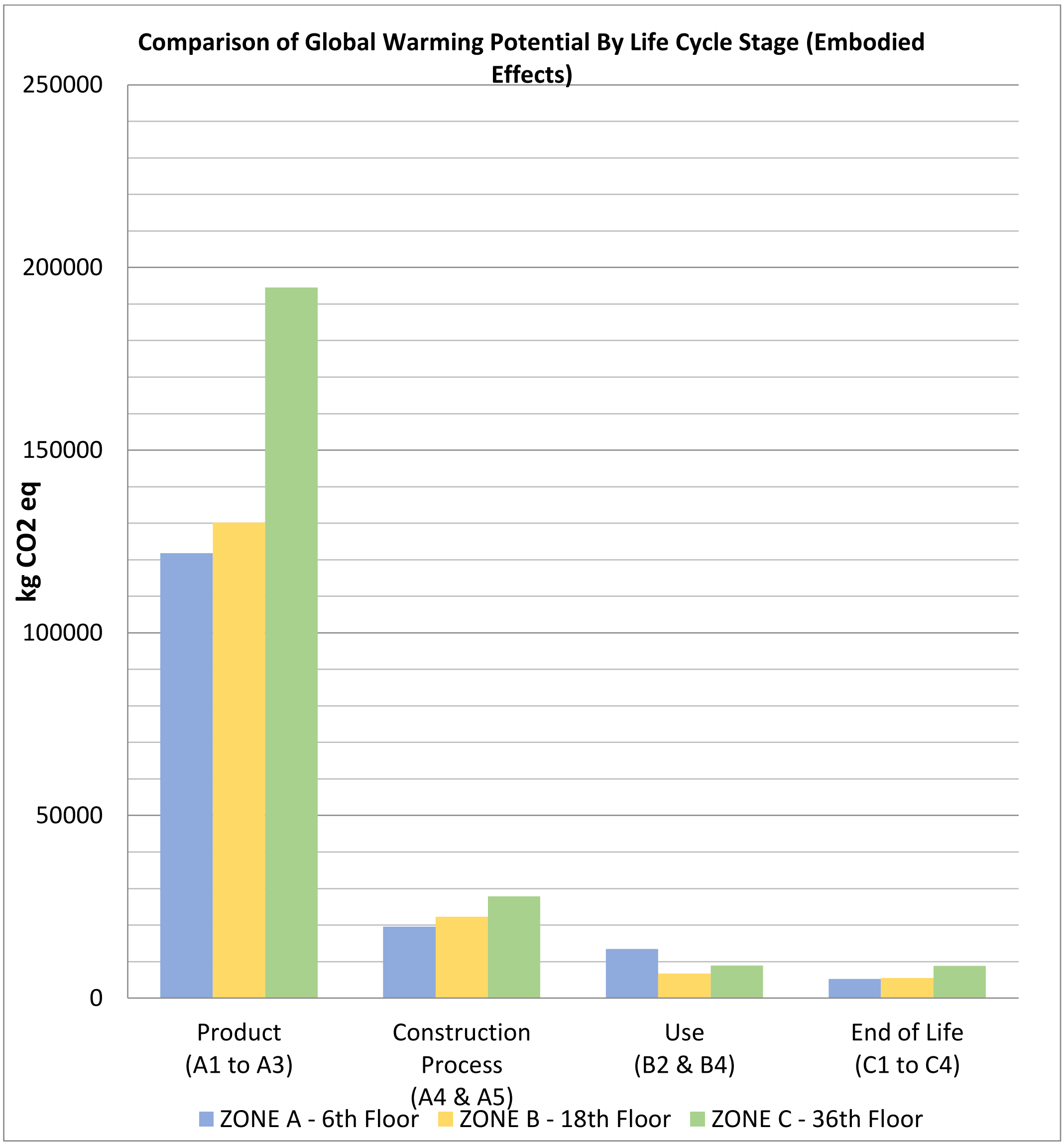


Figure 4.7. Comparison of Global Warming Potential By Life Cycle Stage.

Acidification Potential

The SO2 equivalence effect on a mass basis is used for the calculation of acidification potential.

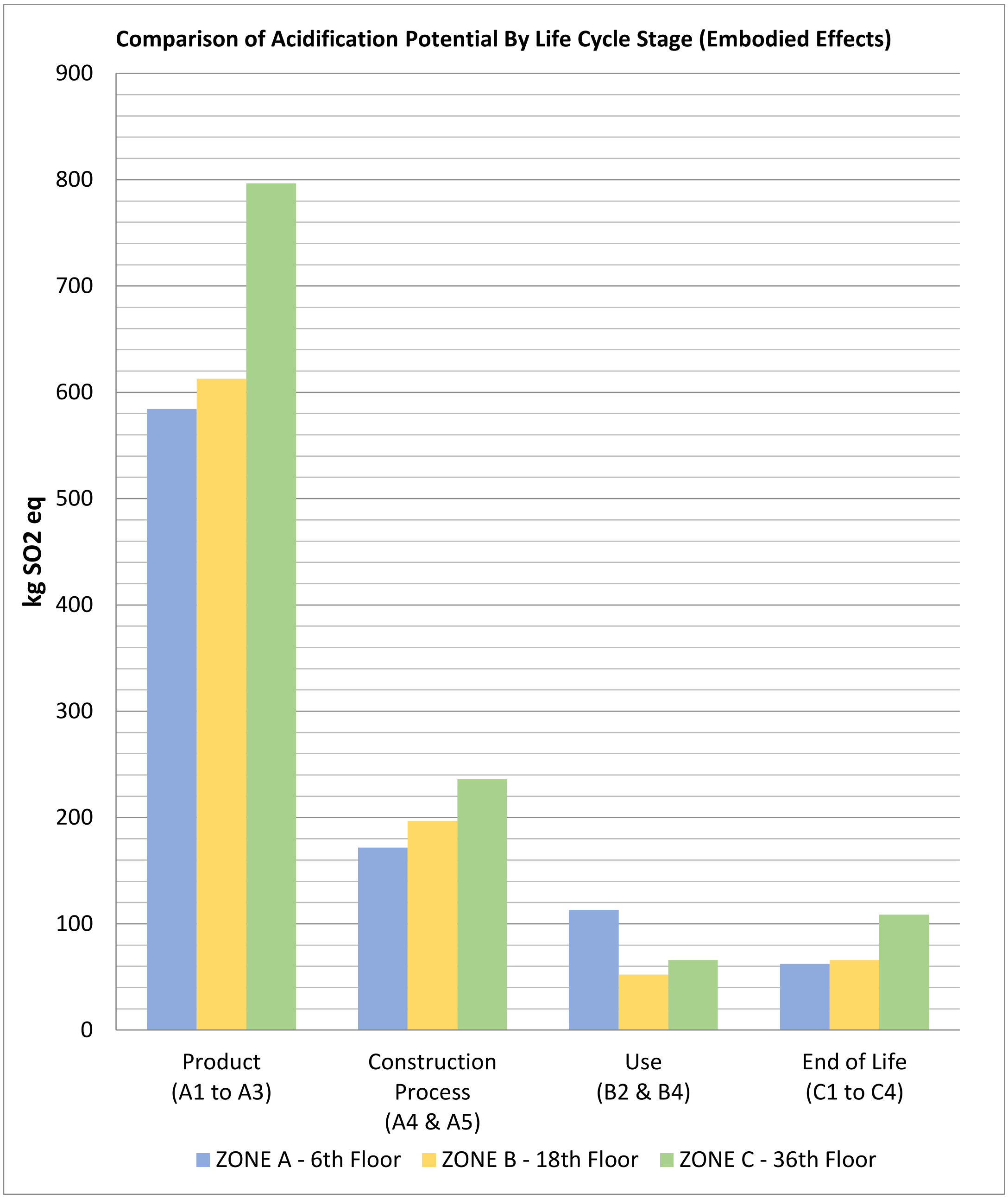


Figure 4.8. Comparison of Acidification Potential By Life Cycle Stage.

Aquatic Eutrophication Potential (EP)

The calculation of aquatic eutrophication potential is based on the equivalent mass of nitrogen(N).

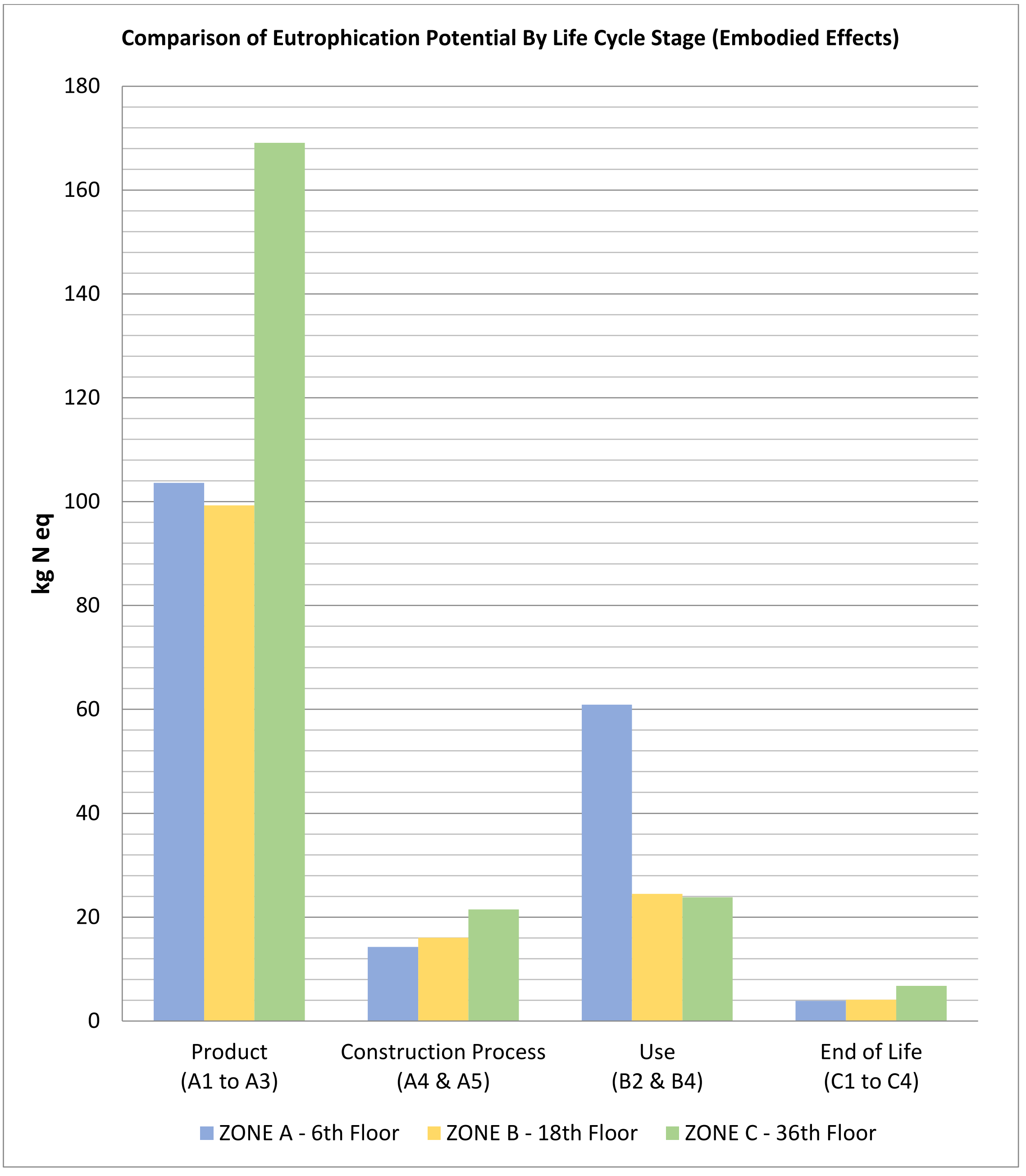


Figure 4.9. Comparison of Eutrophication Potential By Life Cycle Stage.

Human Health (HH) Particulate

Athena Sustainable Materials Institute adressed the plywood product production as an particulate matters reasons in terms of building construction. As the final set of human health particulate impact indicators; Instıtute accept 2.5 micrometers according to Tool for Reduction and Assessment of Chemicals and Other Environmental Impacts (TRACI) (Athena Sustainable Materials Institute, 2019).

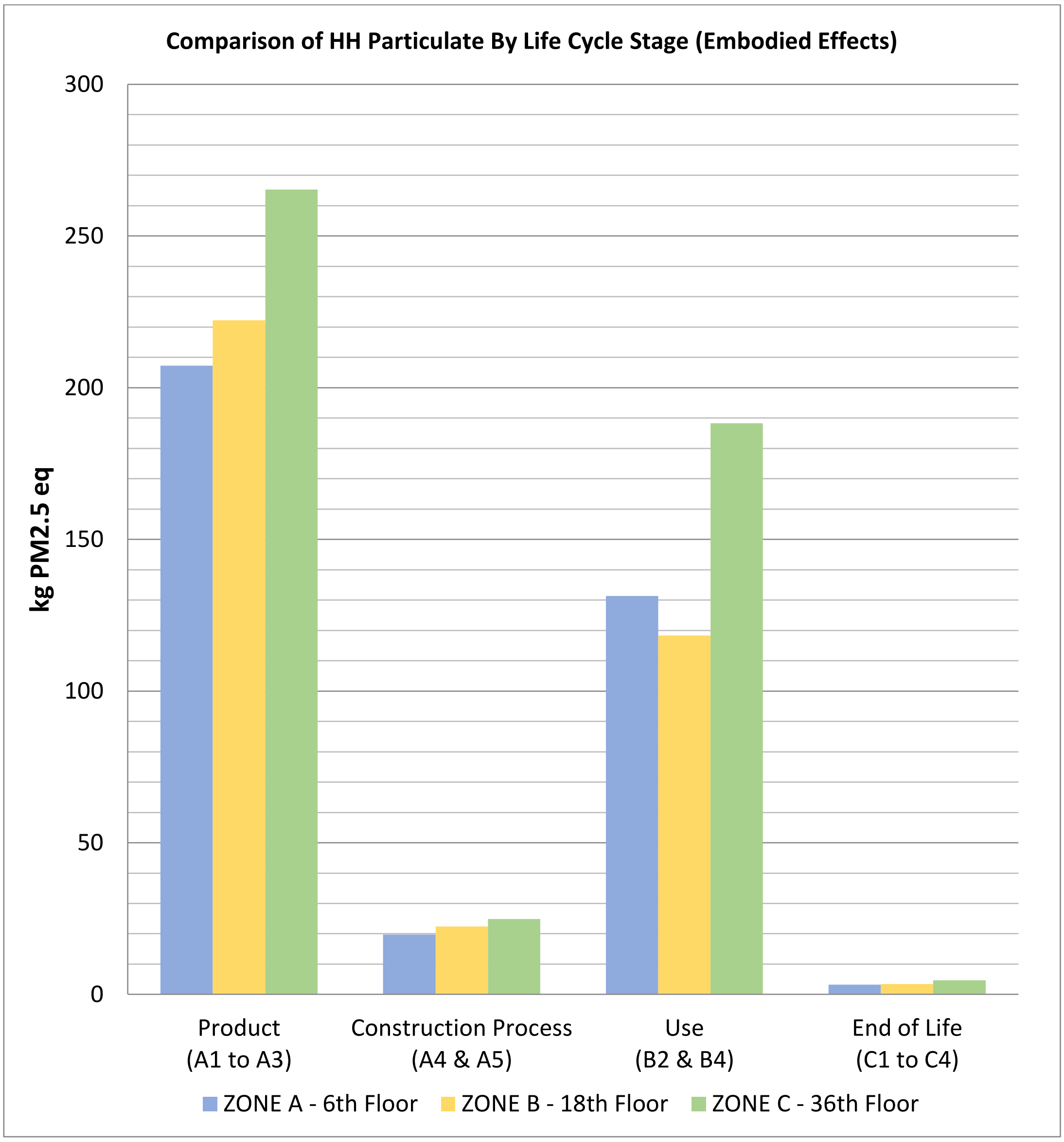


Figure 4.10. Comparison of HH Particulate By Life Cycle Stage.

Ozone Depletion Potential(ODP)

Equivalent CFC-11 in weight unit is calculated for the ozone depletion report (Athena Sustainable Materials Institute, 2019).

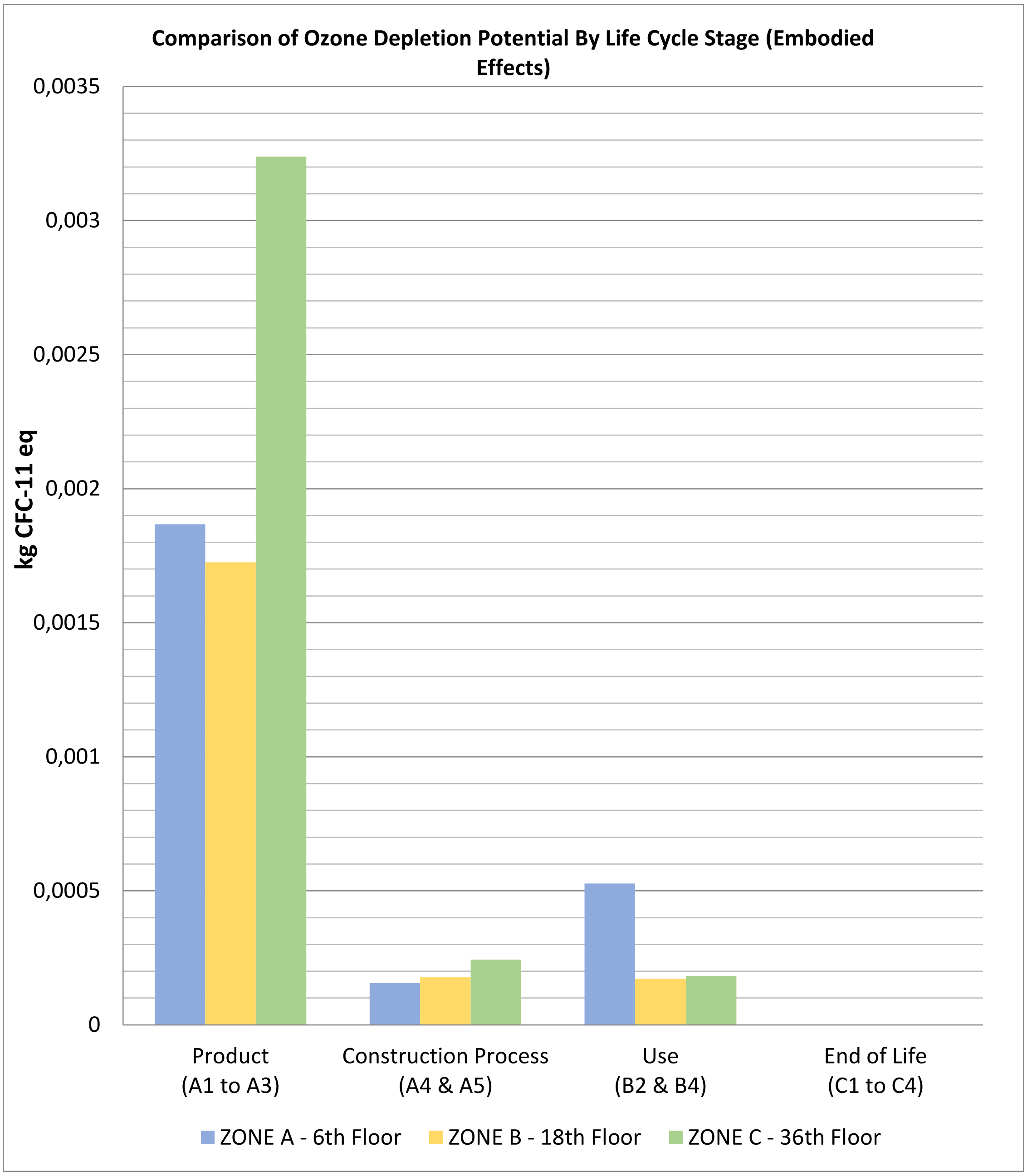


Figure 4.11. Comparison of Ozone Depletion Potential By Life Cycle Stage.

Smog (Photochemical Ozone Formation Potential)

The smog indicator calculation is based on the equivalent mass of ozone (O_3).

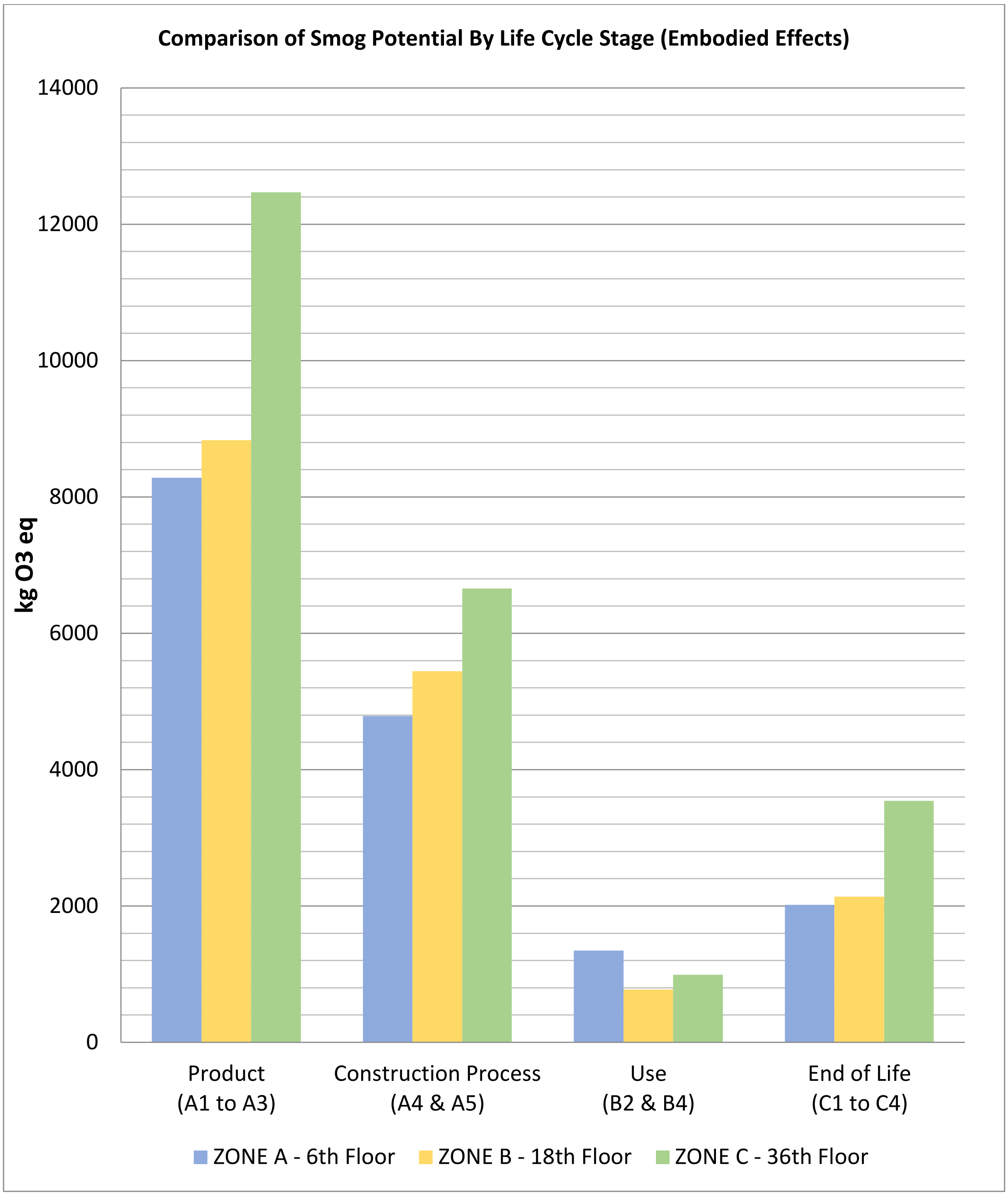


Figure 4.12. Comparison of Smog Potential By Life Cycle Stage.

Table 4.7 Combined summary tables of calculation of each LCA measurement indicator according to four main Life Cycle Stages.

Project Name	Unit	Product (A1 to A3)	Construction Process (A4 & A5)	Use (B2 & B4)	End of Life (C1 to C4)	Total
Comparison of Total Primary Energy By Life Cycle Stage (Embodied Effects)						
ZONE A - 6th Floor	MJ	1.46E+06	2.65E+05	3.25E+05	7.72E+04	**2.13E+06**
ZONE B - 18th Floor	MJ	1.56E+06	3.03E+05	2.26E+05	8.15E+04	**2.17E+06**
ZONE C - 36th Floor	MJ	2.05E+06	3.62E+05	3.29E+05	1.30E+05	**2.87E+06**
Total	**MJ**	**5.07E+06**	**9.31E+05**	**8.80E+05**	**2.89E+05**	**7.17E+06**
Comparison of Global Warming Potential By Life Cycle Stage (Embodied Effects)						
ZONE A - 6th Floor	kg CO2 eq	1.22E+05	1.95E+04	1.34E+04	5.25E+03	**1.60E+05**
ZONE B - 18th Floor	kg CO2 eq	1.30E+05	2.23E+04	6.77E+03	5.54E+03	**1.65E+05**
ZONE C - 36th Floor	kg CO2 eq	1.95E+05	2.79E+04	8.94E+03	8.80E+03	**2.40E+05**
Total	**kg CO2 eq**	**4.46E+05**	**6.97E+04**	**2.92E+04**	**1.96E+04**	**5.65E+05**
Comparison of Acidification Potential By Life Cycle Stage (Embodied Effects)						
ZONE A - 6th Floor	kg SO2 eq	5.84E+02	1.72E+02	1.13E+02	6.23E+01	**9.31E+02**
ZONE B - 18th Floor	kg SO2 eq	6.13E+02	1.97E+02	5.23E+01	6.58E+01	**9.28E+02**
ZONE C - 36th Floor	kg SO2 eq	7.97E+02	2.36E+02	6.58E+01	1.09E+02	**1.21E+03**
Total	**kg SO2 eq**	**1.99E+03**	**6.05E+02**	**2.31E+02**	**2.37E+02**	**3.07E+03**
Comparison of Eutrophication Potential By Life Cycle Stage (Embodied Effects)						
ZONE A - 6th Floor	kg N eq	1.04E+02	1.43E+01	6.09E+01	3.86E+00	**1.83E+02**
ZONE B - 18th Floor	kg N eq	9.93E+01	1.61E+01	2.45E+01	4.09E+00	**1.44E+02**
ZONE C - 36th Floor	kg N eq	1.69E+02	2.15E+01	2.38E+01	6.75E+00	**2.21E+02**
Total	**kg N eq**	**3.72E+02**	**5.18E+01**	**1.09E+02**	**1.47E+01**	**5.48E+02**
Comparison of HH Particulate By Life Cycle Stage (Embodied Effects)						
ZONE A - 6th Floor	kg PM2.5 eq	2.07E+02	1.97E+01	1.31E+02	3.21E+00	**3.61E+02**
ZONE B - 18th Floor	kg PM2.5 eq	2.22E+02	2.24E+01	1.18E+02	3.45E+00	**3.66E+02**
ZONE C - 36th Floor	kg PM2.5 eq	2.65E+02	2.49E+01	1.88E+02	4.68E+00	**4.83E+02**
Total	**kg PM2.5 eq**	**6.95E+02**	**6.70E+01**	**4.38E+02**	**1.13E+01**	**1.21E+03**
Comparison of Ozone Depletion Potential By Life Cycle Stage (Embodied Effects)						
ZONE A - 6th Floor	kg CFC-11 eq	1.87E-03	1.57E-04	5.27E-04	2.17E-07	**2.55E-03**
ZONE B - 18th Floor	kg CFC-11 eq	1.72E-03	1.78E-04	1.72E-04	2.24E-07	**2.08E-03**
ZONE C - 36th Floor	kg CFC-11 eq	3.24E-03	2.43E-04	1.82E-04	3.59E-07	**3.66E-03**
Total	**kg CFC-11 eq**	**6.83E-03**	**5.78E-04**	**8.82E-04**	**8.01E-07**	**8.29E-03**
Comparison of Smog Potential By Life Cycle Stage (Embodied Effects)						
ZONE A - 6th Floor	kg O3 eq	8.28E+03	4.79E+03	1.35E+03	2.02E+03	**1.64E+04**
ZONE B - 18th Floor	kg O3 eq	8.83E+03	5.44E+03	7.74E+02	2.14E+03	**1.72E+04**
ZONE C - 36th Floor	kg O3 eq	1.25E+04	6.66E+03	9.91E+02	3.54E+03	**2.37E+04**
Total	**kg O3 eq**	**2.96E+04**	**1.69E+04**	**3.11E+03**	**7.69E+03**	**5.73E+04**

Combined summary tables of calculation of each LCA measurement indicator according to four main Life Cycle Stage is listed in Table 4.4.

According to the generated comparative results of each LCA measurement indicator by lifecycle stage; residential units generally has the largest impacts in terms of the impact categories while the guest rooms has the least. However the order is changed significantly for the use period. The reason for the different order of the zones during the use period is the predefined building types. Also installed product in use (B1), repair (B3) and refurbishment (B5) information modules are not available for the software.(Table 4.3)

According to Athena Sustainable Materials Institute`s user guide; the algorithms for the assessment of maintenance and replacement periods is differs with the building type parameter. The assumptions are made according to the two levels of maintenance. The more predominant parameter is used for the calculation of owner-occupied buildings while the less dominant parameter is used for the rental, residential, institutional, commercial and industrial buildings. (Athena Sustainable Materials Institute , 2013)

BOQ of the materials are also calculated by software according to the amount of waste materials and the associated materials in need. Bill of materials report obtained from software is presented in Table 4.5. As the ceiling assembly is not available for the software; materials are listed under the ceiling works in Table 3.1 are defined as the floor extra materials.

Table 4.8 Bill of materials report obtained from software.

Material	Unit	Total Quantity			Floors			Walls			Mass Value			Mass Unit
		Zone A - 6th Floor	Zone B - 18th Floor	Zone C - 36th Floor	Zone A - 6th Floor	Zone B - 18th Floor	Zone C - 36th Floor	Zone A - 6th Floor	Zone B - 18th Floor	Zone C - 36th Floor	Zone A - 6th Floor	Zone B - 18th Floor	Zone C - 36th Floor	
1/2" Fire-Rated Type X Gypsum Board	m2	2,418.17	2,266.17	964.69	0.00	0.00	0.00	2,418.17	2,266.17	964.69	19.78	18.54	7.89	Tonnes
1/2" Moisture Resistant Gypsum Board	m2	2,167.48	2,635.90	2,346.17	224.48	185.38	150.74	1,943.00	2,450.52	2,195.42	19.53	23.75	21.14	Tonnes
1/2" Regular Gypsum Board	m2	3,833.93	6,517.55	6,288.51	762.25	1,040.00	1,052.86	3,071.68	5,477.56	5,235.65	30.90	52.53	50.69	Tonnes
1/2" Glass Mat Gypsum Panel	m2	85.80	63.32	64.31	85.80	63.32	64.31	0.00	0.00	0.00	0.85	0.63	0.64	Tonnes
3 mil Polyethylene	m2	286.56	385.33	317.71	0.00	0.00	0.00	286.56	385.33	317.71	0.02	0.03	0.02	Tonnes
Aluminum Clad Wood Window Frame	kg	215.27	102.68	110.45	0.00	0.00	0.00	215.27	102.68	110.45	0.22	0.10	0.11	Tonnes
Clay Tile	m2	186.31	61.21	102.43	112.33	48.37	53.17	73.98	12.84	49.27	9.50	3.12	5.22	Tonnes
Cold Rolled Sheet	Tonnes	0.12	0.15	0.22	0.12	0.15	0.22	0.00	0.00	0.00	0.12	0.15	0.22	Tonnes
Concrete Benchmark CAN 30 MPa	m3	94.95	99.23	98.45	94.95	99.23	98.45	0.00	0.00	0.00	221.33	231.32	229.50	Tonnes
Concrete Benchmark USA 3000 psi	m3	0.90	0.27	3.34	0.00	0.00	0.00	0.90	0.27	3.34	2.06	0.61	7.67	Tonnes
Concrete Benchmark USA 6000 psi	m3	47.10	52.05	180.12	0.00	0.00	0.00	47.10	52.05	180.12	112.85	124.71	431.57	Tonnes
Concrete Tile	m2	10.30	8.95	8.89	10.30	8.95	8.89	0.00	0.00	0.00	0.80	0.70	0.69	Tonnes
Cross Laminated Timber	m3	5.69	1.64	1.46	0.00	0.00	0.00	5.69	1.64	1.46	2.71	0.78	0.69	Tonnes
Double Glazed No Coating Air	m2	304.28	68.56	79.43	0.00	0.00	0.00	304.28	68.56	79.43	4.93	1.11	1.29	Tonnes
Emulsified Asphalt Primer Coat	m3	0.97	0.91	0.72	0.97	0.91	0.72	0.00	0.00	0.00	0.99	0.93	0.73	Tonnes
Expanded Polystyrene	m2 (25mm)	1,774.35	1,809.93	1,816.43	1,774.35	1,809.93	1,816.43	0.00	0.00	0.00	1.28	1.30	1.31	Tonnes

Table 4.8. Continued.

Extruded Polystyrene	m2 (25mm)	966.00	1,048.16	3,691.51	0.00	0.00	0.00	966.00	1,048.16	3,691.51	1.19	1.29	4.54	Tonnes
Galvanized Studs	Tonnes	7.77	9.23	8.21	0.00	0.00	0.00	7.77	9.23	8.21	7.77	9.23	8.21	Tonnes
Hollow Structural Steel	Tonnes	0.23	0.07	0.06	0.00	0.00	0.00	0.23	0.07	0.06	0.23	0.07	0.06	Tonnes
Joint Compound	Tonnes	7.42	10.17	8.38	0.00	0.00	0.00	7.42	10.17	8.38	7.42	10.17	8.38	Tonnes
Large Dimension Softwood Lumber, kiln-dried	m3	2.92	3.17	11.17	0.00	0.00	0.00	2.92	3.17	11.17	1.24	1.34	4.73	Tonnes
Mortar	m3	8.59	7.93	11.31	0.00	0.00	0.00	8.59	7.93	11.31	16.21	14.98	21.36	Tonnes
MW Batt R50	m2 (25mm)	2,813.06	3,622.70	3,042.61	49.17	15.81	16.25	2,763.89	3,606.89	3,026.35	3.72	4.79	4.02	Tonnes
Nails	Tonnes	0.24	0.31	0.26	0.00	0.00	0.00	0.24	0.31	0.26	0.24	0.31	0.26	Tonnes
Natural Stone	m2	903.44	1,013.85	923.01	282.48	479.25	484.04	620.96	534.60	438.97	68.13	76.45	69.60	Tonnes
Paper Tape	Tonnes	0.09	0.12	0.10	0.00	0.00	0.00	0.09	0.12	0.10	0.09	0.12	0.10	Tonnes
Pine Wood tongue and groove siding	m2	2,075.41	1,907.07	1,935.91	1,599.23	1,624.27	1,677.24	476.18	282.80	258.67	16.19	14.88	15.10	Tonnes
Polypropylene	Tonnes	0.12	0.13	0.46	0.00	0.00	0.00	0.12	0.13	0.46	0.12	0.13	0.46	Tonnes
Polypropylene Scrim Kraft Vapour Retarder Cloth	m2	843.68	1,733.93	168.81	0.00	0.00	0.00	843.68	1,733.93	168.81	0.08	0.16	0.02	Tonnes
Rebar, Rod, Light Sections	Tonnes	1.25	0.62	0.98	1.09	0.45	0.44	0.16	0.17	0.54	1.25	0.62	0.98	Tonnes
Screws Nuts & Bolts	Tonnes	0.38	0.39	0.35	0.00	0.00	0.00	0.38	0.39	0.35	0.38	0.39	0.35	Tonnes
Softwood Plywood	m2 (9mm)	23.82	5.56	6.27	0.00	0.00	0.00	23.82	5.56	6.27	0.11	0.03	0.03	Tonnes
Water Based Latex Paint	L	7,662.55	7,249.67	11,735.77	0.00	0.00	0.00	7,662.55	7,249.67	11,735.77	5.75	5.44	8.80	Tonnes

i. LCA Impact per Person of Different Accommodation Zones

For the second part of evaluation input data used is obtained by the calculations of BOQ of the materials for each zones and the number of guests. It was assumed that the number of guests equal to the bed numbers in architectural plans. The BOQ of each zones are calculated by dividing to guests numbers and used as the input for the software. The LCA mesurement indicators were selected same with the first part of the study.

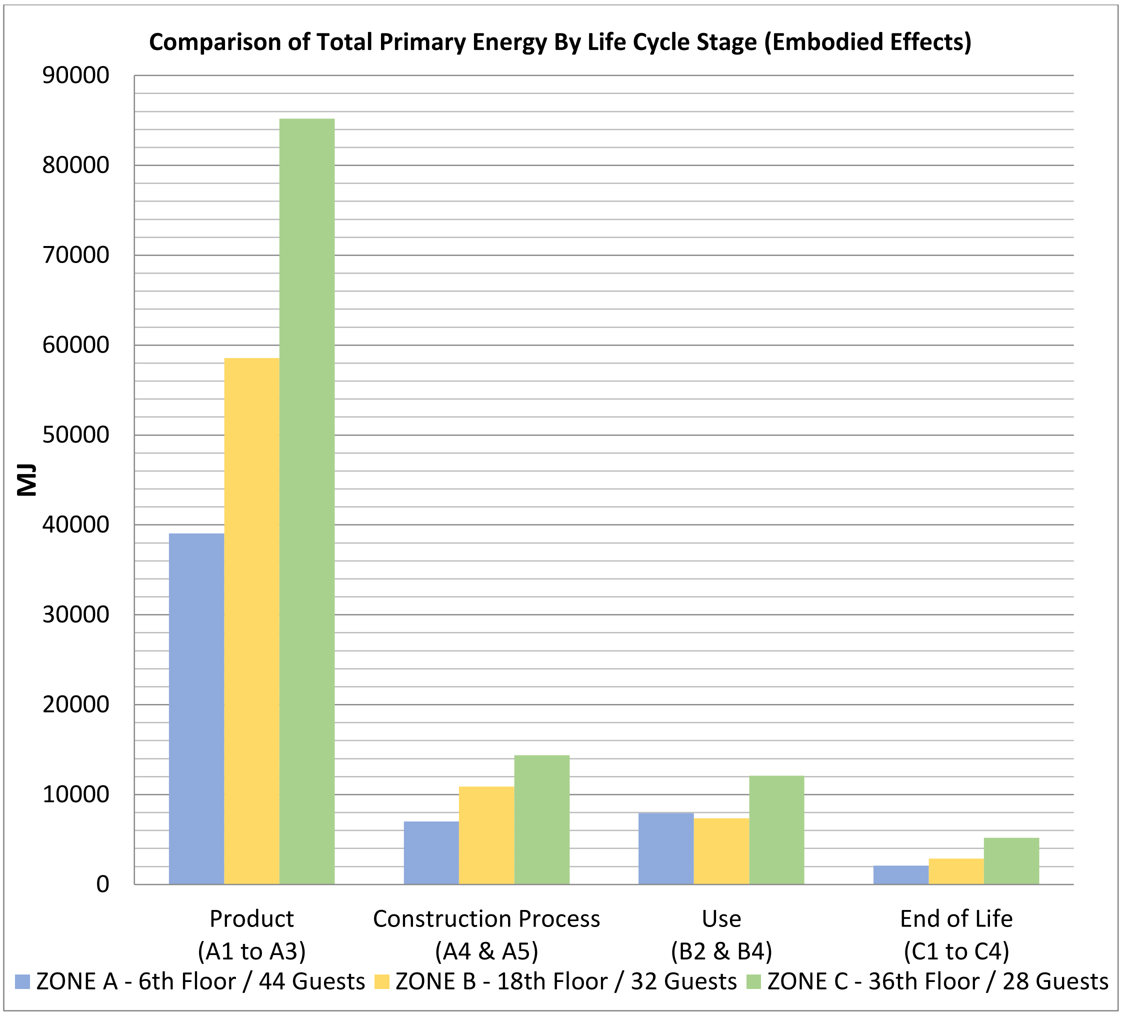


Figure 4.13. Comparison of Total Primary Energy By Life Cycle Stage.

Figure 4.12- Figure 4.13 demonstrate the comparison results of LCA according to total primary energy and global warming potential in terms of guest numbers.

Comparison of the acidification potential, aquatic eutrophication potential, human health particulate, ozone depletion potential, Smog (Photochemical Ozone Formation Potential) measurement graphs are listed in Appendix D.

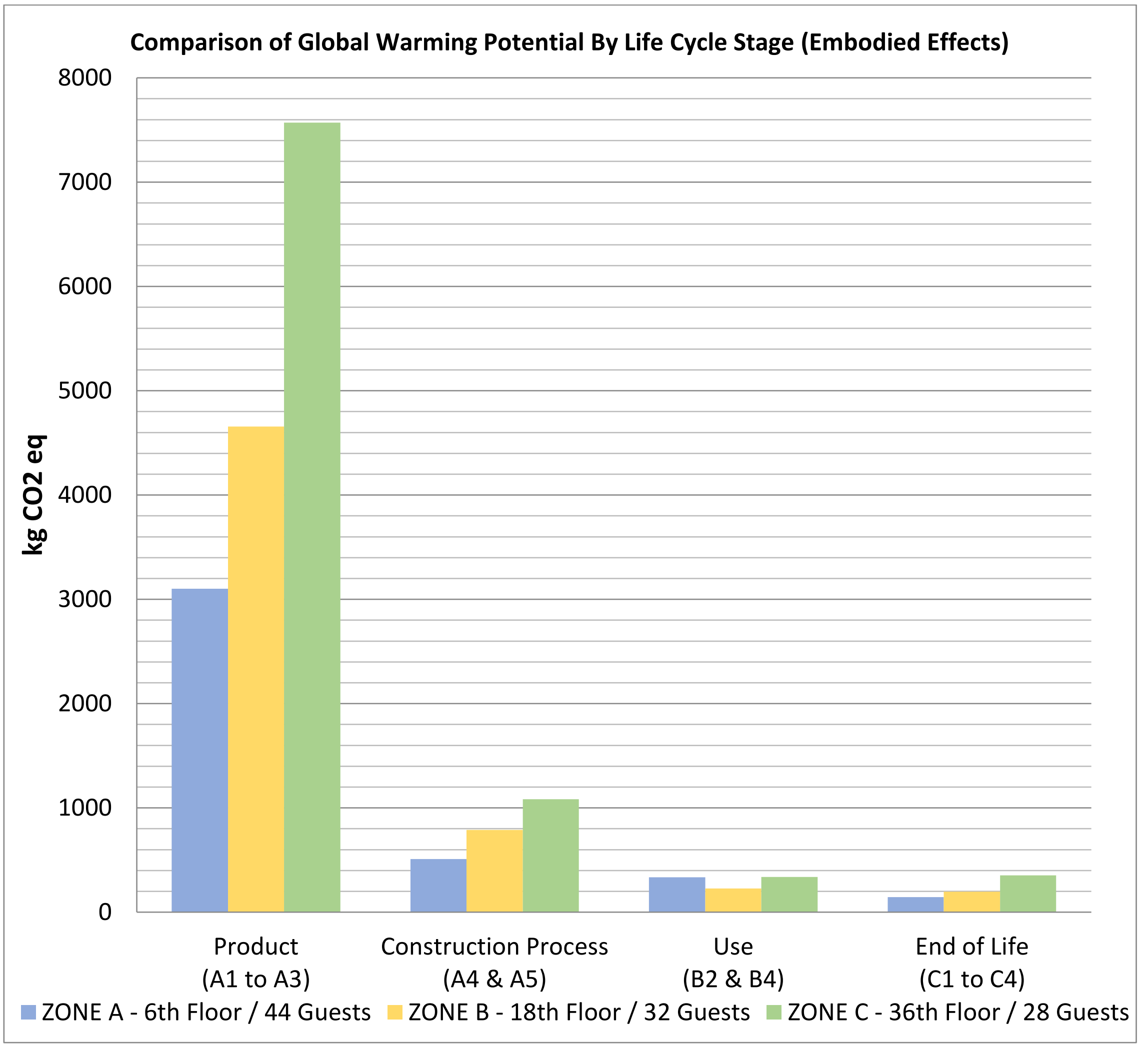


Figure 4.14. Comparison of Global Warming Potential By Life Cycle Stage.

Table 4.9 Combined summary tables of calculation of each LCA measurement indicator according to four main Life Cycle Stage.

Project Name	Unit	Product (A1 to A3)	Construction Process (A4 & A5)	Use (B2 & B4)	End of Life (C1 to C4)	Total
Comparison of Total Primary Energy By Life Cycle Stage (Embodied Effects)						
ZONE A - 6th Floor / 44 Guests	MJ	3.91E+04	7.00E+03	7.94E+03	2.10E+03	**5.61E+04**
ZONE B - 18th Floor / 32 Guests	MJ	5.86E+04	1.09E+04	7.37E+03	2.88E+03	**7.97E+04**
ZONE C - 36th Floor / 28 Guests	MJ	8.52E+04	1.44E+04	1.21E+04	5.18E+03	**1.17E+05**
Total	**MJ**	**1.83E+05**	**3.23E+04**	**2.74E+04**	**1.01E+04**	**2.53E+05**
Comparison of Global Warming Potential By Life Cycle Stage (Embodied Effects)						
ZONE A - 6th Floor / 44 Guests	kg CO2 eq	3.10E+03	5.09E+02	3.34E+02	1.45E+02	**4.09E+03**
ZONE B - 18th Floor / 32 Guests	kg CO2 eq	4.66E+03	7.89E+02	2.28E+02	1.97E+02	**5.87E+03**
ZONE C - 36th Floor / 28 Guests	kg CO2 eq	7.57E+03	1.08E+03	3.37E+02	3.52E+02	**9.34E+03**
Total	**kg CO2 eq**	**1.53E+04**	**2.38E+03**	**9.00E+02**	**6.93E+02**	**1.93E+04**
Comparison of Acidification Potential By Life Cycle Stage (Embodied Effects)						
ZONE A - 6th Floor / 44 Guests	kg SO2 eq	1.50E+01	4.73E+00	2.74E+00	1.59E+00	**2.40E+01**
ZONE B - 18th Floor / 32 Guests	kg SO2 eq	2.21E+01	7.28E+00	1.73E+00	2.26E+00	**3.33E+01**
ZONE C - 36th Floor / 28 Guests	kg SO2 eq	3.18E+01	9.49E+00	2.46E+00	4.26E+00	**4.81E+01**
Total	**kg SO2 eq**	**6.89E+01**	**2.15E+01**	**6.92E+00**	**8.10E+00**	**1.05E+02**
Comparison of Eutrophication Potential By Life Cycle Stage (Embodied Effects)						
ZONE A - 6th Floor / 44 Guests	kg N eq	2.46E+00	3.77E-01	1.40E+00	9.56E-02	**4.33E+00**
ZONE B - 18th Floor / 32 Guests	kg N eq	3.26E+00	5.73E-01	7.73E-01	1.38E-01	**4.75E+00**
ZONE C - 36th Floor / 28 Guests	kg N eq	6.29E+00	8.36E-01	8.60E-01	2.63E-01	**8.25E+00**
Total	**kg N eq**	**1.20E+01**	**1.79E+00**	**3.03E+00**	**4.97E-01**	**1.73E+01**
Comparison of HH Particulate By Life Cycle Stage (Embodied Effects)						
ZONE A - 6th Floor / 44 Guests	kg PM2.5 eq	5.42E+00	4.89E-01	3.01E+00	9.80E-02	**9.02E+00**
ZONE B - 18th Floor / 32 Guests	kg PM2.5 eq	8.09E+00	7.66E-01	3.71E+00	1.44E-01	**1.27E+01**
ZONE C - 36th Floor / 28 Guests	kg PM2.5 eq	1.14E+01	9.84E-01	6.74E+00	2.10E-01	**1.94E+01**
Total	**kg PM2.5 eq**	**2.49E+01**	**2.24E+00**	**1.35E+01**	**4.51E-01**	**4.11E+01**
Comparison of Ozone Depletion Potential By Life Cycle Stage (Embodied Effects)						
ZONE A - 6th Floor / 44 Guests	kg CFC-11 eq	4.22E-05	3.57E-06	1.17E-05	6.88E-09	**5.75E-05**
ZONE B - 18th Floor / 32 Guests	kg CFC-11 eq	5.39E-05	5.62E-06	5.27E-06	8.48E-09	**6.48E-05**
ZONE C - 36th Floor / 28 Guests	kg CFC-11 eq	1.16E-04	8.69E-06	6.38E-06	1.50E-08	**1.31E-04**
Total	**kg CFC-11 eq**	**2.12E-04**	**1.79E-05**	**2.34E-05**	**3.03E-08**	**2.53E-04**
Comparison of Smog Potential By Life Cycle Stage (Embodied Effects)						
ZONE A - 6th Floor / 44 Guests	kg O3 eq	2.17E+02	1.36E+02	3.36E+01	4.98E+01	**4.36E+02**
ZONE B - 18th Floor / 32 Guests	kg O3 eq	3.24E+02	2.06E+02	2.58E+01	7.23E+01	**6.28E+02**
ZONE C - 36th Floor / 28 Guests	kg O3 eq	5.04E+02	2.72E+02	3.72E+01	1.38E+02	**9.51E+02**
Total	**kg O3 eq**	**1.05E+03**	**6.13E+02**	**9.66E+01**	**2.60E+02**	**2.01E+03**

As it can be seen on Figure 4.12, Figure 4.13 and Table 4.6; the differences between the zones becomes more significant when the three accommodation options are compared in terms of guests numbers. In these analyzes made according to the guest numbers; hotel rooms have the least environmental impact, while residential units have the most.

It is important to emphasize that these results can not be shown as an evidence that the building is whether well designed or not in terms of sustainability. However; these results can be considered as a building’s environmental footprint. Also LCA results represent a benchmark for improvements. It is especially important for building types such as hotels, whose retrofitting and refurbishment processes are done periodically. In the light of LCA results; improvements and decisions can be made based on scientific data.

Another important point is LCA is a science based on estimated parameters and calculation therefore LCA can not be considered as an exact science. Instead; approximate results of LCA can help to predict future statements, guide further decisions and allow comparison of different possible options. (Athena Sustainable Materials Institute, 2013). For this very reason LCA data for comparison have to be calculated by the same LCA tool. Each LCA tool's algoritm and parameter differs which can change the outcomes and the results are not comparable.

In the light of LCA results it is also possible to target points for improvements as well as measure the differences between options. The results of LCA also allow to evaluate building assemblies and compare them.

LCA results of the accommodation options shows that the design and material selection of hotel rooms are done more successful comparing with the alternative accommodation options in terms of building environmental impacts. Therefore it can be said that the alternative accommodation options design and material selection can be improved based on the LCA results. As an initial action, changing wall materials of the zone B and C can improve the environmental performance of these zones when focusing on the assemblies evaluation results.

CHAPTER 5

CONCLUSION

As the main criterion for the sustainability of tourism, first of all, the sustainability of the accommodation facilities must be ensured. As known, hotel businesses compete among themselves in order to come to the fore. It is obvious that the success of hotels with sustainability will be very effective in taking steps in this direction for other hotels in this competitive environment. In order to contribute to sustainable tourism, the existence of a procedure that examines touristic accommodations in a special way adopting the principles of sustainability provides a standardized method and rules for the government as well as the professionals. In line with this aim; Environmentally Sensitive Green Star Certification System has awarded to touristic accommodations by the Turkish Ministry of Culture and Tourism. Eventhough the Green Star certification system has been promoted by the ministry with incentives; there is a need to emphasize the success of Green Star certified hotels in order to increase the contribution to the system and raise awareness of sustainability. However the deficiencies of the system shoud be awared of and completed by another assessment methods. Life cycle assessment methods was choosed in order to achieve these deficiences.

Today, both travel agencies and many travelers make their hotel reservations through the online booking websites. A medium-sized hotel owner interviewed by the researcher declared that the comments and ratings made on these online reservation websites have a direct effect on guest preferences. He even gave examples of hotels that went bankrupt due to negative comments and ratings, and said that he can communicate with the reviewers one-to-one when necessary, in the negative comments they received for the hotel he owned. For this very reason in this study; guests ratings assumed a success criteria of hotels. In order to determine the success of Green Star certified hotels; guests` ratings were compiled from one of the most popular travel web site (Trivago.com) as well as the statistical data of Turkish Ministry of Culture and Tourism. The data set analyzed as the first step of the research. The results show that the Green Stars certified hotels are more successful in terms of guests` ratings. During the research review it is acknowleged that the hotels sustainability adoption is also dependent on the hotel owners` attittude and decisions. As the distribution of the Green Star certified hotels are almost zero value for the three and lower star rating hotels. The statistical results also can encourage these lower class hotel owners.

The accommodation options is evolving all around the world by increasing rentable furnished apartments or flats. Due to the diversification of accommodation options, hotel businesses become adapted to this transformation with producing new accommodation options. In this regard; life cycle assesments of three type accommodation options; hotel rooms, service apartments and residential units; are evaluated as a second step of the research. These three accommodation options are planned in a Green Star certified hotel building`s different floors.

The first step of LCA; zone assemblies walls and floors were analyzed seperately. The results show that the contribution of wall comes into prominence respectively Zone A to Zone C due to material selection.

For the second step of LCA; each zone evaluated in terms of LCA masurement indicators. According to the results; environmental impacts especially in product and construction stages increase respectively comparing the options the hotel rooms, service apartments and residences. However this order differs for the use and maintenange stage. Service apartments become the least environmental negative impacts options. The reason for the different order of the zones during the use period is the predefined building types. Also installed product in use (B1), repair (B3) and refurbishment (B5) information modules are not available for the software. For the further researchs another advanced LCA tools can be used or the calculation reports of the refurbishment, repair phase can be analyzed according to the case study building.

For the third step of LCA; comparison of the three accommodation options in terms of guests numbers; it was observed that although the order has not changed, the difference has grown.

It is important to emphasize that these results can not be shown as an evidence that the building is whether well designed or not in terms of sustainability. However; these results can be considered as a building’s environmental footprint. Also LCA results represent a benchmark for improvements. It is especially important for building types such as hotels, whose retrofitting and refurbishment processes are done periodically. In the light of LCA results; improvements and decisions can be made based on scientific data.

LCA results of the accommodation options shows that the design and material selection of hotel rooms are done more succesful comparing with the alternative accommodation options in terms of building environmental impacts. Therefore it can be said that the alternative accommodation options design and material selection can be improved based on the LCA results. As an initial action, changing wall materials of the zone B and C can improve the environmental performance of these zones when focusing on the assemblies evaluation results.

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APPENDICES

A. Data on Green star Hotels

Table A.1: Six Regions of Green Star Certification System (Ministry of Culture and Tourism, 2017).

REGION 1	REGION 2	REGION 3	REGION 4	REGION 5	REGION 6
Ankara	Adana	Balıkesir	Afyonkarahisar	Adıyaman	Ağrı
Antalya	Aydın	Bilecik	Amasya	Aksaray	Ardahan
Bursa	Bolu	Burdur	Artvin	Bayburt	Batman
Eskişehir	Çanakkale	Gaziantep	Bartın	Çankırı	Bingöl
İstanbul	Denizli	Karabük	Çorum	Erzurum	Bitlis
İzmir	Edirne	Karaman	Düzce	Giresun	Diyarbakır
Kocaeli	Isparta	Manisa	Elazığ	Gümüşhane	Hakkari
Muğla	Kayseri	Mersin	Erzincan	Kahramanmaraş	Iğdır
	Kırklareli	Samsun	Hatay	Kilis	Kars
	Konya	Trabzon	Kastamonu	Niğde	Mardin
	Sakarya	Uşak	Kırıkkale	Ordu	Muş
	Tekirdağ	Zonguldak	Kırşehir	Osmaniye	Siirt
	Yalova		Kütahya	Sinop	Şanlıurfa
			Malatya	Tokat	Şırnak
			Nevşehir	Tunceli	Van
			Rize	Yozgat	
			Sivas		

Table A.2: Hotel numbers according to six touristic development regions. Table drawn by author based on data retrieved from (Ministry of Culture and Tourism, 2017).

REGION	GREEN STAR CERTIFIED					N/A					TOTAL
	1 Star	2 Star	3 Star	4 Star	5 Star	1 Star	2 Star	3 Star	4 Star	5 Star	
1	0	1	12	78	258	20	180	487	494	324	1854
2	0	0	0	2	15	5	45	159	93	42	361
3	0	1	0	4	8	11	72	156	74	17	343
4	0	0	0	2	8	6	36	108	50	21	231
5	0	0	4	2	1	6	30	92	32	11	178
6	0	0	0	2	1	3	23	74	32	12	147
TOTAL	0	2	16	90	291	51	386	1076	775	427	3114

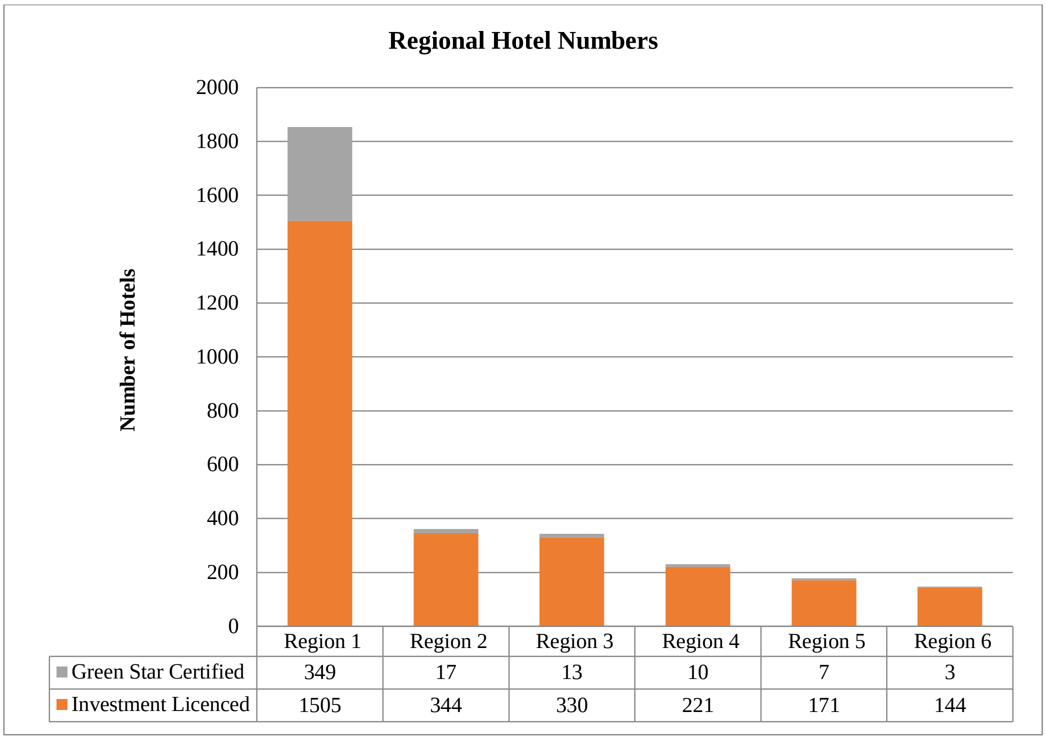

Figure A.1: Hotel numbers according to six touristic development regions. Chart drawn by author based on data retrieved from (Ministry of Culture and Tourism, 2017).

Table A.3: Number of hotels in Istanbul and Antalya. Table drawn by author based on data retrieved from (Ministry of Culture and Tourism, 2017).

PROVINCE	GREEN STAR CERTIFIED					N/A					TOTAL
	1 Star	2 Star	3 Star	4 Star	5 Star	1 Star	2 Star	3 Star	4 Star	5 Star	
İstanbul	0	0	1	13	40	9	44	131	132	72	442
Antalya	0	1	2	38	166	5	30	102	157	172	673

Table A.4: Data collection of hotels' in Istanbul. (Green Star Certified or not) Table drawn by author based on data retrieved from (Ministry of Culture and Tourism, 2017) rating points based on visitors' comments from travel web page Trivago.com .

No	Green Star Certificate	Hotel Name	Hotel Class	Province	Rating Point	Numbers of Points
1	N/A	CLOUD 7 OTEL	1 Star	İstanbul	8.6	271
2	N/A	DEMPA OTELİ	1 Star	İstanbul	7.1	32
3	N/A	FATİH BABEL PARK OTEL	1 Star	İstanbul	7.6	28
4	N/A	HOTEL AMORE	1 Star	İstanbul	5.8	106
5	N/A	HOTEL DUO GALATA (I)	1 Star	İstanbul	8.2	496
6	N/A	ILICAK OTELİ	1 Star	İstanbul	7.5	21
7	N/A	OTEL PRİMA	1 Star	İstanbul	7.4	55
8	N/A	AKKUŞ OTEL	2 Star	İstanbul	6.8	12
9	N/A	BİRBEY OTELİ	2 Star	İstanbul	6.2	60
10	N/A	BON OTEL	2 Star	İstanbul	8.2	354
11	N/A	BRİSTOL OTELİ	2 Star	İstanbul	6.8	62
12	N/A	CİTY LİGHT OTEL	2 Star	İstanbul	7.1	546
13	N/A	EBRU OTELİ	2 Star	İstanbul	6.7	33
14	N/A	GARDEN HOUSE İSTANBUL	2 Star	İstanbul	8.5	1229
15	N/A	GRAND LALELİ HOTEL	2 Star	İstanbul	6.6	34
16	N/A	GRAND MARK OTELİ	2 Star	İstanbul	6.9	250
17	N/A	GRAND REİS OTEL	2 Star	İstanbul	8.1	21
18	N/A	HOTEL İNTER İSTANBUL	2 Star	İstanbul	8.2	293
19	N/A	MODA RİVAS'S HOTEL	2 Star	İstanbul	6.9	66
20	N/A	MORIONE HOTEL	2 Star	İstanbul	8.9	513
21	N/A	OTEL GRAND ÜMİT	2 Star	İstanbul	8	145
22	N/A	OTEL SPECTRA	2 Star	İstanbul	8.2	1312
23	N/A	PERULA HOTEL	2 Star	İstanbul	9.2	5
24	N/A	SENATOR HOTEL TAKSİM	2 Star	İstanbul	8.2	929
25	N/A	TAŞHAN OTELİ	2 Star	İstanbul	6.5	117
26	N/A	THE PERA HİLL HOTEL	2 Star	İstanbul	7.8	478
27	N/A	WALTON OTEL	2 Star	İstanbul	8.4	168
28	N/A	YAVUZ 4 OTEL	2 Star	İstanbul	7.2	963
29	N/A	YUVA OTEL	2 Star	İstanbul	6.8	86
30	YES	HAMPTON BY HİLTON KAYAŞEHİR	3 Star	İstanbul	8	425
31	N/A	ADEN OTEL	3 Star	İstanbul	6.8	108
32	N/A	AMİRAL PALACE OTEL	3 Star	İstanbul	8.2	1066
33	N/A	ASPALACE HOTEL	3 Star	İstanbul	7.4	204
34	N/A	BARIN OTELİ	3 Star	İstanbul	7.5	689
35	N/A	BÇ OTEL	3 Star	İstanbul	7	118
36	N/A	BLİSSTANBUL HOTEL	3 Star	İstanbul	8.6	2932
37	N/A	BLUE HOUSE	3 Star	İstanbul	8.3	187
38	N/A	BUSINESS LİFE OTEL	3 Star	İstanbul	8.3	640
39	N/A	BÜYÜK KEBAN OTELİ	3 Star	İstanbul	7.7	1650
40	N/A	CARATPARK TAKSİM OTEL	3 Star	İstanbul	7.5	109

Table A.4. Continued.

41	N/A	DALAN OTEL	3 Star	İstanbul	7.4	27
42	N/A	ELAN OTELİ	3 Star	İstanbul	7.4	297
43	N/A	EMİN 2 HOTEL	3 Star	İstanbul	6.7	26
44	N/A	ERZURUMLU OTEL	3 Star	İstanbul	7.3	143
45	N/A	EYFEL OTELİ	3 Star	İstanbul	7.1	54
46	N/A	FAVORİ HOTEL	3 Star	İstanbul	8.6	234
47	N/A	GOLDEN CROWN HOTEL	3 Star	İstanbul	7.2	698
48	N/A	GRAND AS HOTEL	3 Star	İstanbul	6.8	259
49	N/A	GRAND EMİN OTEL	3 Star	İstanbul	6.5	124
50	N/A	GRAND EYÜBOĞLU OTEL	3 Star	İstanbul	7.6	30
51	N/A	GRAND HİSAR	3 Star	İstanbul	7	163
52	N/A	GRAND HOTEL AVCILAR	3 Star	İstanbul	7.8	557
53	N/A	GRAND HOTEL SEFEROĞLU	3 Star	İstanbul	7.8	12
54	N/A	GRAND LİZA OTEL	3 Star	İstanbul	6.2	348
55	N/A	GRAND SAĞCANLAR HOTEL	3 Star	İstanbul	7.8	560
56	N/A	GRAND ÜNAL HOTEL- 2	3 Star	İstanbul	6.8	562
57	N/A	GRAND ÜNALHOTEL	3 Star	İstanbul	6.8	562
58	N/A	GRAND ZENTRUM OTELİ	3 Star	İstanbul	6.8	77
59	N/A	HAMPTON BY HİLTON ATAKÖY HOTEL	3 Star	İstanbul	8.7	252
60	N/A	HAREM OTELİ	3 Star	İstanbul	7.3	407
61	N/A	HOLIDAY INN EXPRESS İSTANBUL AIRPORT	3 Star	İstanbul	7.7	282
62	N/A	HOLİDAY INN EXPRESS ATAKÖY METRO	3 Star	İstanbul	8.4	31
63	N/A	HOTEL EXPOCITY İSTANBUL	3 Star	İstanbul	7.6	149
64	N/A	HOTEL GRİTTİ PERA	3 Star	İstanbul	8.1	255
65	N/A	HOTEL İSTANBUL KERVANSARAY	3 Star	İstanbul	5.6	178
66	N/A	HOTEL LA VİLLA BALANCHE	3 Star	İstanbul	8.2	79
67	N/A	HOTEL OSAKA AİRPORT	3 Star	İstanbul	8	561
68	N/A	HOTEL PİSA	3 Star	İstanbul	7.6	137
69	N/A	HOTEL POLAT DEMİR	3 Star	İstanbul	7.9	129
70	N/A	HOTEL RESIDENCE	3 Star	İstanbul	7.4	1020
71	N/A	INNPERA OTEL	3 Star	İstanbul	7.5	1517
72	N/A	İBİS İSTANBUL WEST HOTEL	3 Star	İstanbul	7.6	1762
73	N/A	İBİS OTEL ESENYURT	3 Star	İstanbul	7.9	751
74	N/A	İBİS OTEL TUZLA	3 Star	İstanbul	8.3	181
75	N/A	İSTANBUL GOLDEN CİTY HOTEL	3 Star	İstanbul	8.4	2925
76	N/A	İSTANBUL PANORAMA HOTEL	3 Star	İstanbul	7.2	77
77	N/A	KADAK GARDEN HOTEL	3 Star	İstanbul	7.8	1149
78	N/A	KAYA OTELİ	3 Star	İstanbul	7.2	16
79	N/A	KİLYA HOTEL	3 Star	İstanbul	7.9	182
80	N/A	KİLYOS KALE OTELİ	3 Star	İstanbul	7.4	58
81	N/A	KLAS OTEL	3 Star	İstanbul	7.4	19
82	N/A	KNDF MARİNE OTEL	3 Star	İstanbul	6.2	128
83	N/A	LISTANA HOTEL	3 Star	İstanbul	8.1	91
84	N/A	LİFE COMFORT HOTEL	3 Star	İstanbul	6.4	45
85	N/A	MAREPARK HOTEL	3 Star	İstanbul	7	49
86	N/A	MİNİ HAREM OTEL	3 Star	İstanbul	7.6	20
87	N/A	MOLTON BEYOĞLU MLS	3 Star	İstanbul	7.8	70
88	N/A	MOLTON MONAPART MECİDİYEKÖY	3 Star	İstanbul	7.7	811
89	N/A	MY DORA	3 Star	İstanbul	8.6	410
90	N/A	NOVA PLAZA TAKSİM SQUARE HOTEL	3 Star	İstanbul	7.4	179
91	N/A	NOVOTEL - İBİS OTEL	3 Star	İstanbul	7.7	819
92	N/A	ORİENT MİNTUR OTELİ	3 Star	İstanbul	5.8	210
93	N/A	ORO HERMANOS HOTEL	3 Star	İstanbul	8	258
94	N/A	OTEL ASPEN İSTANBUL	3 Star	İstanbul	6.8	248
95	N/A	OTEL BENLER	3 Star	İstanbul	7.5	47
96	N/A	OTEL GRAND MERİN	3 Star	İstanbul	8.1	109
97	N/A	OTEL NENA	3 Star	İstanbul	8.7	1814
98	N/A	PARK INN BY RADISSON İSTANBUL ODAYERİ	3 Star	İstanbul	8	193
99	N/A	PARKHOUSE HOTEL & SPA	3 Star	İstanbul	7.9	502
100	N/A	PERA SANAT OTEL	3 Star	İstanbul	8.3	203
101	N/A	PERA TULİP	3 Star	İstanbul	7.4	1616
102	N/A	PEYK HOTEL	3 Star	İstanbul	9.2	1022
103	N/A	PIANOFORTE HOTEL	3 Star	İstanbul	7.2	102
104	N/A	PLUS HOTEL BOSTANCI	3 Star	İstanbul	8.3	235
105	N/A	PRESTİGE OTELİ	3 Star	İstanbul	7.4	708
106	N/A	Q HOTEL	3 Star	İstanbul	7.9	637
107	N/A	Q OLD CITY	3 Star	İstanbul	8.4	2476
108	N/A	RAMADA İSTANBUL ALİBEYKÖY	3 Star	İstanbul	8.1	109
109	N/A	RECİTAL OTEL	3 Star	İstanbul	8.6	1684
110	N/A	REGARD HOTEL	3 Star	İstanbul	8.2	64

Table A.4. Continued.

111	N/A	RİOS EDİTİON	3 Star	İstanbul	8.3	294
112	N/A	RİVER OTEL	3 Star	İstanbul	7.9	44
113	N/A	SAMİR OTELİ	3 Star	İstanbul	7.7	344
114	N/A	SANTA SOPHIA	3 Star	İstanbul	6.2	311
115	N/A	SAPKO AIRPORT OTEL	3 Star	İstanbul	8.1	209
116	N/A	SERES HOTEL	3 Star	İstanbul	8	1735
117	N/A	SİDONYA OTEL	3 Star	İstanbul	7.9	422
118	N/A	SİLİVRİ PARK OTEL	3 Star	İstanbul	7.5	196
119	N/A	STAR OTELİ	3 Star	İstanbul	6.8	578
120	N/A	TAKSİM STAR OTELİ	3 Star	İstanbul	6.6	922
121	N/A	TEMPO HOTEL	3 Star	İstanbul	8.6	208
122	N/A	TEMPO HOTEL 4. LEVENT	3 Star	İstanbul	8.5	263
123	N/A	TERAS OTEL	3 Star	İstanbul	7.2	97
124	N/A	THE MERETTO OTEL	3 Star	İstanbul	6.7	232
125	N/A	TITANIC COMPORT HOTEL	3 Star	İstanbul	8.1	454
126	N/A	VATAN ASUR OTELİ	3 Star	İstanbul	7.7	37
127	N/A	VEYRON PARK OTEL	3 Star	İstanbul	7.8	247
128	N/A	VİLLA ZURİCH HOTEL	3 Star	İstanbul	7.2	1194
129	N/A	AC HOTEL MAÇKA BY MARRIOTT	4 Star	İstanbul	8.5	1104
130	N/A	AIR BOSS OTEL	4 Star	İstanbul	7.2	599
131	N/A	ALL SEASONS HOTEL	4 Star	İstanbul	7.2	460
132	N/A	AMETHYST HOTEL	4 Star	İstanbul	7.7	712
133	N/A	AVANTGARDE TAKSİM OTEL	4 Star	İstanbul	8.3	752
134	N/A	BEETHOVEN PREMIUM İSTANBUL HOTELİ	4 Star	İstanbul	8.3	33
135	N/A	BERR OTEL	4 Star	İstanbul	6.9	416
136	N/A	BİLEK OTEL	4 Star	İstanbul	7.5	649
137	N/A	BLACK BİRD	4 Star	İstanbul	7.2	27
138	N/A	BLUE WORLD OTEL	4 Star	İstanbul	7.1	387
139	N/A	BULYES PALAS	4 Star	İstanbul	8.1	600
140	N/A	BÜYÜK ŞAHİNLER OTEL	4 Star	İstanbul	6.5	154
141	N/A	CARLTON OTEL	4 Star	İstanbul	6.2	301
142	N/A	CARTOON OTEL	4 Star	İstanbul	6.7	354
143	N/A	CLARION HOTEL GOLDEN HORN	4 Star	İstanbul	8.7	93
144	N/A	COURTYARD MARRIOTT İSTANBUL İNTERNATIONAL AİRPORT HOTEL	4 Star	İstanbul	7.9	2077
145	N/A	CVK HOTELS	4 Star	İstanbul	7.6	1046
146	N/A	DARKHILL HOTELİ	4 Star	İstanbul	7.4	1534
147	YES	DEDEMAN BOSTANCI OTEL& CONVENTION CENTER	4 Star	İstanbul	8.3	552
148	YES	DEDEMAN PARK LEVENT	4 Star	İstanbul	8.2	636
149	N/A	DİLA HOTEL	4 Star	İstanbul	7.5	940
150	N/A	DİVAN CİTY İSTANBUL OTELİ	4 Star	İstanbul	7.5	943
151	N/A	DİVAN SUITES İSTANBUL G- PLUS	4 Star	İstanbul	8.3	1547
152	N/A	DOSSO DOSSİ SULTANAHMET HOTEL	4 Star	İstanbul	8.9	2660
153	N/A	DOUBLE TREE BY HILTON İSTANBUL TOPKAPI	4 Star	İstanbul	7.9	601
154	N/A	ELİTE WORLD PRESTİGE	4 Star	İstanbul	7.3	761
155	N/A	ELYSIUM STYLES TAKSİM OTEL	4 Star	İstanbul	8.2	387
156	N/A	ERESİN TAKSİM&PREMIER OTEL	4 Star	İstanbul	7.7	385
157	N/A	FEBOR İSTANBUL BOMONTİ HOTEL & SPA	4 Star	İstanbul	8.3	187
158	N/A	FERONYA OTELİ	4 Star	İstanbul	7.4	1209
159	N/A	GOLDEN AGE OTEL	4 Star	İstanbul	6.6	626
160	N/A	GOLDEN HORN SULTANAHMET	4 Star	İstanbul	8.2	2589
161	N/A	GRAND ARAS HOTEL & SUİTES	4 Star	İstanbul	7.8	540
162	N/A	GRAND AŞİYAN OTEL	4 Star	İstanbul	7.9	196
163	N/A	GRAND DE PERA OTEL	4 Star	İstanbul	8.1	373
164	N/A	GRAND DURMAZ HOTEL	4 Star	İstanbul	7.8	635
165	N/A	GRAND HALİÇ OTEL	4 Star	İstanbul	6.7	709
166	N/A	GRAND HOTEL GÜLSOY	4 Star	İstanbul	7.6	326
167	N/A	GRAND STAR OTELİ	4 Star	İstanbul	6.1	827
168	N/A	GRAND YAVUZ OTEL	4 Star	İstanbul	7.2	963
169	N/A	HAMPTON BY HILTON İSTANBUL KURTKÖY HA GÖKÇEN AIRPORT	4 Star	İstanbul	8.5	284
170	YES	HAMPTON BY HILTON İSTANBUL ZEYTİNBURNU OTEL	4 Star	İstanbul	8.5	341
171	N/A	HILTON GARDEN INN BEYLİKDÜZÜ	4 Star	İstanbul	8.7	361
172	YES	HİLTON GARDEN INN İSTANBUL AİRPORT	4 Star	İstanbul	8	1627
173	YES	HİLTON GARDEN INN İSTANBUL GOLDEN HORN	4 Star	İstanbul	7	485
174	N/A	HİLTON GARDEN INN İSTANBUL ÜMRANİYE	4 Star	İstanbul	8.7	442

Table A.4. Continued.

175	N/A	HOLIDAY INN İSTANBUL KADIKÖY	4 Star	İstanbul	8.6	498
176	N/A	HOLIDAY INN İSTANBUL OLD CITY	4 Star	İstanbul	8.3	1661
177	N/A	HOLIDAY INN İSTANBUL TUZLA BAY	4 Star	İstanbul	8.7	82
178	N/A	HOTEL ARCADİA BLUE İSTANBUL	4 Star	İstanbul	8.9	1164
179	N/A	HOTEL GOLDEN WAY	4 Star	İstanbul	8.4	550
180	N/A	HOTEL GRAND ANKA	4 Star	İstanbul	7.3	492
181	N/A	HOTEL MARBLE	4 Star	İstanbul	6.5	640
182	YES	HOTEL SUADİYE	4 Star	İstanbul	8.1	1403
183	N/A	HOTEL VENERA	4 Star	İstanbul	7.6	532
184	N/A	HOTEL VİCENZA	4 Star	İstanbul	7.6	649
185	N/A	ICON İSTANBUL HOTEL	4 Star	İstanbul	8	302
186	N/A	INERA HOTEL	4 Star	İstanbul	8.2	635
187	N/A	İBİS STYLE ATAŞEHİR OTELİ	4 Star	İstanbul	8.3	40
188	N/A	İBİS STYLE İSTANBUL BOMONTİ OTEL	4 Star	İstanbul	8.1	101
189	N/A	İSFANBUL HOLİDAY HOME	4 Star	İstanbul	8.5	710
190	YES	İSTANBUL ANTİK OTEL	4 Star	İstanbul	7.5	58
191	N/A	İSTANBUL CRYSTAL	4 Star	İstanbul	6.5	659
192	N/A	İSTANBUL DORA HOTEL	4 Star	İstanbul	7.5	763
193	N/A	İSTANBUL MY ASSOS HOTEL	4 Star	İstanbul	6.8	415
194	N/A	İSTANBUL ROYAL	4 Star	İstanbul	6.5	223
195	N/A	KALYON OTELİ	4 Star	İstanbul	8	1706
196	N/A	LİVELLO HOTEL	4 Star	İstanbul	8.3	103
197	N/A	MARCURE ALTUNİZADE İSTANBUL	4 Star	İstanbul	8.2	730
198	N/A	MARMARAY HOTEL	4 Star	İstanbul	7	427
199	N/A	MARNAS HOTELS	4 Star	İstanbul	8.1	46
200	N/A	MERCİA HOTELS & RESORT	4 Star	İstanbul	7.7	165
201	N/A	MERCURE İSTANBUL BAKIRKÖY	4 Star	İstanbul	7.8	1135
202	N/A	MERCURE İSTANBUL TAKSİM OTEL	4 Star	İstanbul	8.5	1322
203	N/A	MERCURE İSTANBUL ÜMRANİYE OTEL	4 Star	İstanbul	8.3	244
204	N/A	MILLENNIUM İSTANBUL GOLDEN HORN OTEL	4 Star	İstanbul	8.5	49
205	N/A	NAZ CITY HOTEL	4 Star	İstanbul	8.6	680
206	N/A	NEARPORT HOTEL SABİHA GÖKÇEN AIRPORT	4 Star	İstanbul	8.5	157
207	N/A	NİDYA HOTEL GALATAPORT	4 Star	İstanbul	8	1417
208	N/A	NOVA PLAZA PERA OTEL	4 Star	İstanbul	7.4	179
209	N/A	NOVOTEL - İBİS OTEL	4 Star	İstanbul	7.7	819
210	N/A	OPERA OTEL	4 Star	İstanbul	8.1	987
211	N/A	ORKA ROYAL HOTEL	4 Star	İstanbul	7.4	1403
212	N/A	ORTAKÖY PRİNCESS OTEL	4 Star	İstanbul	5.4	723
213	N/A	OTEL İSTANBUL TREND	4 Star	İstanbul	7.4	478
214	N/A	OTEL NİPPON	4 Star	İstanbul	8.1	1497
215	N/A	OTEL ORAN	4 Star	İstanbul	7.3	796
216	N/A	PARK INN RADISSON İSTANBUL ATAŞEHİR	4 Star	İstanbul	9	379
217	N/A	PORT BOSPHORUS	4 Star	İstanbul	8.36	192
218	N/A	QUA HOTEL	4 Star	İstanbul	7.4	444
219	YES	RAMADA ENCORE AIRPORT OTEL	4 Star	İstanbul	8.3	1991
220	YES	RAMADA ENCORE BAYRAMPAŞA	4 Star	İstanbul	8.1	555
221	N/A	RAMADA İSTANBUL ASIA	4 Star	İstanbul	8.1	1040
222	N/A	RAMADA İSTANBUL OLD CİTY	4 Star	İstanbul	7.8	470
223	N/A	RAMADA İSTANBUL TAKSİM HOTEL	4 Star	İstanbul	7.7	125
224	N/A	REİS İNN HOTEL	4 Star	İstanbul	8.1	533
225	N/A	RICHMOND OTEL	4 Star	İstanbul	8.3	1499
226	YES	RODISSON HOTEL PRESIDENT BEYAZİT İSTANBUL	4 Star	İstanbul	8.3	2000
227	N/A	ROX OTEL ÇOBANÇEŞME	4 Star	İstanbul	8.4	785
228	YES	SHERATON İSTANBUL ATAKÖY OTEL - ATAKÖY MARİNA OTEL	4 Star	İstanbul	7.9	2388
229	N/A	SKALİON HOTEL	4 Star	İstanbul	8.4	2001
230	N/A	TAKSİM METRO PARK	4 Star	İstanbul	8	2097
231	N/A	THE CİTY OTEL	4 Star	İstanbul	6.4	222
232	N/A	THE GREEN PARK -TAKSİM	4 Star	İstanbul	6.8	364
233	YES	THE MARMARA PERA	4 Star	İstanbul	8.1	3601
234	N/A	THE MARMARA ŞİŞLİ	4 Star	İstanbul	7.5	1387
235	N/A	THE PEAK HOTEL	4 Star	İstanbul	7.5	405
236	N/A	TITANIC CITY HOTEL	4 Star	İstanbul	8.5	838
237	N/A	TİLİA HOTEL	4 Star	İstanbul	6.8	509
238	N/A	TOPKAPI İNTER İSTANBUL OTEL	4 Star	İstanbul	7.5	315
239	N/A	TULİP CİTY HOTEL	4 Star	İstanbul	7.2	868
240	N/A	VEYRON HOTELS	4 Star	İstanbul	8.1	279

Table A.4. Continued.

241	N/A	VOLLEY HOTEL İSTANBUL ASİA	4 Star	İstanbul	7.7	172
242	N/A	WOW İSTANBUL OTEL	4 Star	İstanbul	7.9	4884
243	YES	YAŞMAK SULTAN OTELİ	4 Star	İstanbul	8.5	2041
244	N/A	YİĞİTALP OTELİ	4 Star	İstanbul	8.2	771
245	N/A	ZAGREB OTEL	4 Star	İstanbul	7.6	1341
246	N/A	ERESİN HOTELS TOPKAPI	5 Star	İstanbul	7.9	2275
247	N/A	AJWA HOTELS	5 Star	İstanbul	8.7	433
248	N/A	AKGÜN İSTANBUL OTELİ	5 Star	İstanbul	7.1	329
249	N/A	BRICKS HOTEL	5 Star	İstanbul	8.4	208
250	N/A	BYOTELL	5 Star	İstanbul	8	1102
251	N/A	CEVAHİR HOTEL İSTANBUL ASİA	5 Star	İstanbul	8.2	705
252	YES	CONRAD OTEL	5 Star	İstanbul	8.7	1965
253	N/A	CROWEN PLAZA OLD CİTY İSTANBUL	5 Star	İstanbul	7.8	2269
254	YES	CROWNE PLAZA İSTANBUL ASIA HOTEL CONVENTİON CENTER	5 Star	İstanbul	8.6	1553
255	N/A	CROWNE PLAZA İSTANBUL FLORYA	5 Star	İstanbul	8.5	711
256	N/A	CROWNE PLAZA İSTANBUL HARBİYE	5 Star	İstanbul	7.1	1442
257	N/A	CROWNE PLAZA İSTANBUL- ORYAPARK	5 Star	İstanbul	8.7	337
258	N/A	CVK HOTELS& RESORTS-PARK BOSPHORUS İSTANBUL	5 Star	İstanbul	8.7	3405
259	N/A	ÇIRAĞAN SARAYI OTELİ- ÇIRAĞAN PALACE KEMPİNSKİ İSTANBUL	5 Star	İstanbul	9.1	1239
260	YES	DEDEMAN BOSTANCI OTEL& CONVENTION CENTER	5 Star	İstanbul	8.3	552
261	N/A	DEDEMAN İSTANBUL OTELİ	5 Star	İstanbul	7.3	1971
262	YES	DİVAN İSTANBUL	5 Star	İstanbul	7.5	943
263	YES	DİVAN İSTANBUL ASİA OTEL	5 Star	İstanbul	8.7	1613
264	N/A	DOSSO DOSSİ VATAN OTEL	5 Star	İstanbul	8.9	874
265	N/A	DOUBLE TREE BY HİLTON İSTANBUL AVCILAR	5 Star	İstanbul	7.9	1029
266	N/A	DOUBLE TREE BY HİLTON İSTANBUL OLD TOWN	5 Star	İstanbul	8.5	3572
267	YES	DOUBLETREE BY HILTON İSTANBUL-ESENTEPE	5 Star	İstanbul	8.3	499
268	N/A	DOUBLETREE BY HILTON İSTANBUL PİYALE PAŞA OTEL	5 Star	İstanbul	8.1	657
269	YES	DOUBLETREE BY HİLTON İSTANBUL MODA	5 Star	İstanbul	8.7	3538
270	N/A	ELİTE WORD ASIA	5 Star	İstanbul	8.3	313
271	YES	ELİTE WORLD BUSİNESS	5 Star	İstanbul	8.6	5902
272	N/A	ELİTE WORLD EUROPA	5 Star	İstanbul	8.6	649
273	N/A	ESER DİAMOND HOTEL & CONVENTION CENTER İSTANBUL	5 Star	İstanbul	7.2	234
274	YES	ESER OTEL PREMİUM & SPA	5 Star	İstanbul	7.9	848
275	YES	FAİRMONT QUASAR İSTANBUL	5 Star	İstanbul	9	596
276	N/A	GOLDEN TULIP HOTEL BAYRAMPAŞA	5 Star	İstanbul	8.3	147
277	N/A	GORRION HOTEL İSTANBUL	5 Star	İstanbul	8.3	600
278	YES	GRAND CEVAHİR HOTEL	5 Star	İstanbul	7.3	856
279	YES	GRAND HYATT İSTANBUL	5 Star	İstanbul	8.7	2650
280	N/A	GRAND MAKEL HOTEL TOPKAPI	5 Star	İstanbul	7.8	17
281	YES	HILTON İSTANBUL KOZYATAĞI CONFERENCE CENTER & SPA	5 Star	İstanbul	8.6	1328
282	N/A	HİLTON İSTANBUL BAKIRKÖY HOTEL CONFERENCE CENTER	5 Star	İstanbul	7.7	204
283	N/A	HİLTON İSTANBUL MASLAK	5 Star	İstanbul	8.9	488
284	YES	HİLTON OTELİ	5 Star	İstanbul	7.9	1076
285	N/A	HOLIDAY INN İSTANBUL AİRPORT	5 Star	İstanbul	7.8	1828
286	N/A	HOLİDAY INN İSTANBUL ŞİŞLİ	5 Star	İstanbul	7.9	371
287	YES	HOLİDAY İNN İSTANBUL CİTY	5 Star	İstanbul	7.4	1429
288	N/A	HYATT REGENCY İSTANBUL ATAKÖY OTELİ	5 Star	İstanbul	8.5	660
289	N/A	INTERCONTINENTAL	5 Star	İstanbul	8.8	3189
290	N/A	İSTANBUL GÖNEN OTEL	5 Star	İstanbul	8.2	1356
291	N/A	İSTANBUL MARRIOTT HOTEL ŞİŞLİ	5 Star	İstanbul	8.6	1351
292	N/A	İSTANBUL MARRİOTT HOTEL ASİA	5 Star	İstanbul	8.7	767
293	YES	İSTANBUL POLAT RENAISSANCE OTEL	5 Star	İstanbul	8	1395
294	N/A	KAYA İSTANBUL FAIR & CONVENTION HOTEL	5 Star	İstanbul	8.4	208
295	N/A	LASAGRADA HOTEL	5 Star	İstanbul	8.8	257
296	N/A	LAZZONİ OTEL	5 Star	İstanbul	8.7	1614
297	N/A	LE MERIDIEN İSTANBUL ETİLER	5 Star	İstanbul	8.8	1112
298	N/A	LEGACY OTTOMAN HOTEL	5 Star	İstanbul	7.3	2065
299	YES	LİMAK EURASIA LUXURY HOTEL	5 Star	İstanbul	8.4	665

Table A.4. Continued.

300	N/A	LİON EL HOTEL	5 Star	İstanbul	8.4	361
301	N/A	MARMA OTEL	5 Star	İstanbul	7.6	734
302	N/A	MERCURE İSTANBUL BOMONTİ	5 Star	İstanbul	7.9	842
303	N/A	MERCÜRE İSTANBUL CİTY BOSPHORUS	5 Star	İstanbul	8.3	1411
304	YES	MIRACLE İSTANBUL ASİA HOTEL	5 Star	İstanbul	8.1	620
305	N/A	MOVENPİCK HOTEL İSTANBUL GOLDEN HORN	5 Star	İstanbul	8.4	857
306	YES	MÖVENPİCK HOTEL İSTANBUL	5 Star	İstanbul	8.7	2000
307	N/A	NOVOTEL İSTANBUL BOSPHORUS	5 Star	İstanbul	8.6	722
308	YES	PARK INN BY RADİSSON İSTANBUL ATATÜRK AİRPORT OTEL	5 Star	İstanbul	7.9	498
309	N/A	POINT OTEL BARBAROS	5 Star	İstanbul	8.5	1563
310	N/A	PULLMAN & MERCURE İSTANBUL AIRPORT HOTEL & CONVENTENTION CENTER	5 Star	İstanbul	8.3	1411
311	YES	RADISON BLU HOTEL İSTANBUL ASIA	5 Star	İstanbul	8.6	1953
312	YES	RADISSON BLU CONFERENCE & AIRPORT HOTEL İSTANBUL	5 Star	İstanbul	7.4	2021
313	YES	RADISSON BLU HOTEL İSTANBUL PERA	5 Star	İstanbul	8.6	975
314	YES	RADISSON BLU HOTEL& SPA İSTANBUL-TUZLA	5 Star	İstanbul	8.8	2034
315	N/A	RADISSON BLU VADİSTANBUL	5 Star	İstanbul	8.4	54
316	YES	RADISSON SAS BOSPHORUS	5 Star	İstanbul	7.9	1723
317	N/A	RADİSSON BLU HOTEL İSTANBUL OTTOMARE	5 Star	İstanbul	8.3	507
318	YES	RAMADA PLAZA İSTANBUL	5 Star	İstanbul	8.3	1317
319	YES	RAMADA PLAZA İSTANBUL TEKSTİLKENT	5 Star	İstanbul	8	1361
320	YES	RENAİSSANCE İSTANBUL POLAT BOSPHORUS HOTEL	5 Star	İstanbul	8.4	945
321	N/A	RETAJ ROYAL İSTANBUL	5 Star	İstanbul	8.1	1413
322	N/A	ROYAL STAY PALACE	5 Star	İstanbul	8.4	929
323	N/A	SHANGRI-LA BOSPHORUS	5 Star	İstanbul	9.1	1177
324	N/A	SHERATON GRAND İSTANBUL ATAŞEHİR OTEL	5 Star	İstanbul	8.8	180
325	YES	SHERATON İSTANBUL ATAKÖY OTEL - ATAKÖY MARİNA OTEL	5 Star	İstanbul	7.9	2388
326	YES	SILENCE İSTANBUL HOTEL CONVENTİON CENTER	5 Star	İstanbul	8.3	1159
327	N/A	SOFITEL İSTANBUL TAKSİM	5 Star	İstanbul	8.2	15
328	N/A	SURA HAGIA SOPHIA HOTEL & SPA	5 Star	İstanbul	8.4	3555
329	N/A	SÜRMELİ İSTANBUL OTELİ	5 Star	İstanbul	7.1	1022
330	YES	SWİSSOTEL THE BOSPHORUS	5 Star	İstanbul	8.9	2140
331	N/A	THE GREEN PARK	5 Star	İstanbul	7.7	1970
332	N/A	THE GREEN PARK HOTEL-MERTER	5 Star	İstanbul	7	1355
333	N/A	THE GREEN PARK PENDİK HOTELS & CONVENTION CENTER	5 Star	İstanbul	7.7	1970
334	YES	THE MARMARA TAKSİM	5 Star	İstanbul	8.2	1495
335	YES	THE RİTZ CARLTON	5 Star	İstanbul	9.1	1222
336	N/A	TITANIC BUSINESS GOLDEN HORN HOTEL	5 Star	İstanbul	8.4	1521
337	N/A	TİTANİC PORT OTEL	5 Star	İstanbul	8.5	2029
338	N/A	TRYP BY WYNDHAM İSTANBUL EKSPRES	5 Star	İstanbul	8	101
339	N/A	TÜYAP PALAS	5 Star	İstanbul	8	425
340	N/A	WOW İSTANBUL OTEL	5 Star	İstanbul	7.9	4884
341	YES	WYNDHAM GRAND İSTANBUL EUROPE	5 Star	İstanbul	8.8	1987
342	YES	WYNDHAM GRAND İSTANBUL KALAMIŞ MARİNA HOTEL	5 Star	İstanbul	8.9	2742
343	YES	WYNDHAM GRAND İSTANBUL LEVENT	5 Star	İstanbul	9	3014

Table A.5: Data collection of hotels' in Antalya. (Green Star Certified or not) Table drawn by author based on data retrieved from (Ministry of Culture and Tourism, 2017) and rating points based on visitors' comments from travel web page Trivago.com.

No	Green Star Certificate	Hotel Name	Hotel Class	Province	Rating Point	Numbers Of Points
1	N/A	CLUB HOTEL SUNBEL	1 Star	Antalya	6.9	118
2	N/A	DIONYSIA	1 Star	Antalya	8.4	35
3	N/A	MAHPER OTELİ	1 Star	Antalya	7.1	33
4	YES	BELPORT	2 Star	Antalya	7.4	41
5	N/A	GÜLERYÜZ 2 OTEL	2 Star	Antalya	7.9	37
6	N/A	METUR OTEL	2 Star	Antalya	8.4	585
7	N/A	YILDIRIMOĞLU	2 Star	Antalya	7.8	20
8	N/A	ALTINKUM PARK OTEL	3 Star	Antalya	8.2	1426
9	N/A	CLUB BAYAR BEACH OTEL	3 Star	Antalya	5.8	49
10	N/A	FOREST PARK	3 Star	Antalya	7.4	593
11	N/A	GRAND KOLİBRİ OTEL	3 Star	Antalya	6.2	809
12	N/A	HAPPY OTEL	3 Star	Antalya	8.3	15
13	N/A	HOTEL FİNİKE MARİNA	3 Star	Antalya	6.9	68
14	N/A	HOTEL ROYAL HILL	3 Star	Antalya	7.6	38
15	N/A	KLEOPATRA ARSİ OTEL	3 Star	Antalya	7.3	34
16	N/A	LARİSSA SULTAN'S BEACH HOTEL	3 Star	Antalya	7.8	246
17	N/A	MİRAY OTEL	3 Star	Antalya	7	152
18	YES	PALMİYE BEACH OTEL	3 Star	Antalya	6.7	868
19	N/A	PRIME OTEL	3 Star	Antalya	9	846
20	N/A	SEAPORT OTEL	3 Star	Antalya	8.6	39
21	N/A	TOURİST OTEL ANTALYA	3 Star	Antalya	7.3	986
22	N/A	VENESSA OTEL	3 Star	Antalya	8.9	241
23	N/A	ALANYA BÜYÜK OTELİ	4 Star	Antalya	7.9	529
24	N/A	BLUE SKY	4 Star	Antalya	7.5	1059
25	N/A	BOULEYESD OTEL	4 Star	Antalya	8.1	420
26	N/A	CLUB HOTEL TURAN PRİNCE WORLD	4 Star	Antalya	8.3	3197
27	N/A	CLUB TESS OTEL	4 Star	Antalya	5.9	112
28	N/A	DEFNE DREAM	4 Star	Antalya	8.3	1960
29	N/A	EFTALIA AQUA RESORT OTEL	4 Star	Antalya	7.1	1909
30	YES	GARDENİA OTELİ	4 Star	Antalya	8.4	969
31	N/A	JUSTINIANO RESORT OTEL	4 Star	Antalya	7.2	398
32	N/A	LONICERA WORLD RESORT SPA HOTEL	4 Star	Antalya	8.6	3256
33	N/A	MİRABELL OTEL	4 Star	Antalya	5.7	152
34	N/A	NERTON OTEL	4 Star	Antalya	8.9	1230
35	YES	PINE HOUSE	4 Star	Antalya	7.4	791
36	N/A	RİVİERA OTEL	4 Star	Antalya	8.6	1760
37	N/A	SİDE COROLLA	4 Star	Antalya	8	26
38	YES	SİDE LİLYUM HOTEL &SPA	4 Star	Antalya	9.1	2959
39	N/A	SİMENA OTEL	4 Star	Antalya	7.1	25
40	N/A	SULTAN SİPAHİ RESORT OTEL	4 Star	Antalya	7.4	762
41	YES	TRENDY SİDE BEACH	4 Star	Antalya	9.3	4025
42	N/A	XPERİA GRAND BALİ HOTEL	4 Star	Antalya	7.8	799
43	N/A	WASHINGTON RESORT HOTEL&SPA	5 Star	Antalya	8.3	4949
44	YES	ADENYA HOTEL & RESORT	5 Star	Antalya	7.7	78
45	YES	ALKOÇLAR EXCLUSIVE	5 Star	Antalya	8.4	71
46	N/A	AMARA DOLCE VİTA	5 Star	Antalya	8.8	2458
47	N/A	ANTALYA HOTEL SU	5 Star	Antalya	8.2	3590
48	N/A	AVENTURA PARK HOTEL	5 Star	Antalya	8.4	133
49	YES	BAİA LARA HOTEL	5 Star	Antalya	9	3150
50	N/A	BARUT OTEL KEMER	5 Star	Antalya	9.5	4454
51	YES	BELEK BEACH RESORT OTEL	5 Star	Antalya	9	4231
52	YES	CAN GARDEN RESORT OTEL	5 Star	Antalya	9.2	6076
53	N/A	CLUB PARADİSO	5 Star	Antalya	8.2	3977
54	YES	CORNELIA DE LUXE RESORT	5 Star	Antalya	9.1	1426
55	YES	CRYSTAL PALACE FAMILY RESORT	5 Star	Antalya	8.5	1872
56	YES	CRYSTAL TATBEACH GOLF RESORT & SPA	5 Star	Antalya	9	6717
57	YES	DELPHIN PALACE	5 Star	Antalya	9.2	9847
58	YES	DİZALYA PALM GARDEN OTEL	5 Star	Antalya	8.7	1322
59	N/A	DOUBLE TREE BY HILTON ANTALYA CITY CENTER	5 Star	Antalya	8.1	40
60	N/A	DRİTA OTEL	5 Star	Antalya	7.4	1157
61	N/A	GOLDCITY OTEL	5 Star	Antalya	8	3155
62	YES	GRANADA LUXURY RESORT VE SPA	5 Star	Antalya	9.2	6523

Table A.5. Continued.

63	N/A	HANE GARDEN	5 Star	Antalya	8.4	13601
64	N/A	HOLİDAY PARK RESORT HOTEL ALANYA	5 Star	Antalya	7.7	1594
65	N/A	HOTEL ÖZKAYMAK	5 Star	Antalya	5.5	822
66	YES	HOTEL SEASHELL RESORT & SPA	5 Star	Antalya	8.9	2193
67	YES	IC GREEN PALACE	5 Star	Antalya	9.2	5330
68	YES	LİMAK ATLANTİS OTEL	5 Star	Antalya	9.1	4928
69	N/A	LONG BEACH RESORT & SPA DELUXE	5 Star	Antalya	8.2	3916
70	YES	LUNA BLANCA HOTEL & SPA	5 Star	Antalya	8.6	1848
71	YES	MAXX ROYAL KEMER	5 Star	Antalya	9.4	177
72	YES	NASHIRA RESORT HOTEL AQUA SPA	5 Star	Antalya	7.6	4787
73	N/A	OLEANDER OTEL	5 Star	Antalya	9.2	3704
74	YES	ÖZKAYMAK FALEZ OTELİ	5 Star	Antalya	5.5	822
75	N/A	ÖZKAYMAK SELECT RESORT OTEL	5 Star	Antalya	7.5	326
76	N/A	PHASELİS ROSE	5 Star	Antalya	10	6
77	N/A	RIOLAVITAS RESORT & SPA HOTEL	5 Star	Antalya	7.9	407
78	YES	RIXOS PREMIUM TEKİROVA HOTEL	5 Star	Antalya	9.2	6414
79	YES	ROSE RESİDENCE BEACH	5 Star	Antalya	6.7	271
80	YES	ROYAL GARDEN SELECT &SUIT	5 Star	Antalya	8.5	1727
81	YES	SEA LIFE FAMİLY RESORT	5 Star	Antalya	7.8	4351
82	N/A	SEAMELIA BEACH RESORT HOTEL&SPA	5 Star	Antalya	8.9	3913
83	N/A	SERENİS HOTEL	5 Star	Antalya	7.3	259
84	YES	SİDE MARE RESORT & SPA OTEL	5 Star	Antalya	8.1	7055
85	YES	SİRENE BELEK	5 Star	Antalya	8.3	1590
86	N/A	TELATİYE RESORT HOTEL	5 Star	Antalya	8.7	1812
87	YES	THE MARMARA ANTALYA OTELİ	5 Star	Antalya	8.3	1917
88	N/A	TITANIC RESORT OTEL	5 Star	Antalya	9.3	6712
89	YES	TRENDY HOTELS ASPENDOS BEACH	5 Star	Antalya	9.5	7567
90	N/A	XAFİRA DELUXE RESORT & SPA OTEL	5 Star	Antalya	7.5	2717
91	YES	XANADU RESORT HOTEL	5 Star	Antalya	9.1	702

B. Environmental Impacts of Materials

Table B.1. Environmental impact LCA results of autoclaved aerated concrete block. (British Precast Concrete Federation, 2017)

LCA: Results

In Table 1 "Description of the system boundary", all declared modules are indicated with an "X"; Module D which is not declared is indicated with "MND". Indicator values are declared to three valid digits.

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; MND = MODULE NOT DECLARED)

PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	MND

RESULTS OF THE LCA - ENVIRONMENTAL IMPACT: 1m3 Generic Precast Aerated Concrete Block

Parameter	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
GWP	[kg CO_2-Eq.]	168.00	3.62	1.10	-57.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.08	1.43	0.97
ODP	[kg CFC11-Eq.]	7.10E-7	2.45E-12	5.80E-12	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.41E-12	1.48E-11	1.07E-11
AP	[kg SO_2-Eq.]	2.08E-1	1.51E-2	6.84E-4	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	8.67E-3	9.81E-3	5.78E-3
EP	[kg $(PO_4)^{3-}$-Eq.]	1.99E-2	3.70E-3	1.09E-4	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	2.12E-3	2.37E-3	7.86E-4
POCP	[kg ethene-Eq.]	6.00E-2	-5.66E-3	6.68E-5	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	-3.25E-3	1.43E-3	5.55E-4
ADPE	[kg Sb-Eq.]	2.87E-4	6.80E-8	1.58E-7	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	3.90E-8	2.53E-6	3.32E-7
ADPF	[MJ]	1.20E+3	4.98E+1	1.81E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	2.86E+1	2.69E+1	1.25E+1
Caption	GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of land and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources														

Table B.2: Environmental impact LCA results of classic plasterboard. (Knauf Danogips GmbH, 2020).

IMPACT CATEGORY	UNIT	A1-A3	A4	B1-B7	C1	C2	C3	C4	TOTAL
Acidification potential (AP)	kg SO_2 eq.	6,96E-03	6,37E-04	0,00E+00	6,34E-05	1,81E-04	5,65E-04	2,90E-04	**8,69E-03**
Eutrophication potential (EP)	kg PO_4^{3-} eq.	2,02E-03	1,36E-04	0,00E+00	1,19E-05	3,79E-05	1,18E-04	8,85E-05	**2,41E-03**
Global warming potential (GWP100a)	kg CO_2 eq.	1,56E+00	2,33E-01	0,00E+00	2,49E-02	5,05E-02	1,58E-01	3,63E-01	**2,39E+00**
Formation potential of tropospheric ozone (POCP)	kg C_2H_4 eq.	3,56E-04	3,66E-05	0,00E+00	7,09E-06	8,25E-06	2,58E-05	8,46E-06	**4,42E-04**
Abiotic depletion potential – Elements	kg Sb eq.	1,60E-06	4,56E-07	0,00E+00	9,59E-09	1,51E-07	4,73E-07	3,79E-08	**2,72E-06**
Abiotic depletion potential – Fossil resources	MJ, net calorific value	3,25E+01	3,82E+00	0,00E+00	3,22E-01	7,64E-01	2,39E+00	9,20E-01	**4,07E+01**
Water scarcity potential	m^3 eq.	4,47E-01	2,27E-02	0,00E+00	1,76E-03	3,92E-03	1,23E-02	4,05E-03	**4,92E-01**
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC 11 eq.	3,10E-07	4,67E-08	0,00E+00	3,93E-09	9,32E-09	2,91E-08	1,11E-08	**4,10E-07**

C. Life Cycle Assessment Comparison Charts

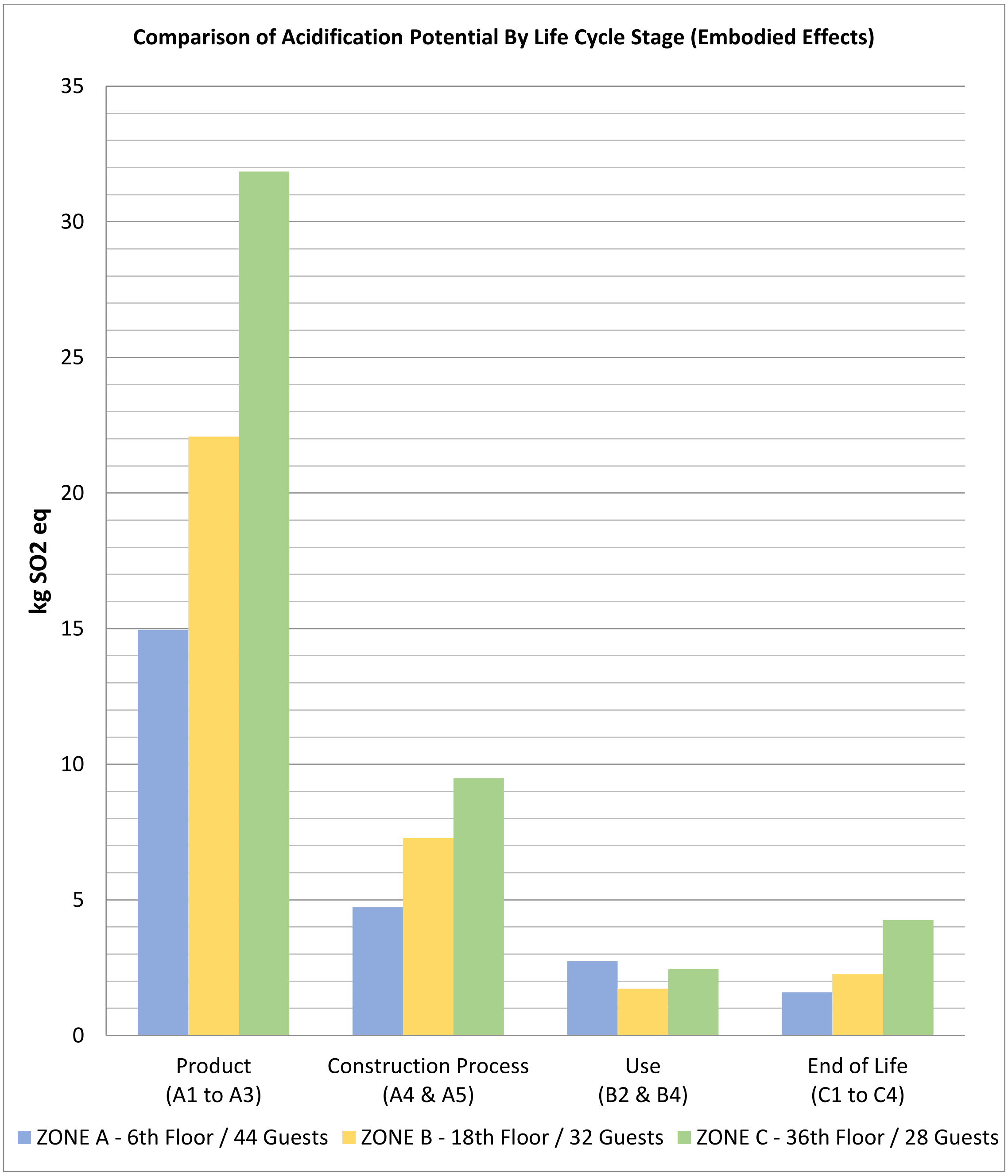

Figure C.1. Comparison of Acidification Potential By Life Cycle Stage.

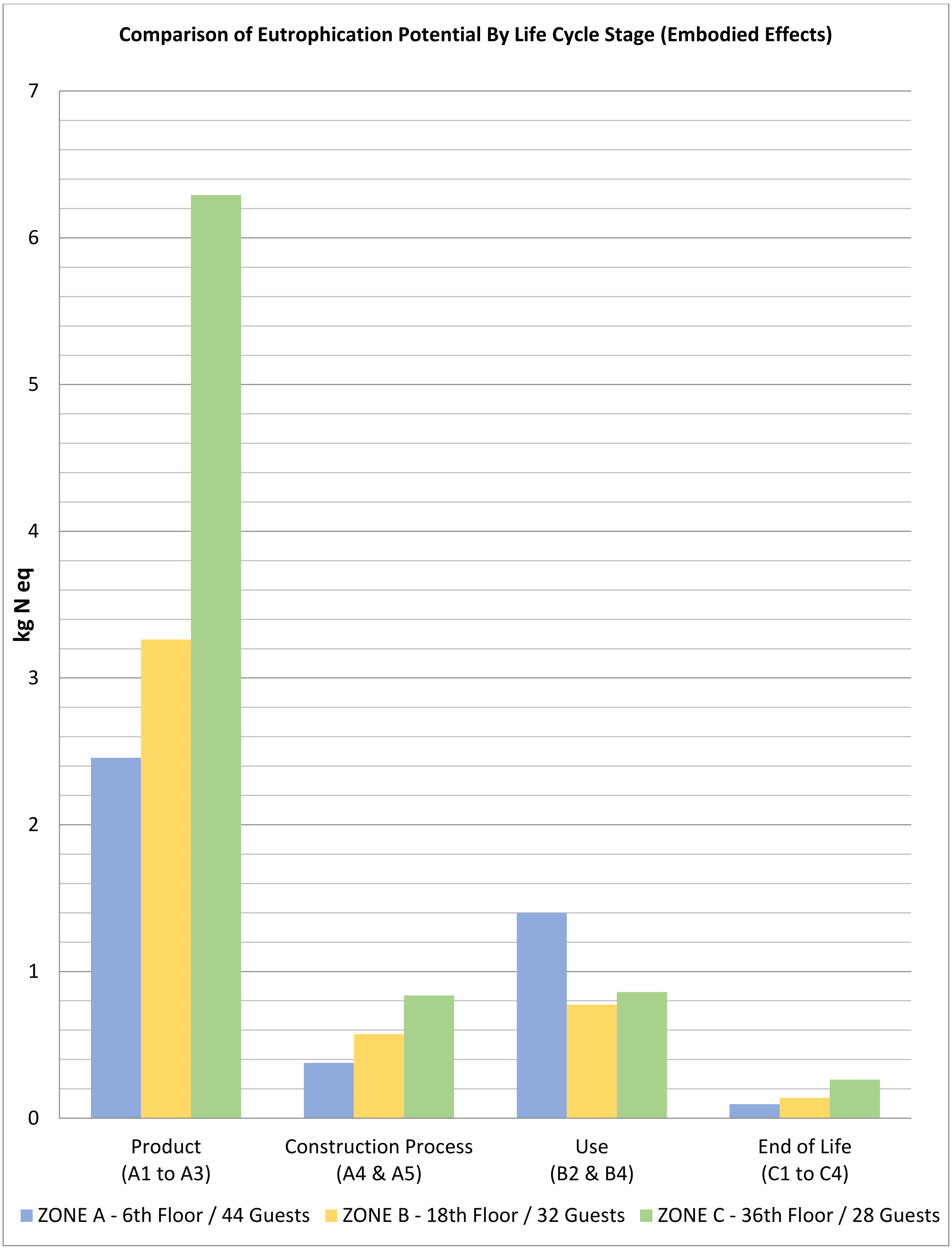

Figure C.2. Comparison of Eutrophication Potential By Life Cycle Stage.

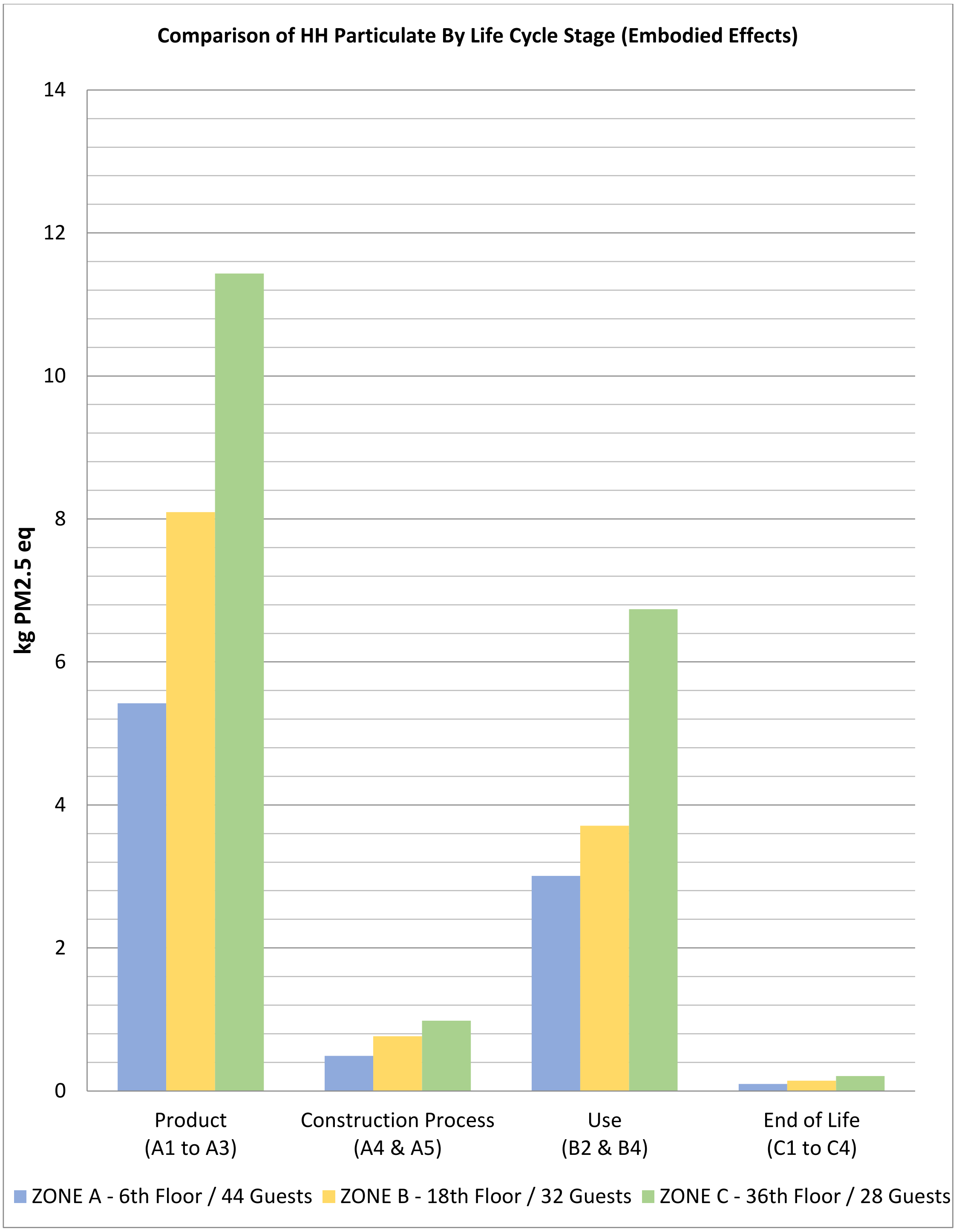

Figure C.3 Comparison of HH Particulate By Life Cycle Stage.

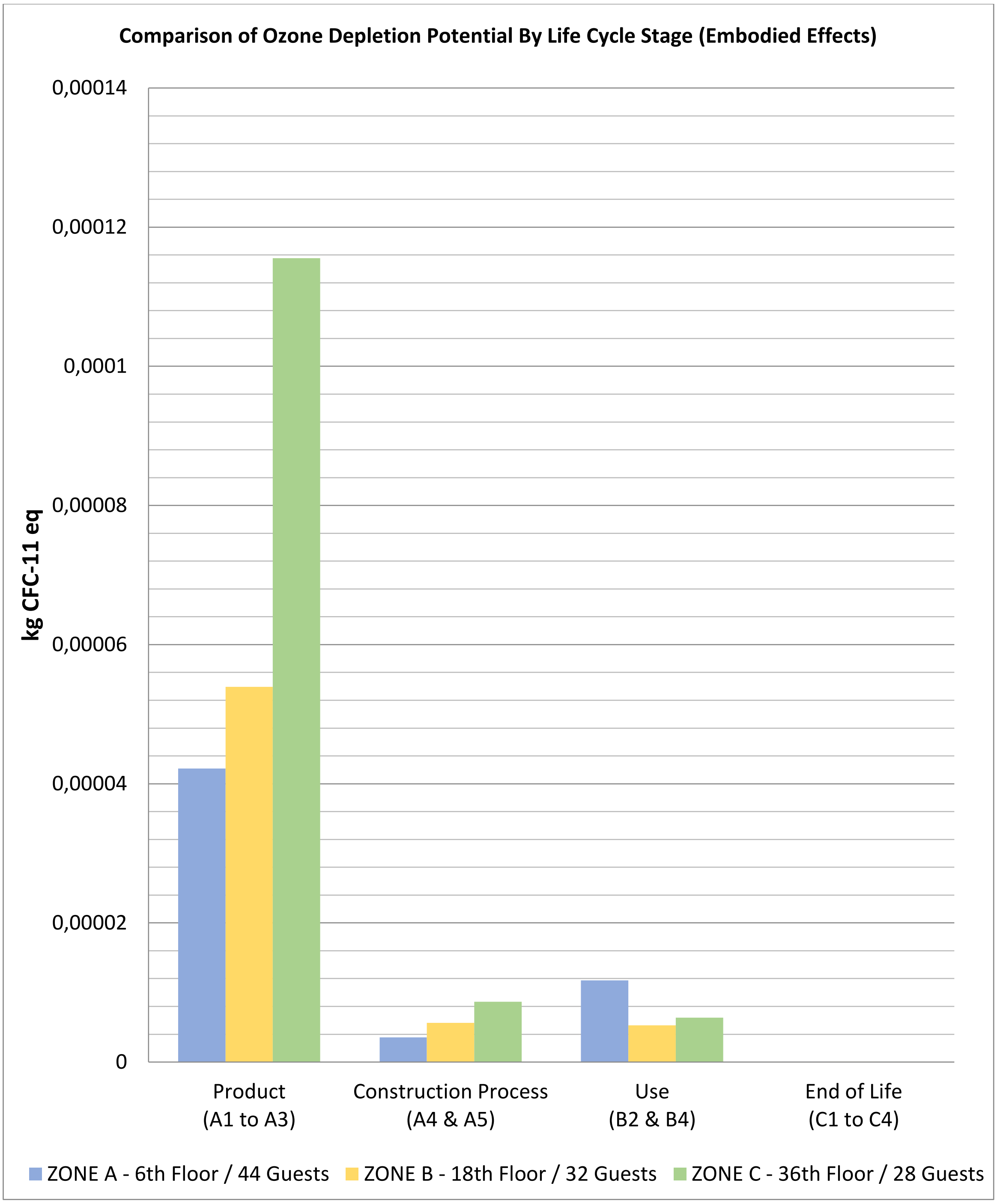

Figure C.4. Comparison of Ozone Depletion Potential By Life Cycle Stage.

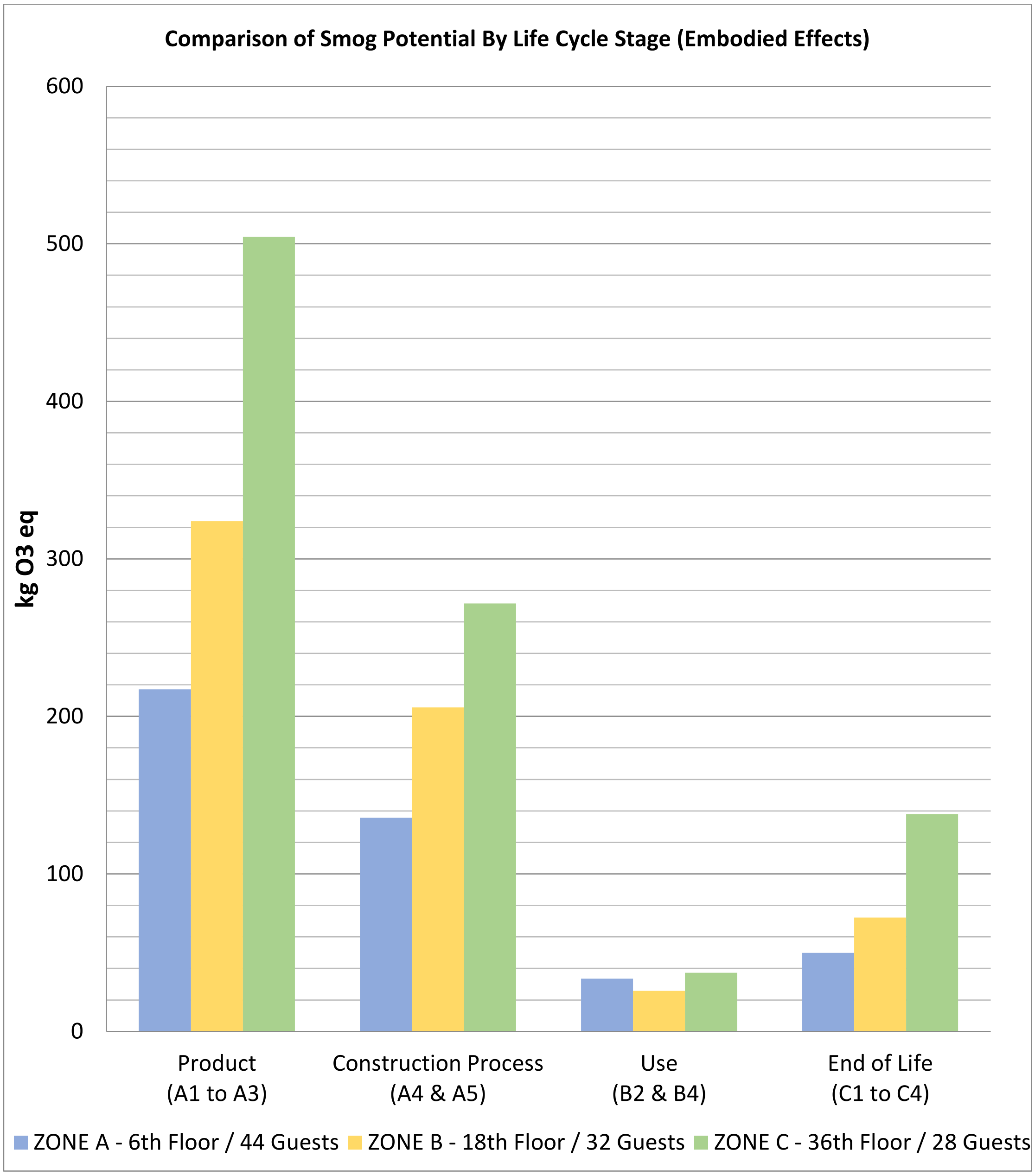

Figure C.5. Comparison of Smog Potential By Life Cycle Stage.