ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL

EMBODIED ENERGY POTENTIAL OF DEMOLITION WASTE CAUSED BY EARTHQUAKE AND URBAN TRANSFORMATION

M.Sc. THESIS

Ceren ÇAKAR

Department of Architecture

Environmental Control & Construction Technology Programme

JULY 2024

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DEPREM VE KENTSEL DÖNÜŞÜM KAYNAKLI YIKIM ATIKLARININ GÖMÜLÜ ENERJİ POTANSİYELİ

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Ceren Çakar , a M.Sc. student of ITU Graduate School student ID 502211502, successfully defended the thesis/dissertation entitled “EMBODIED ENERGY POTENTIAL OF DEMOLITION WASTE CAUSED BY EARTHQUAKE AND URBAN TRANSFORMATION’’, which she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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Date of Submission : 24 May 2024
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To my family and friends,

FOREWORD

I would like to thank everyone who supported me throughout my study. First and foremost, I would like to thank my family, who have supported me in every aspect throughout my life. I am also grateful to my thesis advisor, Asst. Prof. Dr. Cenk Üstündağ, for his guidance; to Prof. Dr. Seden Acun Özgünler for her support; and to Prof. Dr. Oğuz Cem Çelik and Prof. Dr. Mustafa Özgünler for their valuable comments and contributions to my thesis work.

July 2024 Ceren ÇAKAR
(Interior Architect)

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ABBREVIATIONS

AFAD : İl Afet ve Acil Durum Müdürlüğü
BIM : Artificial Neural Network
B.E.S.T : Board of European Student of Technology
CERA : Canterbury Earthquake Recovery Authority
C&DWM : Construction and Demolotion Waste Management
CO_2 : Carbondioxide
ÇEDBİK : Çevre Dostu Yeşil Binalar Derneği
DEZIM : Deprem ve Zemin İnceleme Müdürlüğü
EPD : Environmental Product Data
EE : Embodied Energy
EPD : Environmental Product Data
GIS : Geographic Information System
GWP : Greenhouse Gas Emissions
GBCA : Green Building Council Australia
LCA : Life Cycle Assesment
ICE : Institution of Civil Engineering
IPCC : Intergovernmental Panel on Climate Change
ISO : International Organization for Standadization
OE : Operational Energy
WFD : Water Frame Directive
WMH : Waste Management Hierarchy
SDGs : Sustainable Development Goals
IR : Infrared Radiation
IEA : International Energy Agency
BTU : British Thermal Units
ESA 2010 : European System of Accounts
TUIK : Turkey Statistic Institution
RC : Reinforced Concrete
WRAP : Waste Reduction Action Plan
EC : Embodied Carbon
HVAC : Heating Ventilation Air Condition

BAS	**:** Building Automation System
LED	**:** Light Emitting Diode
IE	**:** Impact Estimator
MGM	**:** General Directorate of Meterology
PVC	**:** Polyvinly Cloride

SYMBOLS

CO_2 e	:	Carbondioxite
cm	:	Centimeter
h	:	hour
kg	:	Base unit of mass
kW	:	Kilowatt
m^2	:	squaremeter
Mw	:	Medium wave
MJ	:	Megajoule
PJ	:	Petajoule

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EMBODIED ENERGY POTENTIAL OF DEMOLITION WASTE CAUSED BY EARTHQUAKE AND URBAN TRANSFORMATION

SUMMARY

Earthquakes have been causing significant destruction and damage in Turkey for centuries. Positioned in a region where many active fault lines intersect, Turkey is experiencing a rapid increase in construction sector activities in many cities with high earthquake risk due to the growing population and industrialization. In the past years, the necessity of earthquake-resistant construction emerged to reduce the loss of life and property caused by earthquakes. Therefore, while current earthquake regulations are prepared for new structures, urban transformation applications have also emerged for existing structures with low seismic resistance and completed lifespans.Although urban transformation applications are essential and beneficial for renewing the building stock and making it more earthquake-resistant, they lead to a significant amount of construction and demolition waste due to the increase in construction and demolition activities in the construction sector.The ongoing earthquakes in Turkey generate sudden and substantial amounts of demolition waste, while increasing urban transformation projects are causing significant environmental problems, thereby enhancing the environmental impacts of the construction sector. This thesis focuses on the environmental harms caused by demolition waste resulting from earthquakes and urban transformations, while also examining the relationship between energy and buildings in detail by considering the embodied energy potential of structures. Following earthquakes in our country, construction waste cannot be managed sustainably and is not being recycled. At this point, deficiencies in the management of construction waste not only cause environmental issues but also prevent the effective use of resources in terms of energy efficiency. Additionally, in the construction sector, particularly in urban transformation projects, there is a lack of infrastructure and incentives for sustainability. This situation leads to ineffective control of environmental factors and the failure to adopt sustainable construction methods. The effective management of construction and demolition waste involves not only storing and removing these wastes from urban centers but also planning them in a way that contributes to environmental sustainability. For this, it is important to focus on

processes such as the reuse and recycling of construction and demolition waste. These wastes consist of a variety and large amounts of building materials. The embodied energy possessed by the building materials used in construction can be reintroduced into the system through their reuse and recycling. Embodied energy is defined as the amount of energy required to produce a unit amount of a material. Various methods are available for calculating the amount of embodied energy.

This thesis conducts a comprehensive literature review on earthquakes, urban transformation, construction and demolition waste, and the relationship between construction and energy. Additionally, the methodology for simulating operational energy and embodied energy aims to evaluate in more detail the issues of non-recyclability of construction waste and the ineffective utilization of embodied energy potential.

Within the scope of this thesis, to better understand the embodied energy potential of construction waste that may arise during accelerated urban transformation activities due to the increased earthquake risk, the embodied energy, excavation waste quantity in case of demolition, and one year's operational energy of the selected sample structure in the example study have been calculated. The embodied energy potential of structures includes the energy incurred in the production, transportation, and assembly of construction materials. This embodied energy potential is a critical factor in determining the environmental impacts of structures throughout their lifespan.

The aim of the thesis is to reveal the environmental damages of urban transformation projects and the reasons for the unsustainable management of construction waste after earthquakes. Additionally, the thesis seeks to propose more effective policy recommendations in this regard. Simultaneously, it aims to understand the relationship between energy and structures by taking into account the embodied energy potential of buildings and to develop strategies for using this potential more sustainably. These efforts could be a significant step in increasing environmental sustainability in the construction sector in Turkey and optimizing energy efficiency.

According to the data obtained from this study, the embodied energy per square meter in reinforced concrete residential buildings with poor concrete quality, which are expected to collapse in the anticipated Istanbul earthquake, is lower compared to current reinforced concrete residential structures. Although this may seem positive in terms of the embodied energy potential of demolition waste after the earthquake, the recycling of demolition waste from these buildings should also be considered in the context of environmental sustainability, given the large number of similar buildings expected to collapse in the anticipated Istanbul earthquake.

- The embodied energy contained in demolition waste represents a substantial potential for recoverable energy. Recovering this energy has the potential to reduce the environmental damages caused by the construction sector.
- The quantities of demolition waste that would occur suddenly due to earthquakes are considerable. Conducting detailed studies on the management of this demolition waste and creating regulations and laws to support these studies are crucial for Istanbul, given its high earthquake risk and population density.
- Sustainable management of construction and demolition waste can reduce the costs associated with construction materials and create new employment opportunities. This approach contributes not only environmentally but also economically to the country.

DEPREM VE KENTSEL DÖNÜŞÜMDEN KAYNAKLANAN YIKIM ATIKLARININ GÖMÜLÜ ENERJİ POTANSİYELİ

ÖZET

Depremler yüzyıllardan beri Türkiye'de ciddi yıkımlara ve zararlara sebep olmaktadır.Türkiye birçok aktif fay hattının kesiştiği bölgede yer alırken hızla artan nüfus ve sanayileşme sebebiyle yüksek deprem riski taşıyan birçok şehirde inşaat sektörü faaliyetleri de hızlı bir şekilde artmaktadır.Geçmiş yıllarda depremler sebebiyle yaşanan can ve mal kayıplarını azaltmak için depreme dayanıklı yapılaşma gerekliliği doğmuştur.Bu sebeple yeni yapılacak yapılar için güncel deprem yönetmelikleri hazırlanırken var olan deprem dayanımı düşük ve kullanım ömrünü tamamlamış yapılar için de kentsel dönüşüm uygulamaları ortaya çıkmıştır. Kentsel dönüşüm uygulamaları yapı stoğunun yenilenmesi ve depreme daha dayanıklı hale getirilmesi için gerekli ve yararlı olmasına rağmen inşaat sektöründeki yapım-yıkım faaliyetlerini artırarak ciddi oranda yapım-yıkım atığı oluşmasına neden olmaktadır.Türkiye'de süre gelen depremler ani ve yoğun miktarda yıkım atığı oluşturmakta, artan kentsel dönüşüm projeleri ise çevresel anlamda ciddi sorunlara yol açmakta ve bu durum inşaat sektörünün çevresel etkilerini artırmaktadır. Bu tez çalışması,deprem ve kentsel dönüşüm kaynaklı oluşabilecek yıkım atıklarının çevresel zararlarına odaklanırken, aynı zamanda yapıların gömülü enerji potansiyelini göz önüne alarak, enerji ve yapı arasındaki ilişkiyi detaylı bir şekilde incelemektedir.Ülkemizde depremler sonrasında ortaya çıkan inşaat atıkları, sürdürülebilir bir şekilde yönetilememekte ve geri dönüştürülememektedir. Bu noktada, inşaat atıklarının yönetimindeki yetersizlikler, sadece çevresel açıdan değil, aynı zamanda enerji verimliliği açısından da kaynakların etkili bir şekilde kullanılamamasına sebep olmaktadır.Ayrıca yapı sektöründe, özellikle kentsel dönüşüm projelerinde, sürdürülebilirlik konularında yetersiz altyapı ve teşvikler mevcuttur. Bu durum, çevresel faktörlerin etkili bir şekilde kontrol edilememesine ve sürdürülebilir inşaat yöntemlerinin benimsenememesine neden olmaktadır.Yapım ve

yıkım atıklarının etkili yönetimi sadece bu atıkların depolanması ve şehir merkezlerinden uzaklaştırılması değil aynı zamanda çevresel sürdürülebilirliğe katkı sağlayacak şekilde planlanmasıdır.Bunun için oluşan yapım ve yıkım atıklarının yeniden kullanımı ve geri dönüştürülmesi gibi işlemlere önem verilmesi gerekmektedir.Bu atıklar çok ve çeşitli yapı malzemelerinden oluşmaktadır.Yapıda kullanılan yapı malzemelerinin sahip olduğu gömülü enerji bu malzemelerin tekrar kullanılması ve geri dönüşümüyle sisteme tekrar kazandırılabilir.Gömülü enerji bir maddeden birim miktarda üretmek için gerekli olan enerji olarak tanımlanabilir.Gömülü enerji miktarını hesaplamak için çeşitli yöntemler bulunmaktadır.

Tez, deprem, kentsel dönüşüm, yapım- yıkım atıkları, yapı ve enerji kavramları ile ilgili geniş bir literatür taraması yapmaktadır. Ayrıca, operasyonel enerji ve gömülü enerjiyi simüle etme metodolojisi, inşaat atıklarının geri dönüştürülememesi ve gömülü enerji potansiyelinin etkili bir şekilde kullanılamaması sorunlarını daha ayrıntılı bir şekilde değerlendirmeyi amaçlamaktadır.Bu tez çalışması kapsamında, beklenen İstanbul depremi kapsamında ortaya çıkabilecek yıkım atıklarının gömülü enerji potansiyelinin daha iyi kavranabilmesi için, örnek çalışmada seçilen örnek yapının gömülü enerjisi,yıkılması durumunda oluşturacağı hafriyat atığı miktarı ve bir yıllık kullanım enerjisi hesaplanmıştır.Yapıların gömülü enerji potansiyeli, inşaat malzemelerinin üretiminden, taşınmasından ve montajından kaynaklanan enerjiyi içermektedir.Bu gömülü enerji potansiyeli, yapıların ömrü boyunca çevresel etkilerini belirlemede kritik bir faktördür.

Tezin amacı deprem kaynaklı oluşan yıkım atıklarının çevresel etkileri ve bu atıkların sürdürülebilir bir şekilde yürütülmesinin önemini ortaya koymak ve bu konuda daha etkili politika önerileri sunmaktır.Aynı zamanda, yapıların gömülü enerji potansiyelini göz önüne alarak, enerji ve yapı arasındaki ilişkiyi anlamak ve bu potansiyeli daha sürdürülebilir bir şekilde kullanmak için stratejiler geliştirmeyi hedeflemektedir. Bu çabalar, Türkiye'deki inşaat sektöründe çevresel sürdürülebilirliği artırmak ve enerji verimliliğini optimize etmek için önemli bir adım olabilir.

Çalışmanın birinci bölümü olan giriş bölümünde ülkemizin deprem,kentsel dönüşüm ve yapım-yıkım atıkları yönetimi konularıyla ilişkilendirmesi yapılmış.Güncel durum ve problemler belirlenmiştir.Ülkemizde yapım ve yıkım atıklarının sürdürülebilir yönetilmesiyle ilgili düzenleme, kanun ,teknik bilgi ve imkanların yetersiz olduğu sonucu vurgulanmıştır.Buna ek olarak tezde belirlenen konu ile alakalı olabilecek geçmiş çalışmalar üzerine incelemeler yapılmıştır.

Çalışmanın ikinci bölümünde, deprem ve kentsel dönüşüm konuları ayrıntılı bir biçimde açıklanmıştır.Depremin maddi, manevi ve çevresel tahribatı detaylı bir şekilde ele alınmıştır.Bu bağlamda depremin, hem fiziksel altyapıda hem de insanların duygusal ve sosyal yönden yaşadığı etkilerin yanı sıra çevresel açıdan da yıkıcı etkileri vurgulanmıştır.Ayrıca, kentsel dönüşümün çevresel boyutu detaylı bir şekilde incelenmiş ve sürdürülebilirlik kavramı ile olan ilişkisi güçlendirilmiştir.

Çalışmanın üçüncü bölümüne ise, yapım ve yıkım atıkları konuları detaylıca ele alınmış. Yapım ve yıkım atıklarının çevresel sürdürülebilirlik kapsamında ektili yönetiminin önemi vurgulanırken.Sürdürülebilir yapım&yıkım atığı yönetiminin prensipleri açıklanmıştır.

Çalışmanın dördüncü bölümünde ise yapılı çevre ve enerji konuları arasındaki bağlantı ele alınarak. Türkiye'de ve dünyada yapı sektörünün enerji kaynakları ile olan ilişkisi açıklanmış. Yapı sektörü kaynaklı enerji tüketiminin ciddiyetine vurgu yapılmıştır.Yapılardaki gömülü ve kullanım enerjileri detaylı olarak açıklanmıştır.

Çalışmanın beşinci bölümünde ise yapılardaki gömülü enerji potansiyelinin daha iyi kavranması için örnek bir yapı seçilerek yapının gömülü enerjisi ve kullanım enerjisi farklı simülasyon programları kullanılarak hesaplanmıştır.Ayrıca örnek yapının yıkılması durumunda ortaya çıkacak yıkım atığı miktarları hesaplanmıştır.

Altıncı bölümde bu sonuçlar olası beklenen İstanbul depremi çerçevesinde baz alınarak beklenen depremin olması durumunda yıkılacak veya hasarlanacak yapıların oluşturduğu yıkım atığı miktarları ve gömülü enerji miktarlarını kavramak için kullanılmıştır.

Yapılan çalışmada örnek yapının gömülü enerji, kullanım enerjisi ve yıkılması durumunda ortaya çıkabilecek yıkım atığı miktarları hesaplanmış olup buna göre genel olarak:

- Geleneksel yapılarda yapının gömülü enerjisi ekonomik kullanım ömrü boyuncaki kullanım enerjisine kıyaslandığında çok daha küçük bir değere sahiptir ancak, genede bu enerji göz ardı edilemeyecek kadar büyüktür ve deprem gibi çoklu yıkımlardaki gömülü enerji potansiyeli çok yüksetir.Bu enerjinin değerlendirilmesi sürdürülebilirlik açısından önem arz etmektedir.

- Örnek çalışamda elde edilen verilere göre, beton kalitesi düşük, beklenen İstanbul depreminde yıkılması ön görülen betonarme konut binaların metrekare başına düşen gömülü enerji miktarları, güncel betonarme konut yapılarına kıyasla daha düşüktür. Bu durum deprem sonrası yıkım atıklarının gömülü enerji potansiyelerinin miktarı için olumlu gibi görünse de, toplamda beklenen İstanbul depremi kapsamında çok fazla benzer binanın yıkılması beklendiği için bu yapılarda da yıkım atıklarının geri dönüşümü çevresel sürdürülebilirlik kapsamında dikkate alınmalıdır.
- Yıkım atıklarının oluşturduğu gömülü enerji çok ciddi oranlarda geri kazanılabilir enerji potansiyeli barındırmaktadır.Bu enerji potansiyeli geri kazanılarak yapı sektörünün oluşturduğu çevresel zararları azaltılabilir.
- Deprem sebebiyle ani oluşacak yıkım atıklarının miktarları çok fazladır ve bu yıkım atıklarının yönetilmesi konusunda detaylı çalışmalar yapmak, bu çalışmaları destekleyecek yönetmelikler ve kanunlar oluşturmak sahip olduğu yüksek deprem riski ve yüksek nüfus yoğunluğu sebebiyle İstanbul İli için hayati önem arz etmektedir.
- Yapım Yıkım atıklarının sürdürülebilir yönetimi yapı malzemeleri için harcanan maliyeti azaltarak ve yeni istihdam kolları oluşturarak sadece çevresel değil aynı zamanda ekonomik olarak da ülkeye katkı sağlayacaktır.

1. INTRODUCTION

Our planetary home, Earth, is a complex combination of geology, climate and ecosystems involved in constant complex interactions These factors shape the planet's life forms, climate and under the various geological features. But in this complex of natural phenomena, the Earth also holds the potential to produce catastrophic phenomena known as natural disasters. Stemming from Earth's own geological and climatic challenges, these events manifest as earthquakes, volcanic eruptions, hurricanes, tsunamis, floods, droughts, etc. Historically, these events have times elevating humans, remaking landscapes, redefining ecosystems, and testing human existence resilience of societies, and can often be described as catastrophic events from natural forces or events and causes These events can cause significant damage to the environment, property and human lives. Natural disasters can take various forms such as earthquakes, hurricanes, hurricanes, floods, wildfires, tsunamis, volcanic eruptions, droughts, etc. Often they happen without warning or with little prediction, and give it's hard to anticipate and prepare for. The effects of natural disasters can be widespread, causing loss of life, displacement of communities, destruction of infrastructure, and long-term economic and environmental consequences. Efforts to mitigate the impact of natural disasters include disaster preparedness, early warning systems, emergency management, disaster recovery and reconstruction efforts. Earthquakes, particularly in countries located in active seismic zones, pose significant risks, leading to substantial loss of life and property damage. To mitigate these risks, countries have implemented various earthquake regulations and standards, and Turkey is one of these nations.

The relationship of the earthquake to Turkey is important because of its location. Turkey is located on several active tectonic plate boundaries and is therefore highly susceptible to seismic activity, including earthquakes. Turkey is on one of the world's most active offenses, and a recurring moment. Over the past decades, these active faults have been responsible for many significant and destructive earthquakes in Turkey. These earthquake events resulted in the loss of many lives, damage to buildings and vital infrastructure in the affected areas (Xiao et al., 2023). The earthquake in the central area of Kahramanmarash caused extensive damage and extensive damage over a large area. On February 6, 2023, two M7.7 and M7.6 earthquakes struck the Pazarczyk and Albiston districts of Kahrammarash. These earthquake events affected not only Kahramanmarash but 11 neighboring provinces including Adana, Adiyaman, Diyarbakır, Elazig, Gaziantep, Hatay, Kahramanmarash itself, Kilis, Malatya, Osmaniye and Şanlıurfa 2023) Istanbul, unfortunately the most densely populated in Turkey It is a large city expected to experience a major earthquake. Current projections suggest a 35–70% probability of M >7 earthquakes along this fault in 2034. Unfortunately, the eastern side of the fault is close to central Istanbul (Bohnhoff et al., 2013). And would not be seismically observed the possibility that it will occur will be greatly affected by the deficiencies of current urban planning and the highly structured belief of old buildings.

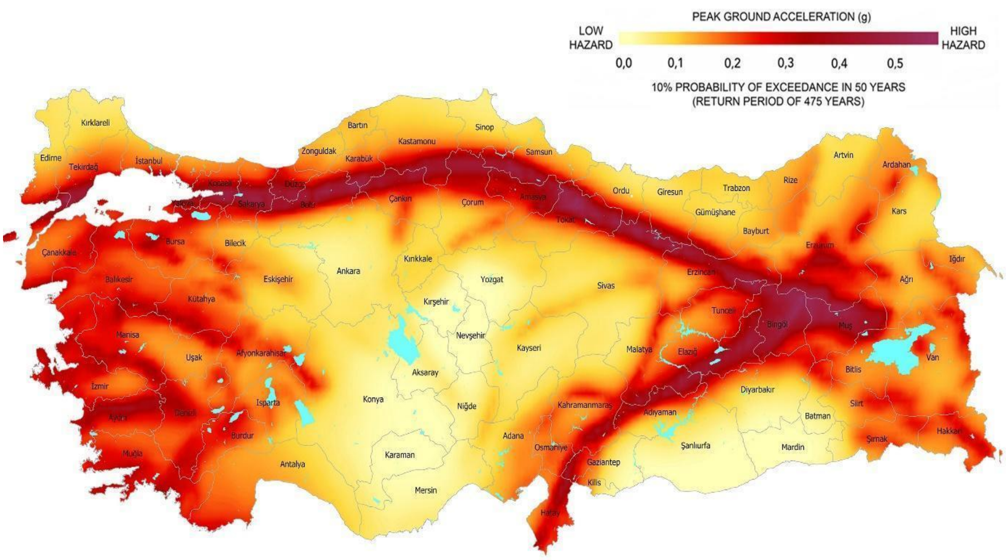

Figure 1.1 : Turkey seismic zones map (AFAD, 2018)

Urban transformation is especially important in densely populated cities like Istanbul. Istanbul stands out as a city in need of new urban areas due to factors such as rapid population growth, unstructured urbanization, aging and accumulation of dangerous buildings. Urban transformation in Istanbul is an important process of local authorities, citizens a their aim is to improve the quality of life in the:

- Soil Pollution: Soil contamination may occur due to improper disposal or irregular waste disposal. The application of chemicals to soil or contaminated soils can adversely affect plant life and water sources.
- Influence on Water Resources: Runoff or infiltration of construction and construction debris can cause water source contamination. This can contaminate the drinking water or harm the ecosystem.
- Air Quality Degradation: The use of construction machinery and vehicles can cause dust, particulate matter and air quality problems. Such factors may be associated with health issues from air pollution.
- Increased Energy Demand: Processing and waste management can increase energy consumption. This could negatively impact environmental sustainability and contribute to increased reliance on fossil fuels.
- Depletion of Natural Resources: Building and construction activities can cause damage to natural resources. Materials such as concrete and steel require extensive use of natural materials.
- Challenges in Waste Management: Improper management of construction and construction waste can lead to environmental challenges. Poorly regulated waste storage or transportation can increase environmental damage.
- Disruption of the Environment: Natural landscapes and green spaces may be disturbed during demolition. This can negatively affect local ecological and environmental well-being.

Hence, embracing sustainable measures such as recycling, waste reduction, energy-efficient practices, and proper waste handling is essential for mitigating the environmental repercussions associated with construction and demolition waste. These initiatives contribute to environmental preservation and the more sustainable utilization of resources.

Population growth-driven rapid urbanization and measures like urban transformation in preparation for the expected Istanbul earthquake continue to steadily increase the quantities of construction and demolition waste in Istanbul. The number of buildings demolished daily as part of urban transformation is also on the rise. While urban transformation is indeed a valuable method for renewing the poor and inadequate building stock in anticipation of an earthquake and achieving more resilient structures, it is necessary to take a deeper perspective on the issue. When constructing more earthquake-resistant buildings, it's essential to simultaneously contribute to urban sustainability and ensure the controlled management of construction and demolition waste. Enhancing resource efficiency via a structured approach to Construction and Demolition Waste Management (C&DWM) offers a fresh outlook that aligns with the Sustainable Development Goals and the principles of a circular economy (Han et al. , 2021).

1.1 Problem Definition

The construction sector plays a crucial role in meeting one of the fundamental needs of modern societies. However, the activities of this sector directly contribute to environmental impacts. In today's context, buildings and the construction sector significantly impact climate change due to their substantial influence on the environment, primarily driven by land and raw material consumption alongside waste generation. Roughly 40% of the total global carbon dioxide emissions are associated with buildings and construction: the operational phase of buildings accounts for 28% of global carbon dioxide emissions, while the construction industry, encompassing the production of buildings and components, contributes to 11% of the global carbon dioxide emissions (Diaz, 2023). For example, products such as concrete have higher carbon emissions, buildings increase energy consumption and water usage, so the environment does greater The innovations in this project have been sustainable practices and green building standards in the practices of the construction industry and the sustainability and importance of the field in terms of environmental impacts environment reducing our environment The construction industry faces scrutiny because of adverse environmental factors.In this context, sustainable practices and green building standards are being developed within the construction sector to reduce environmental effects, focusing on solutions such as energy efficiency, waste management, and the use of environmentally friendly materials. Innovations and environmentally friendly practices in this sector are crucial in minimizing environmental impacts for both the sustainability of the sector and the environment. The construction sector faces scrutiny due to its negative environmental impacts. To mitigate these effects, the industry is striving to implement sustainable methods across its complete production process (Lima et al., 2020).

On the other hand urban transformation in Turkey is intricately linked with addressing earthquake risks due to the country's geographical location. Turkey sits on several active fault lines, making it prone to seismic activity. Consequently, many older buildings and structures are particularly vulnerable to earthquakes, posing risks to the safety and lives of residents.The urban transformation process in Turkey, especially in earthquake-prone areas, aims to address these risks by renovating or reconstructing old, unsafe buildings to meet modern safety standards. By doing so, the aim is to enhance the resilience of the built environment against potential seismic events. This involves reinforcing structures, implementing stricter construction regulations, and encouraging seismic-resistant designs in new constructions.However, challenges persist in implementing comprehensive urban transformation projects, in densely populated urban areas. Issues such as funding, property rights, legal complexities, and community participation can hinder the swift and effective implementation of seismic risk reduction measures. Yet, with a combination of governmental initiatives, public awareness campaigns, and incentivizing safe reconstruction, efforts continue to make urban areas in Turkey more resistant to earthquake risks.The urban transformation process has not been successfully achieved for various reasons. The only form of participation provided by law typically involves negotiations with the authorities, restricting citizens to one-sided information exchange. Consequently, there is no system allowing a large number of participants to voice their needs, wishes, and suggestions regarding the revitalization of their neighborhoods. Additionally, there is a lack of facilitators responsible for organizing participatory activities, mediating complex actions, and addressing the situation (A.Gün et al., 2021).

Furthermore, the construction industry has traditionally focused on reducing emissions in building operations, neglecting the significant impact of embodied carbon, looking for embodied carbon dioxide (CO_2) emissions in buildings removal, construction, delivery, on-site construction, maintenance, and ultimately dismantled or recycled have provided valuable insight into the significant impact of their construction on the environment throughout their life cycle. It has also emerged as an important requirement for materials sustainability has been improved (Diaz, 2023). Carbon emissions from materials used in construction and ongoing maintenance buildings account for about 30 to 40% of the total carbon emissions over the lifetime of a building in (Hammond and Jones, 2008).

Besides, in Turkey, urban transformation has become an increasing necessity aligned with the development of cities. This process involves the renewal of old and risky buildings, reinforcement of infrastructure, and environmental regulations, while the management of construction and demolition waste has become a critical part of this process. However, there are notable inadequacies in the effective and environmentally friendly disposal of this waste. During urban transformation projects, the construction and demolition waste is often collected and transported without adequate planning. This situation makes recycling more difficult and adversely affects the environment and human health. Deficiencies in waste management lead to uncontrolled dumping of garbage, resulting in environmental pollution. Additionally, facilities that are unable to process and process waste that can be recycled or recycled are part of the problem. This situation is not only an environmental loss but also an economic loss. Furthermore, uncontrolled dumping of waste poses a threat to the environment and public health and has a negative impact on urban aesthetics and quality of life. Improperly maintained construction and harmful waste can has adversely affected the success of the urban development process. Effective waste management systems must be developed to manage the collection, transportation, separation and recycling of waste. Additionally, awareness campaigns need to be conducted for education and public awareness on waste management. Only through such measures can the effective management of construction and demolition waste in urban transformation be achieved, paving the way for a sustainable urban life in harmony with the environment.

Also the inadequate recycling and reuse of construction materials in Turkey pose significant challenges to the country's sustainability efforts. Despite the potential for reducing waste and conserving resources, there exists a notable deficiency in effectively recycling and reusing construction materials. A lot of waste is generated in the construction industry, but only a small fraction of this waste is sorted, recycled, or recycled. This mismanagement of construction waste results in negative impacts, increased environmental problems, depletion of raw materials and burden on landfill. Comprehensive planning such as materials a reuse, appropriate waste guidelines and incentives to recycle building materials contribute to this problem. This problem to significantly improve the reuse and reuse of building materials can, leading to environmentally friendly and waste-efficient construction projects The reuse and recycling of building materials is important in terms of sustainability standards. Thus, the B.E.S.T (Certificate of Green Building) enables B.E.S.T. Building building. For example: Building materials used in construction must be selected from reused materials meeting necessary performance criteria. Using reused materials in 15% of specified fundamental building elements (in terms of cost or volume) results in a deduction of 1 point.At least 2.5% (in terms of cost and volume) of renewable and/or recycled raw material content used in specified fundamental building elements results in a deduction of 1 point.The weight of aggregate used in specified fundamental building elements should consist of 20% recycled aggregate. The aggregate should be obtained from the construction site or from a location within a maximum distance of 50 km from the site, resulting in a deduction of 1 point (ÇEDBİK, 2019).

Another issue is the lack of sustainability awareness among individuals involved in the design and implementation processes of buildings. Even if there is a legal framework established for urban transformation and sustainability, the lack of knowledge and consciousness among the team responsible for implementing these principles negatively impacts the process. The issues addressed within the scope of the study are summarized below;

- The significant harmful effects of the construction sector on the environment
- Inadequate infrastructure and incentives in urban transformation and sustainability issues.
- Not giving sufficient importance to the embodied energy potential in structures in research and studies within the construction sector
- Inadequate management of construction and demolition waste that could arise from urban transformation and earthquakes
- Insufficient possibilities for the reuse and recycling of building materials
- Teams working in the construction sector lacking adequate knowledge about the recycling of construction and demolition waste, as well as sustainability.The purpose of the thesis are to elucidate the environmental impacts of urban transformation projects and the reasons behind the unsustainable management of demolition waste after earthquakes.

Additionally, it aims to propose more effective policy recommendations in this regard. Simultaneously, by considering the embodied energy potential of structures, the thesis seeks to comprehend the relationship between energy and construction and develop strategies to harness this potential in a more sustainable manner. These efforts could represent a significant step in enhancing environmental sustainability in the construction sector in Turkey and optimizing energy efficiency.

1.2 Purpose of Thesis

The purpose of the thesis is to elucidate the earthquakes and urban transformation impacts of demolotion wastes and the reasons behind the unsustainable management of demolition waste after earthquakes. Additionally, it aims to propose more effective policy recommendations in this regard. Simultaneously, by considering the embodied energy potential of structures, the thesis seeks to comprehend the relationship between energy and construction and develop strategies to harness this potential in a more sustainable manner. These efforts could represent a significant step in enhancing environmental sustainability in the construction sector in Turkey and optimizing energy efficiency.

1.3 Methodology

The study comprises three main stages. In the first stage, a detailed literature review was conducted. This phase involved a thorough examination of the concepts earthquakes and urban transformations, with a specific focus on evaluating the building stock in Istanbul concerning the anticipated Istanbul earthquake. The study investigated the building stock earmarked for renewal through urban transformation, as well as structures in Istanbul that could be vulnerable to damage or collapse in the event of the expected earthquake. Subsequently, the study delved into the environmental impacts of urban transformation and earthquakes. It explored the effects of the waste generated during building stock renewal through urban transformation and the construction and demolition waste resulting from earthquakes. The literature review concluded with an examination of the concept of sustainable construction, followed by a discussion on the management of construction and demolition waste, and an exploration of Life Cycle Assessment (LCA) in this context.

In the second stage, a specific structure was selected as an example. The study provided details about the chosen structure, along with the reasons for its selection. Two different softwares, DesignBuilder version 4.5.0.148 & EnergyPlus 8. 3, were used to simulate the calculation of the structure's operational energy. The embodied energy calculation for the structure was performed using the Athena Impact Estimator software.

In the third stage, the information gathered from the literature review and the detailed analysis of the calculated operational and embodied energy quantities from the simulation programs were thoroughly examined, and the resulting outputs were interpreted.

1.4 Literature Review

In the subsequent sections of the thesis, the concepts of "earthquake,""urban transformation,""construction and demolition waste,""structure and energy," and "buried energy" are extensively discussed. Within the scope of the main subject of the thesis, the focus on construction and demolition waste is limited to those arising from earthquakes and urban transformation. However, a limited number of sources within the literature specifically address this scope. The literature review has expanded this scope to enable a more comprehensive examination of the topic. The studies reviewed within the literature encompass the management of construction and demolition waste, construction and demolition waste arising from earthquakes and urban transformation, the buried energy potential of construction and demolition waste, and sustainability aspects of construction and demolition waste.

Zhaob et al. (2023), study elucidates the movement of Construction and Demolition (C&D) waste, analyzing the carbon emissions associated with its disposal through the application of Life Cycle Assessment and IPCC methods in Japan. The potential impact of C&D waste recycling on reducing carbon emissions is predicted under three scenarios (Baseline scenario, large area scenario, and Long lifespan scenario) by modeling the flow of building stock (Zhaob et al., 2023). In their studies, Zhang et al. (2023), propose a unique research method combining qualitative and quantitative approaches in big data analysis and machine learning. This method aims to explore knowledge and innovations related to CDWM from academic and industrial perspectives (Zhang et al., 2023). Yeheyis et al. (2012), suggest a conceptual framework for the management of Construction and Demolition (C&D) waste in Canada, aiming to maximize the 3R principles (reduce, reuse, and recycle) and minimize the disposal of construction waste. The framework advocates for the implementation of a sustainable and comprehensive strategy throughout the lifecycle of construction projects (Yeheyis et al., 2012). Salgın (2019), has examined the regulations related to construction and demolition waste management in Turkey, identifying and determining the deficiencies in these regulations. According to Salgın, the regulations concerning hazardous waste categories and those prepared for these wastes are significantly inadequate (Salgın, 2019). Soylu (2020), aimed to develop an approach for the design of disassembly-friendly structural elements with BIM coordination in the context of structural sustainability. The designed structural element aims to provide flexibility for possible interventions such as repairs, alterations, transformations, disassembly, demolitions, and renewals throughout its lifespan. The goal is to minimize structural waste production when the element reaches the end of its life and to plan how these wastes will be transformed during the design phase. It is envisaged that the created disassembly-friendly structural element can be transformed into a database through BIM (Building Information Modeling) and stored, making it usable in future projects. As a result, it is believed that this approach can contribute to the construction industry's adoption of alternative methods and the closed-loop nature of waste cycles (Soylu, 2020). In his study focused on reducing the environmental impacts of construction waste, Çiçekci (2020), highlights the oversight of construction waste within the construction industry throughout the construction period. The objective is to enhance recycling and reuse opportunities by developing a waste management model for the construction process in order to minimize the environmental effects of construction waste (Çiçekci, 2020). Amaral et al. (2020), argue that, prior to physical construction; designers play a crucial role in minimizing construction waste by utilizing component prefabrication, material standardization, and emerging BIM technologies. Designing for limited waste is the fundamental initial step toward an effective waste management plan (Amaral et al., 2020).

Doming and Luo (2023), conducted a study examining the management of Construction and Demolition (C&D) waste in the aftermath of the Canterbury earthquake in New Zealand. Their research identifies constraints and puts forth recommendations to improve recovery efforts in the face of future disasters. The investigation involved in-depth semi-structured interviews and surveys with governmental and non-governmental entities involved in C&D waste management, including the Canterbury Earthquake Recovery Authority (CERA) and accredited demolition contractors. The results underscore the effectiveness of CERA's "pick and go" approach in efficiently directing debris to end-use markets. The study also pinpointed several limitations in the existing C&D waste management process, such as a lack of waste-processing facilities, incomplete policies and regulations, organizational constraints, and insufficient communication and coordination among relevant stakeholders. In the studies by Doğdu and Alkan, the mass quantities of Construction and Demolition Wastes (CDWs) generated during the earthquakes in Kahramanmaraş were calculated and compared with the waste amounts generated in other earthquakes worldwide. The mass distribution of CDWs was computed, identifying the distribution of waste that requires urgent intervention, is recoverable, and can be reused in reconstruction efforts (Doming and Luo, 2023). Demir&Dinçer (2023), estimate that, following the earthquakes on February 6, 2023, in the province of Kahramanmaraş, approximately 15 million tons of construction and demolition waste and 41,000 tons of household waste were generated. Additionally, they propose eight temporary disaster waste sites, considering various environmental and technical criteria (Demir&Dinçer, 2023). Xiao et al. (2023), examine the damage to buildings in the earthquake-affected areas of Turkey, including reinforced and masonry structures. Based on this analysis, the estimated amount and composition ratio of demolition waste generated are outlined. Consequently, the paper suggests a strategy for recycling post-earthquake demolition waste and planning application scenarios for recycled products. In conclusion, the quantity of demolition waste generated after the earthquake varies between 450 and 920 million tons, presenting new ideas for post-disaster reconstruction efforts. Additionally, post-disaster waste management, safe demolition, and environmentally friendly disposal and recycling technologies for demolition and construction waste can offer significant economic and environmental benefits, assisting in the reconstruction of disaster areas and serving as a model for the global resource utilization of construction and demolition waste (Xiao et al., 2023).

Bilgili & Çetinkaya (2023), conducted an examination of the environmental impacts of construction and demolition waste resulting from earthquakes, utilizing a life cycle assessment to calculate these impacts. Initially, they computed the effects of the currently employed landfill process, followed by creating a scenario involving the reuse of concrete, separation, and recycling of recyclable wastes, and sending the remaining waste to a landfill. The findings indicate that if all debris is sent to a landfill, it will generate 11.9 tons of CO_2e in the short term, while significant savings of 18,428.3 tons of CO_2e can be achieved, especially through the reuse of concrete (Bilgili& Çetinkaya, 2023). Karademir & Özbakır (n.d), stated that mapping environmental pollution associated with urban transformation using a Geographic Information System (GIS) aimed to contribute to the development of a method, particularly to reduce environmental problems caused by urban transformation (Karademir& Özbakır, n.d). Gün et al. (2020), aim to critically evaluate the strengths and weaknesses of urban transformation practices in Turkey, focusing particularly on Istanbul, and to create a novel participatory design model for urban transformation processes utilizing context-specific ICT-based participation tools and techniques. Their paper critically examines and discusses urban transformation processes in Istanbul, tracing how these practices unfold on the ground and taking into account the diverse perspectives of stakeholder groups (2020).

According to Häkkinen and colleagues (2015), the evaluation of relevant literature, interviews with practicing architects, and a building case study recommend a gradual progression across all design phases to achieve low-carbon building design. This should systematically describe the status, coverage, and accuracy of greenhouse gas assessments at each design stage (Häkkinen, 2015). Venkatraj et al. (2020), quantify and compare the mutual effects of OE reduction measures on EE demand for eight different building wall assemblies in four distinct climatic zones within the United States. While the calculated energy efficiency factors vary based on different climate regions and construction structures, these factors indicate significant energy efficiency costs for various OE reduction measures. This information can assist in designing evolutionary and deep/machine learning-based algorithms to assess and optimize a building's energy use (Venkatraj et al., 2020). Dixit et al. (2010), have recently focused on the importance of embodied energy in building materials, particularly emphasizing this concealed energy fraction. Current interpretations of embodied energy are highly uncertain and vary significantly, and embodied energy databases face issues of variability and comparability. Furthermore, there is currently no reliable template, standard, or protocol to address these problems in embodied energy inventories. They aim to contribute to the development of a consistent and comparable database by analyzing existing literature (Dixit et al., 2010). Akbarnezhad& Xiao (2017), provide a review of the existing literature on approaches to decrease the embodied carbon of buildings and techniques for assessing the embodied carbon of buildings. The strengths and weaknesses of each method are emphasized (Akbarnezhad& Xiao, 2017). According to Azari& Abbasabadi (2018), past research and practices have primarily focused on reducing operational energy consumption in buildings, leading to an increased share of embodied energy. It provides an overview of methodologies and tools for estimating embodied energy, presents values from the literature for different building types, and examines shifts in the significance of embodied energy in the life cycle energy use of buildings. The article also explores the relationship between embodied energy and building height, particularly in tall buildings. Finally, it covers major strategies to reduce embodied energy, research gaps, and trends in the field (Azari& Abbasabadi, 2018). Chastas et al., (2016), in their literature review, identified a significant 17% difference in the share of embodied energy between nearly zero-energy and the most energy-efficient buildings examined. This difference indicates the relative importance of embodied energy over time and towards, and it could vary when considering the underestimation of embodied energy due to uncertainty and process analysis. The increase in embodied energy in buildings highlights the necessity of a comprehensive life cycle energy analysis within the current framework of energy efficiency regulations (Chastas et al., 2016). Dempsey& Mathews (2023), assert that is oriented toward developing a validated database that includes the records of Environmental Product Data certificates (EPD) necessary for accurate greenhouse gas emissions (GWP) calculations for building materials. The study has created a set of workflows that can be utilized to automate and monitor GWP to aid professionals in achieving the RIAI 2025/2030 embodied carbon targets. The outcomes serve as a proof of concept for automating GWP calculations through the digital building model database, providing the design team with visual feedback to empower their decision-making in the design process (Dempsey& Mathews, 2023). In their study, Zhixing et al. (2019), propose a simplified model for calculating embodied carbon emissions during the building design stage. To achieve this, they conducted a process-based inventory analysis of carbon emissions from materials used in 129 residential buildings, 41 office buildings, and 21 commercial buildings during the materialization phase in China. The results reveal that the average carbon emissions per unit area from building materials used in residential buildings, office buildings, and commercial buildings are 514.66 $kgCO_2e/m^2$ 533.69 $kgCO_2e/m^2$, and 494.19 $kgCO_2e/m^2$, respectively (Zhixing et al., 2019) . In Xia's paper (2023), a thorough evaluation and examination of software applications calculating embodied carbon energy is conducted. Additionally, the study introduces the concept of swiftly obtaining potential material inventories and predicting the CO_2 footprint over the entire lifecycle of a building (Xia, 2023). Erzurum& Bettemir (2023), focus on determining and analyzing the environmental impacts of construction activities. Evaluating the construction process of a single-story building in a rural area, the research examines the effects of different construction options on embodied energy, carbon emissions, and costs. Simulations conducted in the study reveal the impact of construction activities on these factors. The analysis provides insights for researchers working on green building design (Erzurum& Bettemir, 2023). Ding &Ying (2019) has chosen a town in South China for conducting multiple case studies to analyze and compare the energy efficiency of both historic and modern residences. The findings indicate that, over 12 months, modern buildings generally outperform historic houses in terms of energy consumption for heating but consume significantly more energy for cooling. Nevertheless, historic houses surpass modern buildings in embodied energy and carbon analysis. If these historic houses were to be replaced with energy-efficient structures, it would take approximately 18 to 41 years to recover the embodied energy invested in the materials for the new buildings (Ding &Ying, 2019).

In the case study in Chapter 5 of the thesis, similar to the work of Ding and Ying, the operational energy and the embodied energy required to rebuild buildings that will be demolished and reconstructed through urban transformation were calculated using two different simulation programs to make a comparison.

2. EARTHQUAKE AND TURKEY

Turkey, nestled within the seismic girdle of the globe by virtue of its geographic disposition, finds itself subject to the caprice of tectonic upheavals. The North Anatolian Rift, East Anatolian Rift, and sundry other geological creases loom large as formidable fissures, recurrently thrusting Turkey into the throes of seismic convulsions. Hence, it stands to reason that Turkey occupies a precinct fraught with an elevated proclivity for earthquakes.

Over the annals of time, seismic cataclysms in sundry locales of Turkey have underscored the nation's susceptibility to earthquakes. Especially since the mid-twentieth century, a succession of seismic upheavals has wrought havoc upon human existence and infrastructure alike. The seismic convulsion christened the "Gölcük Cataclysm" wrought profound ramifications upon Turkey in 1999, unfolding along the North Anatolian Rift within the Marmara domain. This seismic episode exacted a toll of hundreds of lives and inflicted injuries upon myriad denizens. Moreover, metropolitan bastions like Istanbul bore the brunt of substantial infrastructural devastation. In consequence, this increase in seismicity increased awareness of seismic hazards and pre-emptive measures within Turkey.

Turkey is taking a mix of measures to reduce seismic risk and strengthen social resilience. Efforts including construction of earthquake resistant structures, distribution of earthquake safety measures and contingency plans are poised to make the country ready for earthquakes deal with It required active involvement of the massesAdditionally, the imperative of investing in seismic research and early-warning frameworks cannot be gainsaid.

Turkey's geographic landscape, replete with active tectonic demarcations like the East Mediterranean and North Anatolian fault lines, engenders a milieu rife with seismic perturbations. The ecological repercussions of earthquakes in this milieu are inherently labyrinthine and multifaceted. Earthquakes, particularly those stemming from subterranean tremors, hold the potential to disrupt hydrological systems, precipitating perturbations in water reservoirs. Ruptures in the terrestrial fabric may exacerbate soil erosion, precipitating a diminution in agrarian yields. Furthermore, modifications at ground level can perturb watercourses, thereby accentuating the specter of inundation.

The enduring ecological aftermath of earthquakes is epitomized by structural dilapidation and infrastructure attrition. Such a scenario has the capacity to disrupt the equilibrium of ecosystems and substantially undermine regional ecological integrity. Moreover, landslides and crevasses triggered by seismic upheavals can precipitate profound alterations in natural habitats. Given these exigencies, a comprehensive comprehension of the ecological reverberations of earthquakes in Turkey assumes paramount importance. Devising sustainable development blueprints and implementing risk-mitigation stratagems are indispensable, both for ecological sustainability and societal robustness in the face of seismic exigencies.

Figure 2.1 : Debris removal works in Kahramanmaraş (Url-1)

Figure 2.2 : Heavily damaged buildings in Gölcük (Url-2)

Table 2.1: Richter Scale (Boore, 1989)

Richter Scale	Magnitude Range	Potential Effects
0-3.9	Small	Rarely felt, usually does not cause damage
4.0-4.9	Light	Often felt, but typically does not cause significant damage
5.0-5.9	Moderate	Can cause damage in ffected areas, especially in poorly constructed buildings.
6.0-6.9	Strong	Can cause extensive damage in large areas, especially in poorly constructed buildings
7.0-7.9	Major	Can cause serious damage in cities and large regions
8.0-8.9	Great	Can cause devastating effects in large areas, with destructive impacts on cities
9.0 and above	Huge	Can lead to catastrophic effects in vast regions, affecting very large areas

The following tables provide a summary of possible responses to earthquakes ranked according to the Richter scale. However, it is important to emphasize that the actual consequences of an earthquake depend on the local conditions, soil properties and structural integrity of the buildings. Consequently, the potential ramifications of an earthquake necessitate an appraisal that factors in these local variables and the seismic depth. These seismic events frequently precipitate substantial devastation and human casualties.

Foremost among the calamities wrought by earthquakes is the inadequacy of seismic fortification within the constructed milieu. The rapid urban expansion and burgeoning population density, particularly in metropolitan locales, exacerbate the vulnerability of structures with deficient seismic resilience. The collapse of edifices, infrastructural impairments, and the ensuing economic debilitation constitute pivotal facets of the seismic hazard in the nation.

Furthermore, stricken regions grapple with sociopsychological reverberations. Loss of life, injuries, and the displacement of populace collectively impinge upon the holistic well-being of society. This underscores the reality that earthquakes not only impact tangible infrastructure but also precipitate profound societal repercussions.

2.1 Expected Istanbul Earthquake

Located in a high seismic hazard zone in Turkey, Istanbul lies within reach of the North Anatolian Fault Line running along the Marmara Extension This fault line looks dangerous, and has the chance of a large potential earthquake has threatened Istanbul. Scientists underscore the active nature of this fault line, which historically has precipitated significant seismic upheavals at intermittent intervals.

Of particular note is the Gölcük earthquake of 1999, which unfolded to the southeast of the Marmara Sea and reverberated its impact upon Istanbul. Such occurrences serve as poignant reminders of the seismic predisposition inherent in the region. Experts advocate not only the implementation of preemptive measures but also the cultivation of earthquake preparedness among individuals and communities. This entails formulating emergency protocols and adhering to directives disseminated by local authorities

Given the seismic vulnerability of Istanbul, both non-governmental entities and governmental bodies incessantly revise their strategies for post-earthquake recovery and response, whilst concurrently endeavoring to heighten public awareness. The Project for Updating Expected Earthquake Loss Estimates in Istanbul, spearheaded by the Department of Earthquake Engineering at Boğaziçi University's Kandilli Observatory and Earthquake Research Institute, constitutes a multifaceted endeavor. Employing a plethora of simulations and copious data, this initiative aims to prognosticate potential ramifications in Istanbul across varied seismic scenarios.

The project, calibrated to gauge potential seismic perils and losses in Istanbul, harnesses extant demographic, architectural, and infrastructural registries. Informed by contemporary insights and methodologies pertaining to seismic hazards, the project's findings, predicated on updated infrastructural and superstructural datasets, hold pivotal significance for urban planning, disaster mitigation schemes, and structural amelioration endeavors. Especially poignant as the 20th anniversary of the Kocaeli and Düzce earthquakes looms, this project encompasses seismic hazard assessments, urban infrastructure and superstructure risk appraisals, and seismic risk evaluations.

Projections pertaining to building impairments, loss of life, injuries, and infrastructural impairments are extrapolated based on simulated seismic scenarios featuring a magnitude of Mw=7.5. These scenarios encompass a gamut of 15 disparate seismic scenarios derived from simulation, alongside probabilistic distributions of seismic ground motions corresponding to recurrence intervals of 72, 475, and 2475 years (DEZIM, 2018).

Table 2.2 Damage expectations of simulated scenarios Mw=7.5 **(**DEZIM,2018)

Damage Status	Analysis Method CSM	Analysis Method MADRS	Analysis Method CM	Average	Percentage of Total Buildings
Very Severe	18,58	9309	12595	13495	1,2%
Severe	39512	27131	36391	34345	2,9%
Moderate	143136	129554	166966	146552	12,6%
Light	282953	289787	332139	301626	25,9%
No Damage	682149	710549	618239	670312	57,5%

2.2 History of Earthquake Regulations

While Turkey has developed various strategies to cope with earthquake risks and has enhanced measures such as building standards, ongoing and comprehensive efforts are essential in this regard. Combining scientific, technical, and societal measures in earthquake resilience efforts is critical for minimizing post-earthquake damages and enhancing community resilience. When examining Turkey's earthquake history over the past century, which has three active fault systems, it is observed that many destructive earthquakes have occurred, leading to significant loss of life and property. In these major earthquakes, houses, public buildings, structures deemed as historical monuments, and infrastructure such as roads and bridges have either collapsed or suffered severe damage. To minimize these losses and construct earthquake-resistant buildings, earthquake regulations have been issued at different times (Şenol et al., 2023).

Table 2.3: Turkey earthquake regulations (TDMD)

Name	Year
Italian Building Instructions for Construction in Earthquake Zones	1940
Earthquake Zones Temporary Construction Instructions	1944
Türkiye Earthquake Zones Building Regulations	1949
Regulation on Buildings to be Built in Earthquake Zones	1953
Regulation on Buildings to be Built in Disaster Areas	1962
Regulation on Buildings to be Built in Disaster Areas	1968
Regulation on Building to be Built in Disaster Areas	1975
Regulation on Building to be Built in Disaster Areas	1998
Regulation on Buildings to be Built in Earthquake Zones	2007
Turkey Building Earthquake Regulation	2018

2.3 Urban Transformation

Cities, while meeting the housing needs of large human populations, are structures where economic, social, and cultural interactions take place. They establish networks of production and consumption, providing a much broader spectrum of presentation areas compared to other settlements. Throughout history, urban spaces shaped by extensive human circulation have faced different potentials and challenges, particularly in the last 150 years due to technological advancements (Köse et al., 2023). Today, cities face significant challenges due to rapid population growth, aging infrastructure, and the risks posed by natural disasters. Consequently, urban transformation has become increasingly crucial. Urban transformation is a planned process aimed at strengthening, modernizing, and enhancing the quality of life within cities. The key elements of this transformation include risk reduction and safety, renewal and modernization, infrastructure development, and social impact. Priority goals encompass making non-resilient structures resistant to natural disasters, replacing old buildings with modern ones, improving infrastructure, and addressing the needs of the community. Urban transformation is the planned renewal of physical, social, economic, and environmental structures in urban areas. This renewal aims to enhance the use of existing spaces, improve environmental quality, preserve historical and cultural values, and increase social harmony and economic vitality (Şen, 2024). The urban transformation process typically involves several stages. The initial phase entails analyzing the region and determining its transformation potential. Following this, there's the establishment of legal regulations and acquiring necessary permits, subsequently moving to demolition or renovation. This phase involves renovating or replacing old and risky buildings with modern structures. The final stages include the settlement of new buildings, creating green spaces, and organizing services such as transportation. Urban transformation goes beyond mere physical changes; it also considers social impacts. Community involvement, meeting local needs, and ensuring a fair process are crucial for successful urban transformation. Social impacts, property rights, and community needs should be carefully addressed during this process. Urban remodeling involves the reorganization of urban areas through the introduction of new buildings and public spaces. When urban transformation occurs through a hybrid intervention, it entails the redefinition of public spaces. In contrast, urban renovation represents a comprehensive intervention that not only transforms buildings but also adapts public spaces to meet current requirements. Each of these interventions relies on a preceding diagnostic process to identify essential needs. Defining this diagnostic is a sophisticated linear research endeavor that commonly involves utilizing urban indicators to determine the type of intervention needed. Urban transformation plays a significant role in the future sustainability and livability of cities. Recently, urban planning approaches such as sustainable and smart cities have come to the forefront, exerting pressure on the redevelopment of urban transformation practices. As the dynamics of urbanization change globally, urban transformation applications and approaches also need to evolve. New approaches are particularly necessary to address situations that impact entire cities, such as disaster risks, climate change, energy crises, and urban population growth (Çakır, 2023). However, successful urban transformation projects require careful planning, community involvement, and social consensus. Projects executed in this manner can lead to substantial improvements in urban safety, quality of life, and community well-being.

The objectives of urban transformation projects may include:

Urban transformation projects aim to achieve a myriad of objectives, each tailored to address specific challenges and requirements inherent in the urban landscape:

1.Creating Safe Living Spaces in High-Risk Areas:

- Erecting resilient housing and infrastructure in regions susceptible to natural calamities such as earthquakes or floods.

2. Environmental Planning and Green Spaces:

- Augmenting verdant expanses and integrating environmental planning into urban renewal endeavors.

3. Energy Efficiency and Sustainability:

- Advocating for energy-conserving and sustainable methodologies in new construction ventures.

4. Improvements in Public Transportation and Infrastructure:

- Bolstering public transit networks and ameliorating the overall urban infrastructure framework.

5. Social and Cultural Enhancements:

- Enriching social and cultural enclaves to nurture communal cohesion and camaraderie.

6. Economic Development and Employment Generation:

- Fostering economic vitality through urban revitalization projects and fostering novel avenues for job creation.

7. Increasing Housing Availability:

- Expanding the residential inventory to accommodate burgeoning demand and alleviate housing shortages.

8. Risk Mitigation and Emergency Readiness:

- Formulating contingency protocols to facilitate swift and efficient responses in the event of crises.

9. Enhanced Access to Public Amenities and Services:

- Enhancing accessibility to communal amenities and facilities, while fortifying community hubs.

10. Rehabilitation and Preservation:

- Revitalizing antiquated or underutilized edifices to safeguard urban integrity and historical legacy.

These overarching objectives furnish the foundational scaffold for urban renewal initiatives, albeit with the flexibility to adapt and tailor specific aims to the distinctive exigencies and contexts of individual projects.

2.3.1 Evolution of urban transformation

Urban transformation, an intricate and dynamic process, weaves its history through the fabric of human civilization. To embarking on a comprehensive journey, delving into critical junctures and paradigms that have shaped the complex narrative of urban development from the throes of industrialization to the multifaceted challenges of the present day. The global history of urban transformation is a nuanced narrative spanning centuries, shaped by diverse sociocultural, economic, and environmental factors. With a comprehensive understanding, urban transformation involves the redevelopment and revitalization of the economic and structural conditions of an area, balancing environmental quality and social diversity. In this context, urban transformation is more about planning and managing the existing urban environment than planning and developing new urban areas. Therefore, urban transformation processes are influenced by various actors in city development processes, including urban planners, developers (real estate investors, property development experts, etc.), designers (architects, urban designers, etc.), contractors, citizens (as users), and local governments (Gülümser et al., 2023). The concept of urban transformation, especially in the 19th century, had significant impacts. The Industrial Revolution led to the gathering of people from rural areas to work in large factories, along with an increase in the number of individuals needed for trade and public services in these areas. As a result, the urban population rapidly increased. This, as mentioned earlier, inevitably led to a high level of interaction and transformation between people and their environment. Consequently, a large number of people interacting with a specific region resulted in a notable increase in the pace of changing and transforming the cities where they lived (Demirel, 2018). The Industrial Revolution marked a pivotal era, propelling rapid urbanization and introducing challenges like overcrowding and insufficient infrastructure. The subsequent City Beautiful movement sought to counter these issues through aesthetic urban planning. Following World War II, the post-war era witnessed a transformative overhaul of cityscapes, characterized by the ascendance of urban renewal endeavors in the mid-20th century. However, critiques of authoritative top-down methodologies precipitated a paradigmatic shift towards participatory planning and sustainable development in the latter half of the 20th century. Presently, the urban milieu contends with multifaceted challenges such as gentrification, burgeoning informal settlements, and the imperative for astute smart city solutions. Against the backdrop of globalization and the specter of climate change, the United Nations' Sustainable Development Goals underscore the paramountcy of crafting inclusive, resilient, and sustainable urban habitats. As we cast our gaze towards the horizon, forthcoming trends are poised to be shaped by pioneering strides in technology, a rekindled emphasis on equity, and concerted endeavors to engender cities that are both conducive to habitation and environmentally sound.

- The Genesis: Urbanization and Industrial Revolution (18th–19th centuries):

The inception of urban transformation traces its origins to the era of industrialization. The 18th and 19th centuries bore witness to a momentous upheaval as cities burgeoned into vibrant hubs of commerce and industry. The advent of the Industrial Revolution, characterized by its revolutionary technologies, not only catalyzed economic expansion but also precipitated the swift urbanization that served as the bedrock for subsequent phases of urban renewal.

- Post-World War II Urban Renewal: A Landscape in Ruins (1945–1970s):

The post-World War II era unveiled cities scarred by conflict and destruction, birthing an urgent need for urban renewal. This period witnessed ambitious endeavors aimed at resurrecting urban centers from the ashes of war. Projects, though well-intentioned, faced criticism as lofty ideals clashed with the stark realities of community displacements and the erosion of historical urban fabric.

- Modernist Megaprojects and Their Critiques (1960s–1980s):

The mid-20th century witnessed the rise of modernist urban planning typified by ambitious megaprojects. These colossal undertakings sought to redefine urban panoramas but were not impervious to criticism. Detractors highlighted the social disparities, cultural homogenization, and ecological ramifications stemming from centralized planning, prompting a reassessment of the magnitude and principles guiding urban development.

- Sustainability and the Rise of Smart Cities (1990s–2000s):

During the latter half of the 20th century, there was a significant move towards sustainable urban development. The concept of "smart cities" gained traction, utilizing advancements in technology to enhance urban living experiences. The notion of "smart cities" rose to prominence, harnessing technological progress to enrich urban life. Sustainability emerged as a central tenet, stressing resource optimization, environmental mindfulness, and civic involvement as fundamental facets of urban design.

- Gentrification, Regeneration, and Community-led Movements (1980s–present):

Amidst the latter part of the 20th century, a nuanced dance unfolded, entwining the realms of urban rejuvenation and gentrification. Gentrification, distinguished by its intricate socio-economic ramifications, progressed in tandem with endeavors aimed at breathing new life into deteriorating urban areas. Simultaneously, grassroots movements advocating for inclusivity, social parity, and the preservation of communal identity challenged the established norms of urban development.

- Contemporary Challenges: Resilience and Adaptive Urbanism (21st century):

The awn dof the 21st century brought forth unprecedented trials for metropolitan regions. Resilience and flexible approaches emerged as focal points in tackling climate variability, environmental upheavals, and worldwide health emergencies. The incorporation of verdant expanses, eco-friendly infrastructure, and community-led endeavors epitomizes a contemporary shift towards comprehensive and adaptable urbanism, wherein cities adapt in tandem with the demands of their denizens.

The tale of urban metamorphosis unfurls as a lavish mosaic, intricately entwined with strands of industrialization, post-war reconstruction, modernist aspirations, sustainable initiatives, socio-economic transitions, and grassroots movements. This historical journey acts as a guiding light, directing urban planners and policymakers towards discerning and contextually aware strategies in confronting the complexities of urban growth. The narrative of urban transformation surpasses mere architectural accomplishments; it mirrors societal dreams, principles, and the perpetual evolution of urban existence.

2.3.2The significance of urban transformation

Urban transformation represents a dynamic process that plays a pivotal role in reshaping cities, driving sustainable development, and fostering an improved quality of life. It encompasses a multitude of advantages that influence safety, the environment, economic growth, social integration, and property value. Urban transformation is a migration of individuals from rural environments to urban regions, encompassing a range of phenomena such as increased income levels, enhanced infrastructure, improved health facilities, and access to educational resources. While these phenomena contribute to the improvement of people's well-being by significantly elevating their living standards, the human activities associated with these changes also contribute to an escalating environmental burden, primarily through emissions, largely originating from the energy industry (Ahmad et al., 2023).

Primarily, the enhancement of safety and resilience stands as one of the most significant advantages of urban transformation. By renovating, reinforcing, or replacing aged and vulnerable structures, cities become more resistant to natural disasters. This proactive stance towards urban advancement substantially mitigates risks linked to seismic events, floods, or other potential perils, nurturing a safer milieu for inhabitants and notably curbing potential casualties and property loss. Additionally, environmental sustainability stands as a pivotal facet of urban evolution. The adoption of eco-friendly designs, energy-efficient technologies and waste-reducing features in renovated buildings, not only reduces environmental impact but contributes to global shift towards sustainability Green space, flexible waste management, eco-friendly construction practices And integration significantly reduces the city’s carbon footprint, which will have healthy and environmentally friendly living spaces that are eco-friendly, energy-efficient technologies, and waste reduction in redesigned buildings are not to clean up the environment not only the environment but also the global transition towards a more sustainable future The implementation of contributing green spaces, effective waste management and sustainable construction reduces the city’s carbon footprint substantially, creating a more healthy and balanced environment. Urban transformation also contributes to improving living conditions in cities. The construction of modern buildings with upgraded amenities, improvement of public infrastructure, creation of pedestrian-friendly zones, and the enhancement of parks and recreational spaces significantly enhances the living standards and comfort of city dwellers. Revitalized urban spaces provide a harmonious blend of convenience, comfort, and aesthetics, ultimately elevating the residents' quality of life. The urban transformation of many contemporary cities has been shaped around the concepts of 'culture-led regeneration' and the 'creative city.' However, the implemented policies often fall short of the initial expectations. In fact, they have been linked to negative effects such as gentrification, polarization of the labor market, casualization of the cultural sector, and the commoditization of the creative process, as well as the trivialization of heritage assets. Given this reality, it is appropriate to inquire whether culture and creativity can become the driving forces behind sustainable regeneration—materially, economically, socioculturally, and environmentally viable in the long term—without leading to such undesired outcomes (Casals-Alsina, 2023). From an economic perspective, the redevelopment of urban areas acts as an economic stimulant. The revitalization of regions typically results in increased property values, attracting investments and stimulating economic growth. This resurgence in urban zones also spurs employment opportunities, generating a positive ripple effect on local economies. Increased demand for various services, including retail, entertainment, and construction, helps bolster economic prosperity. The social dimension of urban transformation is equally critical. Through urban restructuring, the focus extends to catering to the diverse needs of the community, fostering social inclusivity and cohesion. Enhancements in infrastructure, the establishment of communal areas, and promotion of community involvement culminate in a more interconnected, lively, and participatory society. Lastly, the escalation in property worth stands as a notable consequence of urban revitalization. The refurbishment of neighborhoods, erection of contemporary structures, and overall enhancement of urban scenery frequently elevate the value of adjacent properties, benefiting homeowners and investors alike. Urban transformation embodies a multifaceted progression that positively influences safety, sustainability, standard of living, economic expansion, social cohesion, and property evaluations. This approach not only creates safer and more sustainable urban environments but also significantly contributes to the overall well-being of societies, presenting a roadmap for a more prosperous and harmonious future. In Turkey, the concept of urban transformation was initially applied until the late 1990s to improve deteriorated and blighted areas of cities through an integrated approach addressing economic, social, environmental, and physical issues. Regulations implemented after 1999 focused on reconstructing buildings vulnerable to disasters and strengthening those with repair possibilities. However, within the scope of urban transformation, instead of maintenance, repair, or reinforcement efforts, there has been a tendency towards the rapid demolition and reconstruction of buildings (Doğan&Koman, 2022).

In Turkey, the concepts of urban transformation and sustainability have become increasingly significant fields of research and planning in response to the growing population and urbanization pressures. Urban transformation is typically a process carried out in urban areas to strengthen the existing building stock and enhance the quality of life. However, focusing on sustainability principles during this transformation process requires a comprehensive approach that encompasses environmental, economic, and social dimensions. The Ministry of Environment, Urbanization, and Climate Change in Turkey has announced that approximately 14 million out of 19 million residential buildings in the existing housing stock need to be assessed for disaster risk. It is emphasized that buildings lacking earthquake-resistant design and implementation criteria pose a risk, and it is projected that they need to be demolished within the next 20 years. Consequently, the ministry aims to facilitate the demolition and reconstruction of an average of 334,000 buildings annually as part of urban renewal efforts (2019).

Sustainable urban transformation denotes an integrated strategy that includes elements such as energy efficiency, environmental quality, social participation, and economic development. In this context, urban transformation projects should not only be limited to structural improvements but should also support sustainable urban development by reducing environmental impacts and strengthening social balance. Factors such as community participation, preservation of cultural values, increased green spaces, and energy-saving measures should be taken into account to ensure that urban transformation projects are managed in line with sustainability goals. The integration of urban transformation and sustainability concepts is a crucial step in creating healthier, more livable, and environmentally compatible cities in Turkey's rapidly changing urban landscape. In contemporary urban transformation processes, demolition activities are carried out without conducting analyses of building structures and their surroundings, and without questioning the possibilities of disassembly, demolition, and recycling of building components. Additionally, companies, aiming to reduce demolition costs, often opt for less qualified teams and prefer conventional tools and methods during demolition processes. This situation leads to the formation of structural waste, noise, and dust, increased traffic load, and the release of toxic and hazardous substances. It not only harms the environment, human health, and natural resources but also has negative implications for the country's economy

(Doğan&Koman, 2022). Key princibles of sustainable urban transformation are listed below

- Social Participation and Collaboration:
    - ➢ Projects should involve the participation and feedback of affected communities. Continuous dialogue is necessary to understand community needs and expectations.
- Reduction of Environmental Impact:
    - ➢ Focus on environmental factors such as energy efficiency, green infrastructure, and waste management. The use of sustainable materials and energy-saving measures can minimize the environmental footprint of projects.
- Respect for Cultural and Historical Values:
    - ➢ Urban transformation projects should preserve the cultural and historical heritage of the region. Preserving traditional architectural elements and significant historical structures contributes to maintaining the city's identity.
- Increase in Green Spaces:
    - ➢ Sustainable urban transformation should provide more green areas and open spaces. This not only enhances environmental sustainability but also improves the quality of life for residents.
- Transportation and Infrastructure Improvements:
    - ➢ Investments in public transportation, increased bicycle paths, and pedestrian-friendly areas promote sustainable transportation. Additionally, energy-efficient infrastructure systems are crucial.
- Economic Development:
    - ➢ Projects should be designed to strengthen the local economy and reduce social inequalities. Support for local job opportunities and small businesses is important.
- Disaster Resilience:
    - ➢ To reduce earthquake and other natural disaster risks, buildings should be reinforced, and structural measures should be implemented.

- Continuous Monitoring and Evaluation:
    - ➢ Regularly monitoring and evaluating project effectiveness allows for adaptation and improvement in the sustainable urban transformation process.

2.3.3 Turkey urban transformation history

Turkey has been undergoing a process of urban transformation and redevelopment in various cities. The first urban renewal actions in Turkey are known to be based on physical content urban planning regulations for organizing the fire-prone areas of Istanbul in the last century of the Ottoman Empire. The fire site plan prepared after the Aksaray fire in 1854 and the fire zone map prepared after the Hocapaşa fire in 1864 can be evaluated within this context (Yenice, 2014). Urbanization in Turkey began during the Republic era and continued until the dominance of major cities in the late 1950s. Migration emerged as a fundamental factor behind rapid economic growth, resulting in a significant influx of people from rural to urban areas. This trend posed a serious challenge to housing construction. During the economic development of the country in the 1950s and 1980s, migration from rural to urban areas increased even more than expected. This migration occurred repeatedly due to the opening of new factories in cities, leading to the emergence of shantytown neighborhoods around the city, primarily in vacant areas near factories. The urban changes during this period prompted the redevelopment of shantytown neighborhoods around cities for residential purposes, followed by further restructuring to accommodate various population groups (Kocaer, 2023).

- Gecekondu Settlements:
    - ➢ In the mid-20th century, informal settlements known as "gecekondu" (meaning "built overnight") emerged on the outskirts of major Turkish cities. These settlements were often constructed without proper permits and infrastructure.
- Urbanization and Modernization:
    - ➢ Turkey experienced rapid urbanization from the mid-20th century onwards as people migrated from rural areas to cities in search of better economic opportunities. - The government initiated modernization projects, including the development of infrastructure, housing, and public spaces.

- Gecekondu Transformation Programs:
    - ➢ In the late 20th and early 21st centuries, the Turkish government implemented various programs to transform gece kondu areas. These initiatives aimed to provide legal recognition, infrastructure improvements, and urban planning to these informal settlements.
- Urban Renewal and Regeneration:
    - ➢ Urban renewal projects became more prominent, especially in older neighborhoods with aging infrastructure.
    - ➢ The government aimed to improve living conditions, enhance infrastructure, and create more sustainable and resilient urban environments.
- Istanbul as a Focus:

➢ Istanbul, as Turkey's largest city, has been a focal point for urban transformation. Various districts, such as Beyoğlu and Fikirtepe, have undergone redevelopment to address issues like dilapidated buildings, inadequate infrastructure, and population density.

- Government Initiatives:
    - ➢ The Turkish government has been involved in urban transformation through legal frameworks and financial incentives for property owners to participate in renewal projects.
    - ➢ The Housing Development Administration of Turkey (TOKI) has played a role in constructing new housing developments as part of these transformation efforts.
- Challenges and Criticisms:
    - ➢ The urban transformation process has not been without challenges. There have been concerns about displacement, gentrification, and the impact on the social fabric of communities.
    - ➢ Some projects faced resistance from residents and activists who opposed the demolition of historical or culturally significant structures.

It's important to note that the success and effectiveness of urban transformation projects can vary, and ongoing dialogue between the government, local communities, and urban planners is crucial for addressing the diverse needs of different neighborhoods. For the latest and more specific information on Turkey's urban transformation, I recommend checking with official government sources or recent news updates.

2.3.4 Sustainability principles in urban transformation projects

Amid urban metamorphosis endeavors, the principles of sustainability encompass a myriad of facets, amalgamating environmental, economic, and social dimensions (Williamson et al. 2003). Delineate sustainability as the endeavor to enrich and safeguard human life quality while refraining from surpassing the ecosystem's carrying capacity. This elucidation is encapsulated by the abbreviation ESD, which delineates the impact of human endeavors on the Earth's carrying capacity. The letter 'E' envelops environmental, ecological, and even economic considerations. 'S' signifies sustainable or sustainability, while 'D' may denote development or design, contingent upon the context. The utilization of the ESD depiction, with its recent utilization, has yielded a broader perspective, furnishing a novel outlook on the globe and accentuating the global magnitude of the predicament. It underscores that these quandaries ensue due to population proliferation and the repercussions of human presence on the planet (Toptaş, 2012). From an environmental sustainability vantage point, urban metamorphosis endeavors ought to take into account quandaries such as energy conservation, water management, waste management, abatement of environmental pollution, and the utilization of eco-friendly materials (Karakaş & Özgen, 2016).

Energy Efficiency:

- ➢ Ensuring energy efficiency in the design and construction of buildings, reducing energy consumption, and incorporating renewable energy sources.

- Green Spaces and Biodiversity:
  - ➢ Increasing green areas in urban transformation projects, preserving natural habitats to encourage biodiversity and enhance the environment.
- Water Management:
  - ➢ Adopting sustainable water policies by promoting water conservation, rainwater harvesting, and efficient water use.
- Waste Management:

    - ➢ Implementing waste reduction, recycling, and proper waste management strategies to minimize environmental impact.
- Reducing Environmental Pollution:
    - ➢ Implementing measures to reduce environmental pollution, such as promoting public transportation to mitigate air pollution caused by transportation.
- Preservation of Historical and Cultural Values:
    - ➢ Respecting and protecting historical and cultural values during urban transformation processes.
- Community Participation and Social Balance:
    - ➢ Encouraging the involvement of the local community, maintaining social balance, and considering social impacts in urban transformation processes.
- Use of Eco-friendly Materials:
    - ➢ Choosing environmentally friendly and sustainable materials in construction to reduce environmental impact.

Urban metamorphosis endeavors meticulously crafted and executed in alignment with these tenets possess the capability to address present exigencies while simultaneously contributing to the advancement of sustainable urban evolution by taking into account the imperatives of forthcoming generations. "Sustainable urban transformation" delineates the integration of sustainability tenets in the process of rejuvenating metropolises. This endeavor necessitates a holistic methodology that concurrently addresses environmental, economic, and social sustainability tenets (Şen, 2022). The sustainable urban transformation paradigm constitutes an approach that encompasses sustainability tenets and implements them in the rejuvenation process of urban centers. This paradigm furnishes a balanced methodology for the rejuvenation of urban centers by simultaneously tackling environmental, economic, and social sustainability tenets (Cengiz& Eren, 2016). Sustainable urban transformation embodies a comprehensive and forward-thinking tactic that transcends mere environmental considerations, incorporating social equity and economic vigor as well. The approach acknowledges the dynamic and interconnected nature of urban landscapes, wherein environmental, social, and economic factors intertwine. It entails collaborative endeavors from governmental entities, enterprises, communities, and urban strategists to forge resilient urban vistas. Sustainability entails perceiving societal advancement beyond the proximate, the momentary, and the surface-level. It encompasses embracing the overarching notion that humanity ought to adopt a decentralized stance rather than one empowered by the exploitation of natural assets. Fundamentally, sustainability advocates for a paradigm shift, accentuating a protracted, holistic approach that acknowledges the interdependence of ecological, social, and economic frameworks. By recognizing our interrelatedness with the milieu and comprehending the ramifications of our actions, we can aspire towards a more balanced and accountable approach to advancement—one that contemplates the welfare of both present and forthcoming generations (Mercader-Moyano & Romas Martin, 2022). Verdant expanses and eco-conscious infrastructure, such as verdure-filled spaces, verdant rooftops, and sustainable conveyance systems, constitute indispensable constituents. Moreover, sustainable urban transformation underscores the significance of social inclusivity by nurturing affordable habitation, communal participation, and accessibility to indispensable amenities for all inhabitants. Economic resilience is also addressed through the fostering of green vocations, innovation nuclei, and the cultivation of circular economies. By integrating these principles, cities can evolve into thriving, sustainable ecosystems that not only endure environmental challenges but also enhance the overall well-being of their inhabitants and contribute positively to the global environment. In the contemporary realm of new and innovative design planning, discourse, and practical contexts related to climate change, there has been a resurgence of interest in some traditional urban planning tools and techniques. These once-dismissed ideas have re-emerged in the urban planning dialectic as novel research objects. The study revisits old discursive concepts and zoning methods that have been employed since the early twentieth century, emphasizing the separation of "industrial,""residential," and "green" areas. These previously established criteria, once considered outdated, have regained significance in the research aimed at shaping the future planning of cities. This reevaluation highlights the cyclical nature of urban planning approaches and underscores the importance of incorporating proven principles into the evolving discourse of contemporary city planning, particularly in the face of climate change challenges (Coşkun, 2022).

Since the 1990s, sustainability has been associated with various terms, leading to the perception that environmental concerns, such as green and ecological design, have evolved into what is now recognized as sustainable architecture. Despite the lack of climate change awareness in Turkey before the 1996 Istanbul Conference, global awareness began to surge following the 1992 Rio Conference. Subsequently, urban planning dynamics shifted worldwide, focusing on human well-being, sustainability, and resilience (Coşkun, 2022). While developing cities, including Istanbul, grappled with issues associated with massive inner migration and industrialization, the post-1980s era brought about a more innovative approach to solving urban challenges, spurred by increasing concerns about climate change. The transformation of Istanbul into a meg a-city with a 16 million population exacerbated problems related to urban and climatic effects. The dynamics of industrial-based cities faced complications due to the rapidly changing urban landscape, particularly concerning climate issues. In response to these challenges, the traditional centralization of business, commercial, and industrial functions within cities gave way to a dispersed model across broader areas connected by complex highway networks. In Istanbul, this manifested as urban sprawl, characterized by the expansion of industrial and residential areas and highways. This expansion posed a threat to green spaces and forests, intensifying existing environmental issues induced by inner and transnational migration.

The rapid urban transformation unfolding in Istanbul introduces a multifaceted challenge as the city undergoes extensive redevelopment. While this process aims to upgrade infrastructure and housing, it gives rise to sustainability issues. The demolition of older structures, often with historical significance, erodes cultural heritage. The subsequent construction of high-rise buildings and expansive developments contributes to heightened energy consumption and resource strain. Furthermore, the swift pace of urban transformation can lead to unplanned development, neglecting the importance of green spaces and intensifying the urban heat island effect. In order to advance the urban landscape of Istanbul, it is imperative to strike a delicate balance between modernization and sustainability. This necessitates thorough urban planning, robust community engagement, and the integration of sustainable principles to preserve the city's unique identity while nurturing an environmentally aware and adaptable urban setting.

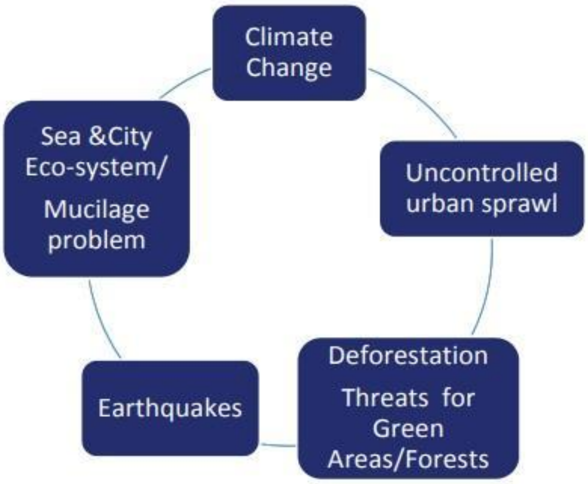

Figure 2.3: Main problematics and threats for Istanbul city eco-system

(Coşkun, 2022)

Sustainable environmental development encompasses several key principles. It aims to reduce the generation of waste, promote the reuse of waste, and minimize the negative impact on human health or eliminate these adverse effects altogether. Additionally, sustainable environmental development supports the widespread use of renewable resources. Efficient conservation and storage of energy are also crucial aspects within this framework. The avoidance of toxic substances in production processes and the prevention of environmental pollution are fundamental principles of sustainable environmental development. These principles seek to ensure both the sustainable utilization of natural resources and the construction of a future that causes minimal harm to human health and the environment (Toptaş, 2012).

3. CONSTRUCTION AND DEMOLITION WASTE

Construction entails the intricate process of erecting infrastructure, edifices, or other architectural configurations. It involves a sequence of intricate tasks and endeavors that transmute raw materials, resources, and labor into a culminated outcome. Construction ventures span a diverse range in terms of magnitude and intricateness, encompassing modest residential dwellings to expansive commercial complexes, bridges, thoroughfares, and beyond. Demolition, conversely, signifies the deliberate and methodical disassembly, obliteration, or eradication of structures, buildings, or infrastructure. The action of demolition involves dismantling or leveling a structure, whether in part or in entirety, for reasons of safety, to facilitate new construction undertakings, or as part of urban revitalization initiatives. Demolition may be executed for various intents, including the replacement of outdated structures, clearing sites for redevelopment, or addressing safety risks posed by unstable or dilapidated constructions. Deconstruction, introduced by Jacques Derrida in the 1960s, challenges structuralism and asserts that language is a flexible tool, allowing the reconstruction of old texts and the creation of new meanings. Initially a philosophical concept, deconstruction extended to various fields and became a movement in architecture in the 1980s. In the 1990s, deconstruction was proposed as a crucial strategy to address environmental issues caused by conventional demolition, emphasizing the reuse and recycling of materials in architecture. It involves disassembling a system's components for successful reuse or recycling. Historically, some buildings were designed with reusable or recyclable materials, reflecting the practical application of deconstruction in architecture. Overall, deconstruction is not just a theoretical idea; it's a practical strategy applied in various fields for creative reconstruction and sustainable practices (Doğan& Koman,2022).

Construction and Demolition (C&D) Debris denotes refuse generated throughout the construction, renovation, or demolition of structures, embracing diverse building categories, including residential and nonresidential edifices, alongside thoroughfares and viaducts. Conventional constituents of C&D debris encompass materials such as concrete, asphalt, timber, metals, gypsum wallboard, and roofing. Certain state delineations of C&D debris also encompass land clearing refuse, encompassing stumps, rocks, and soil (Franklin Associates, 1998). In the context of WFD2008, 'waste' is construed as any substance or object that the possessor discards, intends to discard, or is mandated to discard. Generally perceived unfavorably as something to be disposed of, waste frequently undergoes a transformation when its intrinsic value is acknowledged. Some researchers, however, characterize 'waste' as a valuable 'resource.' For instance, the resource value of waste has empowered individuals in developing nations to sustain themselves, aligning with a current trend that is progressively shifting from the concept of 'end-of-pipe waste management' to a more comprehensive approach known as 'resource management' (Ghalfalkar et al. , 2015). Construction and Demolition (C&D) waste, often referred to as C&D debris, is a type of waste generated during various phases of construction, renovation, demolition, and deconstruction projects. This waste category comprises a diverse range of materials and substances that result from these construction-related activities. Unlike typical household waste or industrial waste, C&D waste is distinct in its origin and composition. C &D debris is the term used for rubbish from the construction, remodeling or demolition of building structures (Statistics Canada, 2000). They embrace concrete, steel, lumber products, asphalt shingles and bricks. The processing of C&D waste may lead to significant levels of pollution and loss of land use potential. Incorporation of recycled materials reduces the consumption of virgin resources as well as energy which goes a long way to reducing environmental impact (Huang et al., 2020). Construction and Demolition (C&D) waste also referred to as C&D refuse represents a wide range of materials generated from within the built environment through construction, refurbishment, demolition and deconstruction activities. The global economy's main sector is the construction and demolition (C&D), which shapes infrastructure and urban landscapes. However, Construction and Demolition waste also known as Construction And Demolition Waste (C&D Refuse or C&D Detritus) arises in this sector in large quantities. For instance, construction consumes about 32% of the world's total resources including 12% of its freshwater supply while accounting for up to 40% of its total energy use. Almost half. Inadequate CDW management contributes to significant societal and environmental problems, while also squandering valuable resources. These challenges have both direct and indirect implications for the achievement of the United Nations' Sustainable Development Goals (Zhang et al.,2023).

C&D waste originates from diverse sources within the construction and demolition industry:

Construction Activities:

- Wastes are produced during the construction phase of buildings, infrastructures and facilities due to excess supplies, spoilt or unserviceable materials and changes necessitated by the building process.

Renovation and Remodeling:

- The refurbishment or upgrading of current structures constitutes renovation projects. This results in points where waste is generated as old materials such as floors, walls, fixtures and electrical systems are either replaced or removed.

Demolition and Deconstruction:

- This majorly refers to the partial or complete dismantling of structures resulting in a significant accumulation of C&D wastes. It includes taking apart whole buildings, gutting their entirety out from inside, and removal of parts that have been selected.

3.1 Historical Improvements of C&D Waste Management

Since the end of World War II, most regulations in developed countries have actively promoted construction demolition (C&D) waste management and many of these regulations have been established with the goal of reduction in response to the environment. Incentives have been heavily introduced to encourage the use of alternative resources and to prevent the dumping of C&D waste in landfills or through incineration, with heavy taxes and penalties being used as a deterrent (Poon, 2007). Construction and construction (C&D) waste management and historical development in Turkey is driven by regulatory changes and a series of developmental milestones Many countries in the world have made significant progress in construction and construction (C&D) waste management so the in the. Various approaches have been implemented Over the years, construction and construction (C&D) waste management has undergone significant changes, driven by increased recognition of environmental concerns, evolving regulations, technological advances and a broader commitment to sustainability, the historical developments in C&D waste management can be summarized as follows.

- Early Practices (Pre-20th Century)
  - ➢ In the early stages of construction, waste generated from building activities was typically disposed of indiscriminately, with minimal regard for environmental consequences or resource conservation. Materials were often discarded on-site or in nearby open areas, reflecting a lack of structured waste management practices.
- Mid-20th Century:
  - ➢ As urbanization and construction activities expanded during the mid-20th century, the predominant method of C&D waste disposal shifted to landfills. However, this approach raised concerns about limited landfill space, soil and water contamination, and the inefficient use of valuable resources.
- Late 20th Century:
  - ➢ The late 20th century marked a turning point in C&D waste management, characterized b
- Landfill Regulations:
  - ➢ Governments began implementing regulations to govern the disposal of C&D waste in landfills, imposing restrictions on the types of materials accepted and encouraging improved waste separation.
- Recycling Initiatives:
  - ➢ Recycling programs for C&D waste materials gained momentum, with a focus on recovering materials like concrete, asphalt, wood, and metals for reuse in construction and manufacturing.
- Awareness of Hazardous Materials:
  - ➢ Increased awareness of hazardous materials, such as asbestos and lead-based paint, led to stricter regulations governing their handling and removal during demolition projects.
- Late 20th Century to Early 21st Century:

- ➢ This period witnessed further progress in C&D waste management, including:

- Sustainable Construction Practices:
  - ➢ The adoption of sustainable building practices, including green building certification programs, promoted resource-efficient construction, waste reduction, and sustainable material choices.
- Demolition and Deconstruction:
  - ➢ Deconstruction techniques gained popularity, enabling the salvage of valuable building materials for reuse and recycling, thereby reducing waste generated during demolition.
- Regulatory Frameworks:
  - ➢ Many countries developed comprehensive regulatory frameworks and waste management plans specifically addressing C&D waste, with a focus on waste reduction, recycling, and responsible disposal.
- Recent Developments:
  - ➢ In recent years, C&D waste management has continued to evolve:
- Technology Integration:
  - ➢ Advancements in technology, such as waste tracking systems and sorting equipment, have enhanced the efficiency and accuracy of C&D waste management processes.
- Circular Economy:
  - ➢ The concept of a circular economy, where materials are repurposed, recycled, and reused, has gained prominence, influencing C&D waste management strategies.
- Sustainability Goals:
  - ➢ Governments and organizations worldwide have set ambitious sustainability goals, including targets for C&D waste reduction and increased recycling rates.
- Public Awareness:
  - ➢ Heightened public awareness of environmental issues has encouraged responsible C&D waste management practices among stakeholders.
- Innovative Materials:

➢ Research and development efforts have yielded innovative, sustainable building materials made from recycled C&D waste.

3.2 C&D Waste Management Standardization

Construction, demolition and waste management often face challenges arising from lack of standards. Unlike some other industries, there are no universally accepted standards or guidelines for the handling, disposal and recycling of construction and construction waste These standardized practices can has led to inconsistencies in waste management methods, leading to environmental and legal challenges. The lack of integrated systems means that different regions or even individual construction projects adopt different waste collection, recycling and disposal processes This fragmentation hinders efficiency. And makes it difficult to compare a environment and assess the impact of various projects on the environment or establish best practices for the projects as a whole, since different interpretations of waste disposal legislation can has been unique. Addressing this lack of standards is critical for promoting sustainable practices, reducing the environmental impact of construction and demolition activities, and for entrepreneurs are heavily involved in waste management efforts

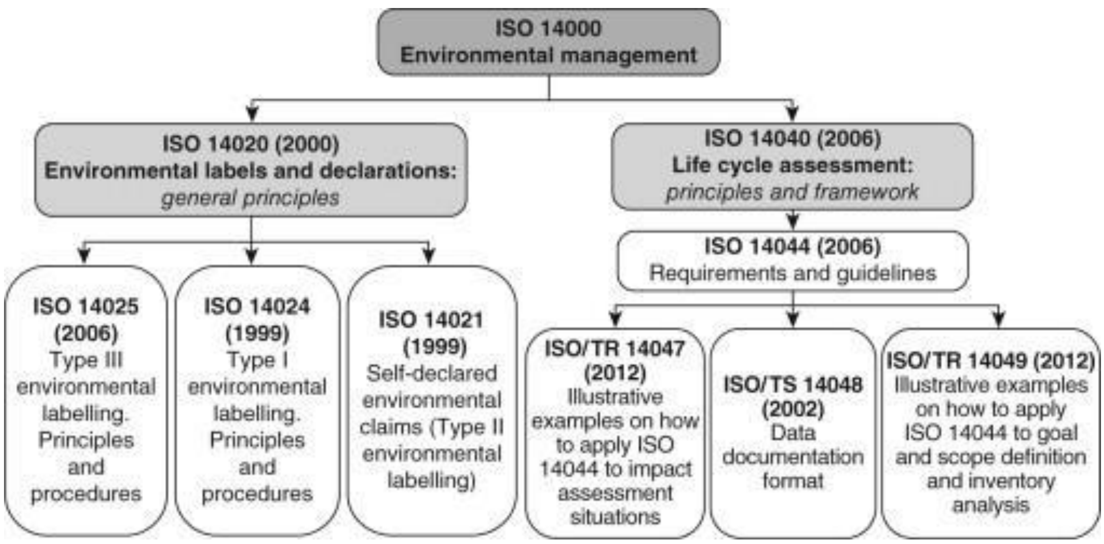

Figure 3.1: Regulatory framework for environmental certification(Bovea, Ibanez-Fores and Aqusti-Juan, 2014)

ISO 14001, the international standard for environmental management, plays an important role in developing sustainable practices in the building and construction industry ISO 14001 accreditation enables construction companies to manage the environment environment is systematically addressed in their operations, including waste management. Includes key features and the basis of the environmental policy model. These elements include the development and implementation of environmental policies, appropriate planning, effective implementation and implementation, system testing and discipline procedures, regular performance reviews, and commitment to continuously improve 14001 for a systematic approach to integrating waste management into the overall environmental management system. This includes labeling procedures, setting goals to reduce waste, and continuously improving practices. By complying with ISO 1400, construction companies not only improve their environmental performance, but also contribute to a more sustainable and responsible approach to waste management keep it in line with global efforts as well.

The Waste Management Hierarchy (WMH), widely embraced by the Western world and parts of Asia since 1980, is a commonly accepted approach. This approach is also known in the literature as the "3R principle (reduce, recycle, reuse)." The WMH is a preference-based system that aims to prevent and/or reduce environmental impacts such as waste generation, resource consumption, and air and water pollution. It is a prioritized approach that focuses on strategies to enhance energy efficiency and make waste management more sustainable (Çiçekci, 2020). With sustainability as an objective, it is common for an integrated waste management strategy to strive to select options at as high level as possible within the “waste management hierarchy.” The hierarchy ranks waste management options according to what is best for the environment. It gives top priority to prevent waste at its source. When waste is created, it gives priority to preparing waste for reuse, then recycling, the energy recovery, and lastly landfilling (Dyer et al., 2019).

Figure 3.2: Waste hierarchy as in the WFD2008.(Gharfalkar et al., 2015)

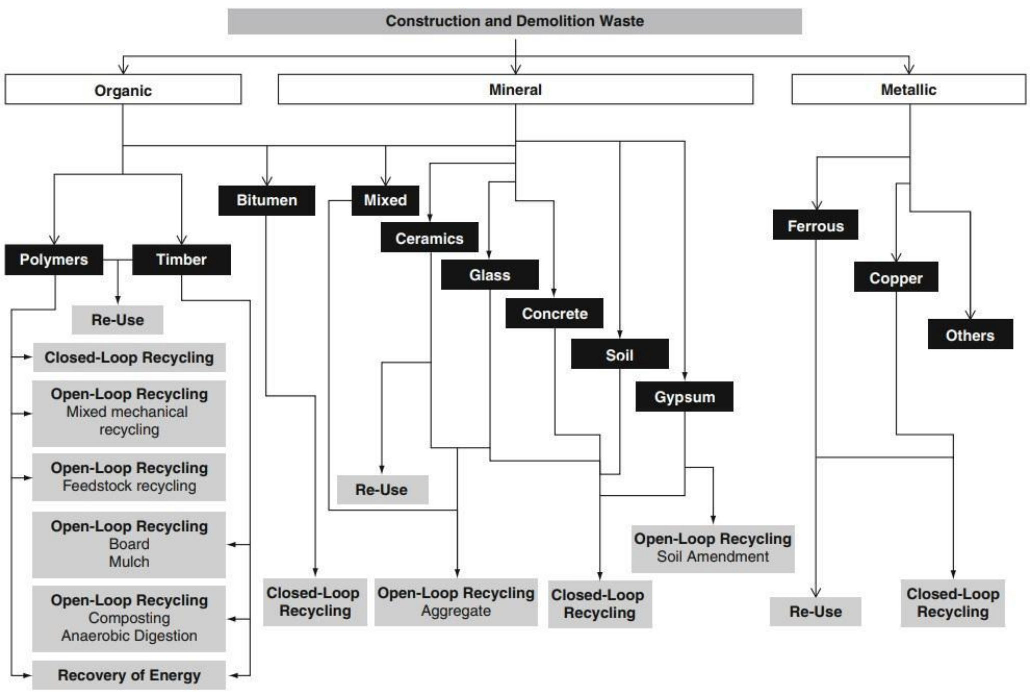

Figure 3.3: Closed-loop recycling of demolition waste(Dyer et al., 2019)

While recycling construction and demolition waste offers environmental benefits, careful management is necessary to mitigate potential hazards to human health and the environment, including addressing issues related to dust, asbestos, leaching, and wastewater.

Table 3.1: Some Europe country's CDW recycling rates

(Karademir& Özbakır, 2018)

Country	CDW(Tonnes)	Recycle Rate
Holland	78.331.000	98,10%
Denmark	2.104.000	94,90%
Estonia	436.000	91,90%
Germany	190.990.000	86,30%
Turkey	158.000.000	31 %

When buildings undergo demolition, a significant volume of waste is often generated within a relatively brief timeframe, influenced by the chosen demolition technique. In terms of each individual building, the amount of waste resulting from demolition can be notably higher, ranging from 20 to 30 times more than the debris produced during the construction phase. This disparity underscores the substantial impact that the demolition process can have on waste generation, highlighting the importance of adopting sustainable practices and effective waste management strategies to mitigate the environmental consequences associated with large-scale demolition activities (Dyer et al., 2019). It's important to note that the effectiveness of C&D waste management practices can vary within countries, and regional policies and regulations may differ. The "best" country for C&D waste management often depends on specific goals, such as waste reduction, recycling rates, and sustainable construction practices. Researchers and policymakers often look to these countries as examples of successful C&D waste management and may adapt their strategies to suit local needs and priorities.

3.3 Evaluation of Construction and Demolition Waste in Turkey

Increasing construction activities depending on building demand caused by population growth, economic changes and related factors put enormous stress on waste generation in Turkey. It is estimated that the amount of Construction and Demolition (C&D) waste in Turkey will reach 300 million tons by 2023. To take action and set effective waste management strategies for the construction industry induced wastes are gaining importance day by day in environmental burden for Turkey as well as all over the world (Çiçekci, 2020).

- Historical Perspective:

- Turkey has a long history of construction and demolition waste management. Over time, however, formal laws and regulations have become increasingly popular, especially as they relate to their environmental impact.

- Legal Framework:
  - A formal construction and waste management regulation in Turkey was established with the introduction of the "Solid Waste Management Control Regulation" in 2001. This regulation regulates waste management and aims to reduce resources environmental impact
- Waste Hierarchy:
  - Waste management practices in Turkey adhere to the principles of waste hierarchy. These principles include waste reduction, recycling, recycling, energy recovery and disposal as a last resort.
- Promotion of Reuse and Recycling:
  - Turkey actively encourages the reuse and recycling of construction and demolition waste through various incentives and policy measures. The construction sector is particularly encouraged to reuse materials, and efforts are underway to establish recycling facilities.
- Addressing Environmental Impact:
  - To mitigate the environmental impact of construction and demolition waste, environmental factors are taken into account throughout the waste management process. Measures are being implemented to control the environmental consequences associated with waste disposal sites.
- Continued Progress and Future Initiatives:
  - Turkey is committed to continuing to improve construction and waste management, with a focus on reducing the environmental impact Ongoing efforts include the establishment of new consumption centers function again and develop waste reduction strategies.In a nutshell, it was developed by Turkey.

The existing waste management legislation in Turkey has been developed in alignment with European Union standards, but widespread implementation remains a challenge. Insufficient application, monitoring, and enforcement activities by relevant institutions are observed (Buzkan & Erman, 2020). Despite adopting the waste management hierarchy, the actual practice in the country does not align with it, especially concerning structural waste. Limited statistical data on structural waste, the lack of widespread structural waste recycling centers, and the increasing urbanization lead to the perception that waste is predominantly landfilled. Recommendations to address the shortcomings in legislation and promote recycling include implementing deterrent regulations against illegal waste dumping, encouraging controlled landfill use, and expanding structural waste recycling facilities. The adoption of a by-product concept similar to Japan, supported by state-sponsored transformation, is suggested to boost the use of by-products in public and private construction. Generating numerical data on the quantity and quality of structural waste is crucial for effective waste management, planning, and recycling. Making ISO 14000 series mandatory for construction sector firms, submitting recycling and usage/demolition plans before demolition permits, official tracking of structural waste during construction, and supporting research and development efforts to increase recycling rates are also recommended. Additionally, measures to prevent or reduce structural waste formation, considering material particle size selection in comparison to spatial dimensions, and prioritizing research to enhance recycling rates should be supported alongside efforts to prevent and reduce waste.

Table 3.2: Annual CDW quantity of provinces in Istanbul (Güllü, 2022)

District	Building Quantity	Independent Section	Avarage Floor	Building to be demolished	Total CDW (Tonnes)	Annual CDW (Tonnes)
Esenyurt	41.409	397531	9,6	23189	11594520	483105
K.Çekmece	38.331	324112	8,5	21465	10732680	447195
Kadıköy	24.398	319162	13,1	13663	8197728	341572
Pendik	48.646	308251	6,3	27242	13620880	567537
Ümraniye	49.952	302251	6,1	27973	13986560	582773
Fatih	45.093	293574	6,5	25252	12626040	626085
Bağcılar	42.625	281185	6,6	23870	11935000	497292
Üsküdar	43.763	254157	5,8	24507	9802912	408455
Bahçelievler	21.913	248072	11,3	12271	6135640	255652
Maltepe	27461	243723	8,9	15378	7689080	320378
Kartal	28361	215161	7,6	15882	7941080	330878
Ataşehir	28260	214233	7,6	15826	7912800	329700
Kâğıthane	27820	207873	7,5	15579	7789600	324567
G.O.Paşa	27592	196879	7,1	15452	7725760	321907
Sultangazi	34051	192589	5,7	19069	7627424	317809
Başakşehir	22962	190801	8,3	12859	6429360	267890
Avcılar	26263	185416	7,1	14707	7353640	306402
Şişli	19077	184450	9,7	10683	6409872	267078
Esenler	25142	179025	7,1	14080	7039760	293323
Sarıyer	48262	175423	3,6	27027	8108016	337834
Eyüpsultan	30611	171473	5,6	17142	6856864	285703
Bayrampaşa	20373	154473	7,6	11409	5704440	237685
Beyoğlu	26045	151480	5,8	14585	5834080	243087
B.Çekmece	30547	147887	4,8	17106	6842528	285105
Sancaktepe	29236	147137	5	16372	6548864	272869
Beylikdüzü	13429	145364	10,9	7520	3760120	156672
Zeytinburnu	14586	137701	9,4	8168	4084080	170170
Silivri	52198	135257	2,6	29231	5846176	243591
Güngören	10737	129143	12	6013	3006360	125265
Tuzla	24115	120933	5	13504	5401760	225073
Bakırköy	11684	119083	10,2	6543	3925824	163576
Sultanbeyli	34359	118416	3,5	19241	5772312	240513
Beykoz	46396	113716	2,5	25982	5196352	216515
Arnavutköy	34940	110286	3,2	19566	5869920	244580
Beşiktaş	16387	109336	6,7	9177	5506032	229418
Çekmeköy	19654	103277	5,3	11006	4402496	183437
Çatalca	23350	55388	2,4	13076	2615200	108967
Şile	19378	37567	1,9	10852	2170336	90431
Adalar	6483	21205	3,3	3631	1089144	45381
TOTAL	1.135.889	7.142.990	6,3	636.098	318.048.920	11.295.468

3.4 Life Cycle Assessment

Life Cycle Assessment (LCA) is a rigorous and systematic methodology used to comprehensively assess and quantify the environmental impact of a product, process, use or life cycle, including manufacturing, transport, processing, or ultimately disposal and recycling. This careful analysis involves identifying and quantifying inputs and outputs at every stage from energy consumption to materials consumption to disposal and waste the Life Cycle Assessment (LCA) is a systematic way of assessing the environmental impacts associated with a product, process, or resource from its extraction activity throughout the life cycle until disposal conclusion. The assessment covers all processes, including construction, transportation, use and disposal, taking into account various environmental factors such as energy consumption, waste, emissions internal and waste management LCA collects data and analyzes the inputs and outputs at each stage of the life cycle to assess the performance of the proposed environmental quality system. The aim is to provide comprehensive and quantitative analysis to facilitate informed decision-making and identify opportunities for environmental sustainability of products and services. The concept of a "life cycle" includes interconnected phases, incorporating loops that represent actions such as the reuse and recycling of post-consumer products during the end-of-life phase or the recycling of production scrap. This diagram underscores the cyclical nature of these processes, emphasizing the potential for resource conservation and waste reduction through sustainable practices (Barbhuiya & Das, 2023).

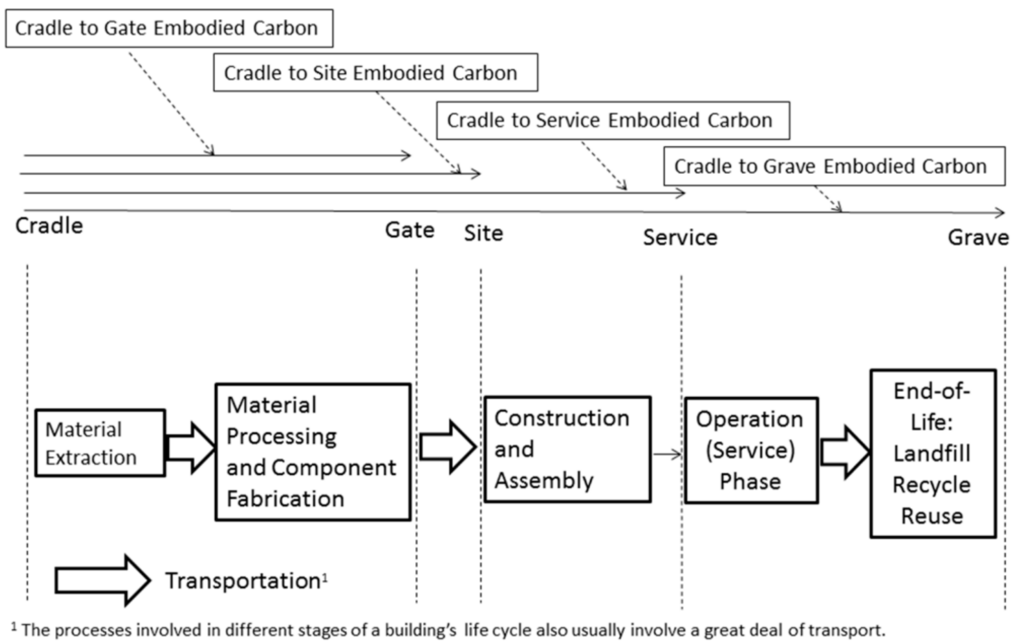

Figure 3.4: Different phases of building's life cycle(Akbarnezhad & Xiao, 2017**)**

"Cradle-to-site" and "cradle-to-grave" are comprehensive life cycle assessment (LCA) methodologies that delve into the complete life cycle of a product, offering a more thorough understanding of its environmental implications. "Cradle-to-site" expands the conventional "gate" boundary to encompass not just the manufacturing process but also the subsequent transportation and delivery to a specific location or site. This extension is particularly pertinent in assessing the environmental impacts associated with the logistics and distribution phases, providing insights into the overall sustainability of the supply chain. A cradle-to-site analysis supports defining the embodied energy of specific building components as the energy needed for extracting raw materials, processing them, assembling them into usable products, and transporting them to the construction site. This definition is particularly applicable when assessing the comparative scale of building components, aligning more with the "good" in Cleveland & Morris's definition as it excludes any costs associated with maintenance or end-of-life considerations. In contrast, a cradle-to-gate model solely accounts for the energy required to manufacture the final product without taking additional factors into consideration (ICE, 2022).

In contrast, "cradle-to-grave" represents the broadest design constraint under LCA. This approach considers the entire life cycle of a product, from start-up or withdrawal (cradle) to eventual disposal or end-of-life management (grave) It does not include production and what not only transported but semi-consumables, recyclables, . recycling possibilities and environmental consequences of its disposal In the method, embodied energy represents the energy consumption of the building over its lifetime. This includes the initial input of energy, including the energy required for physical construction and accumulation. This method considers the entire lifecycle of a building but excludes operating capacity for heating, cooling, and other services (ICE, 2022). In doing so, it provides a more complete and nuanced view of a product's environment we are surrounded by footprints "from cradle to grave, " enabling a comprehensive analysis of sustainability in the various stages of its life."From cradle." to site" and "cradle to grave" analyzes provide valuable insights for sustainability decision making. These approaches facilitate the identification of opportunities for improvement throughout the life cycle, inform efforts to reduce resources a environment, increase resource efficiency, and promote sustainability practices and policies.

The utilization of Life Cycle Assessment (LCA) has been extensive in evaluating the embodied carbon content in diverse building materials and elements, along with determining the carbon emission rates linked to various machinery and processes engaged in both the construction and operation phases of a building. LCA offers a comprehensive methodology for assessing the environmental effects of buildings, encompassing associated emissions and energy consumption. The typical LCA methodologies can be classified into statistical analysis, process-based analysis, economic input-output analysis, and hybrid analysis methods(Akbarnezhad & Xiao, 2017).

LCA has transcended its academic origins to become an invaluable decision-making tool for stakeholders in industrial, policy, and environmental sectors. By providing a nuanced view of the multimodal environmental response, LCA facilitates informed decision-making and policy implementation. Decision makers can identify critical areas for improvement, compare scenarios, and make choices consistent with sustainability goals.

Furthermore, LCA plays an important role in modeling eco-design, driving innovation towards sustainable materials and processes. Its structural and quantitative approach helps reveal hidden environmental trade-offs and promotes the adoption of actions to reduce negative impacts As sustainable development becomes more prominent on the global agenda, LCA goes so develops, and provides a strong foundation for evidence-based decision-making.

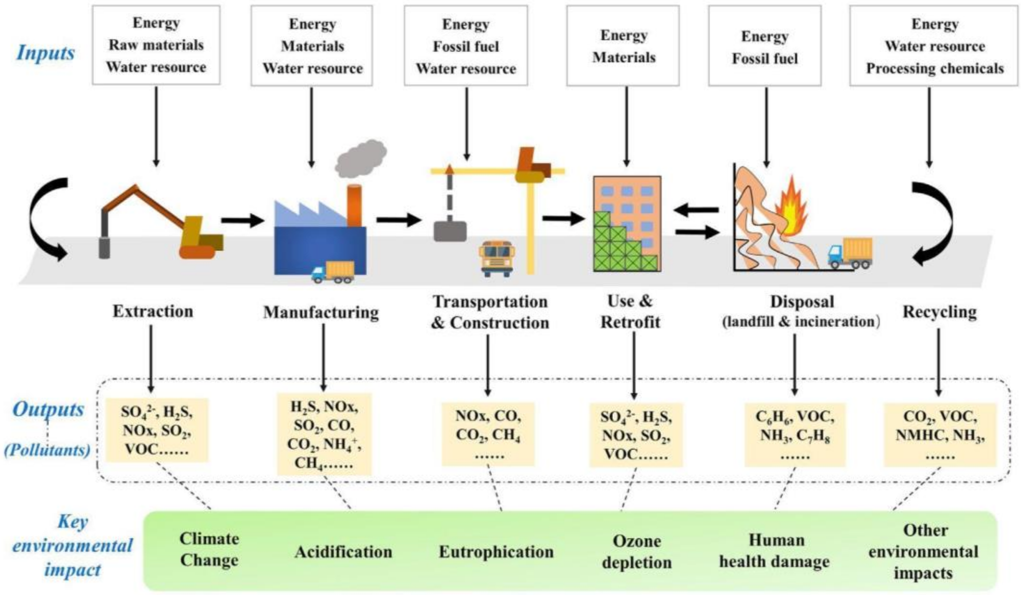

Figure 3.5 : Key Environmental Impacts during the Life Cycle of Building Materials(Hang et al., 2023)

4. ENVIRONMENT & ENERGY

The environment, a multidimensional entity in both living and nonliving forms, manifests itself as a complex integrated ecosystem in which different forms of life coexist The term "things." environment" refers to the state of living organisms. It involves the interaction of living (living) and abiotic (non-living) factors to create social conditions. The environment includes various elements such as air, water, soil, plants, animals, microorganisms, and physical and atmospheric conditions such as temperature, humidity and sunlight. This includes all urban areas, infrastructure, and human impacts on the area. Ecology is the study of the interactions between organisms and their environments, and the impact of human activity on the natural world. Almost any human activity that damages nature is considered characterize or degrade the environment as pollutants. Although environmental degradation is not new, it continues to be the world's most important challenge for humanity, contributing significantly to environmental issues of disease and mortality no.(Ukaogo et al., 2020).

Environmental science and environmental studies are disciplines that focus on analyzing and understanding environmental challenges. Environmental health is critical to the well-being of organisms, ecosystems, and ultimately all living things, including humans. The cumulative impact of human activities on our planet, especially the ever-increasing production of greenhouse gases, especially carbon dioxide (CO_2), due until the burning of fossil fuels during the Industrial Revolution and the decades that followed. The buildup of CO_2 in the atmosphere traps infrared (IR) radiation from the Earth's surface by absorbing sunlight. This process contributes to the warming of our planet, resulting in a disturbing and ongoing trend of global surface and ocean temperature increases, commonly referred to as global warming.(Zandalinas et al., 2021). Environmental protection and sustainable practices aim to protect and preserve the environment for present and future generations Integrity. The mechanism of genetic and ethnic structure is important and have provided an environmental skeleton, however, the problem with these records. -In invasion has been an accidental consequence of harm Loss of biodiversity, disturbance of ecosystems, and concomitant threat to human health emphasize the need for conservation emphasize examples of so. Robust and sustainable environmental management necessitates interdisciplinary approaches, regulatory frameworks, and concerted global efforts to circumvent further ecological deterioration.

The built environment is an expression of social mobility and human intelligence visible as a complex combination of physical design, architecture and urban design. At its core, the environment the built environment is a repository of cultural aspirations and social values. The architectural planning of the localized mass transfer to memory citizens and the development of these structures is not the only response to social mobility. It's a successful tapestry that's definitely the city's policy, and the formulas. A diverse list of products. Everything in this setting, from the grandeur of the skyscrapers to the eerie simplicity of residential homes, tells a unique story of human intelligence and social progress

Architecture, content and aesthetics are working on aesthetics, cultural primacy and complexity of designs, gardens, public spaces and complex complexes. and precautionary construction practices in the built climate Additional safety The details of the built environment in a busy city or quiet rural area determine the way individuals use it to interact with and experience their surroundings, creating connections between the practical, the artistic, the functional and the expressive

The intentional design of space and infrastructure systems greatly influences how individuals navigate and interact with their environment. In this context, thoughtful urban planning is a cornerstone for building community resilience, promoting inclusion, and addressing social inequalities. Environmental sustainability is another important aspect of the built environment, especially in the modern era marked by environmental concerns.

Building construction and maintenance contributes significantly to consumption, waste generation and energy use. Thus, sustainable architectural practices are urban designs that make environmental integration not just an aesthetic priority but an ethical and practical one necessary for sustainability in the sky change control to reduce environmental impacts. In addition, the built environment is intrinsically linked to broader geopolitical considerations and globalization. Urbanization and infrastructure are key indicators of a country's economic strength and global status. Thus, energy politics is intertwined with strategic urban spatial planning, often in the form of transnational relations and international cooperation

The built environment stands as a dynamic concept in which social issues unfold and shape the course of human development. This academic research emphasizes and calls upon the diversity of the built environment, recognizing and calling for its complexity and significance in its profound impact on culture, society and the environment scholars and practitioners to develop ongoing research, innovation and sustainable practices to address challenges and opportunities changing built environments.

Energy, as, fuels economic, technological and social development. Characteristics of Fossil Fuels Traditional energy matrices have historically backed technological change and social progress. However, the deleterious environmental ramifications attendant to their extraction and consumption, notably climate change and environmental pollution, have catalyzed an imperative paradigm shift. Energy, a cornerstone of physics and thermodynamics, represents a fundamental property that underlies the capacity to perform work and induce change. It manifests in diverse forms, seamlessly transitioning between potential and kinetic states, across an array of domains encompassing mechanical, thermal, electrical, chemical, and nuclear realms. The conservation of energy, a cardinal principle, dictates that within an isolated system, the total energy remains constant, albeit capable of transformation between its myriad manifestations. From a societal standpoint, energy assumes a pivotal role as the linchpin of contemporary existence, propelling economic endeavors, catalyzing technological innovations, and sustaining the multifaceted dimensions of daily life.

Historically, non-renewable resources, especially fossil fuels—including coal, oil, and natural gas—have played an important role in meeting the limitless global energy demand, but the environment meeting increasing waste associated with extraction and incineration accelerated the paradigmatic shift to sustainable alternatives Renewable energy inclusion has gained popularity, due to with materials because of a truly harmonious and permanent environment.The vital energy is embodied in every aspect of modern life and forms the foundation for the fabric of modern society. At its core, energy is the driving force behind technology, economic prosperity and technological innovation. It powers manufacturing machinery, energizes transportation systems that connect distant places, and sustains the complex network of communications and information exchanges that define our interconnected world.

The availability and efficiency of energy sources directly affects living standards and guides societies. Access to reliable and affordable energy is not only a convenience but a prerequisite for development and determines the competitiveness of a country in the global arena In contrast conversely, energy deficiencies or inefficiencies can lead to economic stagnation, impede growth and increase social inequality.

It extends beyond the dimension of economic strength to geopolitical considerations and global security. Countries engage in active policy to acquire energy resources, leading to closer international relations and geopolitical development. Historically, the quest for energy security has been the source of conflicts, treaties, and diplomatic negotiations. In today's context, the need to address climate change has given rise to the need to turn to energy practices permanently increased. The environmental impact of conventional energy sources burning fossil fuels on the environment has spurred a global shift to cleaner alternatives. Developing and integrating renewable energy sources such as solar, wind and hydropower has become central to reducing greenhouse gas emissions and ensuring a sustainable future. Specifically, energy is not just a commodity but a key driver that weaves together social mobility, a strong economic fabric of energy and environmental stewardship. Recognizing the multifaceted importance of energy is critical to meeting the complex challenges of the 21st century and charting a course towards a sustainable and resilient global future has been established This transition to a more diverse and sustainable energy system is driven by a combination of scientific advances, policy needs, and coordinated global efforts Translation The changing energy landscape requires an approach that it is all-encompassing that not only meets the immediate needs of humanity but protects the integrity of the planet and its ecosystems for future generations. In the United States, buildings alone account for about 40% of all energy consumption. Currently, individuals spend about 90% of their time at home, depending on many electrical appliances, further increasing per capita energy consumption (Amaral et al., 2020).

The ascendancy of renewable energy sources, comprising solar, wind, hydropower, geothermal, and biomass, constitutes a salient response to the exigencies of sustainability. This transition is underscored by a concerted effort to attenuate greenhouse gas emissions and cultivate a resilient energy infrastructure. Technological innovations, energy efficiency imperatives, and systemic shifts in global energy consumption patterns are pivotal facets of this epochal transition toward sustainable energy paradigms. Energy plays a central role in numerous United Nations Sustainable Development Goals. Countries should harmonize the three fundamental dimensions of the global energy trilemma: affordability and accessibility of energy, energy security, and environmental sustainability. Achieving a balance in these three aspects is crucial for establishing a strong foundation for prosperity and competitiveness (Khan et al., 2021). The abrupt increase in energy consumption and carbon dioxide emissions (CO_2) in recent times is cause for concern. Some attribute this surge to the growing population in urban areas, while others argue that it may be linked to the production of goods and services. Regardless of the root cause, energy has undeniably become a decisive factor in determining sustainable development. Consequently, there are projections indicating that global energy consumption in the industrial sector will elevate to around 30% by 2050. Additionally, the consumption of end-products is anticipated to surpass the approximate figure of 310 quadrillions British Thermal Units (BTU) (Zakari et al., 2021).

The nexus between energy exigencies and environmental imperatives crystallizes within the ambit of sustainable development. Conjoining the burgeoning needs of a burgeoning global populace with the imperative of environmental stewardship mandates nuanced and strategic interventions across sectors, engendering a dynamic confluence of scientific, policy, and technological frameworks.

4.1 Turkey Energy Demands

It faces various strategic challenges in Turkey related to its energy dependence. The country relies heavily on external resources to meet a large part of its energy needs, and relies heavily on energy imports Energy sources such as natural gas and oil play an important role in Turkey energy mix, with natural gas as the main contributor. However, a significant proportion of natural gas is imported, creating weaknesses in the security of energy supply. Most of Turkey's natural gas needs are met by imports from Russia, Iran, etc. Oil and oil products also play an important role in Turkey's energy dependence. Fuel is used extensively for transportation and industrial purposes, much of which is sourced externally. It is obtained through the Physical Energy Flow Accounting System when Turkey's energy consumption data is analyzed in environmental and economic accounting systems The purpose of this calculation is to identify the relationship with the environment and between economic activities in accordance with ESA 2010 standards. These figures are based on energy balance tables published by the Turkish Statistical Agency and the Ministry of Energy and Natural Resources.

According to the latest published data, the total energy flows for the period 2017-2021 are calculated as 19,184 petajoules. Concerning the sources of these energy flows, energy products contribute the most with a share of 53,3%. The share of energy residuals is 36.8%, while natural energy inputs account for 9.9%.In 2021, there was a notable increase in the final consumption of energy products, reaching 5,560 petajoules with a 9.8% growth compared to the previous year. In the sectoral breakdown of final energy consumption, the manufacturing industry stands out with a share of 34,7%. Looking at sectors, manufacturing is followed by trade, services, and the public sector with a 24.4% share, while households contribute 30.4%.Examining the final usage of energy products by type in 2021, petroleum products take the lead with a 39.3% share. Following them are natural gas with 22,8%, electricity with 21.5%, coal products with 10.0%, heat with 5.2%, and other products with 1.2%.In the analysis of final energy consumption by households based on purpose, heating/cooling holds the largest share with 47.1%. This indicates that a significant portion of energy is used for residential climate control needs (TUIK, 2022).

To meet these challenges, Turkey has taken appropriate measures to reduce energy dependence and increase energy supply security. Initiatives include investing in domestic energy sources, improving energy efficiency, promoting renewable energy industries such as wind and solar, and nuclear analysis of energy consumption This effort aims to diversify energy consumption and reduce dependence on external sources.

However, reducing energy dependence is a complex and long-term process that requires sustained effort and comprehensive planning. Turkey’s energy policy focuses on building a sustainable and diversified energy sector, and the success of this effort will have significant economic and environmental consequences.

4.2 Energy in Buildings

Embodied energy and productivity are two important concepts in sustainability and building design. Embodied energy refers to the total energy consumption throughout the life of a product or structure, including the extraction, production, transportation, construction, maintenance, and final use of raw materials disposal Represents latent energy embodied in a building or product. Reducing embodied energy is essential to reducing the overall environmental impact of the project. On the other hand, the energy required for the daily operation of the building, such as heating, cooling, lighting and mechanical, relates to work capacity Sustainable design aims to provide physical and productive energy all well done, finding a balance of energy efficiency, reducing environmental impact, It also ensures durability By addressing these aspects, architects and engineers can has contributed greatly to the development of sustainable and environmentally friendly buildings.

The boundaries of the system have been expanded to include the functional and physical capabilities of the building. Energy consumption includes the energy required for heating, cooling, ventilation, domestic hot water, lighting, appliances and auxiliary systems in the building On the other hand, embodied energy resources, whose to construction site maintenance and modifications, energy dismantling, and end-of-life transportation and Logistics (Chastas et al., 2016).

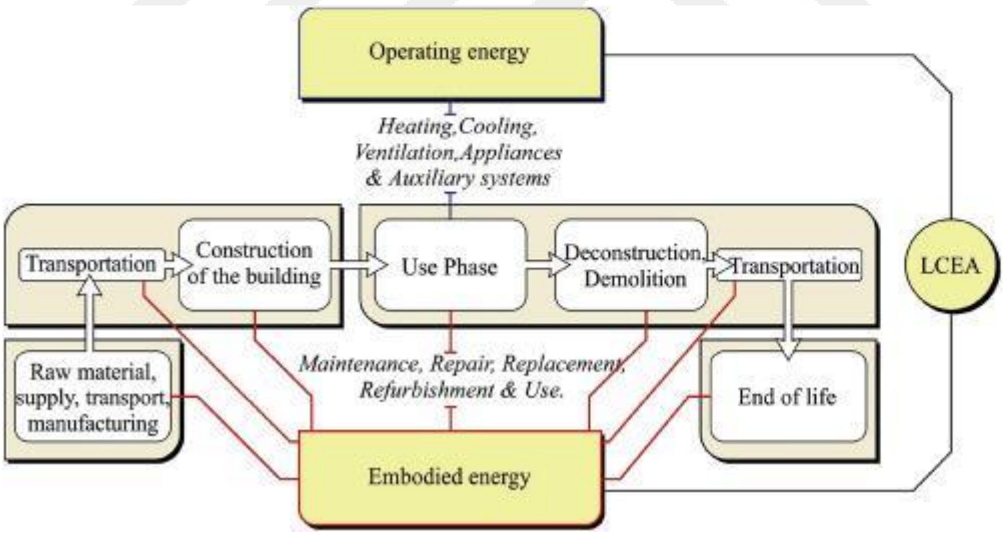

Figure 4.1 : Boundaries of the system, inputs outputs and flows in Life Cycle Energy Analysis (LCEA) of buildings (Chastas et al., 2016)

4.2.1 Embodied energy

The energy dictionary provides a definition for embodied energy, stating that it is the total energy needs linked, either directly or indirectly, to the provision of a product or service (Cleveland & Morris, 2009). The concept of embodied energy pertains to the total energy expended throughout the life cycle of a building material. This encompasses energy consumption in various stages, such as the production phase involving mining and manufacturing, on-site transportation, construction and assembly, renovation activities, and, ultimately, the demolition process. Recent studies have been dedicated to understanding the importance of embodied energy within building materials, emphasizing the significance of this component in the overall context of sequestered energy. Analyzing the embodied energy in building materials is crucial for assessing the environmental impact of construction processes and making informed decisions to enhance the sustainability of building practices (Dixit et al., 2010). Generally, it is assumed that the energy consumption during the operational phase of a building and the associated emissions are much higher than the embodied energy and emissions. Therefore, significant efforts are made to reduce energy consumption, particularly with innovations and technological developments in the renewable energy field and incentives to change energy use behaviors in the 21st century, offering promising reductions in energy consumption during the operational phase. However, these measures can lead to an increase in the use of high-energy-performance building materials, consequently raising the energy and carbon emissions required at the beginning of the building production. This rise explains the increasing importance of embodied energy in the total life cycle of a structure (Koç et al., 2022). In the literature, embodied energy (EE) is defined in two primary ways. Some interpretations restrict it to the energy consumed exclusively during the construction of a building, encompassing the energy expended in the manufacturing, transportation, and assembly of construction materials. However, in a more comprehensive cradle-to-grave definition, embodied energy is characterized as the total energy utilized not only in the construction phase but also throughout the ongoing maintenance and eventual demolition of a building. This all-encompassing perspective provides a holistic view of the energy footprint associated with a structure, considering its entire life cycle from inception to disposal (Azari & Abbasabadi, 2018). Embodied carbon refers to all the greenhouse gases associated with the manufacture, transportation and disposal of a product or material throughout its lifecycle. Embodied energy refers to the total energy consumption during the life of a product, considering all processes from removal to disposable raw materials. It is measured in units of energy such as joules. Embodied carbon, on the other hand, specifically takes into account the total carbon dioxide and greenhouse gas emissions associated with a product's lifetime, measured in mass units such as kilograms of CO_2 equivalent. Both measures are important for sustainability assessment, and their reduction is a common goal of promoting eco -friendly practices and the concept is widely used in the construction industry, especially in assessing the environmental impact of buildings and building materials. It helps to understand the carbon footprint associated with products and manufacturing processes.

There are two main aspects of embodied carbon:

- Upfront or "first-life" carbon: This encompasses emissions from extracting raw materials, manufacturing, and transporting the product to the construction site.
- Operational carbon: This includes emissions from the use and maintenance of the product throughout its lifespan, such as energy consumption for heating, cooling, and lighting in the case of buildings.

Reducing embodied carbon stands as a pivotal aim in sustainable design and construction endeavors. This necessitates the utilization of materials boasting diminished carbon footprints, streamlining manufacturing processes, reducing transportation distances, and fostering the ethos of reuse and recycling. Life Cycle Assessment (LCA) methodologies commonly serve as the linchpin for quantifying embodied carbon and scrutinizing the environmental ramifications of diverse materials and design selections.

The correlation between embodied carbon and sustainability assumes a central role in nurturing environmentally conscientious practices, particularly within the construction and design realms. Embodied carbon epitomizes the aggregate greenhouse gas emissions entwined with the complete life cycle of a product, spanning resource extraction, fabrication, conveyance, utilization, and disposal. Conversely, sustainability endeavors to curtail the ecological impact of human undertakings to safeguard enduring ecological equilibrium. Global Warming Potential (GWP), a parameter utilized to gauge the warming potency of a greenhouse gas relative to carbon dioxide (CO_2) across a designated timeframe, streamlines the uniform assessment of diverse gases boasting disparate atmospheric lifespans and heat-trapping capabilities.

The comprehensive emissions emanating from a structure, encapsulating emissions originating from materials, energy consumption, and conveyance, are frequently delineated through entrenched life cycle cost analysis (LCA) methodologies.

The total emissions of a building, which encompass emissions from materials, energy usage, and transportation, are commonly determined through established life cycle cost analysis (LCA) methodology. These comprehensive calculations necessitate domain-specific knowledge across various engineering disciplines. The impact of an individual component or action is presented as part of the entire building, making the optimization of specific measures a multidisciplinary challenge. This approach can sometimes lead to the perception that the effect of individual measures is minimal in comparison to the overall building. However, a truly optimal solution for a complex system inherently involves the amalgamation of numerous small optimizations (Petersen & Thiis, 2023).

The building and construction industry play a significant role in global greenhouse gas (GHG) emissions, contributing up to 30% annually. This places the industry among the top seven major contributors to the heightened global warming effect . Without substantial improvements in the energy efficiency of buildings, the ongoing urbanization trend is projected to result in a doubling of GHG emissions associated with the building and construction sector in the next 20 years. Greenhouse gasses primarily comprise six gasses with confirmed global warming effects: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6). Among these, CO_2, , and N_2O significantly contribute to global warming, accounting for approximately 97% of the total global warming potential (Akbarnezhad & Xiao, 2017). By addressing embodied carbon, sustainable practices aim to reduce the carbon footprint of buildings and infrastructure, mitigating their contribution to climate change. This involves choosing materials with lower carbon emissions, optimizing manufacturing processes, and embracing circular economy principles, such as recycling and reusing materials. The incorporation of embodied carbon considerations in building standards and certifications reflects a growing awareness of the need for holistic, life cycle-based assessments to guide environmentally conscious decision-making. In essence, the commitment to sustainability involves a conscientious effort to minimize embodied carbon, promoting resource efficiency, innovation in materials, and a resilient built environment that aligns with the broader goals of ecological stewardship. Until recently, the focus was primarily on operating energy in the consideration of total life cycle energy, given its larger share. However, with the introduction of energy-efficient equipment, appliances, and advancements in insulation materials, the potential to reduce operating energy has grown. Consequently, the current emphasis has shifted to also include embodied energy in building materials (Dixit et al., 2010).

4.2.1.1 Reducing embodied energy

Reducing embodied carbon is a key focus in sustainable design and construction. Various strategies can be employed to minimize the environmental impact associated with the production, use, and disposal of building materials. Architectural and engineering choices wield considerable influence over the quantity of waste generated in the construction phase. The design phase of construction presents the optimal opportunity to address waste management effectively. Architects and engineers, as the designers, serve as the primary defense against a project fraught with waste generation. Their pivotal role in waste management is best fulfilled by concentrating on eliminating waste through thoughtful design. Inefficient design decisions contribute significantly to on-site construction waste, and approximately one-third of on-site waste results from architects failing to implement waste reduction measures during the design phase. Although aesthetics and client preferences may influence design management to some extent, architects bear the responsibility to enact measures independently. Designers can integrate waste management solutions into their designs, demonstrating and educating clients on the economic, social, and environmental benefits (Amaral et al., 2020).

Reducing carbon emissions is of paramount importance in addressing the global challenge of climate change and its far-reaching impacts on ecosystems, human health, and socio-economic systems. Achieving low embodied energy (EE) intensity in buildings is often linked to the utilization of local materials and the construction of lightweight buildings. Beyond their market advantages, incorporating locally available and produced materials in construction offers benefits such as reduced transportation distances and fuel consumption, thereby lowering transportation-caused EE. Additionally, the selection of materials manufactured through low-energy procedures is crucial for enhancing efficiency in embodied energy. From an embodied energy perspective, key criteria for the selection of construction materials should encompass local availability, manufacturing energy intensity, recyclability potential, recycled content, renewability potential, capacity to minimize construction waste, lifespan and durability, and maintenance needs. Architectural design choices that maximize spatial flexibility, efficient use of floor space, reduced reliance on building materials in buildings and building envelopes, and increased production capacity also contribute to achievement low physical fitness (Azari & Abbasabadi, 2018). Carbon emissions, primarily in the form of carbon dioxide (CO_2) and other greenhouse gases, contribute significantly to the warming of the Earth's atmosphere, causing harmful changes in climate, sea level rise and climate a it is terrible in intensity and in large numbers. Steel and concrete manufacturing has significant environmental impacts, especially in terms of carbon emissions and the use of non-renewable materials.

Construction, responsible for more than half of the world's steel consumption, and cement production alone contributed to roughly 8% of anthropogenic CO_2 emissions in 2012. Designers and engineers are exploring various ways to reduce emissions, including substituting and reducing materials (Feickert & Mueller, 2023) . Some of the consequences of uncontrolled carbon and biodiversity loss, agricultural crop damage and food security risks. In addition, the health effects of increased air pollution due to carbon dioxide emission pose a threat to human well-being. Reducing carbon emissions through sustainable practices, adoption of renewable energy and international cooperation is essential to protect the planet and ensure a sustainable future policymakers, businesses and individuals alike recognize the urgency of this issue and collectively strive to reduce carbon emissions to minimize the negative impacts of climate change. The need to reduce carbon emissions goes beyond environmental concerns and directly interacts with socio-economic issues. Climate change exacerbates existing vulnerabilities, disproportionately affects marginalized communities, and exacerbates social inequalities. The impact of extreme weather events such as hurricanes, floods, and droughts often affect low income people who have little money to adapt and bounce back from this can lead to displacement, competition goes high in terms of resources, and increased geopolitical conflict.

Economically, the consequences of climate change and uncontrolled carbon emissions are far-reaching. Disruptions in global supply chains, rising costs associated with climate-related risks, and potential loss of infrastructure due to sea level rise pose significant risks to economic recovery so On the contrary, adopting sustainable practices and shifting towards low-carbon technologies to spur innovation, create new jobs, economic resilience and can feed. In that challenges in these aspects, global cooperation is needed to effectively address carbon reduction. International agreements such as the Paris Agreement emphasize the responsibility of all countries to limit global warming and reduce the impacts of climate change Collaborative efforts in research, technology transfer and policy implementation is needed to achieve global carbon emission reductions The need to reduce carbon emissions goes beyond environmental risk reduction; This includes social equality, economic stability, and international cooperation. Adopting sustainable practices and transitioning to a zero-carbon future is an investment in the well-being of present and future generations, as well as the overall health and resilience of our planet. Such strategies can be used have been used to reduce physical strength. These are listed below.

- Material Selection:
  - ➢ Choose materials with lower embodied carbon. Consider alternatives with a smaller environmental footprint during extraction, production, and transportation.
  - ➢ Prioritize recycled or reclaimed materials to promote circular economy principles and reduce the need for new resource extraction.
- Optimized Design:
  - ➢ Design buildings with a focus on efficiency, minimizing the overall quantity of materials required.
  - ➢ Consider modular and prefabricated construction methods, which can reduce waste and construction time.
- Local Sourcing:
  - ➢ Source materials locally to minimize transportation-related emissions. This strategy not only reduces carbon emissions but also supports local economies.
- Alternative Construction Techniques:
  - ➢ Explore alternative construction techniques that use materials with lower embodied carbon. For example, consider timber construction as an alternative to traditional concrete and steel.
- Energy-Efficient Manufacturing:

- ➢ Choose materials produced using energy-efficient manufacturing processes. Utilize renewable energy sources in manufacturing facilities to reduce the carbon intensity of production.

- Carbon Offsetting:
    - ➢ Invest in carbon offset programs or projects to balance out unavoidable emissions. This involves supporting initiatives that remove or reduce an equivalent amount of carbon dioxide from the atmosphere.
- Life Cycle Assessment (LCA):
    - ➢ Conduct a life cycle assessment to evaluate the environmental impact of materials and design choices comprehensively. This can inform decision-making and guide the selection of low-carbon alternatives.
- Building Information Modeling (BIM):
    - ➢ Utilize BIM technology to simulate and analyze the environmental impact of different design scenarios. This can help optimize the design for reduced embodied carbon.
- Education and Awareness:

➢ Educate architects, designers, builders, and clients about the importance of embodied carbon and sustainable practices. Increased awareness can drive demand for eco-friendly materials and construction methods.

- Policy and Certification:

➢ Advocate for and comply with building standards and certifications that incorporate embodied carbon considerations. This includes certifications like LEED, which reward projects for sustainable practices.

- Innovation and Research:

➢ Invest in research and development to discover and implement innovative materials and construction techniques with lower embodied carbon.

By integrating these strategies, stakeholders in the construction industry can contribute to significant reductions in embodied carbon, promoting a more sustainable and environmentally friendly approach to building design and construction.

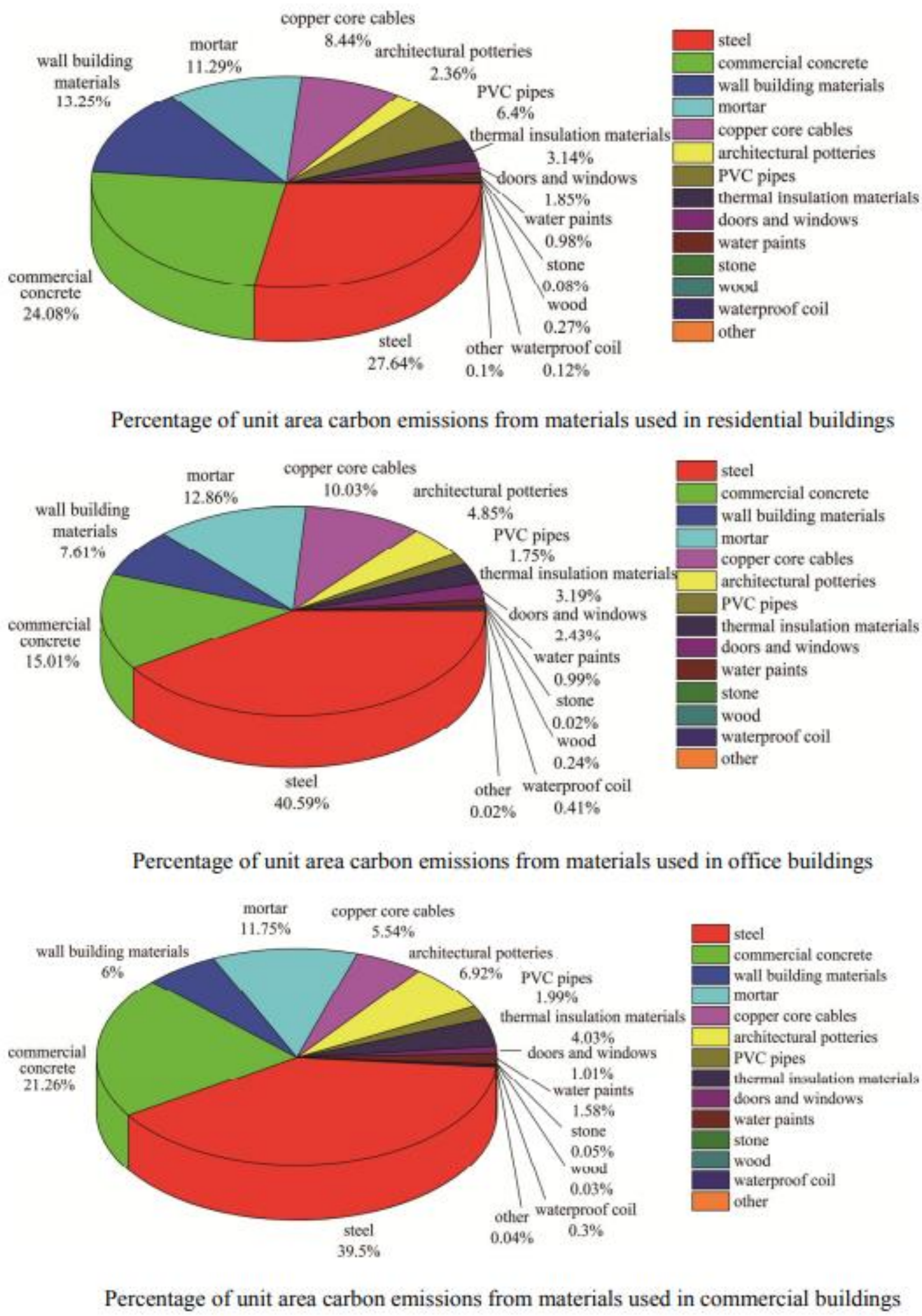

Figure 4.2 :Percentage of unit area carbon emissions from materials used in three types of building (Zhixing et al., 2019)

The embodied energy of common building materials in buildings generally varies based on the amount of energy expended during production, transportation, and assembly. Main structural materials such as concrete, steel, aluminum, and glass are typically known for their high embodied energy. The energy used in cement production contributes to the elevated embodied energy of concrete, while the energyintensive processes involved in steel and aluminum production increase the embodied energy of these materials. Additionally, the transportation of these materials, often from distant locations, impacts the embodied energy by increasing energy consumption during transportation. On the other hand, natural and lightweight materials like wood generally have lower embodied energy. Sustainable construction practices, including the use of recycled materials, sourcing materials locally, and implementing energy-efficient measures, are becoming increasingly important strategies for reducing the embodied energy in buildings. The carbon emissions from ten major building materials contribute to 99% of the total carbon emissions during the materialization phase of construction. These materials include steel, commercial concrete, wall building materials, mortar, copper core cables, architectural potteries, PVC pipes, thermal insulation materials, doors and windows, and water paints. To reduce carbon emissions, architects are encouraged to control the quantities of these materials in architectural design and opt for environmentally friendly alternatives. Timber structures and light steel structures are highlighted as options that significantly lower energy consumption during the materialization phase, offering benefits such as vibration resistance, recyclability, and increased floor area. Choosing environmentally friendly materials in the design stage is emphasized for minimizing energy consumption (Zhixing et al., 2019).

4.2.1.2 Estimating of embodied energy

Analysis of embodied energy and the carbon footprint of processes and products has emerged as an important process in sustainable development and environmental protection Embodied energy costs the total energy consumption during the life of a product, involving extraction, manufacture, transportation and disposal. Similarly, embodied carbon includes all of the greenhouse gases associated with these life cycles. An accurate assessment of the effects of goods and services on the environment is needed in the face of growing concerns about climate change and resource scarcity

This not only involves grasping the immediate operational energy usage but also considering the concealed or embodied effects. This introductory discussion delves into the importance of estimating embodied energy and carbon, examining its implications for informed decision-making, resource stewardship, and the global initiative to address climate change. Various embodied carbon (EC) estimating databases are available for both early-stage and detailed stage estimations, including the University of Bath's Inventory of Carbon and Energy (ICE), Waste Reduction Action Plan (WRAP), and Hutchins UK Building Blackbook, among others. The presence of different tools and varying system boundaries makes it challenging to compare EC calculations, and even within the same system boundary, discrepancies may arise. This raises concerns about the accuracy and reliability of existing estimating methods, highlighting the need for a consistent and accurate methodology. A new methodology called SCEEM has been introduced to address these challenges and provide accurate and consistent EC estimates (Rodrigo et al., 2023).

Type	EC estimating tool	System Boundary	Details	Estimating Method	Type of Application	Publicly Available	Free	Location	Last Updated	Reference
Databases	ICE	cradle-to-gate	EC	Process	Excel Sheet	Yes	Yes	UK	August 2019	Hammond and Jones (2008)
	Hutchins UK Building Blackbook	cradle-to-gate	EC	Process	Book	Yes	No	UK	2010	Franklin and Andrews (2010)
	WRAP		EC	Process	Web Application	For registered users	Yes	UK		WRAP (2018)
	Ecoinvent	cradle-to-gate	LCA	Process	Web Application	Yes	No	Switzerland	Oct 2017	Frischknecht and Rebitzer (2005)
	AusLCI	cradle-to-gate	EPD	Process	Excel Sheets/ XML Format	Yes	Yes	Australia	2016	The Australian National Life Cycle Inventory Database. (2020)
	EPiC	cradle-to-gate	EE and EC	Hybrid	Book	Yes	Yes	Australia	2019	Crawford et al. (2019)
	The GreenBook 2020	cradle-to-end of construction	EC	Process	Book	Yes	No	Australia	Nov 2019	The GreenBook (2020)

Figure 4.3 : Summary of the EC estimating database (Rodrigo et al., 2023)

Embodied carbon accounting tools have become important tools for promoting sustainable development and informed decision making in construction and manufacturing. Entrenched in life cycle assessment methods these tools play an important role in quantification and analysis of greenhouse gas emissions associated with materials and product life cycles steps are covered. An important feature of these tools is that they can provide a comprehensive view of the impact on the environment across the board, helping stakeholders identify areas of carbon reduction efforts. Extensive summaries including facilitate integrated and comprehensive and contextual analysis.

As this work progresses, these tools are becoming increasingly user-friendly and accessible, empowering architects, engineers, and decision-makers to tap into complex carbon embodied soils in order to contribute to a more sustainable built environment of operational energy. Conversely (OE) estimates, embodied energy (EE) estimates incorporate high levels of uncertainty from various sources. This uncertainty stems from challenges with data quality, which affect the positioning of EE studies in terms of time, geography, and methodological aspects, and is further contributed by inconsistencies across data sources give rise to this uncertainty. Broadly speaking, three main approaches have been used in EE estimation: systems-based life cycle analysis (LCA), economics, input-output-based LCA, and hybrid LCA It is important to emphasize that the application of these methods extends beyond the realm of of EE statistics. It is designed to characterize a wide range of environmental impacts by monitoring different processes such as extraction, processing, transportation and disposal These applications enable environmental production comprehensive environmental analysis, and enable informed decisions to pursue sustainable practices in various sectors (Azari & Abbasabadi, 2018).

4.2.2 Operating energy

The energy performance of a building includes the total energy consumption associated with the daily operation of the building, an important factor in the overall sustainability assessment This broad term includes energy expenditure for a variety of components, including, but not limited to, heating, ventilation, air conditioning (HVAC) systems, lighting housings, electronics HVAC systems necessary to provide optimal indoor conditions and typically represents the largest portion of a building's energy generating system (HVAC) available. In addition to the power on and plug-in . Heating, cooling, and lighting requirements are influenced by the location of the building (climate zone) and the desired level of comfort to live in. High levels of OE are often required to meet heating and cooling needs a available in buildings in extreme weather conditions is addressed (Venkatraj et al., 2020). Installation of low-energy thermostats and lighting, as a proactive measure to reduce the environmental footprint of sustainable building operations. Construction, as a supplement to properly insulated walls, reduces an important contribution to heating and cooling, so that the electrical efficiency of the power plant must be improved in sustainable construction. Look for evidence that paradigm shifts in the system happen

This transition not only aligns with global initiatives to combat climate change but also yields substantial long-term cost savings for building proprietors. The meticulous measurement and adept management of building operating energy emerge as integral components within the realm of sustainable urban planning, fostering an energy-conscious and environmentally responsible ethos throughout the construction and occupancy phases. This holistic approach strives to strike a balance between human comfort, operational efficiency, and ecological stewardship.

4.2.2.1 Reducing operating energy

The urgent need to address climate change and reduce carbon emissions has elevated the significance of energy efficiency in the discourse on sustainable building practices. As pivotal energy consumers, buildings present a compelling arena for implementing strategies that not only reduce operating energy but also contribute to broader environmental goals.

- Technological Innovations in HVAC Systems:
    - ➢ Technological innovations within Heating, Ventilation, and Air Conditioning (HVAC) systems stand out as a promising avenue for reducing building operating energy. Advanced systems, such as variable refrigerant flow (VRF) and geothermal heat pumps, exhibit superior energy efficiency and have been extensively studied in academic literature. These technologies not only optimize climate control but also contribute to significant reductions in energy consumption, aligning with the growing imperative of sustainable building practices.
- Building Automation Systems (BAS):
    - ➢ The integration of Building Automation Systems emerges as a transformative strategy for achieving optimal energy efficiency. Academic research underscores the potential of BAS in real-time monitoring and control of building systems. By facilitating adaptive adjustments based on occupancy patterns, external conditions, and energy demand, BAS can lead to substantial reductions in energy consumption. This academic insight provides a robust foundation for the widespread adoption of automation technologies in building operations.
- Passive Design Principles:

- ➢ Academic discourse highlights the pivotal role of passive design principles in reducing the dependence on mechanical systems for temperature regulation. Rigorous research supports the notion that proper building orientation, effective insulation, and the strategic use of shading devices significantly decrease energy demand. Beyond the quantifiable energy savings, these passive strategies enhance occupant comfort and well-being, reinforcing the academic call for holistic approaches to building design. Passive design involves harnessing natural energy flows to maintain thermal comfort. It revolves around selecting the right building orientation, materials, and landscaping. Proper building orientation and the specification of the building envelope's fabric are essential to prevent or minimize heat gain. Shading is also implemented to reduce solar radiation. These techniques and strategies can be complemented by technologies (passive and/or active), customizable controls, and enriched by biophilic design patterns to enhance health and well-being in the built environment (Altan et al.,2016). The term 'Passive Design' refers to design strategies, technologies, and solutions that efficiently utilize the environmental conditions outside the building to maximize energy and cost savings while ensuring the fundamental building facilities and provisions (such as indoor comfort, safety, health, etc.) are not compromised (Jadhav, 2016).

Environmental conditions can offer various advantages or disadvantages to the building, including:

1. Daylighting: Can reduce energy used for artificial lighting, but excessive and improper exposure may result in glare and other forms of visual discomfort.
2. Natural ventilation: Can decrease mechanical ventilation energy for air movement but may lead to hygiene issues and over-cooling in cold climates.
3. Natural cooling: Aiming to reduce the need for excessive air-conditioning or mechanical cooling in hot climates.
4. Natural heating: Utilizing the sun's energy to provide indoor heat in cold climates instead of relying on excessive artificial heating. However, this needs careful management in hot climates to reduce air-conditioning energy use.

5. Shading: (from trees or neighboring buildings) Can reduce heat from direct sun exposure in hot climates but might obstruct views and natural light, leading to heat loss in cold climates.

- 4. Energy-Efficient Lighting and Controls:
    - ➢ Lighting, as a major contributor to a building's energy footprint, is a focal point in academic investigations. Studies delve into the benefits of energy-efficient lighting, particularly the widespread adoption of Light Emitting Diode (LED) technology. Beyond the energy savings, academic insights extend to the implementation of lighting controls, such as occupancy sensors and daylight harvesting systems, demonstrating their efficacy in further optimizing energy usage while maintaining a comfortable and well-lit environment.

- 5. Renewable Energy Integration:
    - ➢ Academic research underscores the pivotal role of renewable energy sources in the pursuit of sustainable building operations. Solar photovoltaic panels and wind turbines have been extensively studied for their efficacy in generating on-site clean energy. The academic community recognizes that integrating renewable energy sources not only addresses a building's energy needs but also contributes to a broader transition toward a decentralized and resilient energy infrastructure.

- Life Cycle Assessments (LCA):
    - ➢ Beyond the immediate energy-saving strategies, academics delve into the realm of life cycle assessments (LCA) to comprehensively evaluate the environmental impact of building materials and technologies. Understanding the embodied energy in construction materials and the long-term environmental implications of building choices provides a more nuanced and holistic perspective for sustainable building practices.

Educational research provides a multi-pronged framework for reducing energy consumption in buildings. The combination of advanced HVAC technology, architectural design, passive building principles, energy efficient lighting, and renewable energy creates complex systems as planners, architects and architects practitioners navigate the complex environment of sustainable development and enable The ongoing dialogue between academia and actions are crucial to ensure that buildings play a greater role in reducing processes, promoting innovation encourage, and global sustainability goals in climate change mitigation

5. CASE STUDY

5.1 Information of Case Study

The case building is located in Vişnezade neighborhood, Beşiktaş district, Istanbul province, on Hüsrev Gerede Street. The reason for using this building in the sample study is primarily due to its non-compliance with the current earthquake regulations approved in the permit project in 1972 and its possession of typical architectural features of the building stock in its region. It is an apartment building identified as a risky structure by the Beşiktaş Municipality, expected to be vulnerable to earthquakes with a magnitude of 7 or higher, such as the anticipated Istanbul earthquake, and not meeting the requirements of current earthquake regulations.

Figure 5.1: Location of case building in Turkey

Figure 5.2: Location of case building in Istanbul

The structure consists of 6 regular floors and 1 rooftop floor. The total height is 21 meters, and the total closed area is calculated as 2030 square meters. The floor-to-floor heights are 2.90 meters. In the sample structure, reinforced concrete shear walls and frame systems are used together. A beam slab system is preferred as the reinforced concrete floor system. The exterior walls of the building are 20 cm thick and made of perforated bricks. Internal partition walls, when constructed in all independent sections over approximately 52 years, exhibit variations in divider systems, but generally, perforated bricks with a thickness of 10 cm are used on all floors.When looking at the floor plan of the building, the floor units include a living room, kitchen, master bedroom, children & guest bedroom, bathroom, toilet, storage, and balcony.

Table 5.1: Floor units' squaremeters

Units	m²
Living Room	90
Kitchen	32
Master Bedroom	24
Children&Guest Bedroom	22.5
Bathroom	10
Toilet	4
Storage	12
Balcony	20
Total	250

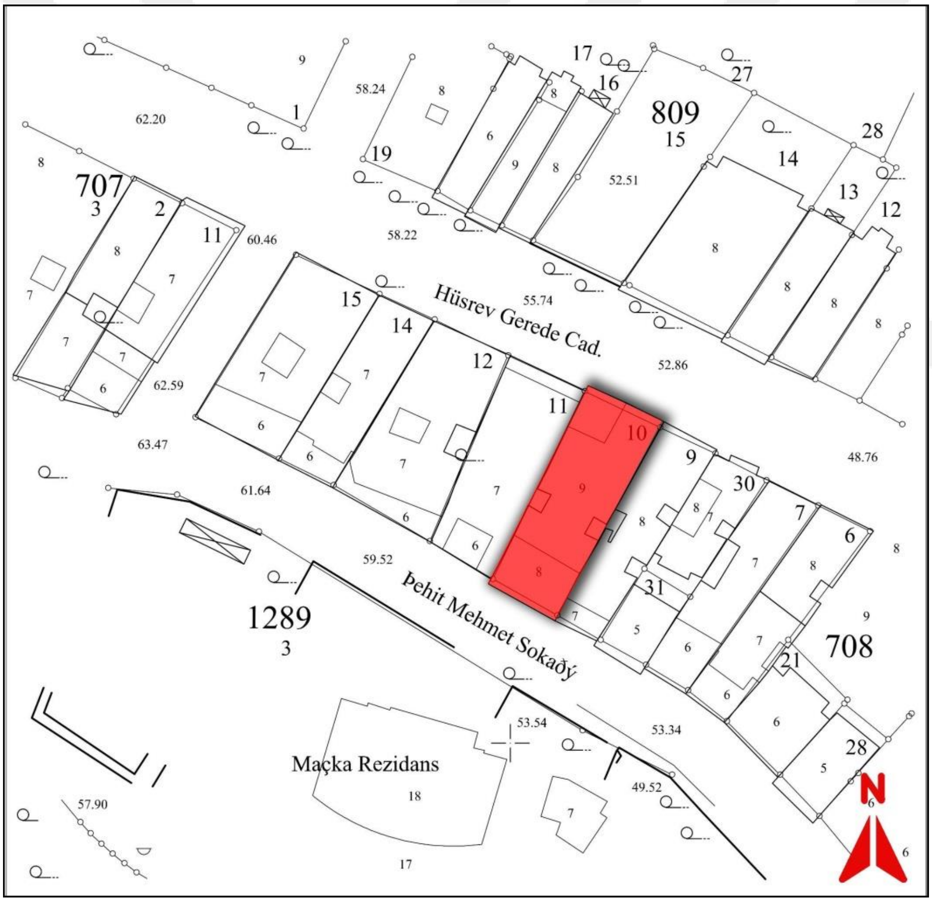

Figure 5.3: Case building site plan scale 1/1000

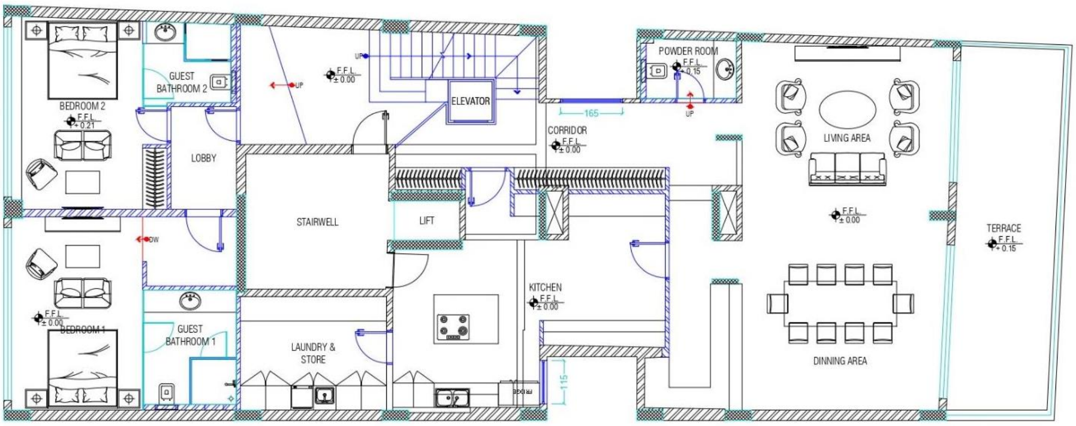

Figure 5.4 Case building floor plan

Firstly, in the scenario of the building's demolition due to urban transformation or earthquake, the material quantities of the entire structure (6 normal floors and 1 rooftop floor) have been calculated to determine the embodied energy content. This quantity calculation was carried out using the Athena Impact Estimator software, taking into account the structural system, square meters, floor heights, divider systems, and building layering. The necessary information was input into the software based on these inputs, and the software calculated the material quantities for the entire structure.

Bill of Materials Report

Project: CASE BUILDING

Material	Unit	Total Quantity	Columns & Beams	Floors	Foundations	Roofs	Walls	Project Extra Materials	Mass Value	Mass Unit
Clay Tile	m2	159,2160	0,0000	159,2160	0,0000	0,0000	0,0000	0,0000	8,1200	Tonnes
Concrete Benchmark USA 3000 psi	m3	108,1029	0,0000	79,2605	28,8424	0,0000	0,0000	0,0000	247,9199	Tonnes
Expanded Polystyrene	m2 (25mm)	291,9575	0,0000	0,0000	291,9575	0,0000	0,0000	0,0000	0,2102	Tonnes
Nails	Tonnes	0,0170	0,0000	0,0000	0,0170	0,0000	0,0000	0,0000	0,0170	Tonnes
Rebar, Rod, Light Sections	Tonnes	4,1000	0,0000	4,1000	0,0000	0,0000	0,0000	0,0000	4,1000	Tonnes
Softwood Plywood	m2 (9mm)	118,6500	0,0000	118,6500	0,0000	0,0000	0,0000	0,0000	0,5390	Tonnes
Welded Wire Mesh / Ladder Wire	Tonnes	0,2485	0,0000	0,0000	0,2485	0,0000	0,0000	0,0000	0,2485	Tonnes

Figure 5.5 : Interface of Athena Impact Estimator Bill of Materials Report

In the above table, each unit of the case building, categorized internally by the Athena Impact Estimator software, represents the weights of all units that make up the structure, individually and collectively, expressed in tons. The quantity calculation has been performed for each building unit. In the event of the demolition of this structure, it will generate approximately 2289 tons of excavation waste. In excavation markets, 1 cubic meter of excavation waste is estimated to weigh about 1.6 tons. Therefore, to calculate the volume of excavation waste, we can divide the total weight by 1.6, resulting in approximately 1430 m³.Assuming an average capacity of 20 to 24 m³ per excavation truck, the removal of the excavation waste generated by the sample structure from the demolition site would require approximately 70 excavation trucks.

5.2 Embodied Energy Consumption Simulation of Case Building by Athena Impact Estimator

There are generally two main methods commonly used to calculate the embodied energy and embodied carbon dioxide emissions of structures. The first method involves manually obtaining values from the International Construction Database (ICE) version 3.0, updated by ICE in November 2019, which contains unit weights, unit embodied energy values, and unit carbon dioxide emission values for various building materials. These values are then multiplied by the quantities of building components used in the structure.

The second method is to use online or desktop software for these calculations. After an in-depth literature review, Athena Impact Estimator software was chosen for this study due to its user-friendly interface, being freely available, and having been utilized in numerous previous studies. The existing data of the sample structure were input into the software to calculate the embodied energy and embodied carbon dioxide emissions.

The Athena Impact Estimator for Buildings is an environmental impact assessment-based software package designed to assist architects, engineers, and analysts in seamlessly integrating environmental information in the early stages of a project.

This building-scale tool, utilized by construction teams, is employed to explore the environmental impact of different material options and core-shell system alternatives. Initially released in 2002, this tool has undergone numerous updates since its inception. The Building for IE (Impact Estimator) was developed in collaboration with Morrison Hershfield and is financially supported by our sponsors. The Athena Impact Estimator is suitable for new constructions, renovations, and additions across all building types in North America. It can model over 1,200 structural and envelope-assembly combinations, allowing for quick and easy comparisons of multiple design options. The Impact Estimator provides a comprehensive inventory profile of a building's entire life cycle. Inventory results encompass flows from cradle to grave, including energy and raw material flows, as well as emissions to air, water, and soil.

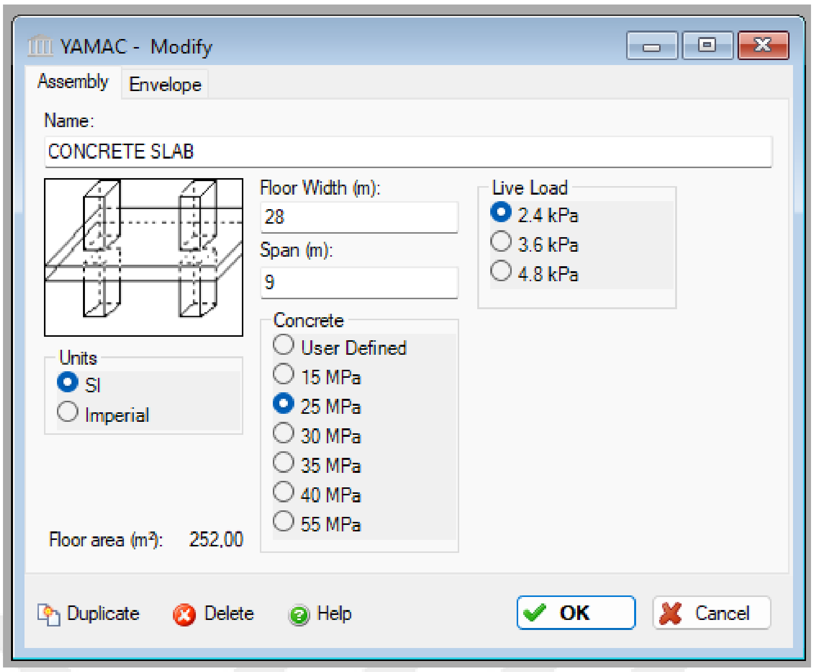

Figure 5.5 : Interface of Athena Impact Estimator Modelling Part

In the table below, unit embodied energy, unit carbon dioxide emission, and unit weight values for the building materials of the sample structure are tabulated based on the information obtained from ICE DB V3.0.

Despite the lowest concrete quality provided in the Athena Impact Estimator program being C15, it has been determined that the concrete quality of structures built in Turkey before the 1990s is generally at C10 - C6 levels (Işık, 2021). For this reason, the "User Defined" option has been selected for concrete quality in the program, and the concrete quality of the sample structure has been defined as C8.

The low quality of concrete is a critical factor in terms of the durability and safety of the structure. Considering this situation in the Athena Impact Estimator program is important for the accurate assessment of existing structures and for taking appropriate strengthening or improvement measures. A concrete quality of C8 is significantly below modern standards and may require special attention and evaluation for such structures.

Table 5.2: Athena Impact Estimator Results

Department	Embodied Energy	Unit	Embodied Global Warming Potential	Unit
Foundation	109.999,6	MJ	10.669,10	$kgCO_2$ eq
Floors	1.112.112	MJ	208.205,90	$kgCO_2$ eq
Walls	1.473.143	MJ	130.0028	$kgCO_2$ eq
Roof	68.936,20	MJ	60.019	$kgCO_2$ eq
Total	2.248.617,80	MJ	409.122,00	$kgCO_2$ eq

5.3 Operational Energy Consumption Simulation of Case Building by Designbuilder

In this step, to better comprehend the embodied energy quantity of the sample structure and for the calculation of the operational energy, the usage energy of the structure has been computed using the DesignBuilder simulation software. The current as-built conditions were accurately surveyed, and the measurements and data obtained were utilized to model the current state of the structure in the DesignBuilder software, with the updated as-built information drawn in the AutoCAD software.

DesignBuilder is a software tool used for energy performance simulations and building performance analyses. This software is designed to evaluate various performance aspects of buildings, including energy efficiency, sustainability, and indoor environmental comfort. Here are some key features and information about DesignBuilder:

- Energy Modeling:
  - ➢ DesignBuilder is used to model and simulate the energy consumption of buildings, assisting in making decisions related to energy efficiency in building design.
- Building Performance Analysis:
  - ➢ The software provides various tools and simulation features to analyze building performance. This may include factors such as indoor environmental comfort and temperature control.
- Sustainability Assessments:

  - ➢ It can be used to assess building performance in alignment with sustainability goals and implement sustainable design strategies.
- Energy Saving Strategies:
  - ➢ DesignBuilder can be used to test and optimize energy-saving strategies, aiding building owners and designers in reducing energy costs.
- Visual and User-Friendly Interface:
  - ➢ With a user-friendly graphical interface, DesignBuilder offers visual modeling tools to streamline the design process.
- BIM Integration:
  - ➢ In some versions, DesignBuilder can integrate with Building Information Modeling (BIM) platforms, enhancing the efficiency of design processes.
- Support for Various Building Types:
  - ➢ DesignBuilder supports energy modeling and performance analysis for various building types, including residential buildings, commercial structures, educational facilities, and more.

Tools like DesignBuilder play a crucial role in developing energy-efficient and sustainable building designs. They are utilized by engineers, architects, energy consultants, and building designers to support data-driven decision-making during the design process, aiming to improve building performance and meet sustainability goals.

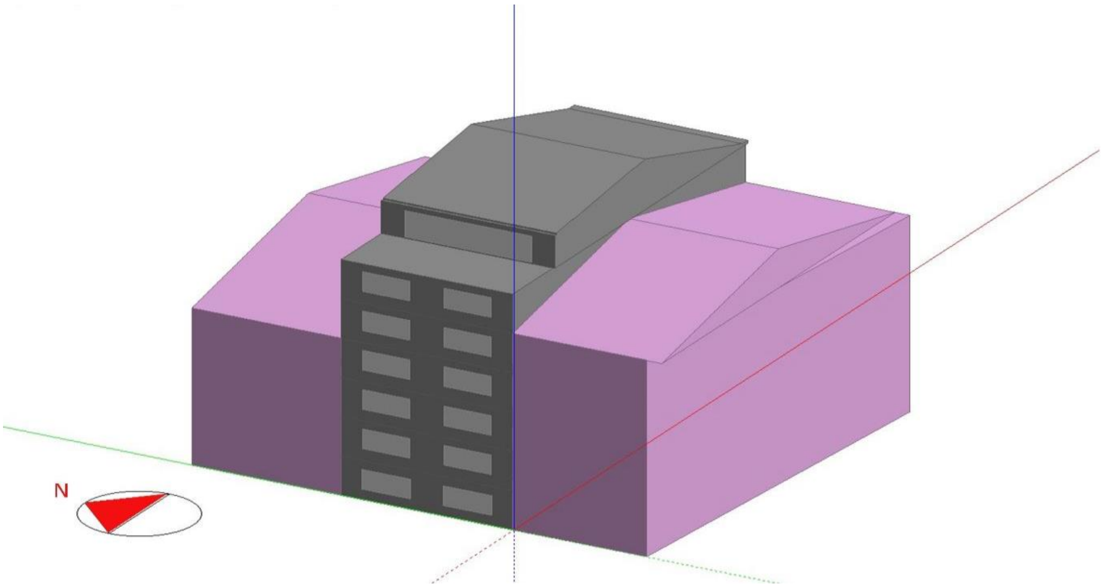

Figure 5.6: Case building 3D model in Designbuildier

As seen in Figure 5.6, the structure consists of six regular floors and one rooftop floor, arranged in a contiguous layout along the north and south directions. Window openings are only present on the west-east axis, and all external walls have 5cm XPS thermal insulation on the brick. The external walls, internal walls, floors, and roof layers of the structure have been categorized, and their U values have been calculated.

Istanbul is under the influence of Marmara (Transitional) climate. Winters are warm and rainy, summers are hot and humid. If we look closely at the annual climate data of Istanbul;

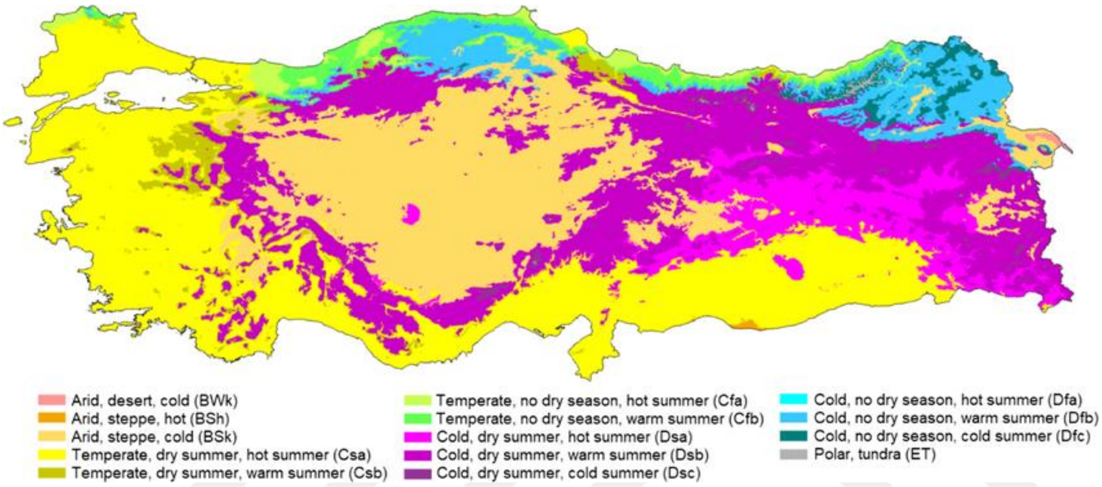

Figure 5.7 : Climate classification of Turkey(MGM)

Figure 5.7 demonstrates that Turkey is classified six different climate types such as; very humid, humid, semi-humid, semi-arid, arid, very arid. Meanwhile, Istanbul has defined as humid climate. If we focus specially to Istanbul, Figure 5.7 illustrates that climate regions of Istanbul;

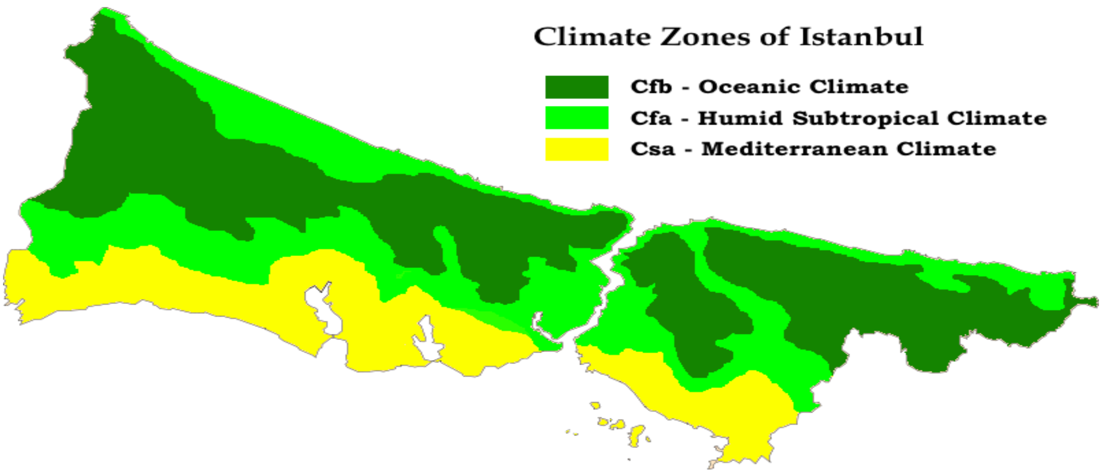

Figure 5.8: Climate zones of Istanbul(Köppen)

According to Figure 5.8 Istanbul consists of three kinds of climate region; (Cfb) oceanic climate, (Cfa) humid subtropical, (Csa) hot summer Mediterranean, however case building is located at the intersection of (Cfb) and (Cfa) climate regions. Moreover, according to Köppen climate zone classification (Cfa) - Humid subtropical climate is hot and muggy in summers, with frequent thunderstorms. In addition, winters are mild and precipitation comes from mid-latitude cyclones. Furthermore, ın the climate zone (Cfb), the average temperature value in all months is below 22°C. It also has an average temperature higher than 10°C for at least four months throughout the year. In addition, the precipitation is evenly distributed throughout the year (Köppen, 1918).We can also observe the accuracy of Köppen's classification method by checking the annual climate data created by the General Directorate of Meteorology (MGM) for Istanbul.

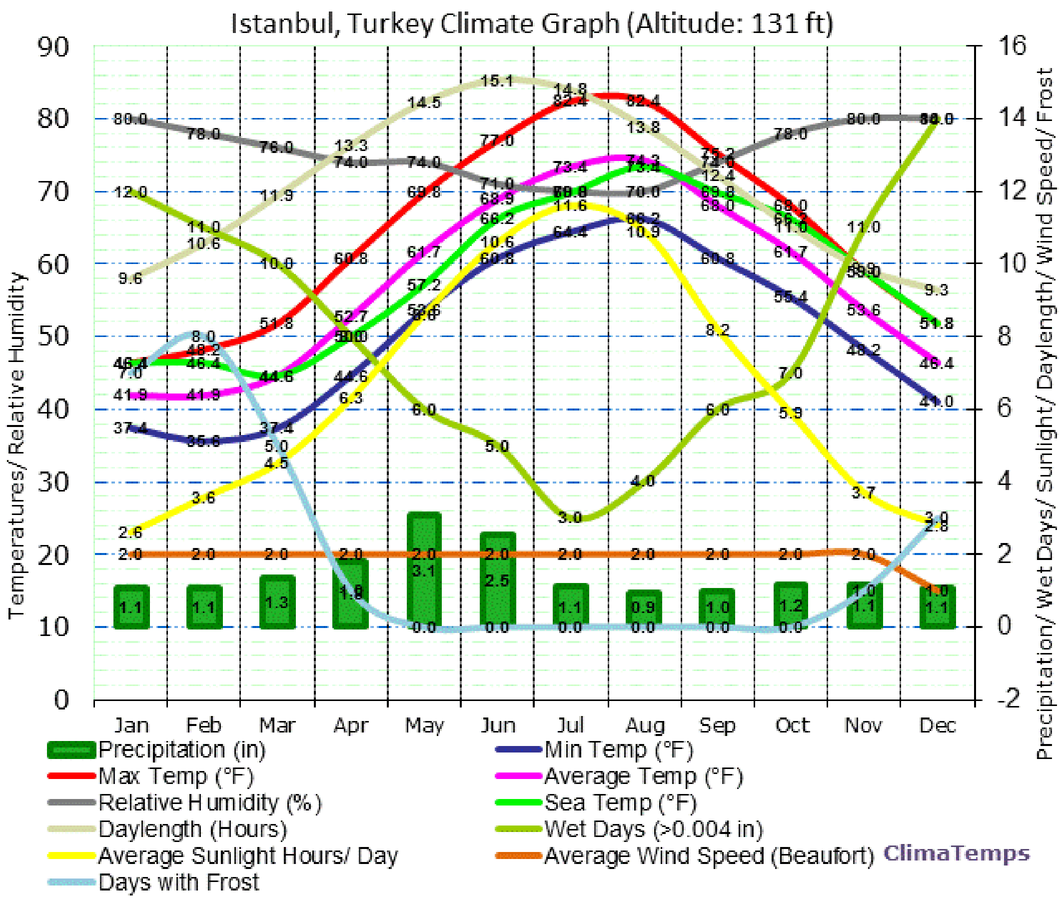

Figure 5.9 : Turkey climate datas(MGM)

The case building under consideration is subject to the thermal insulation regulations outlined in TS 825 for Buildings within the 2nd-degree heating degree-day zone of Istanbul. Notably, as the edifice predates the promulgation of this standard, the extant layering across its components fails to satisfy the prescribed U values. In response to perceived occupant dissatisfaction, discerned during the structure's lifecycle, interventions were implemented. Specifically, a 5 cm XPS thermal insulation layer was incorporated into the wall layering, and within the roof stratum, 5 cm of mineral wool was interposed amid wooden beams. Resultantly, the U-value for the roof layering was computed as U: 0.32 W/m²K. This parameter aligns with the U: 0.32 W/m²K stipulated in TS 825 for the 2nd-degree heating degree-day zone. Subsequent enhancements yielded a U-value of 0.58 W/m²K for the external wall layering, satisfying the prescribed 0.60 W/m²K in TS 825 for the 2nd-degree heating degree-day zone. Furthermore, alterations were affected in the window frames, transitioning from the original single-glazed wooden frames to PVC double-glazed counterparts. Consequently, the present U-value for the windows stands at U: 2.76 W/m²K, juxtaposed against the TS 825 specification of U: 2.40 W/m²K. Despite this deviation, the replacement engendered superior thermal insulation compared to the original single-glazed frames. The current state of the structure has been methodically modeled within the DesignBuilder simulation program, meticulously incorporating the updated layering and U values. Subsequently, the annual heating and cooling loads for the building have been discerningly computed.

Following the input of various parameters such as the building layering , solar orientation, square meterage, site plan, floor heights, and details regarding the heating and cooling systems into the DesignBuilder program, the simulation was executed to model the annual heating and cooling loads of the structure in its current state. The outcomes derived from the simulation are presented below:

Table 5.3: Operational energy of case building

Heating Energy Consumption	Unit	Cooling Energy Consumption	Unit	Total Energy Consumption	Unit
39.561,79	kWh	30.724	kWh	70.258,79	kWh

6. RESULTS AND DISSCUSION

The simulation results obtained in the Athena Impact Estimator simulation program have provided data regarding the embodied energy of the structure. In the second step, in order to better understand the numerical value of the embodied energy of the structure, the annual energy usage of the building was simulated in the Design Builder program. It was determined that a radiator heating system and an air conditioning system were used in the building, and calculations were performed in the simulation program based on these inputs. The heating and cooling loads were calculated in kWh as the unit of energy usage, while the embodied energy values were calculated in MJ. Therefore, in order to make an accurate comparison, it is necessary to express the energy units in the same type.

1 kWh =3.6 MJ

70.258,79 kWh =252.931, 644 MJ

Table 5.4 Results of Embodied Energy &Operating Energy

Total Embodied Energy of Case Building (MJ)	Total Operating Energy of Case Building per year (MJ)
2.248.617,80	252.931,644

After calculating the one-year operational energy of the building, the average economic life of the building was taken as 50 years, and the ratio of the 50-year usage energy to the embodied energy of the building was calculated. According to Chastas et al., the embodied energy potential of traditional buildings was calculated as 6-20% of the operational energy throughout the life cycle of the buildings (2016). Selected in the case building, the embodied energy and operational energy ratios are in this percentage.

50 yr x 252.931,644 MJ = 12.646.582,2 MJyr

2.248.617,80 MJ = 17, 78 % 12.646.582,2 MJyr

Most of the buildings that are planned to be demolished are expected to be traditional buildings.

According to the studies conducted by Azkur & Canan, the average embodied energy per square meter in reinforced concrete residential buildings is specified as 2699 MJ/m² (2022). In the context of this thesis, the embodied energy per square meter of the selected case residential building was calculated to be 1107 MJ/m². The reason for the lower embodied energy per square meter in the selected building compared to the specified amount for reinforced concrete residential buildings is thought to be due to the concrete quality of the sample building being significantly below the expected and current standards. While it is anticipated that the concrete quality of the sample building and other potentially demolished buildings will similarly be low, considering the assumption that many buildings will be demolished, these seemingly low amounts of embodied energy will combine to result in significant energy losses.

The embodied energy of all the materials used in the example building is approximately 13 times the total annual heating and cooling loads of the entire structure. In other words, if this building is demolished and the excavation materials are not recycled, the energy consumed for heating and cooling in 13 years for a multi-story residential building with 6 normal floors and 1 penthouse floor, totaling 2030 m², will be lost in landfill storage centers. This example study is only applicable to a single residential structure. If we scale this amount to all urban renewal projects or the number of structures expected to be demolished, we can recognize the potential for a significant amount of recoverable energy. Given that a large part of our country is located in an earthquake-prone zone, the general focus is to minimize loss of life and property due to earthquakes. However, there is still no systematic regulation, procedure, and regulation regarding the excavation wastes that will arise after an earthquake. We had to confront the problems created by this glaring deficiency, especially after the earthquakes on February 6, referred to as the earthquake of the century that occurred not long ago. The significant amount of excavation waste that emerged after the earthquake disaster on February 6 posed a major problem, and both the state and local governments were caught unprepared for this issue.According to Bilgili &Çetinkaya, Turkey, being a country prone to earthquakes, is consistently exposed to potential risks. While the primary focus is on implementing necessary measures to prevent destruction and loss of life, it remains likely that a certain degree of damage may still occur based on the earthquake's intensity and various other factors. The successive earthquakes on February 6, 2023, inflicted significant damage across a wide area, resulting in numerous casualties and the destruction of buildings. In the current scenario, it is imperative to undertake essential arrangements to minimize losses and mitigate the environmental impact of debris as much as possible. The tons of debris generated post-earthquake were temporarily disposed of in landfills (2023).

Mw=7.5 magnitude scenario earthquake is expected to result in an estimated 43% average damage to buildings in Istanbul. It is anticipated that 26% of the buildings will experience light damage, 13% moderate damage, 3% severe damage, and 1% very severe damage. The total number of buildings analyzed in Istanbul is 1,166,330. Buildings with severe and very severe damage incur damage that is beyond repair, necessitating their demolition and reconstruction. Additionally, it is often more cost-effective to demolish and rebuild buildings with moderate damage rather than repairing them. It is estimated that approximately 17% of buildings in Istanbul (about 194,000 buildings) will experience moderate to severe damage in the scenario earthquake (Kandilli Rasathanesi, 2020).When considering the estimated 194,000 moderately and heavily damaged structures in the event of this earthquake scenario, a significant amount of excavation waste is expected to be generated. The Istanbul Province's Earthquake Loss Estimate Update report indicates that calculations suggest the emergence of debris weighing 25 million tons after a scenario earthquake in Istanbul with a magnitude of Mw=7.5 (2020). In the event of the occurrence of an earthquake of this magnitude, the prompt and organized removal and management of this substantial amount of excavation waste from the damaged areas are crucial not only for environmental sustainability but also for the vital safety of lives and properties within the community.In the Istanbul earthquake scenario, the amount of demolition waste expected to suddenly and simultaneously occur highlights that controlled and planned management of this waste is important not only for the building-energy relationship but also impacts public health, national security, and the economy.

The handling of approximately 25 million tons of excavation waste, including transportation, storage, sorting, and recycling for reuse, would require extensive and detailed management planning and the use of comprehensive systems.

When compared with the embodied energy potential of just 2289 tons of excavation waste generated from the demolition of the sample structure, the significance of the embodied energy potential of the demolition waste that would be created by the expected Istanbul earthquake can be better understood.

When considering the construction waste generated by the replacement of demolished or damaged structures with new buildings, taking into account new energy and resource usage, the concept of embodied energy in buildings should be taken seriously for the sake of environmental sustainability. Therefore, the reuse and recycling of construction and demolition waste are of great importance, not only for energy and resource conservation but also to prevent a large amount of excavation waste from being disposed of recklessly in nature, posing a significant threat to the environment, wildlife, and human health.

It is of urgent importance that state and local governments take into account all these factors and undertake extensive and systematic planning for the sustainable management of construction and demolition waste. For this, successful and up-to-date examples related to the recycling and management of construction and demolition waste should be followed, developed, and implemented in collaboration between the industry and academia.

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