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THE SUSTAINABLE BUILDINGS E-LEARNING PROGRAM

Module 1

OVERVIEW OF SUSTAINABLE BUILDINGS

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TÜRKİYE SUSTAINABLE BUILDINGS NETWORK

TÜRKİYE SUSTAINABLE BUILDINGS NETWORK

The Türkiye Sustainable Buildings Network was established as part of the "Türkiye Sustainable Buildings Network Project," which is co-funded by the European Union under the Civil Society Action towards European Green Deal Grant Scheme. The project is coordinated by WRI Türkiye, in partnership with the Zero Energy and Passive House Association (SEPEV) and with the support of the Danish Green Growth Network (DGGN).

The network operates with the aim of supporting climate action in the building and construction sector, promoting green transformation, enhancing the technical knowledge and skills of sector stakeholders, and mainstreaming the concept of sustainable buildings.

As part of this effort, the Sustainable Buildings E-Learning Program has been developed to serve as a comprehensive knowledge resource for all stakeholders in the building sector. The program consists of 10 training modules designed to contribute to the sector's sustainability, energy efficiency, and low-carbon transition goals.

For more information about the Türkiye Sustainable Buildings Network and to access other modules, please visit **the link**.

MODULE OBJECTIVES

The objectives of this module are as follows:

1. ***Understanding the Fundamental Concepts of Sustainable Buildings:***
   - *Gain knowledge about sustainable building practices by understanding the definition, importance, and key characteristics of sustainable buildings.*
2. ***Applying Environmental Sustainability Principles in Buildings:***
   - *Design efficient and environmentally friendly buildings by integrating environmental sustainability practices such as energy efficiency, renewable energy integration, water efficiency, and the use of sustainable materials.*
   - *Incorporate Life-Cycle Assessment (LCA) and circular economy principles into material use and waste management processes in buildings.*
3. ***Enhancing User Health and Comfort Through Social Sustainability:***
   - *Prioritize factors such as health, well-being, and social equity in the design process to create accessible, inclusive, and healthy living spaces.*
4. ***Ensuring Economic Sustainability and Understanding Long-Term Cost Benefits:***
   - *Analyze the financial advantages of sustainable buildings by evaluating life-cycle costs and economic resilience to comprehend long-term financial benefits.*
5. ***Effectively Utilizing Sustainable Building Technologies and Tools:***
   - *Understand the role of Building Information Modeling (BIM) and smart building technologies in sustainable design processes and integrate these technologies with efficient performance monitoring and measurement tools to achieve optimization.*
6. ***Gaining Knowledge on Regulatory Frameworks and Policies:***
   - *Comprehend national and international regulations, green building certification systems, and public-private partnerships to understand how to implement local and global standards in sustainable building projects.*
7. ***Examining and Implementing Successful Case Studies of Sustainable Buildings:***
   - *Analyze successful case studies such as net-zero energy buildings, green office buildings, and green residential projects to evaluate design strategies and the social and environmental benefits achieved in sustainable building projects.*

These objectives aim to provide comprehensive knowledge on sustainable building design and practices, addressing environmental, social, and economic sustainability in an integrated manner.

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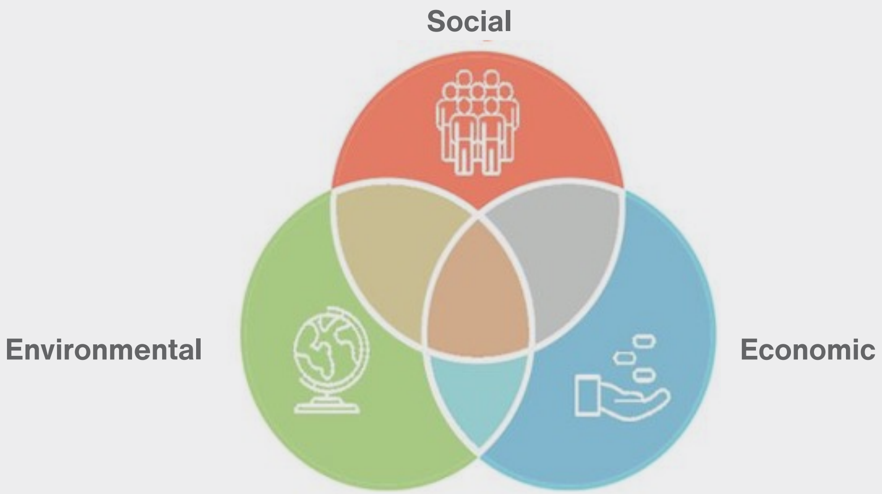
Section 1

INTRODUCTION TO SUSTAINABLE BUILDINGS

1.1. Overview of Sustainable Buildings

Sustainability, as defined by the United Nations Brundtland Commission, is "meeting the needs of the present without compromising the ability of future generations to meet their own needs" [1].

SUSTAINABLE DEVELOPMENT GOALS:



Sustainable development refers to achieving progress without harming the ability of future generations to meet their needs. It can also be defined as ensuring balance across **environmental, economic, and social** dimensions to safeguard both the present and the future.

In 2015, the United Nations adopted the Sustainable Development Goals (SDGs), a global call to action that provides a roadmap for achieving sustainable development by 2030 [2].

[1] United Nations Brundtland Commission. (1987). Report of the World Commission on Environment and Development:Our Common Future, Brundtland Report.

[2] https://turkiye.un.org/tr/sdgs

1.2. Definition of Sustainable Buildings

Sustainable buildings are structures that are designed, constructed, operated, and decommissioned while maintaining a balance between environmental, economic, and social factors.

The design of sustainable built environments and buildings is based on preserving and enhancing people, places, and the natural environment. Additionally, it plays a crucial role in reducing greenhouse gas emissions and addressing the climate crisis.

Sustainable buildings are designed with environmental and social benefits in mind while also considering economic sustainability and resilience to disasters. These buildings not only meet present-day needs but also aim to create healthy, efficient, and balanced living spaces for future generations [3].

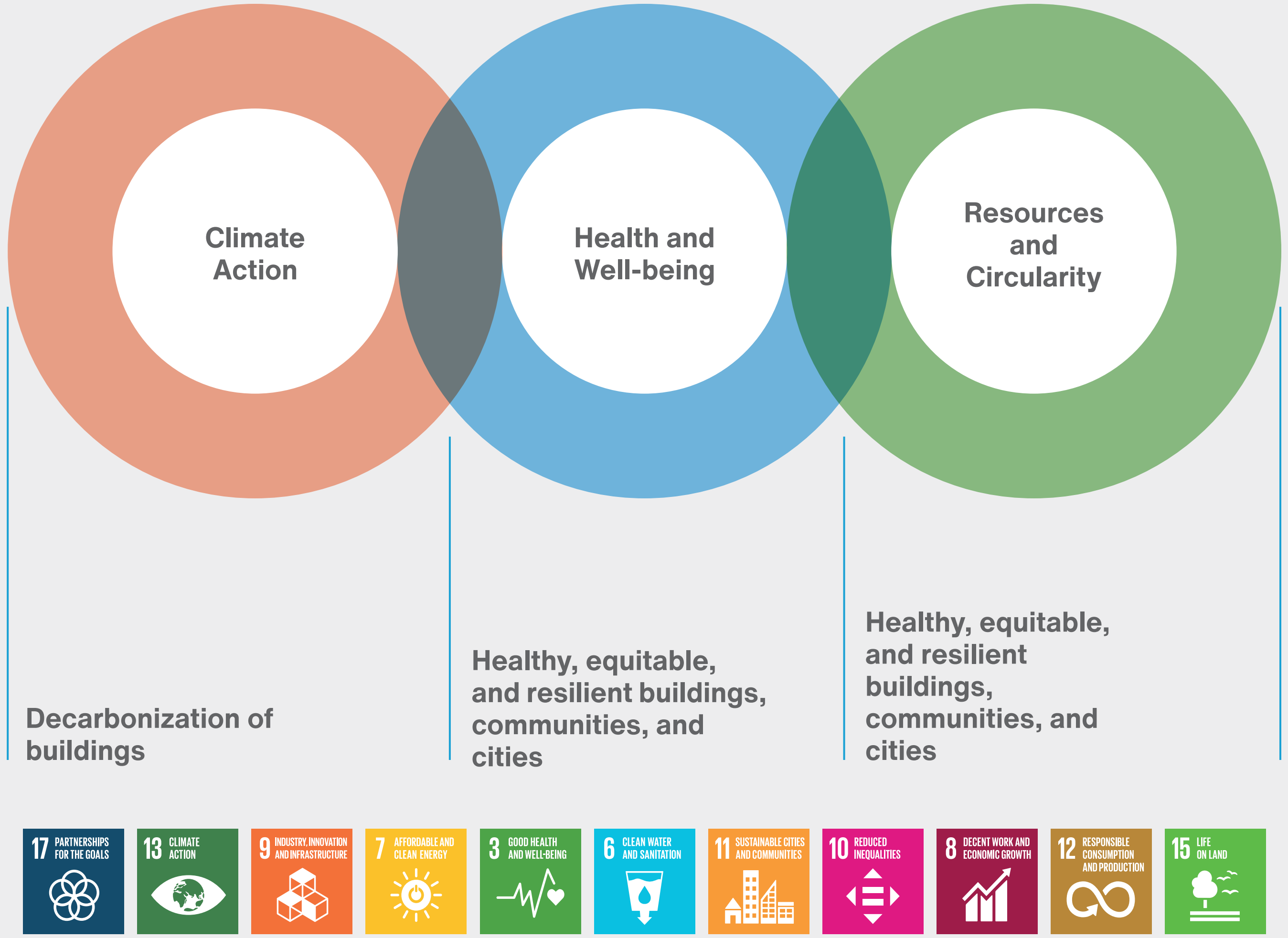


Figure 1. The General Objectives of Sustainable Buildings and Their Relationship with the Sustainable Development Goals [3].

[3] https://worldgbc.org/what-is-a-sustainable-built-environment/

1.3. The Importance of Sustainable Buildings

Globally, buildings are responsible for 39% of energy consumption and related CO_2 emissions. Of this total, 28% originates from operational emissions, while the remaining 11% results from material use and construction processes [3].

By 2050, the global population is expected to increase by 27%, reaching 9.8 billion, and by 2060, the total global building area is projected to double. Consequently, all environmental, social, and economic impacts associated with the built environment are expected to rise significantly [3].

It is evident that **sustainable built environments—**and consequently, **sustainable buildings—**play a crucial role in enabling the transition toward a decarbonized global economy. In addition to being a critical solution to climate change, sustainable buildings contribute to creating resilient and thriving communities while also driving economic growth.

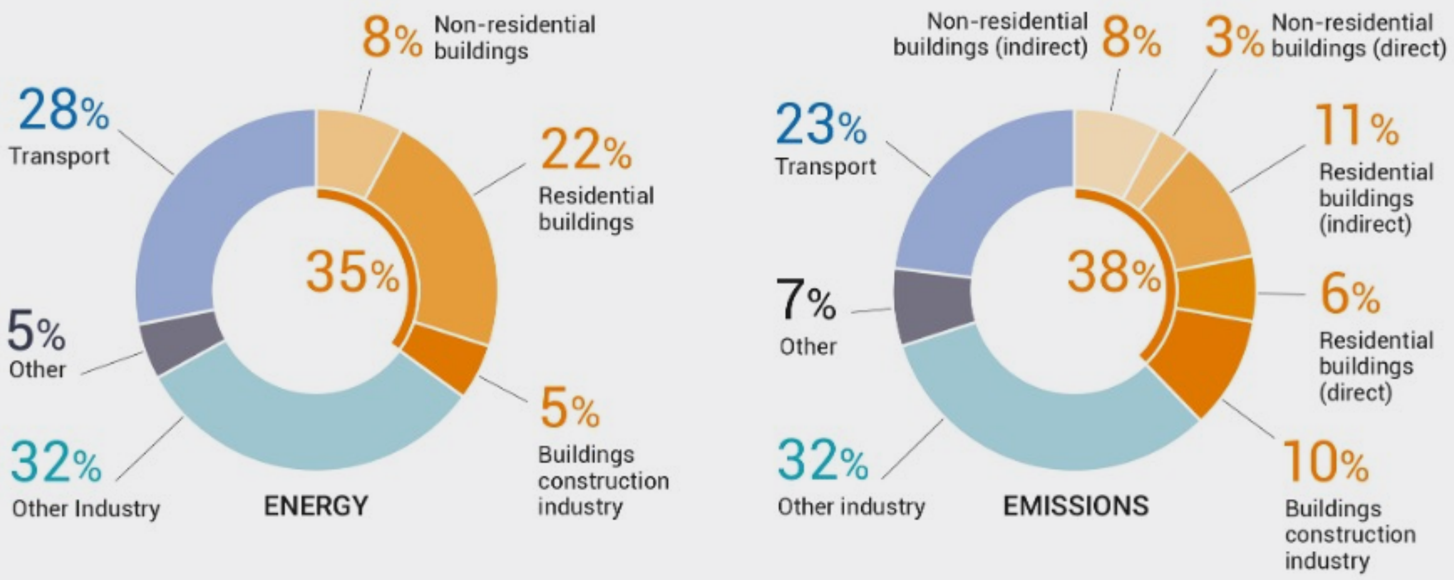


Figure 2. The Building Sector's Share in Global Energy Use and Emissions [4].

[4]. 2020 GLOBAL STATUS REPORT 2020 GLOBAL STATUS REPORT FOR BUILDINGS AND CONSTRUCTION FOR BUILDINGS AND CONSTRUCTION Towards a zero-emissions, efficient and resilient buildings and construction sector: /https://globalabc.org/sites/default/files/inline-files/2020%20Buildings%20GSR_FULL%20REPORT.pdf

1.4. Key Features of Sustainable Buildings

- **Efficient Use of Energy, Water, and Other Resources:** Sustainable buildings use energy, water, and other natural resources efficiently throughout their life cycle, preventing waste and reducing negative environmental impacts.
- **Reuse of Materials, Waste Management, and Recycling:** These buildings promote the reuse and recycling of materials during construction and operation, minimizing waste generation.
- **Use of Renewable Energy Sources:** Sustainable buildings meet their energy needs through renewable sources, reducing their carbon footprint.
- **Compliance with User Health and Comfort Standards:** These buildings incorporate appropriate measures to enhance user health and comfort.
- **Implementation of CO_2 Reduction Measures:** To minimize carbon emissions, sustainable buildings use low-emission materials and energy-efficient systems.
- **Improvement of Indoor Environmental Quality:** Factors affecting indoor environmental quality are optimized to enhance the quality of life for occupants.
- **Green Spaces and Ecosystem-Friendly Designs:** Sustainable buildings include green spaces and ecosystem-friendly features, contributing to environmental protection.
- **Resilience to Climate Change:** These buildings are designed to withstand the impacts of climate change and to be resilient against natural and human-induced disasters.
- **Economic Efficiency and Circularity with the Whole Life-Cycle Approach:** Sustainable buildings follow the whole life-cycle approach to ensure economic efficiency and compliance with circular economy principles. They facilitate resource recovery during construction and operation. The whole life-cycle concept aims to monitor, manage, and improve the environmental impacts of a building's construction, use, and demolition. This approach not only protects the environment but also supports economic savings and social responsibility.

1.4. Key Features of Sustainable Buildings

Key Features That Define Buildings as "Sustainable"

- Efficient Use of Energy, Water, and Other Resources
- Reuse and Recycling of Materials
- Use of Renewable Energy Sources
- Compliance with User Health and Comfort Standards
- Implementation of CO_2 Reduction and Decarbonization Measures
- Improvement of Indoor Environmental Quality
- Green Spaces and Ecosystem-Friendly Designs
- Resilience to Climate Change
- Economic Efficiency and Circularity with the Whole Life-Cycle Approach

Section **2**

ENVIRONMENTAL SUSTAINABILITY IN BUILDINGS

What Parameters are Environmental Sustainability in Buildings Linked to?

Figure 3. Parameters Required for Sustainable Buildings [5].

2.1. Energy Efficiency in Buildings

2.2. Use of Renewable Energy in Buildings

2.3. Optimization of Indoor Environmental Quality

2.4. Efficiency in Building Materials and the Use of Sustainable Building Materials

2.5. Reduction of Waste Generation in the Construction and Operational Processes (Recycling Materials in Demolition and Reconstruction Processes)

2.6. Water Efficiency and Conservation in Buildings

2.7. Land and Material Selection for Biodiversity Balance

[5] Green Smart Building: Requisites, Architecture, Challenges, and Use Cases, chapter 2

2.1. Energy Efficiency in Buildings

WHAT DOES ENERGY EFFICIENCY MEAN?

Energy efficiency in buildings refers to reducing energy consumption without compromising the standard of living or the quality of services provided [6].

Why is Energy Efficiency Important in Buildings? [7]

- **Environmental:** It reduces greenhouse gas (GHG) emissions and other pollutants. It can also decrease water usage.
- **Economic:** It can lower individual utility bills, create employment opportunities, and help stabilize electricity prices and fluctuations.
- **Infrastructure System Benefits:** It can provide long-term benefits by reducing overall electricity demand, thus minimizing the need for new investments in electricity generation and transmission infrastructure.
- **Risk Management:** It helps diversify infrastructure resource portfolios and provides protection against uncertainties associated with fluctuating fuel prices.

WHY DO BUILDINGS CONSUME ENERGY?

Buildings consume energy for interior comfort needs such as heating, cooling, ventilation, and lighting, depending on the characteristics of the climate zone in which they are located.

The most important step in reducing this consumption is to **select Passive System Parameters (shown on the next slide) appropriate for the climate zone during the early stage, i.e., during the building's design phase.** At this point, the material layering in the building envelope (façade, floor, roof) is one of the most important parameters.

As shown in Figure 4 (on the next slide), the building envelope is the component that is in constant contact with external weather conditions and where heat transfer occurs. Therefore, decisions made about the material layering in the building envelope will allow for the selection of smaller capacity technical systems, such as the building system, artificial lighting system, etc., in later stages.

[6] Enerji Verimliliği Kanunu, 5627, 02/05/2007

[7] https://www.epa.gov/statelocalenergy/local-energy-efficiency-benefits-and-opportunities#one

2.1. Energy Efficiency in Buildings

What Are the Parameters Affecting Building Energy Efficiency?
(Module 9: Energy Efficiency in Buildings)

- **Passive Design Parameters [8]**
  - Location, Orientation, Surroundings, and Form of the Building
  - Thermophysical Properties of the Building Envelope
    - Transparency ratio
    - Thermal transmittance values of opaque and transparent components
    - Sealing of building openings
  - Lighting Systems
    - Transparency ratio
    - Light transmission values of transparent components
    - Use of natural lighting
  - Solar Control
    - Use and characteristics of shading elements
  - Passive Cooling
    - Natural & cross ventilation, night ventilation, etc. systems
  - Passive Heating
    - Double-wall façades and similar systems
  - Water Management
    - Rainwater collection, reuse
- **Building Automation and Management Systems**
  - Daylight-dependent automation strategies for lighting
  - Daylight-dependent control of shading elements
  - User sensor systems
  - Automation in climate control systems
- **Heating, Cooling, and Ventilation Systems**
  - Air handling units, VRF systems
  - Cogeneration/trigeneration systems
  - Heat pumps
- **Renewable Energy Systems**
  - Integrated or separate photovoltaic (PV) systems
  - Solar water heating systems

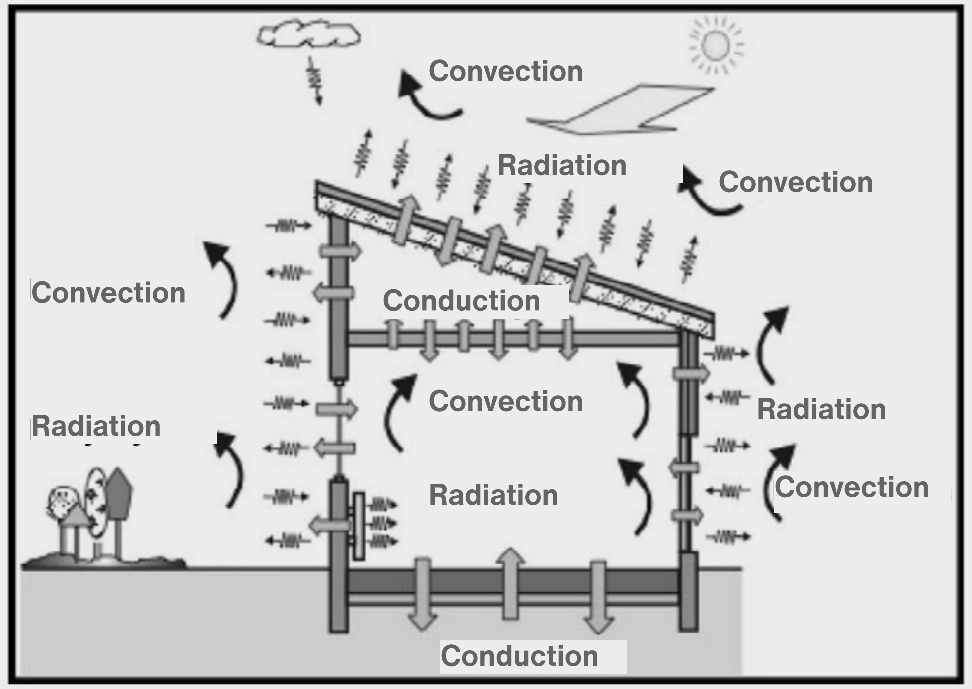


Figure 4. Schematic Representation of Heat Transfers in a Building [9]

[8] Pacheco, R., . Ordónez, J., Martinez, G. (2012). Energy efficient design of building: A review. Renewable and Sustainable Energy Reviews, vol. 16, 3559-3573.
[9] Kuznik, F., David, D., Johannes, K., Roux, J-J.. (2011). A review on phase change materials integrated in building walls. Renewable and Sustainable Energy Reviews, 15, 379-391.

2.2. Renewable Energy Use in Buildings

Nearly Zero Energy Building (NZEB):

Definition in the EU: Buildings with high energy performance and very low-energy needs that are largely met on-site or from nearby renewable energy sources [10].

Definition in Türkiye: Buildings with high energy performance and a certain level of renewable energy use. As a definition of high energy performance, the buildings meeting NZEB criteria must have an Energy Performance Certificate rating of B or better; for renewable energy use, at least 10% of the primary energy demand must be met through renewable energy [11].

EPBD 2024/1275 (ENERGY PERFORMANCE OF BUILDINGS DIRECTIVE) [12]:

Regulations in Türkiye are being made in accordance with this directive.

NZEB: The European Commission's Joint Research Centre has determined that this requirement will increase the energy performance of new buildings in the EU by 70% compared to 2006 [13].

Zero-Emission Buildings: There are no on-site carbon emissions from fossil fuels, and these buildings have very high energy performance.

The directive requires that, by January 1, 2030, all new residential and non-residential buildings must be zero-emission buildings. Therefore, the new rules will align the energy performance of buildings with the EU's 2050 climate neutrality target and **the principle of energy efficiency first.**

WHAT IS RENEWABLE ENERGY?

Renewable energy is energy obtained from natural resources that regenerate at a rate higher than their consumption. Renewable energy sources are abundant around us. Producing renewable energy creates much lower emissions than burning fossil fuels. The transition from fossil fuels, which currently contribute a significant share of emissions, to renewable energy is crucial in addressing the climate crisis [14].

[10] https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/nearly-zero-energy-and-zero-emission-buildings_en

[11] BİNALARDA ENERJİ PERFORMANSI YÖNETMELİĞİ, 19/02/2022

[12] Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the Energy Performance of Buildings (Recast), 2024/1275, 2024.

[13] Progress of the Member States in implementing the Energy Performance of Building Directive, JRC Science for Policy Report, 2021. doi:10.2760/914310 (online)

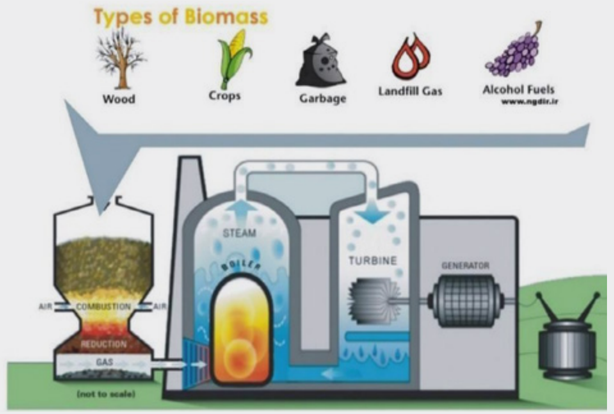
[14] https://www.un.org/en/climatechange/what-is-renewable-energy

2.2. Renewable Energy Use in Buildings

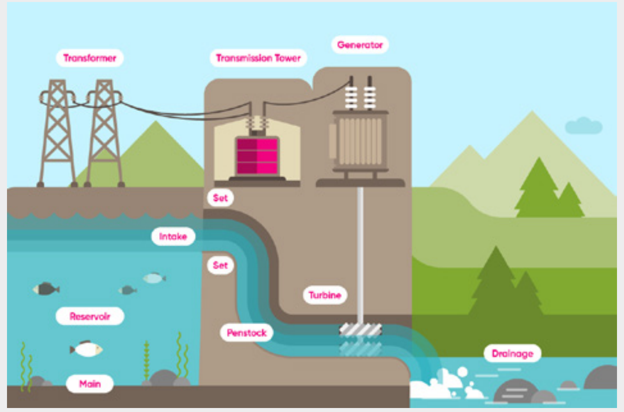
Solar Energy Systems [15, 16]

Wind Energy Systems [17]

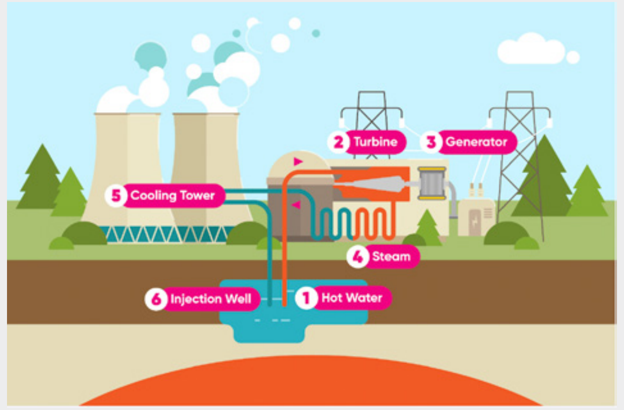
Biomass Energy Systems [18]



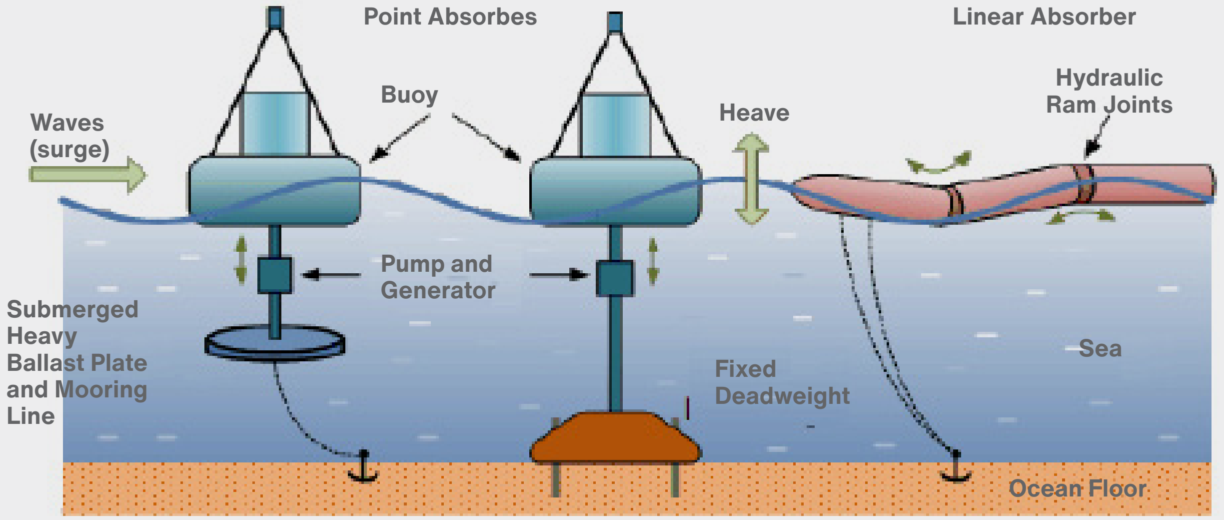
Hydroelectric Energy Systems [19]



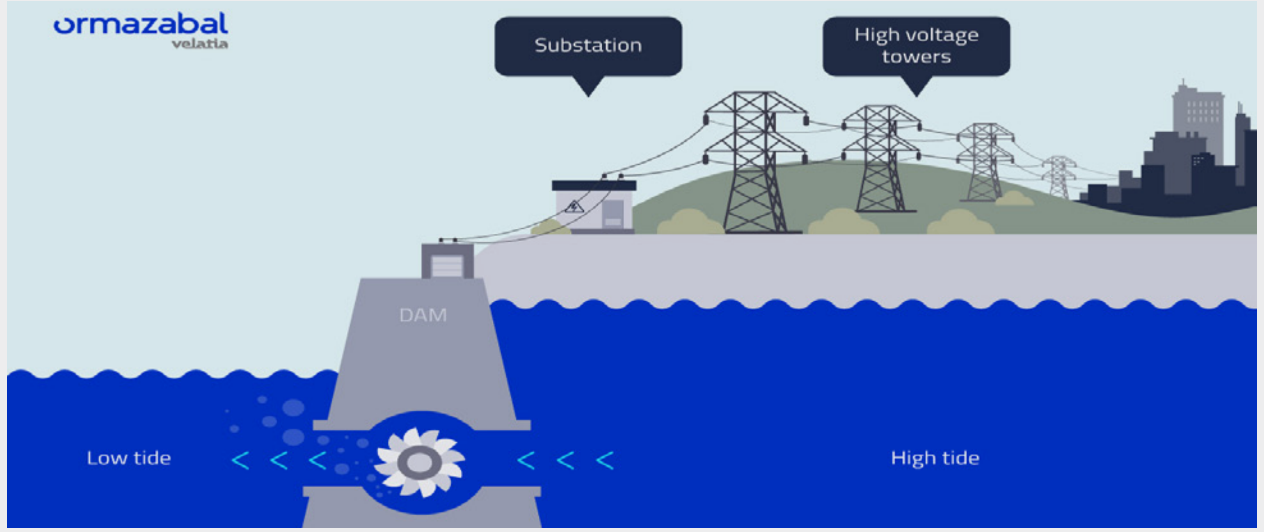
Geothermal Energy Systems [20]



Wave Energy Systems [21]



Tidal Energy Systems [22]



Trigeneration and Cogeneration Systems, as well as **Ground and Air-Source Heat Pumps,** can also be considered renewable energy systems. However, unlike other systems, they are not entirely natural resource-based.

[15] https://www.solarpowerworldonline.com/2018/10/what-is-a-half-cell-solar-panel/

[16]https://raven123456.en.made-in-china.com/product/YSjxpwLbhMRJ/China-Solar-Water-Heating-Panel.html?pv_id=1igj3fjve895&faw_id=1igj3fm7tdd8

[17] https://egesa.com.tr/hizmetler/ruzgar-enerjisi-sistemleri-res

[18] https://www.hmi.com.tr/19-biyokutle-enerji-uretim-santral-otomasyonu--blog-detay

[19] https://www.aydemperakende.com.tr/blog/hidroelektrik-enerji-nedir-ve-nasil-uretilir

[20] https://www.aydemperakende.com.tr/blog/jeotermal-enerji-nedir-nasil-elde-edilir

[21] https://www.alternative-energy-tutorials.com/wave-energy/wave-energy-devices.html

[22] https://www.ormazabal.com/en-gb/tidal-energy-what-is-and-how-does-it-work/

2.3. Optimization of Indoor Environmental Quality (IEQ)

WHAT IS INDOOR ENVIRONMENTAL QUALITY (IEQ)?

Indoor Environmental Quality (IEQ) refers to the conditions inside a building, including air quality, lighting, thermal conditions, and ergonomics, as well as their impact on occupants or users [23].

Figure 5. How Do IEQ Parameters Affect Humans? [24]

WHY IS INDOOR ENVIRONMENTAL QUALITY (IEQ) IMPORTANT?

- Provides stimulating and comfortable environments for building occupants.
- Minimizes the risk of building-related health issues.
- Protects human health, enhances quality of life, and reduces stress and potential injuries.
- Ensures users perform at their best.
- Increases the resale value of the building.
- Reduces liability for building owners.
- Generates return on investment through strategies that improve long-term employee health and productivity [23].

WHAT ARE THE STRATEGIES FOR OPTIMIZING INDOOR ENVIRONMENTAL QUALITY?

- Air Quality Improvements
  - Operable Windows, filtration.
- Lighting System Design
  - User control, use of daylight.
- Ensuring Thermal Comfort (By Providing User Control)
- Ensuring Acoustic Comfort
- Sustainable Material Selection
- Ergonomics and Design
- Education and Awareness

[23] https://www.usgbc.org/articles/green-building-101-what-indoor-environmental-quality
[24] https://medium.com/@ieqandwellbeing/indoor-environmental-quality-parameter-56aab5cffd8

2.4. Efficiency in Building Materials and the Use of Sustainable Building Materials

(For more information on sustainable building materials, please refer to Module 3: Sustainable Building Materials.)

WHAT ARE SUSTAINABLE BUILDING MATERIALS?

Sustainable building materials are eco-friendly or environmentally conscious materials. They are primarily sourced from renewable resources rather than non-renewable ones. These materials minimize energy consumption during production and use, and throughout their whole life-cycle, they generate no harmful waste or emissions that could impact the environment or human health [25, 26].

CHARACTERISTICS OF SUSTAINABLE BUILDING MATERIALS:

- Low Carbon Footprint
- Low Energy Consumption
- Use of Renewable Resources
- Recyclability
- Low Waste Production
- Low Greenhouse Gas Emissions
- Support for the Local Economy

[25] Ding, G., K., C. (2014). 3 - Life Cycle Assessment (LCA) of Sustainable Building Materials: An Overview. Eco-efficient Construction and Building Materials, Woodhead Publishing, pp. 38-62. doi: https://doi.org/10.1533/9780857097729.1.38

[26] Çüçen, A., Solak , A. (2023). Sürdürülebilir Yapı Malzemeleri Üzerine Bir Araştırma. Teknik Bilimler Dergisi, vol. 13 (1), pp. 1-8, 2023.

2.4. Efficiency in Building Materials and the Use of Sustainable Building Materials

(For more information on sustainable building materials, please refer to Module 3: Sustainable Building Materials.)

What Is Life-Cycle Assessment (LCA)? [27]

Life-Cycle Assessment (LCA) is a process that evaluates the environmental impacts of a product throughout its entire lifespan, enhancing resource efficiency and reducing liabilities. It can be used to analyze the environmental effects of a product or the function it is designed to perform. LCA is often referred to as a “cradle-to-grave” or “cradle-to-cradle” analysis.

Key Elements:

- Identifying and measuring relevant environmental burdens, such as consumed energy, raw materials, emissions, and waste.
- Assessing the potential environmental impacts of these burdens.
- Evaluating available options to mitigate these environmental impacts.

Life-Cycle Assessment of Building Materials

Life-Cycle Assessment (LCA) is an analytical technique that evaluates the environmental impacts of a product or material at all stages of its life cycle. This includes raw material extraction, processing and production, distribution, use, final disposal and/or recovery, and transportation [29].

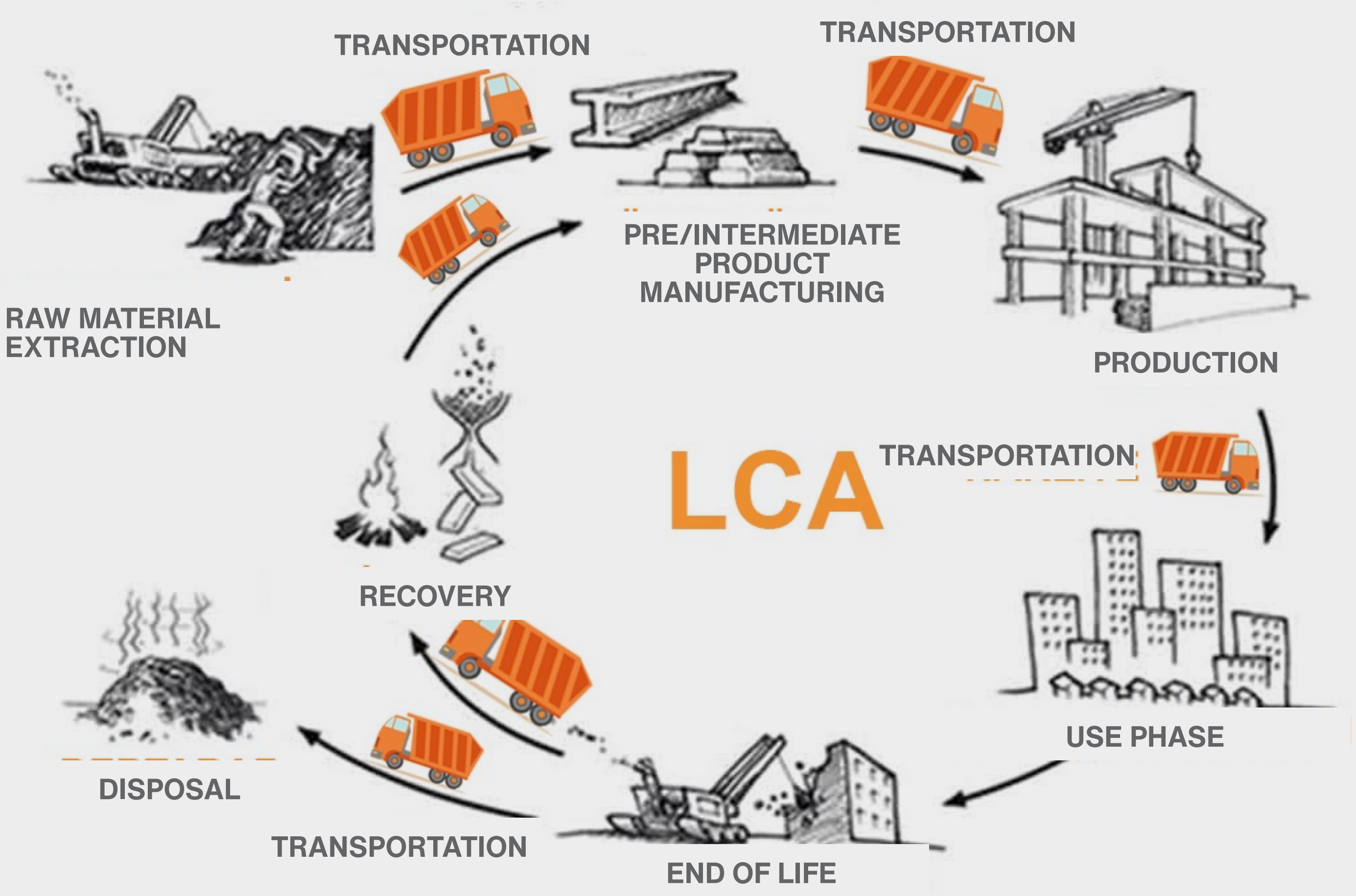


Figure 6. LCA in Building Materials [28]

[27] https://www.eea.europa.eu/help/glossary/eea-glossary/life-cycle-assessment

[28] https://www.circular-flooring.eu/news/what-is-a-life-cycle-assessment/

[29] Türkiye’nin Döngüsel Ekonomiye Geçiş Potansiyelinin Değerlendirilmesi için Teknik Destek Projesi, Sözleşme No: EuropeAid/140562/IH/SER/TR, Faaliyet 1.1 - Ön Değerlendirme Raporu, 2022. https://www.istockphoto.com/tr/vekt%C3%B6r/b%C3%BCy%C3%BCk-a%C4%9F%C4%B1r-turuncu-kamyon-yol-%C3%A7al%C4%B1%C5%9Fmalar%C4%B1-ve-yap%C4%B1-alan%C4%B1-serisi-vekt%C3%B6r-%C3%A7izimler-gm658906104-120513927

2.5. Reducing Waste Generation in Construction and Operation Processes

(For more information on sustainable construction and demolition practices, please refer to Module 4: Sustainable Construction and Demolition Practices)

CONSTRUCTION AND DEMOLITION WASTE

Construction and demolition (C&D) waste is the largest waste stream in the EU by weight, accounting for over 800 million tons per year—approximately 32% of the total waste generated [30].

There is significant potential to enhance resource efficiency in managing this waste stream. C&D waste consists of a mix of different materials, including inert and non-inert, hazardous and non-hazardous waste. It is primarily composed of relatively heavy and easily recyclable but low-value mineral components such as bricks, tiles, and concrete. Additionally, it contains materials with a positive market value (such as metals) or those with potential value when collected separately in clean fractions (such as plastics).

The Waste Framework Directive [31] set a 70% target for preparation for reuse, recycling, and other material recovery for this waste stream by 2020. This target has been updated for 2025, 2030, and 2035. The performance of Member States varies significantly; more than half reported achieving the 2020 target during the 2013–2015 period, with some exceeding a 90% recovery rate [30].

Waste Hierarchy [31]:

- Prevention
- Preparation for reuse
- Recycling
- Other recovery methods, such as energy recovery
- Disposal

[30] Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the implementation of EU waste legislation, including the early warning report for Member States at risk of missing the 2020 preparation for re-use/recycling target on municipal waste. COM(2018) 656 final.

[31] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. 02008L0098 EN 05.07.2018.

2.5. Reducing Waste Generation in Construction and Operation Processes

(For more information on sustainable construction and demolition practices, please refer to Module 4: Sustainable Construction and Demolition Practices)

OPERATIONAL WASTE

Operational waste refers to various types of waste generated during the use phase of buildings. The types and quantities of waste vary depending on factors such as building typology (residential, non-residential, etc.), building lifespan, and waste management practices implemented within the building.

Under this category, packaging waste and household waste are particularly significant.

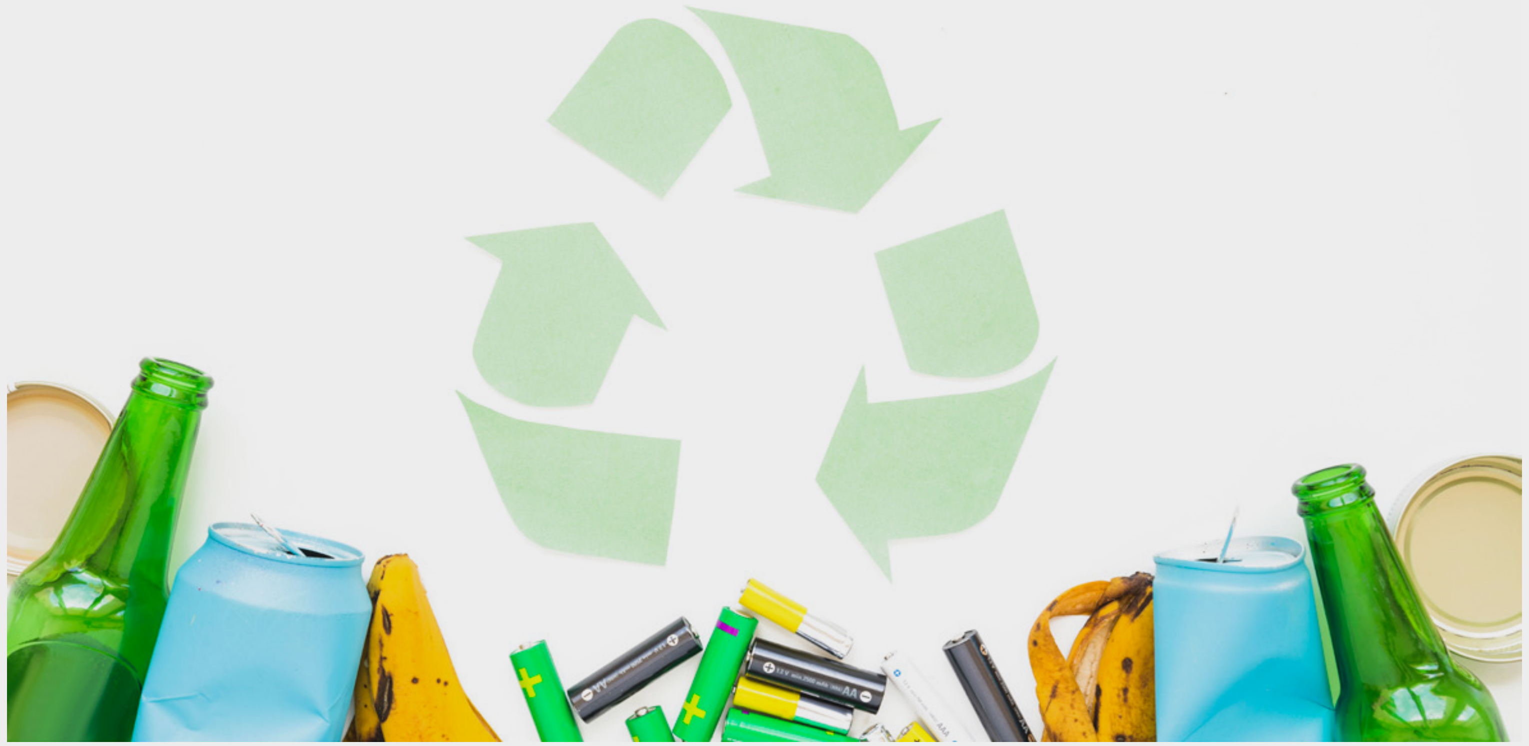
Packaging waste can be generated at all stages of a building's life cycle. During the operational phase, it mainly consists of the packaging of consumed products.

Household waste includes food waste, paper and cardboard, plastic waste, and glass waste.

Waste from **maintenance and renovation** may include old building materials, furniture, lighting fixtures, and electronic waste.

Liquid waste can include chemical waste from cleaning agents, oily or contaminated water, etc.

Household waste management has been a major challenge for governments in developing countries. Population growth, rapid urbanization, financial expansion, and rising living standards—especially in metropolitan areas—have significantly increased solid waste generation worldwide. These trends pose serious challenges, particularly in terms of ecological preservation and sustainable growth. One potential solution to address this issue is the implementation of a sustainable household waste management system aligned with circular economy principles. [32]



[32] Bishnoi, M., M., Verma, A., Kuswaha, A., Goswami, S. (2022). Chapter 9 - Social factors influencing household waste management. Emerging Trends to Approaching Zero Waste, pp. 197-213. Doi: https://doi.org/10.1016/B978-0-323-85403-0.00008-6

2.5. Reducing Waste Generation in Construction and Operation Processes

(For more information on sustainable building materials, please refer to Module 3: Sustainable Building Materials.)

CIRCULAR ECONOMY

A production and consumption model that involves sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products for as long as possible. This approach extends the life cycle of products [33].

Benefits of the Circular Economy [33]:

- Environmental protection
- Reduced dependence on raw materials
- Job creation and cost savings for consumers

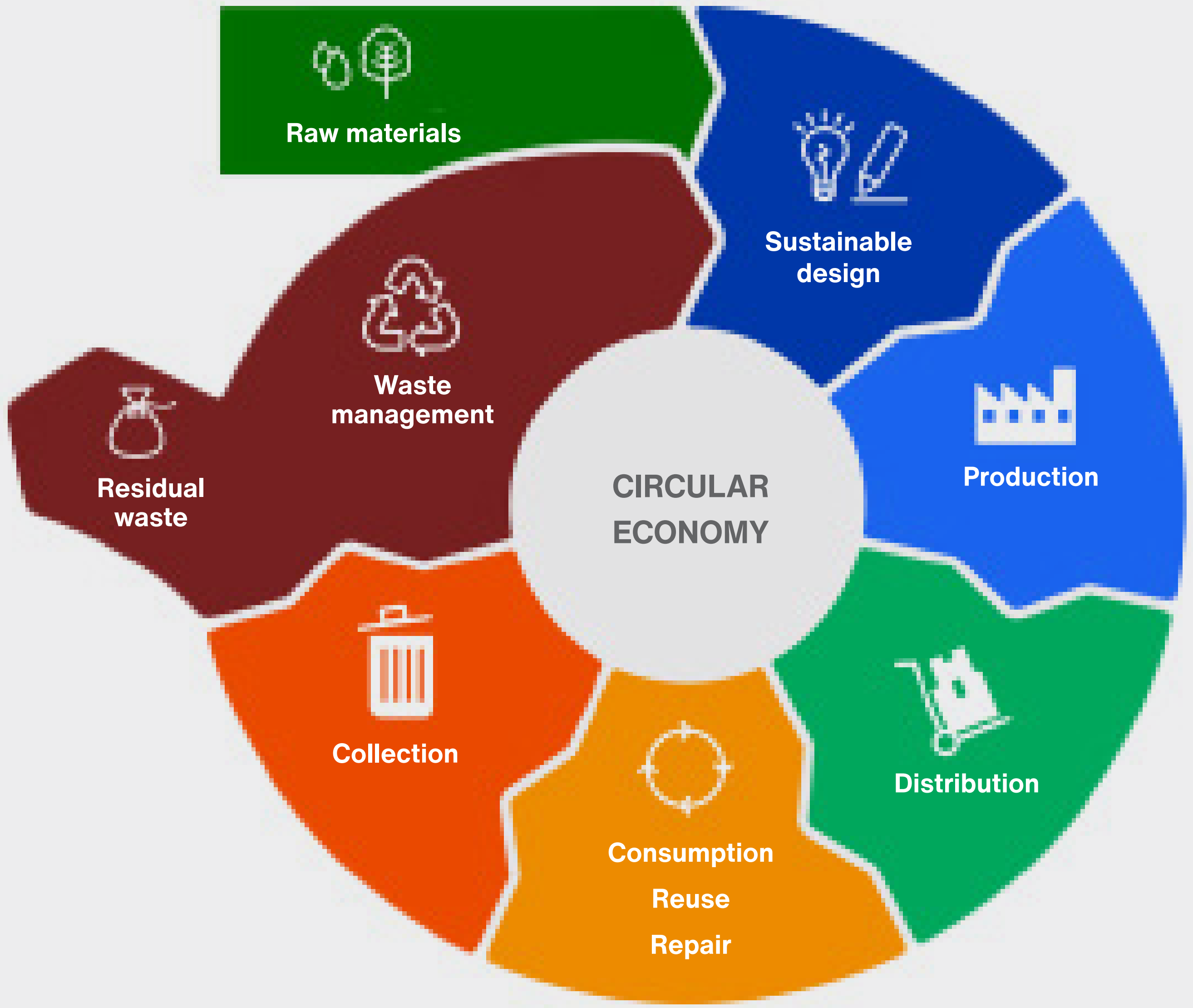


Figure 7. Circular Economy Model [33]

[33] European Parliament Research Service. https://www.europarl.europa.eu/topics/en/article/20151201STO05603/circular-economy-definition-importance-and-benefits

2.5. Reducing Waste Generation in Construction and Operation Processes

(For more information on sustainable building materials, please refer to Module 3: Sustainable Building Materials.)

The Intersection of the Circular Economy and the Sustainable Development Goals

The 2030 Agenda for Sustainable Development, adopted by all United Nations (UN) Member States in 2015, provides a common plan for peace and prosperity for people and the planet, both now and in the future. At the heart of the agenda are 17 Sustainable Development Goals (SDGs), which call for urgent action by all countries, both developed and developing, within a global partnership [34].

The circular economy is related to all of these goals. For example: [35]

SDG 6 – Clean Water and Sanitation: Within the target areas, 6.3. Improve Water Quality and 6.4. Increase Water-Use Efficiency can be achieved through **circular economy practices in water consumption and the reuse of consumed water.**

SDG 11 – Sustainable Cities and Communities: Target areas such as 11.6. Improve Air Quality and Waste Management in Cities, 11.b. Increase the Number of Cities Implementing Integrated Policies and Plans towards Inclusion, Resource Efficiency, Mitigation, and Adaptation to Climate Change, and 11.C. Provide Support for Least Developed Countries Including Through Financial and Technical Assistance, in Building Sustainable and Resilient Buildings Using Local Materials, **can be achieved through circular economy practices such as waste separation, reuse, efficient resource use in a circular manner, use of local materials, and reducing carbon emissions and energy consumption associated with the life cycle of materials.**

SDG 12 – Responsible Consumption and Production: Within the target areas, 12.2. Ensure the Sustainable Management and Efficient Use of Natural Resources, 12.3. Halve Global per Capita Food Waste, 12.4. Ensure Responsible Management of Chemicals and Waste, 12.5. Substantially Reduce Waste Generation through Prevention, Reduction, Recycling, and Reuse, 12.7. Promote Sustainable Public Procurement Practices, 12.8. Ensure People Have the Relevant Information and Awareness for Sustainable Development and Lifestyles in Harmony with Nature, and 12.c. Rationalize Inefficient Fossil-Fuel Subsidies that Encourage Wasteful Consumption, **can all be addressed through the cradle-to-cradle application of the circular economy.**

[34] https://sdgs.un.org/goals

[35] New Economics for Sustainable Development: Circular Economy, United Nations Economist Network, https://www.un.org/en/desa/unen/policy-briefs

2.5.Reducing Waste Generation in Construction and Operation Processes

WASTE TYPE	CONTENTS	WASTE MANAGEMENT-1	WASTE MANAGEMENT-2
Construction and Demolition Waste	Glass, Plastic, Rubber, Gypsum Board, Ceramics, Bricks, Concrete, Metal, Wood Waste, Lumber Products	▪ On-site processing and separation ▪ Waste processing facility ▪ Landfill	If on-site processing and separation are done: ▪ On-site storage ▪ Off-site reuse ▪ Waste processing facility ▪ Landfill
Unprocessed Natural Excavation Material	Clay, Gravel, Sand, Soil, Fine Rock Particles	▪ On-site storage ▪ Off-site reuse ▪ Waste processing facility ▪ Landfill	
Excavation Material (excluding Asbestos-contaminated Soil)	Excavation material that may be contaminated with physical or chemical pollutants	▪ Off-site reuse ▪ Waste processing facility ▪ On-site storage ▪ On-site maintenance/improvement ▪ Landfill	If on-site maintenance/improvement is done: ▪ Off-site reuse
Asbestos Waste (including Asbestos-contaminated Soil)		▪ On-site storage ▪ Landfill ▪ Waste storage	
Waste Tires		▪ Waste processing facility ▪ Off-site reuse ▪ Landfill	
Restricted Solid Waste	Solid waste that is not related to the operational phase, potentially contaminated	▪ On-site immobilization or improvement ▪ Waste processing facility ▪ Landfill	
Hazardous Waste	Coal Tar, Coal Tar Pitch, Lead-Acid or Nickel-Cadmium Batteries, Lead Paint Waste, etc.	▪ On-site immobilization or improvement ▪ Waste processing facility	If on-site immobilization or improvement is done: ▪ Landfill

[36] Construction and demolition waste – A management toolkit. 2020 State of NSW and the NSW Environment Protection Authority.

2.6. Water Efficiency and Conservation in Buildings

WHAT IS WATER EFFICIENCY?

Water efficiency refers to the smart use of water resources through technologies that conserve water and simple actions that can be implemented at home. Efficient use of water will help ensure reliable water resources for today and future generations [37].

According to climate change predictions for the next 100 years, it is expected that water resources in our country will decrease by approximately 25% [38].

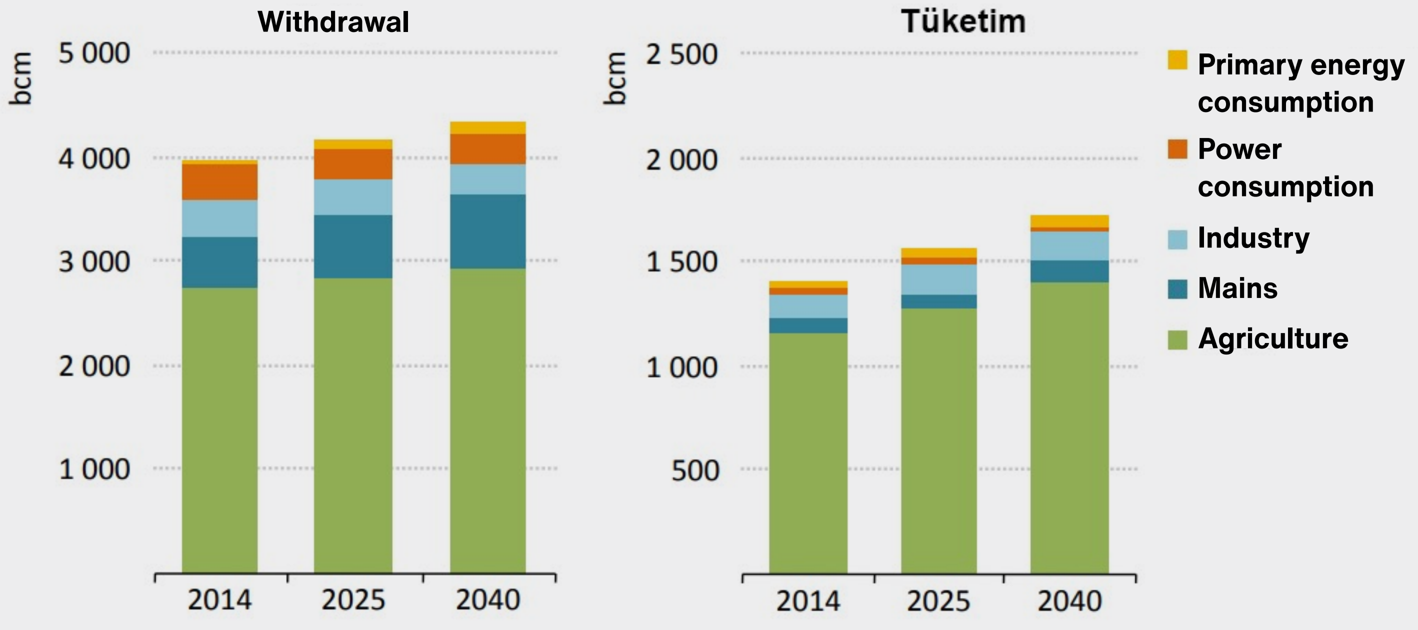


Figure 9. Sectoral Global Water Demand by 2040 [40]

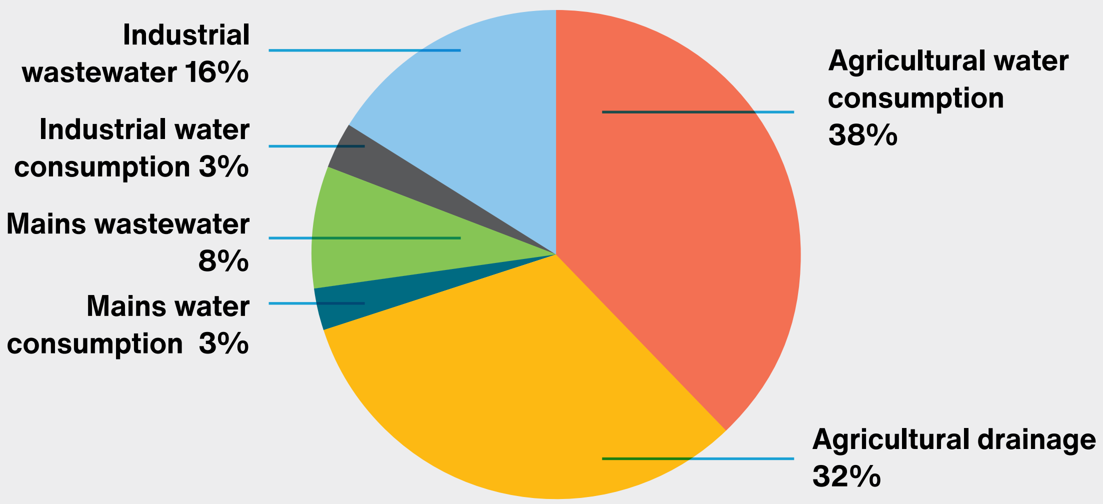


Figure 8. Water Consumption and Wastewater by Sector Worldwide [39]

Urban Water Efficiency →	Reducing water losses in drinking water supply and distribution. Municipalities are responsible.
Agricultural Water Efficiency →	Increasing irrigation efficiency by controlling water usage in irrigation systems and reducing water losses.
Industrial Water Efficiency →	The use of clean production technologies in the industrial sector.
Individual Water Efficiency →	Efficient behaviors in the daily lives of individuals, including their water usage habits.

[37] Water Sense – An EPA Partnership Program: https://19january2017snapshot.epa.gov/www3/watersense/our_water/why_water_efficiency.html

[38] https://www.suverimliligi.gov.tr/

[39] Kuski, L., Maia, E., Moura, P., Caetano, N., Felgueiras, C. (2020). Development of a decentralized monitoring system of domestic water consumption. Energy Reports, vol. 6 (1), pp. 856-861.

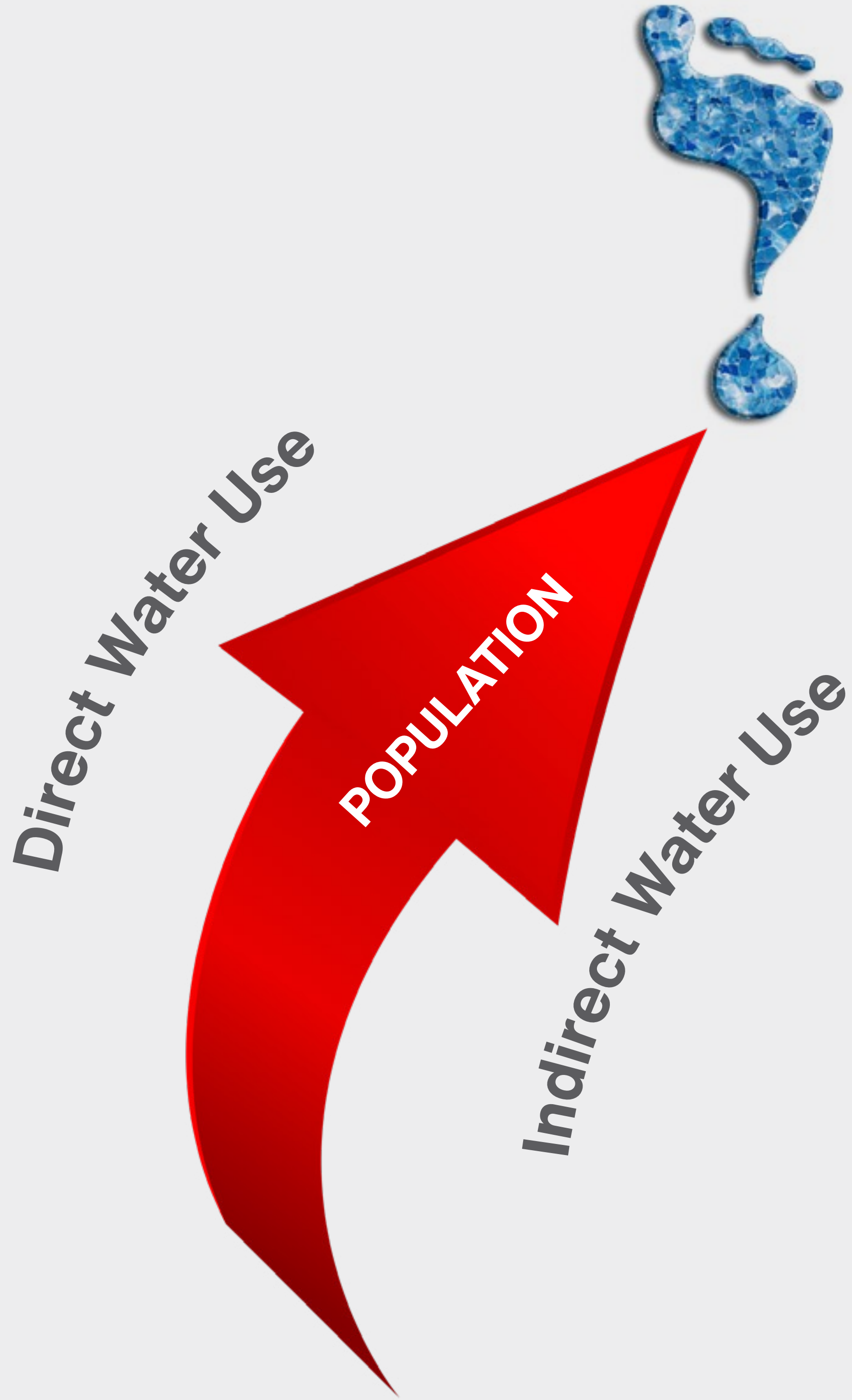
[40] Water Energy Nexus, International Energy Agency, OECD/IEA, 2016.

2.6. Water Efficiency and Conservation in Buildings

WHAT IS WATER FOOTPRINT?

Water footprint is an indicator of the actual water consumption in the production of goods and services, considering both direct and indirect water use in a holistic manner [38].

- **Direct Water Footprint:** Refers to the water consumption and pollution associated with a consumer's or producer's direct water use [41].
- **Indirect Water Footprint:** Refers to the water consumption and pollution associated with the production of consumed or produced goods. It represents the "hidden/embedded water" within products [41].



WHAT IS THE PURPOSE OF WATER FOOTPRINT?

The water footprint of products: [38]

Manufacturing Production Use → **Calculates the amount of polluted water.** → **Reveals the amount of water used in the processes.**

It provides a reference framework to help individuals, businesses, and countries use water more efficiently and sustainably [41].

[41] *https://watercalculator.org/footprint/what-is-a-water-footprint/*

2.6. Water Efficiency and Conservation in Buildings

- **Blue Water Footprint:** The amount of surface water and groundwater required (either evaporated or directly used) to produce a product.
- **Green Water Footprint:** The amount of rainwater required (either evaporated or directly used) to produce a product.
- **Grey Water Footprint:** The amount of fresh water needed to dilute the wastewater generated during production to meet local water quality standards [41].

Experts predict that global water demand will exceed supply by 40% by 2030 [41].

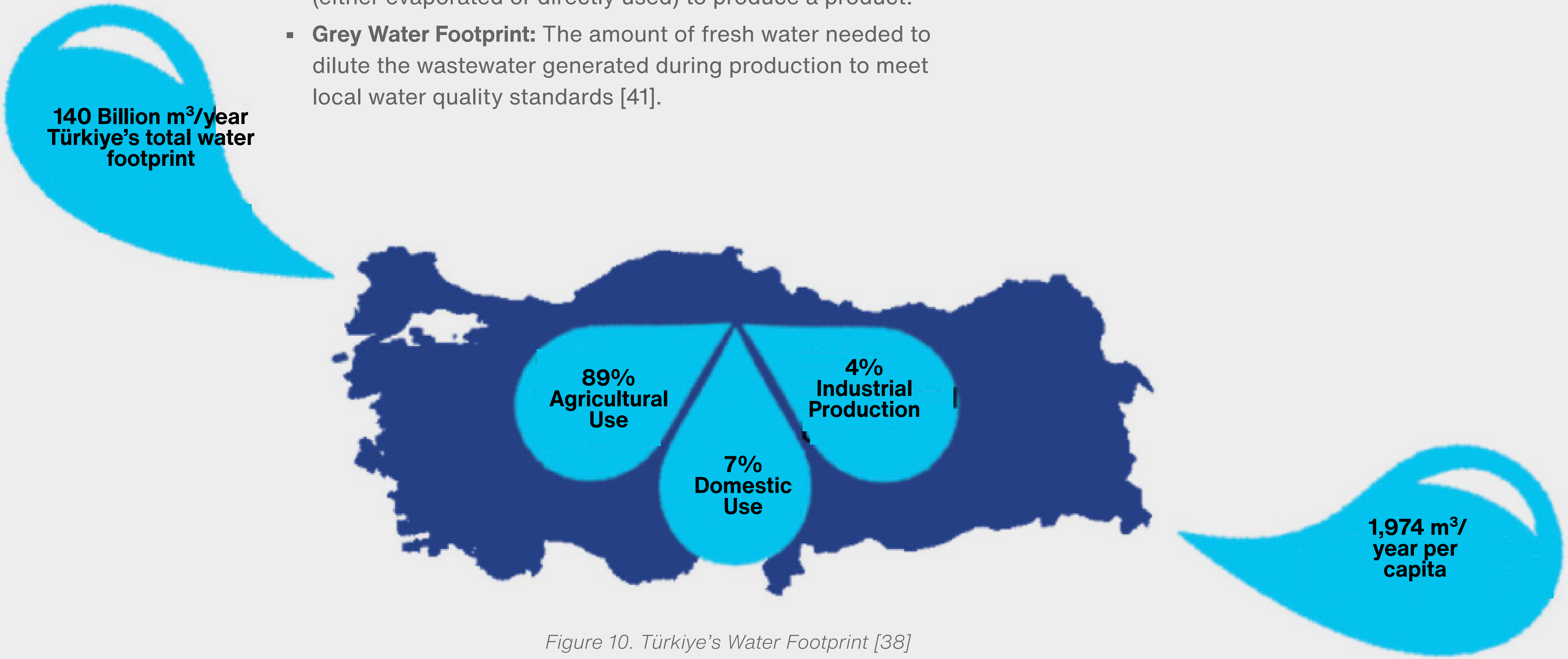


Figure 10. Türkiye's Water Footprint [38]

2.6. Water Efficiency and Conservation in Buildings

As all production processes are water-dependent, the construction process and the production process of construction materials are also water-dependent [42].

The water footprint resulting from the material production, construction, and operation processes of buildings can be reduced with the following recommendations:

- Companies should identify the amount of water used, its impact, and risks throughout their supply chains.
- Training construction site teams on water footprints to ensure efficient water use during the construction process.
- Optimizing the use of green, blue, and grey water types according to the activities in both the material production and construction processes.
- Selecting materials with consideration of their water footprints.
- Considering the need for and frequency of material replacement during the building's operational life, as this will affect the material's water footprint. Therefore, the lifespan of the selected materials should be taken into account.
- Selecting water-efficient models for plumbing fixtures during the design phase.
- Collecting rainwater.
- Ensuring the recycling of wastewater (greywater).
- Ensuring the use of treated wastewater.

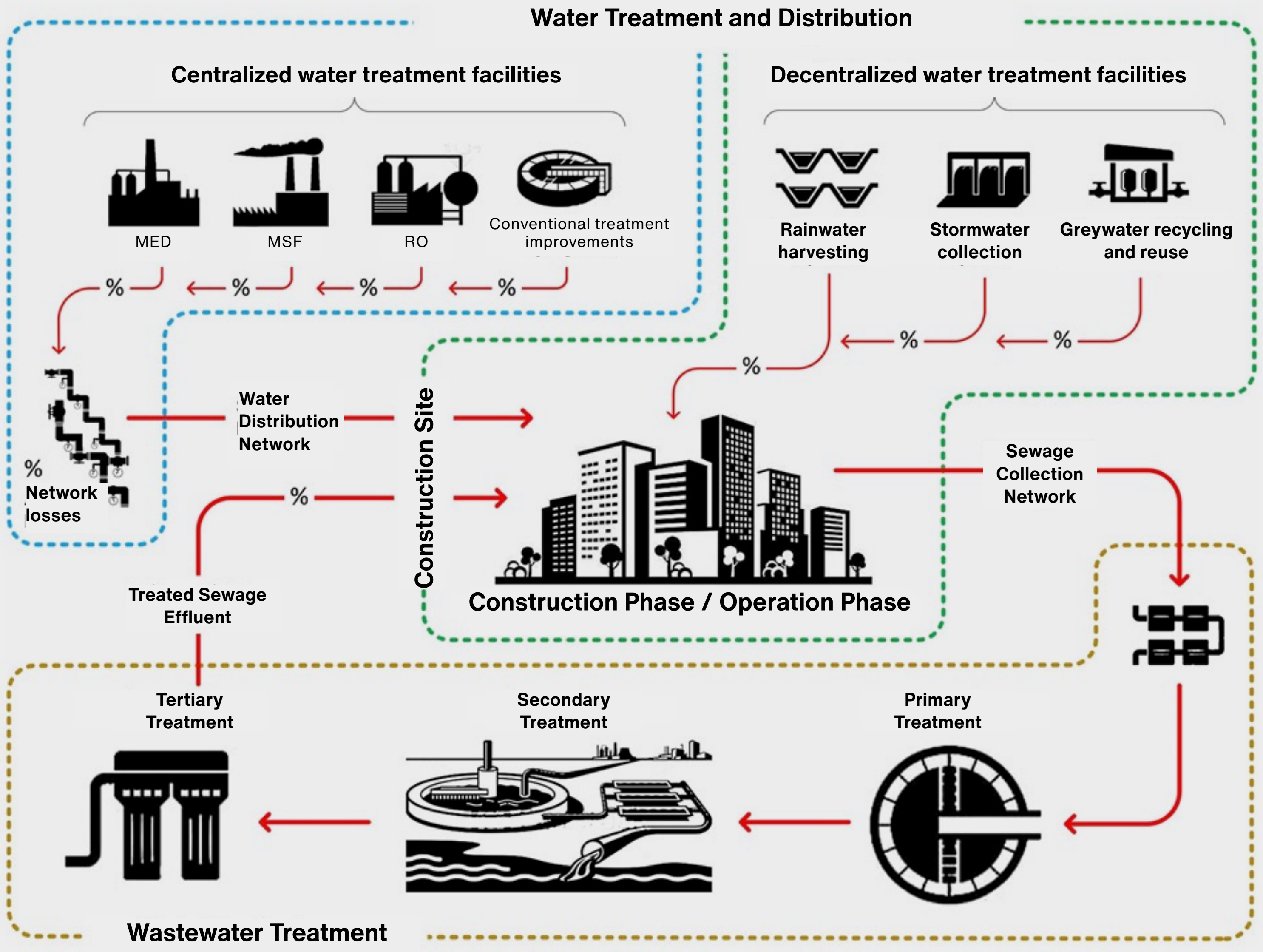


Figure 11. Built Environment Hydraulic Cycle. Its three main stages: 1. Water Treatment and Distribution, 2. Water Use in Buildings, 3. Wastewater Treatment [43]

[42] Sertyeşilışık, B., Sertyeşilışık, E. (2017). İnşaat Sektöründe Su Kaynaklarının Verimli Kullanılmasına Yönelik Strateji Önerileri. Türk Bilimsel Derlemeler Dergisi, 10 (2), pp. 6-9.

[43] Mannan, M., Al-Ghamdi, S., G. (2020). Environmental impact of water-use in buildings: Latest developments from a life-cycle assessment perspective. Journal of Environmental Management, 261, https://doi.org/10.1016/j.jenvman.2020.110198

2.7. Land and Material Selection for Biodiversity Balance

WHAT IS BIODIVERSITY?

Biodiversity, or biological diversity, refers to the variety of life on Earth in all its forms, from genes and bacteria to entire ecosystems such as forests and coral reefs. The biodiversity we see today is the result of an ongoing transformation increasingly influenced by human activities [44].

IMPORTANCE: Biodiversity is fundamental to human well-being, a healthy planet, and economic prosperity for all. We depend on it for food, medicine, energy, clean air and water, protection against natural disasters, as well as recreation and cultural inspiration. It supports all life systems on Earth [45].

CAUSES OF BIODIVERSITY LOSS: One of the main drivers of biodiversity loss is land use by humans, primarily for food production. Human activities have already altered more than 70% of ice-free land. When land is converted into agricultural areas, some animal and plant species lose their habitats and face the risk of extinction.

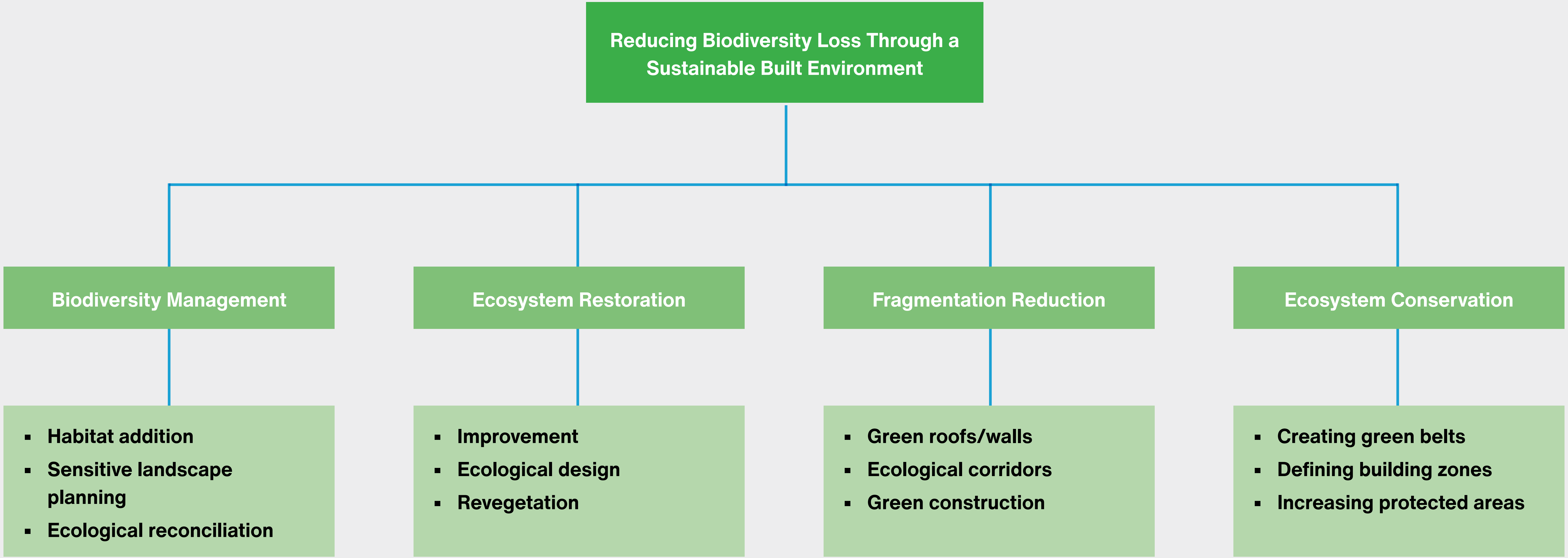
However, climate change is becoming an increasingly significant factor in biodiversity loss. It has already altered marine, terrestrial, and freshwater ecosystems worldwide [44].

THE ROLE OF BIODIVERSITY IN PREVENTING CLIMATE CHANGE: When human activities generate greenhouse gases, approximately half of the emissions remain in the atmosphere, while the other half is absorbed by land and ocean ecosystems. These ecosystems and the biodiversity within them act as natural carbon sinks, providing nature-based solutions to climate change. **Nearly one-third of the greenhouse gas emission reductions needed in the next decade can be achieved by enhancing nature's ability to absorb emissions [44].**

[44] https://www.un.org/en/climatechange/science/climate-issues/biodiversity

[45] Kunming-Montreal Global biodiversity framework. Convention on Biological Diversity, CBD/COP/15/L.25, 2022.

2.7. Land and Material Selection for Biodiversity Balance



Key Resource:

23 Targets - Kunming-Montreal Global Biodiversity Framework

Figure 12. Reducing Biodiversity Loss Through a Sustainable Built Environment [46]

[46] Opoku, A. (2019). Biodiversity and the built environment: Implications for the Sustainable Development Goals (SDGs). Resources, Conservation and Recycling, vol. 141, pp. 1-7.

2.7. Land and Material Selection for Biodiversity Balance

Impact of Land Use in Built Environment Construction on Biodiversity [47]:

- Change in land use purpose
- Exploitation of organisms living on the land
- Climate change
- Pollution
- Formation of invasive harmful species

All these factors result in Biodiversity Loss.

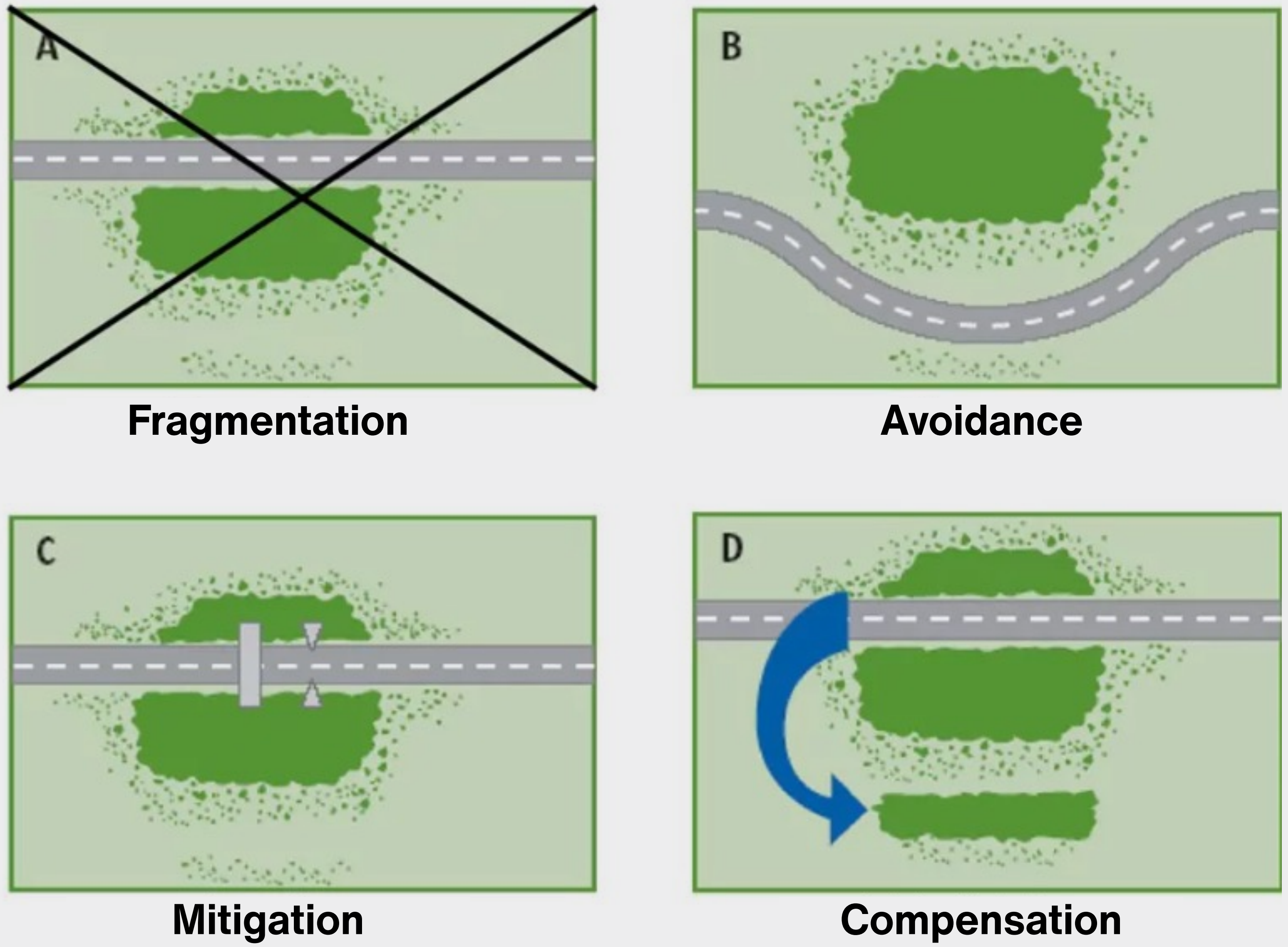


Figure 13. Reducing Construction-Induced Biodiversity Loss [47, 48, 49]

[47] *Biodiversity and the Built Environment, Irish Green Building Council (IGBC).*
[48] *https://www.gray.com/insights/greenfield-vs-brownfield-whats-better-for-your-manufacturing-facility/*
[49] *https://constructionmanagement.co.uk/courses/cpd-managing-biodiversity-on-construction-sites/*

2.7. Land and Material Selection for Biodiversity Balance

Impact of Buildings on Biodiversity Throughout Their Whole Life-Cycle[47]:

Design Phase:

- Selecting the appropriate location
- Assessing existing biodiversity on-site and developing a biodiversity strategy for the area
- Determining the materials to be used

Raw Materials:

- Extraction – Causes habitat fragmentation and destruction
- Material Production & Transportation – Leads to habitat fragmentation, destruction, and greenhouse gas emissions

Construction Phase:

- Habitat destruction and fragmentation
- Risks to wildlife on-site (e.g., pits, trenches, etc.)
- Pollution
- Risks associated with invasive alien species

Handover Phase:

- Engaging with users

Operation Phase:

- Lack of maintenance – Causes habitat destruction and fragmentation

End-of-Life Phase:

- Waste

PREVENTING BIODIVERSITY DAMAGE:

- Nature-based solutions (green roofs, vertical gardens, etc.) can be developed.
- Environmental Impact Assessment (EIA) reports should evaluate the potential effects of the project on the environment, along with alternative solutions.
- Plans should be developed to protect natural habitats, such as the Natura 2000 network.
- The redevelopment of unused or abandoned industrial areas (brownfields) should be encouraged.
- Habitat protection strategies should be implemented in construction processes through directives like the EU Habitats Directive (92/43/EEC), and the degradation of natural areas should be minimized.
- Projects should be developed for reforestation and restoring natural vegetation on post-construction sites.

Section **3**

SOCIAL SUSTAINABILITY IN BUILDINGS

3.1. Definition of Social Sustainability in Buildings

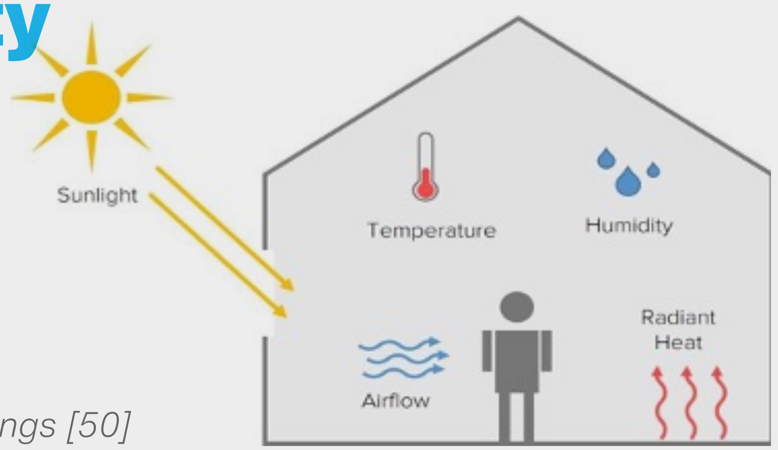
Social sustainability in buildings refers to an approach that aims to create healthy, safe, and comfortable living environments for people in order to support the long-term well-being of communities.

This approach to **social sustainability in buildings** encompasses not only environmental impacts but also considers social and psychological effects. It involves the creation of buildings and built environments in accordance with universal and inclusive design principles. Design and implementation strategies developed within this context are based on principles of **accessibility** and **inclusivity,** aiming to strengthen social ties and enhance individuals' quality of life. In this way, it is aimed to create **barrier-free** and **participatory** spaces suitable for the **physical, psychological,** and **social** needs of individuals.

Characteristics of Buildings in Terms of Social Sustainability

- Designs that improve user health and well-being
- Biophilic design strategies
- Accessible and inclusive design
- Social equity, interaction, and community participation (The role of buildings in promoting social equity and community well-being)
- Economic accessibility – affordable and sustainable housing
- User behavior and sustainability

3.2. Characteristics of Buildings in Terms of Social Sustainability



Comfort Conditions in Buildings [50]

Designs That Enhance User Health and Well-being:

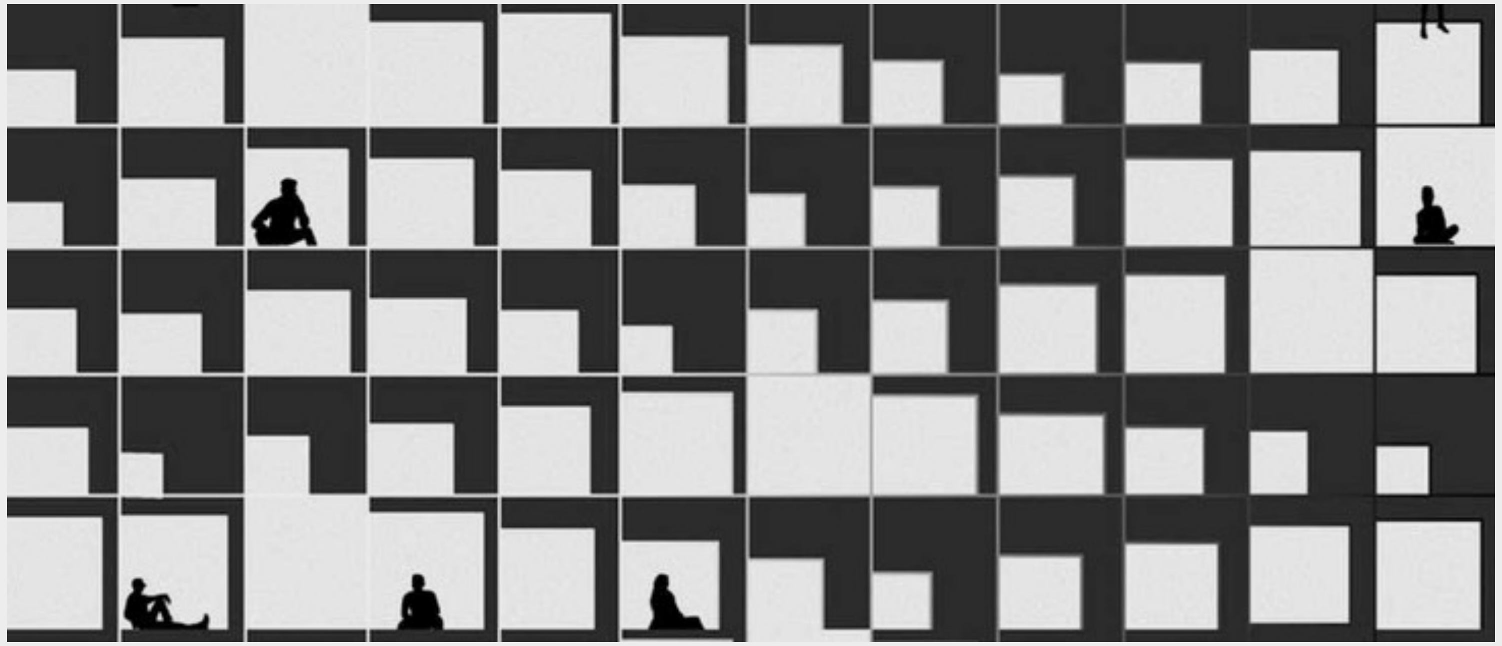
Ensuring thermal comfort conditions, controlling indoor temperature and humidity, and preferring passive heating and cooling systems.	**Ensuring visual comfort and the use of daylight,** use of shading strategies and glare control, efficient use of artificial lighting systems, and prevention of light pollution.	**Ensuring acoustic comfort** and noise control, preventing noise pollution through the use of sound insulation in indoor spaces, and ensuring speech intelligibility.
Use of indoor air quality and natural ventilation, ensuring indoor air quality, continuous flow of fresh air, removal of polluted air (allergens and toxic substances) from indoor spaces, renewal of indoor air with fresh air, and reduction of harmful chemicals.	**Water efficiency, ensuring access to clean water to protect health and hygiene,** considering environmental impacts and user health and hygiene through the use of water-saving systems, and implementation of water-efficient systems for water purification and indoor cleaning.	**Reducing the urban heat island effect,** balancing ambient temperatures and enhancing user comfort through green roofs, gardens, and landscaping in buildings, and providing passive cooling around the building by reflecting heat with reflective and cooling materials used on roofs and façades.
Universal and Inclusive Designs ▪ **Accessibility:** Providing accessible solutions in design (such as ramps for persons with disabilities, wide doors, elevators, etc.) that address the needs of all individuals, creating equal opportunities for all users. ▪ **Inclusive Communities:** Creating shared spaces in building design that promote social interaction by considering diverse groups such as persons with disabilities and the elderly.	**Biophilic Designs** ▪ **Connection with Nature:** Strengthening the connection between people and nature through biophilic design, incorporating natural materials and plants into interior spaces to enable users to interact with nature, ensuring positive psychological and physiological effects, using elements such as natural views and the sound of water in interior spaces, and supporting outdoor views.	**Designs That Promote Physical Activity** ▪ **Walking Paths and Sports Areas:** Planning designs that encourage physical activity within and around buildings (such as walking paths, bicycle parking areas, gyms, etc.) ▪ **Ergonomic Design:** Supporting a healthy lifestyle through ergonomic designs shaped according to the physical needs of different users.

[50] https://ggbec.co.uk/quick-guide-overheating-thermal-comfort/

3.2. Characteristics of Buildings in Terms of Social Sustainability

Economic Accessibility – Affordable and Sustainable Housing:

Economic accessibility – the provision of affordable and sustainable housing for low-income individuals, the construction of these housing units using energy-efficient, low-maintenance, and environmentally friendly materials, the provision of long-term benefits both environmentally and economically, and the contribution to social equity and improved quality of life, thereby supporting social sustainability.



[51]

User Behavior and Sustainability:

User behaviors directly affect building sustainability in areas such as energy saving, water use, and waste management. Strategies such as education, reward systems, and community participation should be implemented for sustainable practices. Social sustainability in buildings can be strengthened through accessibility, community spaces, and the sharing economy. Through social education programs, users can become environmentally friendly and socially responsible individuals.

[51] https://entrerayas.com/architecture-housing-for-all-is-not-just-a-tagline-it-is-a-duty-a-demand-and-a-commitment-thomas-vonier-uia-president/

Section **4**

ECONOMIC SUSTAINABILITY IN BUILDINGS

4.1. Cost Advantages of Sustainable Buildings

Sustainable buildings offer cost advantages while reducing their environmental impacts. These advantages include [52]:

1. Reduction in Construction and Logistics Costs: Sustainable site selection helps reduce the amount of materials and labor required for construction, while shorter transportation distances lower logistics costs.

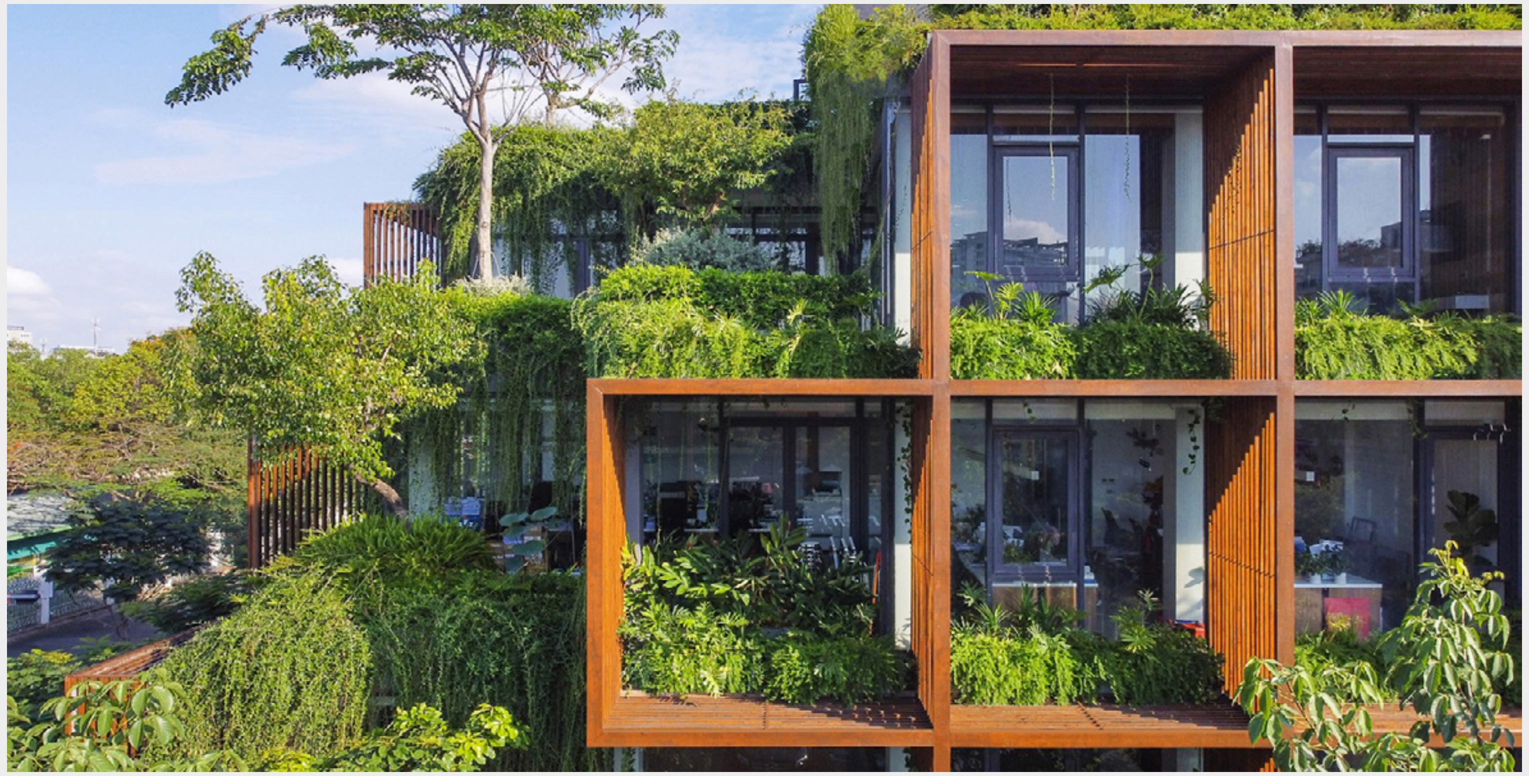
2. Water Conservation: Water-saving systems (such as sensor faucets, aerators, dual-flush toilets, and waterless urinals) significantly reduce annual water bills. Additionally, the treatment and reuse of greywater, blackwater, and rainwater reduces the burden on municipal infrastructure, thereby lowering costs.

3. Increased Energy Efficiency: Energy-efficient systems and renewable energy technologies (e.g., heat pumps, LED fixtures, solar collectors, PV panels, etc.) reduce buildings' energy consumption, resulting in substantial annual energy savings. Moreover, lower peak energy demand decreases the need for new energy infrastructure, which in turn reduces public expenditures.

4. Increase in Market Value: As interest in sustainable buildings grows, the market value of such structures is also expected to rise. Especially due to their energy efficiency and low operating costs, sustainable buildings are seen as long-term investments, making them more attractive to investors and buyers.

5. Local Economic Development: Sustainable projects that utilize local labor can create employment opportunities, contributing to the strengthening of local economies. In addition, these buildings stimulate demand for environmentally friendly products and services, fostering the development of new business sectors.

6. Long-Lasting Buildings and Equipment: Smart commissioning practices ensure that buildings and systems operate efficiently for longer periods, thereby reducing maintenance and repair costs. The use of durable, long-lasting materials not only minimizes environmental impacts but also lowers renovation costs.



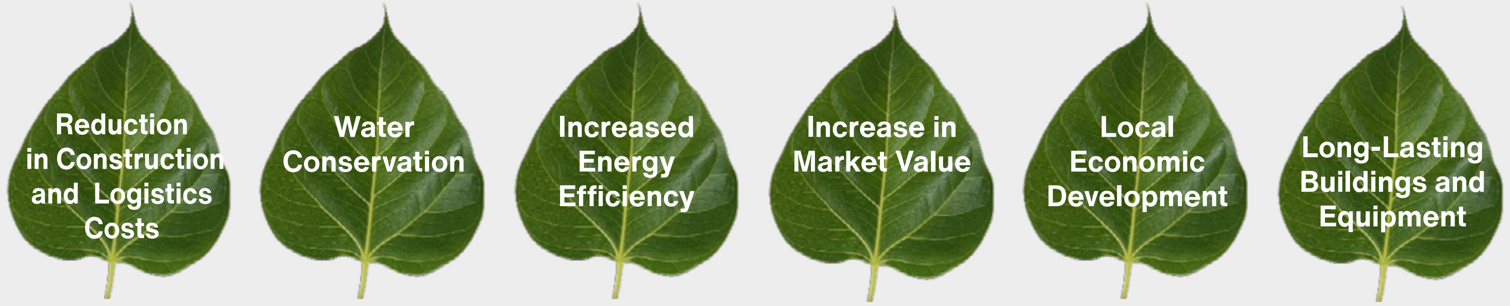


Figure 14. Economic Benefits of Green Buildings

[52] https://www.completecommunitiesde.org/green-building-practices/

4.2. Life-Cycle Cost (LCC) in Sustainable Buildings

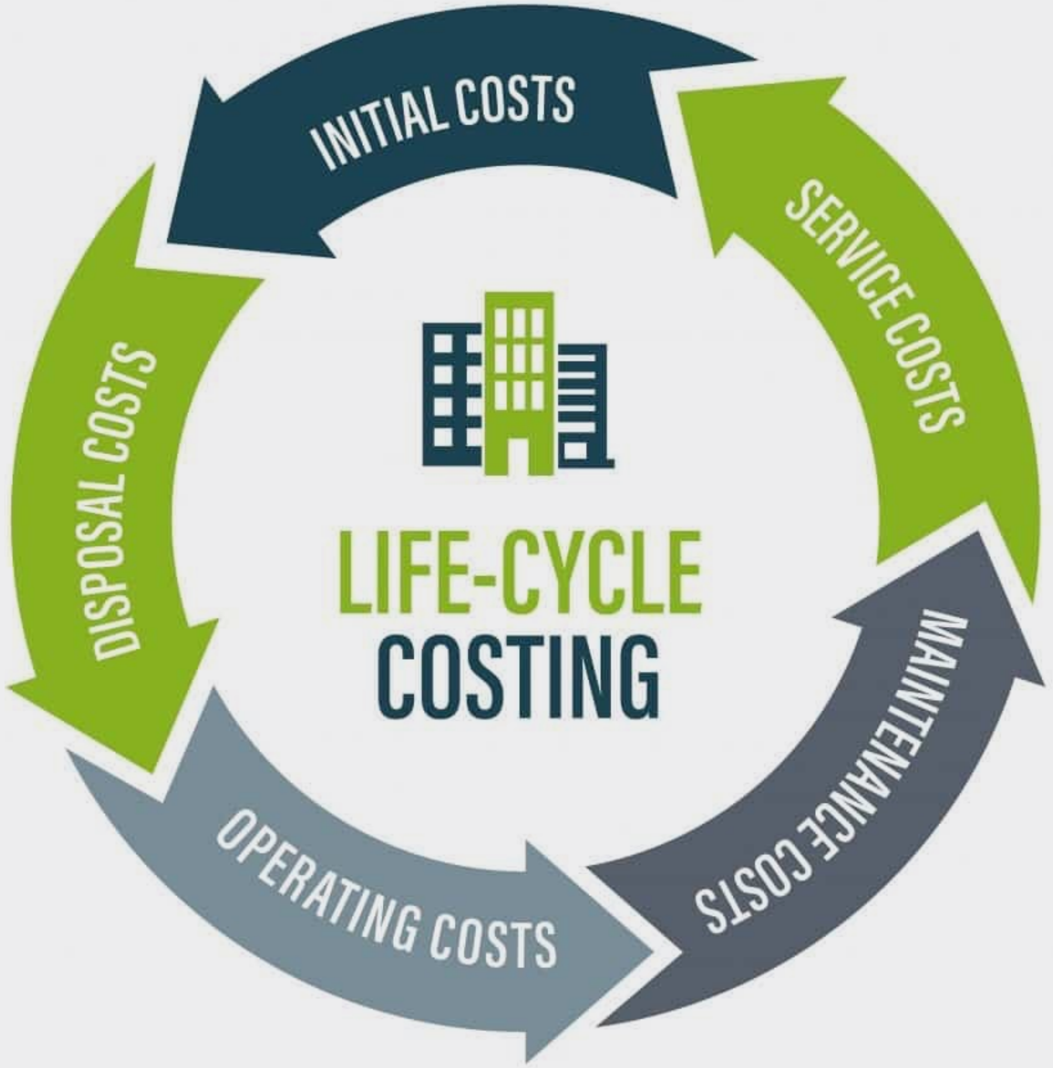


Figure 15. Life-Cycle Costing Diagram in Buildings [53]

What is Life-Cycle Cost (LCC)?

When purchasing a product, service, or undertaking a project, it is essential to consider not only the initial cost but also all potential costs that may arise throughout its entire life span. Life-Cycle Cost (LCC) is an approach that encompasses all costs incurred during processes such as acquisition, ownership, and waste management [54].

What is the role of the LCC method in improving the economic performance of buildings?

Life-Cycle Costing is a method used to assess all the costs incurred from a building's design and construction to its operation, maintenance, and eventual demolition, evaluating the building's overall economic performance [55,56].

[53] https://buildpass.co.uk/blog/what-is-life-cycle-costing-and-why-should-we-get-on-board-early/
[54] https://green-business.ec.europa.eu/green-public-procurement/life-cycle-costing_en
[55] A. Boussabaine, R. Kirkham, Whole Life-Cycle Costing: Risk and Risk Responses, Blackwell Publishing Ltd, Oxford, UK, 2004.
[56] J.W. Bull, Life Cycle Costing for Construction, Taylor & Francis, London, United Kingdom, 2003, http://dx.doi.org/10.4324/9780203487723

4.2. Life-Cycle Cost (LCC) in Sustainable Buildings

The building-related costs included in this method are outlined below:

- **Initial Costs:** These are the expenses related to procurement during the design and construction phases of a building. They include materials, labor, engineering, design, permits, and other associated expenditures. This cost represents all expenditures necessary to implement the project.
- **Maintenance Costs:** These are the regular expenses required to preserve the building's functionality, including routine maintenance, emergency repairs, system upgrades, and general upkeep services. This cost reflects the expenditures incurred throughout the building's life span.
- **Operating Costs:** These are the ongoing expenses required to maintain the daily operations of a building. They include energy (electricity, water, natural gas), heating, cooling, security, cleaning, and other operational expenditures. This cost encompasses all spending necessary for the building to remain functional.
- **Service Costs:** These refer to the costs associated with maintaining the services provided by the building. They include expenditures for delivering services required by users (e.g., elevator maintenance, security services). This cost is essential for ensuring continuous service provision.
- **Demolition Cost:** These are the expenses incurred when the building reaches the end of its life span, covering demolition and waste management activities. They include demolition operations, waste transportation, recycling, and other related expenditures. This cost reflects the spending required for decommissioning the structure and managing the resulting waste.

The LCC approach has been developed for use in parallel with Life-Cycle Assessment (LCA) in a consistent manner [57]. LCA is a critical tool for better understanding the total costs and environmental impacts of sustainable buildings. Designers can benefit from computational tools that perform such analyses (Reference – Module 3).

[55] A. Boussabaine, R. Kirkham, Whole Life-Cycle Costing: Risk and Risk Responses, Blackwell Publishing Ltd, Oxford, UK, 2004.

[56] J.W. Bull, Life Cycle Costing for Construction, Taylor & Francis, London, United Kingdom, 2003, http://dx.doi.org/10.4324/9780203487723

[57] Padilla-Rivera, A., Paredes, M. G., & Güereca, L. P. (2019). A systematic review of the sustainability assessment of bioenergy: The case of gaseous biofuels. Biomass and Bioenergy, 125, 79-94.

4.3. Economic Resilience and Sustainability

Economic resilience refers to the ability of an economy to quickly resume its fundamental functions after being affected by a crisis, minimizing the duration of time it cannot perform its essential functions [58]. Ensuring economic resilience at a local or regional level requires the ability to foresee risks, assess how these risks may impact key economic assets, and build the capacity to respond [59].

Why is economic resilience a critical factor for ensuring the sustainability of a building?

Economic resilience refers to the characteristics needed for a building to be economically sustainable. This concept includes the following elements:

LONG-TERM RETURN ON INVESTMENT (ROI)

Sustainable buildings provide a high return on investment in the long term due to energy savings and low maintenance costs. The operational and maintenance costs are generally lower compared to existing buildings [60].

MARKET DEMAND

As the demand for eco-friendly buildings increases, the economic resilience of these buildings also improves. The growing environmental awareness among consumers enhances the interest in sustainable buildings [61].

RISK MANAGEMENT

Designs that are resilient to risks such as climate change and natural disasters support economic sustainability. These designs create a secure environment for investors by reducing potential losses [62].

SOCIAL AND ECONOMIC IMPACTS

Sustainable buildings contribute to local economies and enhance social benefits, thereby increasing economic resilience. These buildings have the potential to create local employment and strengthen the social fabric of communities [63].

[58] https://sustainable-prosperity.eu/sustainable-prosperity/economic-resilience/
[59] https://www.eda.gov/resources/comprehensive-economic-development-strategy/content/economic-resilience
[60] Kats, G. (2015). "The Role of Sustainable Building in the Long-term Economic Performance." Journal of Sustainable Development.
[61] Dixon, T., & Colantonio, A. (2013). "Sustainable Housing: The Role of Market Demand." Sustainable Cities and Society.
[62] Klein, R. J. T., & Nicholls, R. J. (2012). "Linking Climate Change Adaptation and Disaster Risk Reduction." Climate and Development.
[63] Feride, K. (2020). "The Impact of Sustainable Buildings on Local Economies and Societal Benefits." International Journal of Environmental Research and Public Health.

Section **5**

TOOLS AND TECHNOLOGIES FOR SUSTAINABLE BUILDINGS

5.1. Building Information Modeling (BIM) for Sustainable Design

(For more information on innovative building technologies, please refer to Module 6: Innovative Building Technologies.)

Building Information Modeling (BIM) provides a digital platform to optimize factors such as energy efficiency, material usage, and life-cycle analysis in sustainable design processes. This allows for better management of the environmental impacts of sustainable designs and enables more informed decisions during the design phase.

Processes related to **Building Information Modeling (BIM)** include programming, conceptual design, detailed design, analysis, documentation, fabrication, construction (4D and 5D), logistics, operation and maintenance, demolition, and renovation [64].

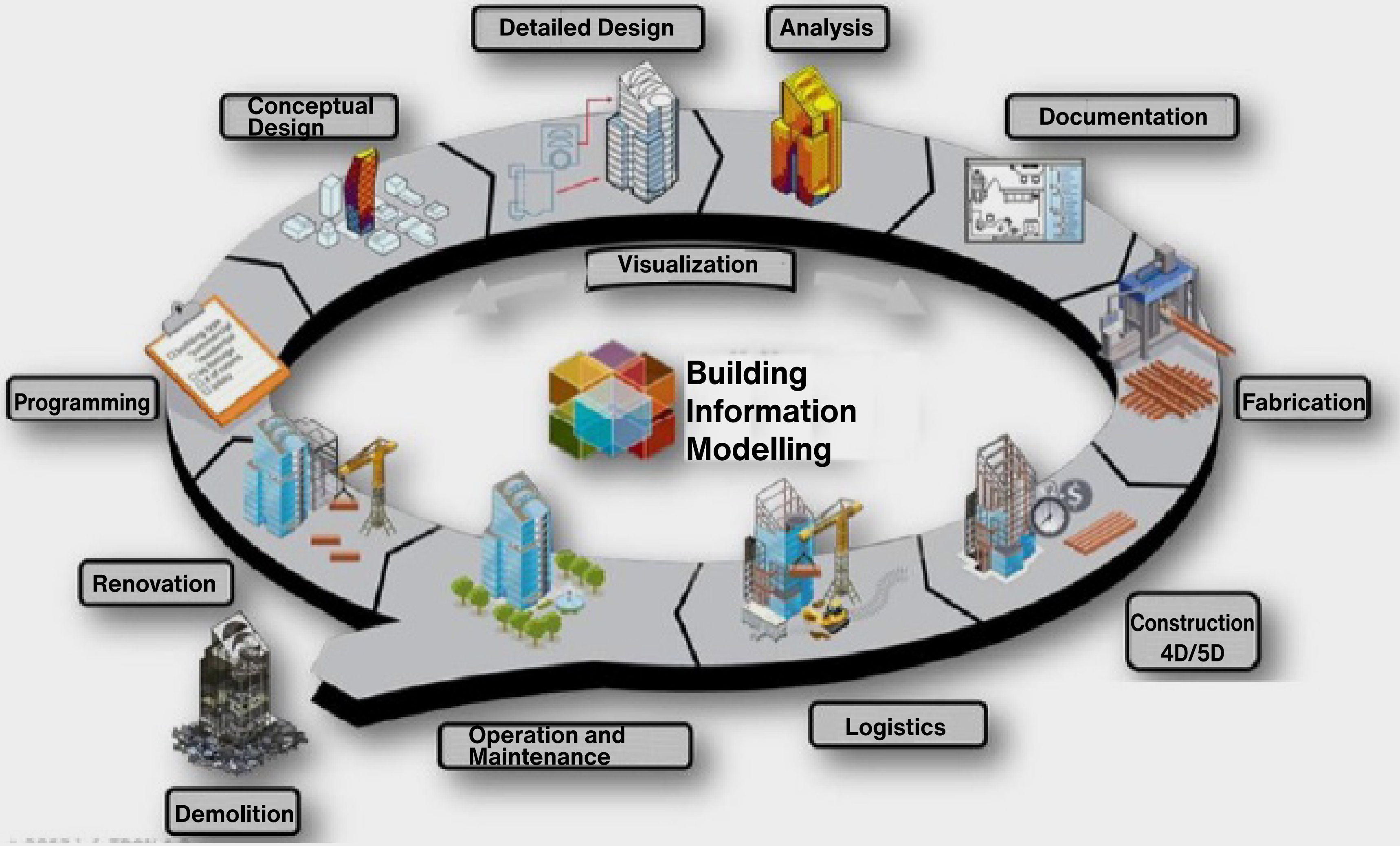


Figure 16. BIM processes [64]

[64] https://mies.com.tr/wp-content/uploads/2024/07/page_18.png

5.2. Smart Building Technologies

SMART TECHNOLOGIES IN BUILDINGS:

The digitalization of buildings is a key component of the EU's clean energy transition—smart technologies can enhance energy efficiency, make buildings more responsive to the needs of their occupants, and increase the flexibility of energy systems [65].

A smart building can sense, interpret, communicate, and effectively respond to changing conditions, such as the operation of technical building systems, external environment, and grid demands [65].

EPBD 2024/1275 Smart Readiness Indicator (SRI):

- Optimize energy efficiency and overall performance.
- Adapt operation to the user's needs.
- Align with signals from the grid.

NZEBs (Nearly Zero-Energy Buildings) include the use of smart technologies, such as building automation systems, IoT devices, and advanced energy management systems, that can help optimize energy use and contribute to meeting NZEB standards.

SRI should be used to measure the capacity of buildings to adapt their operation to the needs of occupants and the grid, and to improve energy efficiency and overall performance using information and communication technologies and electronic systems [12].

Users must be aware of the use of smart building technologies. Awareness should be raised among building occupants about the value behind building automation and the electronic monitoring of technical building systems, ensuring trust in the actual savings that these advanced features offer [12].

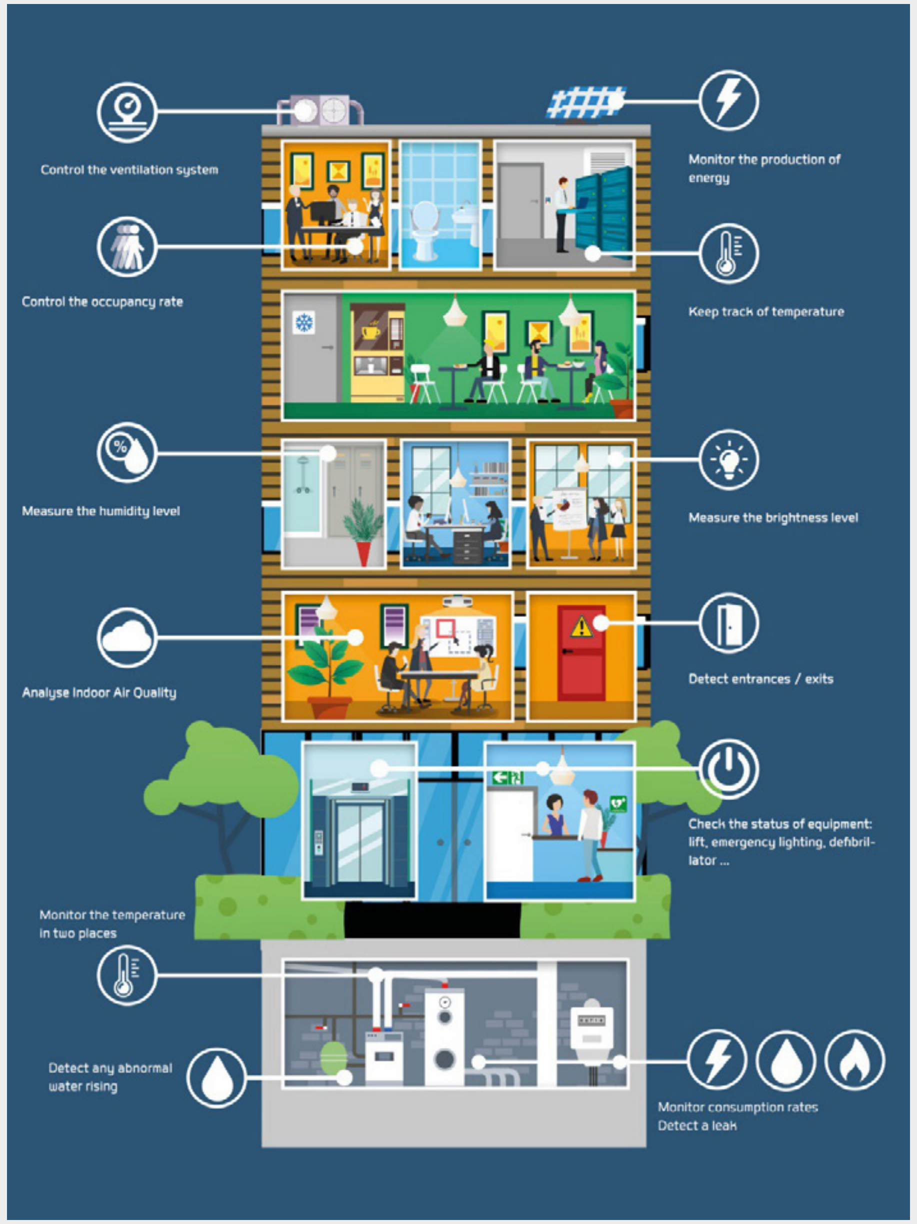


Figure 17. Smart Building Technologies [66]

[65] https://build-up.ec.europa.eu/en/resources-and-tools/articles/overview-article-smart-buildings-and-smart-technologies-europe-state
[66] https://www.adeunis.com/en/smart-building-iot/

5.3. Monitoring and Measuring Building Performance

MONITORING BUILDING PERFORMANCE is a cornerstone of successful building decarbonization efforts. It involves the continuous monitoring and analysis of various aspects of a building's operations, including energy consumption, emissions, and overall operational efficiency. Performance monitoring allows us to identify areas where buildings may be operating inefficiently [67].

WHAT CAN BE ACHIEVED:

- With information on energy usage patterns, facility teams can identify specific systems or behaviors causing excessive energy consumption.
- This real-time feedback loop immediately addresses deviations from sustainability targets, whether they result from human behavior or system malfunctions.
- [67, 69] By detecting issues that could lead to increased energy consumption or emissions over time, it helps prevent long-term inefficiencies [67, 69].

OBJECTIVES:

- Control of energy costs and energy consumption
- Minimization of environmental impacts
- Enhancement of image through marketing
- Load forecasting, energy management, and reliability improvement [68]

BUILDING PERFORMANCE CATEGORIES THAT CAN BE MONITORED:

- **Energy Usage** (Heating, cooling, lighting, and equipment usage)
- **Water Usage** (Plumbing, irrigation, and other applications; helps detect leaks and reduce waste.)
- **Indoor Air Quality** (Measurement of pollutants, humidity, and ventilation levels; temperature, HVAC systems, humidity, CO_2 levels, and air pressure measurements)
- **Waste Management** (Monitoring waste disposal and recycling systems)
- **Occupancy Density** (Should be monitored in various areas of the building to assist with space optimization and security planning.)
- **User Feedback** (Soliciting input on comfort, security, and amenities helps teams improve the overall user experience.) [43]

LEED

INTERNATIONAL WELL BUILDING INSTITUTE™

[67] https://www.usgbc.org/articles/enhancing-building-decarbonization-through-performance-monitoring
[68] https://www.energy.gov/eere/buildings/performance-metrics-tiers
[69] https://green.org/2024/01/30/real-time-monitoring-of-building-performance/

Section **6**

REGULATORY FRAMEWORKS AND POLICIES

6.1. National and International Regulations for Sustainable Buildings

Regulatory frameworks for sustainable buildings are defined by various laws and regulations at both national and international levels. These regulations include the following:

- **International Agreements:** The objectives of these agreements are to protect natural resources, reduce greenhouse gas emissions, promote sustainable development, foster international cooperation, create sustainable cities and communities, and enhance energy efficiency in buildings. These agreements are listed below in chronological order.
- **National Legislation:** Countries develop laws and regulations that set standards for sustainable buildings. These include regulations on energy efficiency and construction standards. In Türkiye, numerous laws and regulations have been enacted over the past two decades to enhance the sustainability of buildings. These efforts have been led by the Ministry of Energy and Natural Resources and the Ministry of Environment, Urbanization, and Climate Change of the Republic of Türkiye.

1978	1992	1997	2000	2015	2015	2016	2018
United Nations Environment Programme (UNEP)	Rio Declaration	Kyoto Protocol	Millennium Development Goals (MDGs)	Sustainable Development Goals (SDGs)	Paris Agreement	New Urban Agenda	Global Climate Action Agenda

6.1. National and International Regulations for Sustainable Buildings

- Some of the most significant regulations are listed below:
  Energy Efficiency Law – 2007 [70],
  TS825 Thermal Insulation Requirements for Buildings Standard – 2008 [71],
  Regulation of Energy Performance in Buildings (BEP-TR) – 2008 [72],
  Regulation on Green Certificates for Buildings and Settlements (YeS-TR) – 2019 [73],
  Guideline for Nearly Zero Energy Buildings (nZEB) – 2020 [74],
  Türkiye Building Sector Decarbonization Roadmap – 2023 [75],
  Energy Efficiency 2030 Strategy and the 2nd National Energy Efficiency Action Plan – 2024-2030 [76]

- **Local Regulations:** Municipalities may promote the construction of sustainable buildings based on local needs. KİPTAŞ, a subsidiary of the Istanbul Metropolitan Municipality, reached an agreement with property owners through negotiations conducted via a “Reconciliation Office” established a few years after the Yeşilpınar Neighborhood of the Eyüpsultan district was declared a risk area in 2016 due to unplanned urbanization and a structurally vulnerable building stock. Residents were relocated from their existing buildings and provided with moving and rental support, and the construction of earthquake-resistant housing commenced. Under the project, whose groundbreaking ceremony took place on May 25, 2021, a total of 678 independent units were built. The first phase, consisting of 155 apartments, was delivered to beneficiaries on January 26, 2023, while the second phase was delivered at a later stage [77].

Figure 18. Urban transformation efforts in the Yeşilpınar Neighborhood of Eyüpsultan district [78].

[70] https://enerjiverimliligi.enerji.gov.tr/template/dist/pdf/EnerjiKanun.pdf
[71] https://www.resmigazete.gov.tr/eskiler/2008/08/20080826-7-1.doc
[72] https://www.resmigazete.gov.tr/eskiler/2008/12/20081205-9.htm
[73] https://www.yes-tr.com/
[74] https://webdosya.csb.gov.tr/db/meslekihizmetler/icerikler/nseb_rehber--20201117075919.pdf
[75] https://webdosya.csb.gov.tr/db/meslekihizmetler/menu/turkiye_bina_sektoru_karbonsuzlasma_yol_haritasi_-v1_20231218095757.pdf
[76] https://enerji.gov.tr/Media/Dizin/BHIM/tr/Duyurular/T%C3%BCrkiyeninEnerjiVerimlili%C4%9Fi2030StratejisiveIIUlusalEnerjiVerimlili%C4%9FiEylemPlan%C4%B1_202401161407.pdf
[77] https://www.kiptas.istanbul/haber/kiptas-eyupsultan-yesilpnar-evleri-2-etap-anahtar-teslim-toreni-gerceklesti
[78] https://www.baretdergisi.com/eyupsultan-da-yerinde-donusum-icin-dev-sitedeki-7-blok-yikildi/24441/

6.2. The Role of Governments and Municipalities

Governments and municipalities play a key role in the development of sustainable buildings. These roles include:

Policy Development: Governments can develop policies that promote sustainable construction practices. In 2002, the European Union published the Energy Performance of Buildings Directive (EPBD) to improve energy efficiency in buildings and introduce certification systems based on energy classes [79]. In line with EU legislation, Türkiye issued the Regulation of Energy Performance in Buildings in 2008, making it mandatory for buildings to obtain an Energy Performance Certificate using the BEP-TR methodology [80, 81].

EPBD - 2002 **BEP-TR - 2008**

Figure 19. Regulations developed by the EU and Türkiye to improve energy efficiency in buildings [82, 83].

Figure 20. Energy Performance Certificate (EPC) issued to buildings in Türkiye through the BEP-TR system [84].

[79] A.Z. Yilmaz, A. Akguc, G. Gali, N. Ganic Saglam, T. Ashrafian, Determination of Turkish Reference Residential Buildings and National Method for Defining Cost Optimum Energy Efficiency Level of Buildings, Scientific and Technological Research Council of Turkey (TUBITAK), 2015. Project no:113M596.

[80] TC. Çevre Şehircilik ve İklim Değişikliği Bakanlığı, Binalarda Enerji Performansı Yönetmeliği, T.C. Resmi Gazete, 27075, Ankara, (2008).

[81] TC. Çevre Şehircilik ve İklim Değişikliği Bakanlığı, Binalarda Enerji Performansı Ulusal Hesaplama Yöntemine Dair Tebliğ (Tebliğ No: YİG/2010-02).

[82] https://pixabay.com/images/search/eu%20flag/

[83] https://www.pngall.com/turkey-flag-png/

[84] https://bestenerji.com.tr/hizmetler/enerji-kimlik-belgesi-uzmanligi-egitimi/

6.2. The Role of Governments and Municipalities

In 2010, the EPBD was updated (EPBD-recast) to introduce the concept of "cost-optimal energy efficiency." The recast directive required EU member states to calculate cost-optimal levels of energy efficiency for buildings. Later, in 2020, the European Commission proposed the European Climate Law, aiming to make the EU climate-neutral by 2050 [85]. Today, the development of highly innovative building materials and energy-efficient systems has facilitated the construction of nearly zero-energy buildings (nZEB), encouraging countries to adopt more effective policies in this area. The goal is to promote the widespread adoption of sustainable buildings and ensure energy savings. In general, nZEBs are defined as highly energy-efficient buildings that are powered in part or entirely by renewable energy sources. Some EU countries have gone beyond nZEB targets by aiming for zero-energy buildings (Netherlands), positive energy buildings (Denmark, France), climate-neutral buildings (Germany), and zero-carbon buildings (United Kingdom) [86]. Decisions related to nZEBs under the 2010 EPBD are presented in a timeline in Figure 6 [87].

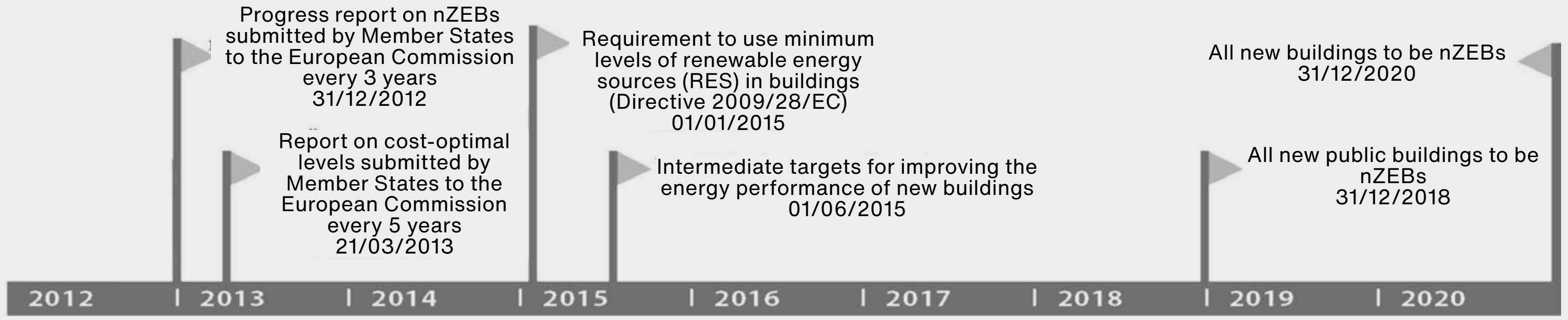


Figure 21. Key milestone years for nZEB implementation in the EU [87].

The Government of Türkiye also promotes sustainable building practices through strategic planning documents such as the 2024–2030 Climate Change Mitigation and Adaptation Strategy and Action Plans. The Energy Efficiency Law, enacted in 2007 and updated in 2024, aims to improve energy efficiency in buildings and set energy performance standards for new constructions. Furthermore, based on Directive 2010/31/EU, Türkiye published the Guideline for Nearly-Zero Energy Buildings (nZEB) in 2020, **outlining strategies** for all buildings in the country to become nZEBs by 2053.

[85] https://climate.ec.europa.eu/eu-action/european-climate-law_en
[86] BPIE (Buildings Performance Institute Europe). (2015). Nearly Zero Energy Buildings Definitions Across Europe. nZEB definitions.
[87] S. Maçka Kalfa And N. Sönmez, "Avrupa Birliği Binaların Enerji Performansı Direktifi Bağlamında Üye Ülkelerin Yaklaşık Sıfır Enerji Bina Yaklaşımları ve Türkiye'de Mevcut Durum Analizi," Yapı , no.474, pp.60-65, 2022

6.2. The Role of Governments and Municipalities

Financial Incentives: Tax reductions, grant programs, or low-interest loans can be offered to support the construction of sustainable buildings.

Energy Efficiency Support Programs:

- **European Green Deal:**

  The EU has developed a comprehensive strategy to combat climate change and achieve sustainable development goals. This strategy aims to reduce the EU's carbon emissions to net zero by 2050, promote a circular economy by combining economic and environmental sustainability, and enhance the energy efficiency of buildings [88].

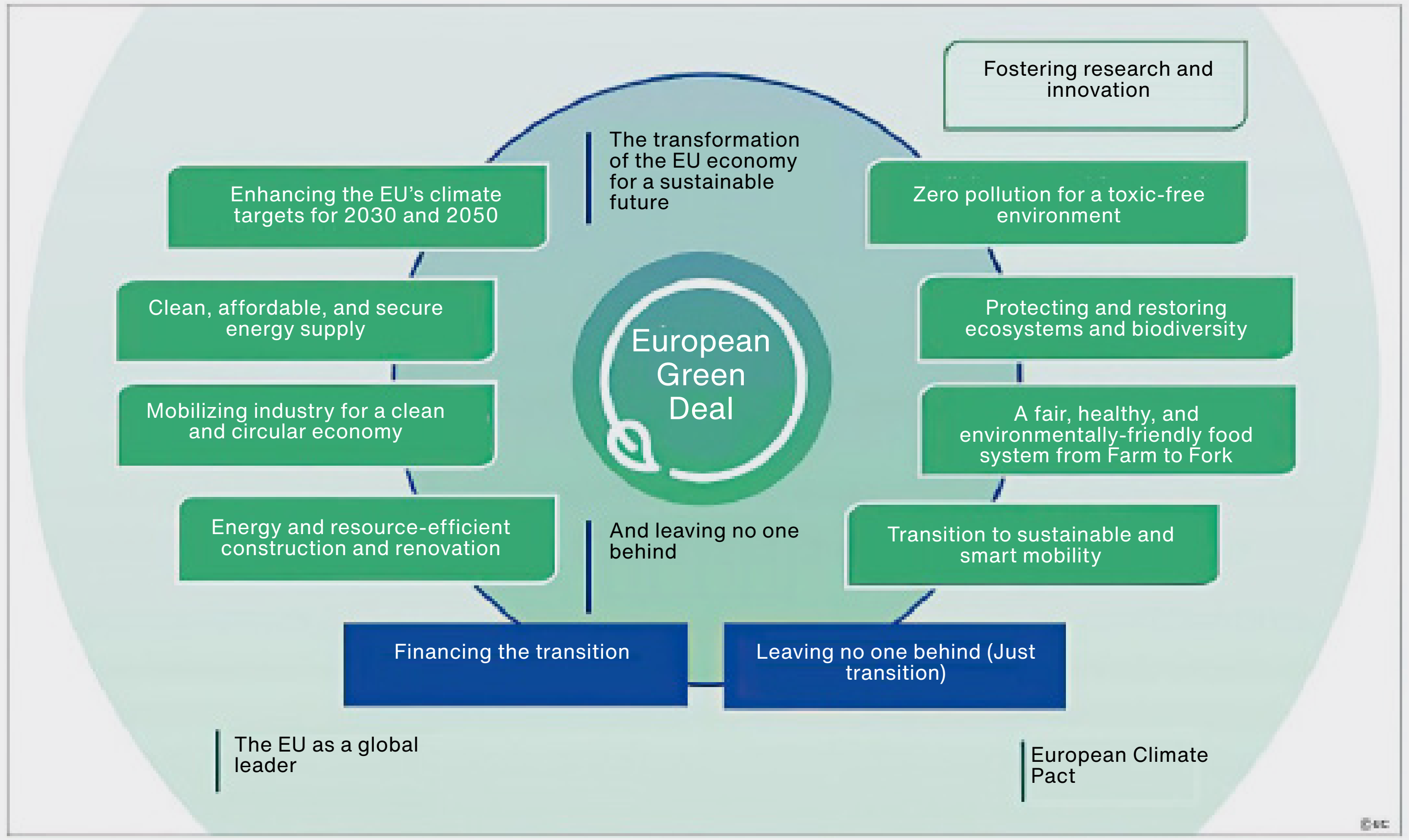


Figure 22. The transformation of the EU economy for a sustainable future [89].

To achieve the objectives of the European Green Deal, approximately EUR 1 trillion in sustainable investments is planned over the next decade [89]. This plan supports research and innovation projects such as Horizon Europe and provides financial assistance for workers in the fossil fuel sector during the transition period through the Just Transition Fund. In addition, grants and low-interest loans are offered for renewable energy projects, along with tax reductions or direct grant support for electric vehicle purchases.

On the other hand, in line with the comprehensive changes outlined in the European Green Deal and EU policies, as well as the transformation of the international economy and trade, the Green Deal Action Plan was published in 2021 by the Ministry of Trade of the Republic of Türkiye. This action plan aims to support the transformation toward a sustainable, resource-efficient, and green economy that aligns with Türkiye's development goals [90].

[88] https://www.consilium.europa.eu/en/policies/green-deal/#what
[89] https://www.ab.gov.tr/53729.html
[90] https://dongusel.csb.gov.tr/en/turkiye-green-deal-action-plan-i-106993

6.2. The Role of Governments and Municipalities

- **Green Mortgages:**

  A green mortgage is a type of mortgage in which a bank or lender offers favorable terms to a homebuyer if the property they intend to purchase meets certain environmental standards.

  This may apply either to newly built homes with a certified level of sustainability or to borrowers who commit to renovating an existing building to improve its environmental performance. In short, a green mortgage is specifically targeted at green buildings. It typically offers borrowers lower interest rates and increased credit availability [91].There are also consultancy firms that provide services in the field of green finance.

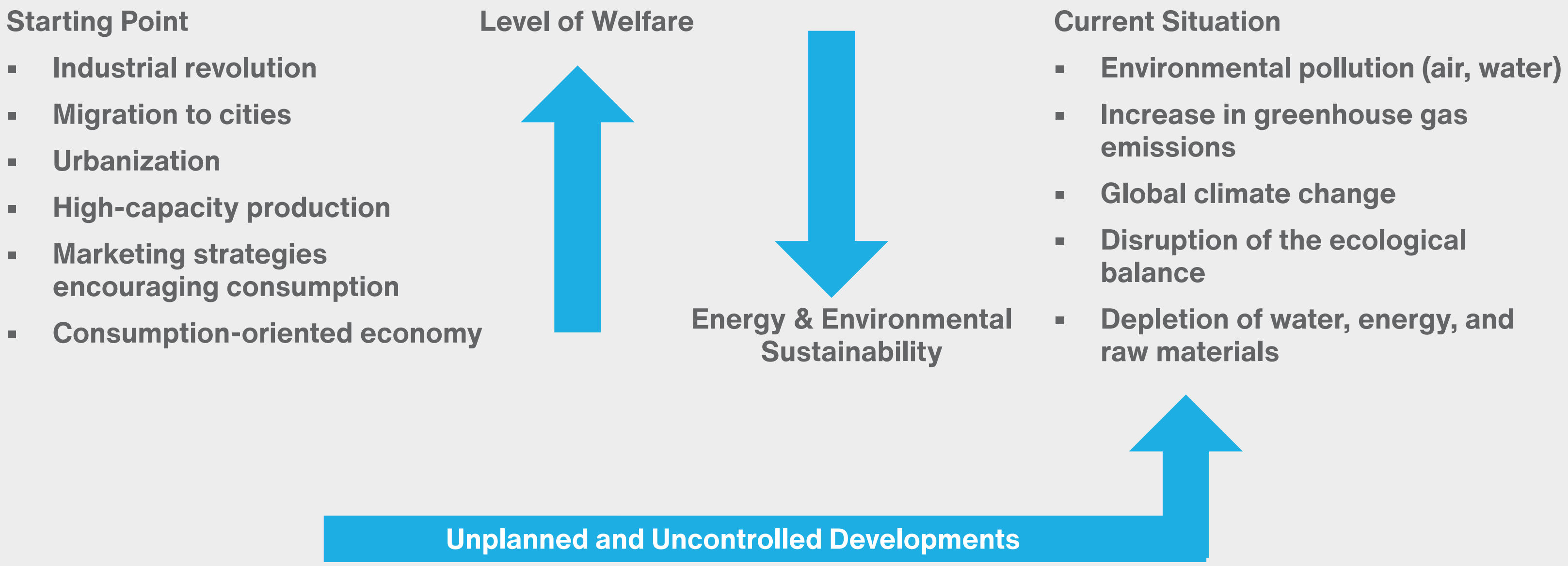
  In Türkiye, green finance practices are implemented by banks in various ways to promote environmental sustainability. Through offering lower interest rates and extended credit facilities, banks aim to support economic and environmental sustainability in buildings. In addition, they organize training programs for their clients to raise awareness about green finance and collaborate with expert organizations and public institutions to expand the adoption of green finance practices. (For more information on financing instruments for sustainable buildings, please refer to Module 7: Financing Instruments for Sustainable Buildings.)

Figure 23. An example of a promotional visual prepared by companies in the field of green finance [92].

[91] https://worldgbc.org/article/what-are-green-mortgages-how-will-they-revolutionise-home-energy-efficiency/
[92] https://yesmortgageservices.co.uk/green-mortgages/

6.3. Green Building Certification Systems

The reasons behind the emergence of the concepts of sustainable design and green buildings, along with the resulting challenges, are summarized in the diagram below.



In response to this situation, national governments have started to develop strategies aimed at improving the energy efficiency of buildings—particularly those with high energy consumption—and reducing their environmental impacts. In parallel, interest in environmentally friendly building construction has increased, and the concept of "Green Architecture" or "Green Building" has gained importance as an environmentally conscious alternative for buildings. In the early 1990s, the Building Research Establishment (BRE), one of the UK's national institutions, pioneered the development of green building rating (certification) systems. The aim of these systems is to establish specific standards and criteria that reduce the environmental impact of buildings and promote sustainability. These systems encourage environmentally friendly practices throughout the design, construction, and operation phases of buildings.

Objectives of green building certification systems:

Sustainability: To enhance energy and water efficiency in buildings.

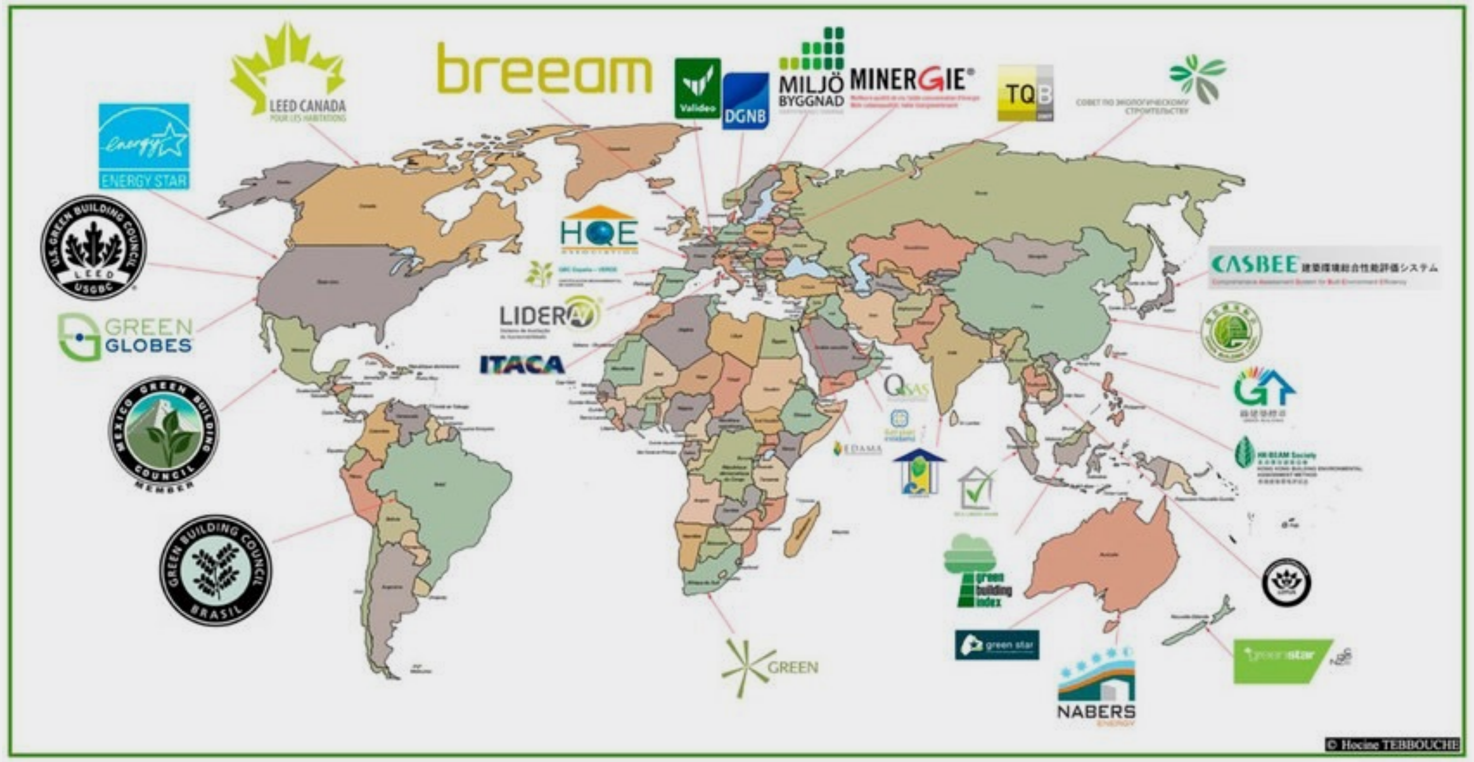
Environmental Protection: To conserve natural resources and reduce pollution.

Health and Comfort: To improve indoor environmental quality for occupants.

Raising Awareness: To promote sustainable practices and increase public awareness.

6.3. Green Building Certification Systems

The distribution of green building certification systems across countries worldwide is shown below [93].



Major certification systems include:

BREEAM: Established in 1990 by the BRE in the UK, BREEAM is recognized as a pioneering system for green building assessment. It represents the first comprehensive framework for evaluating the sustainability of buildings and is regularly updated to reflect advancements in environmental standards and practices [94].

LEED: The LEED Certification process, which began in the United States in 1998, was developed by the U.S. Green Building Council (USGBC). The aim of this certification process is to establish sustainable systems and standards by leading the way in energy and environmental design [95].

DGNB: The German Sustainable Building Council (Deutsche Gesellschaft für Nachhaltiges Bauen [DGNB]) was established in 2007. This system is more comprehensive compared to others, as it evaluates the environmental impact of buildings using a life-cycle approach and also takes into account social and economic factors [96].

YeS-TR: This is Türkiye's national green building certification system, implemented by the Ministry of Environment, Urbanization, and Climate Change in 2019. This certification is used to assess and certify buildings and settlements within the framework of sustainability [97].

[93] https://www.linkedin.com/pulse/green-building-certification-enough-dr-mohammed-al-surf/
[94] https://breeam.com/
[95] https://www.usgbc.org/leed
[96] https://www.dgnb.de/en
[97] https://yestr.org/

Section **7**

CASE STUDIES OF SUSTAINABLE BUILDINGS

7.1. Case Study 1 – Net-Zero Energy Buildings

Discovery Elementary School:

Architect: VMDO Architects	**Construction Year:** 12/06/2017
Location: Arlington, Virginia, USA	**Area:** 9,066.2 m^2

ILFI Zero Energy Certification: This is the first net-zero energy school in the Mid-Atlantic region, the largest net-zero energy building in the United States with full air conditioning, and the second-largest of its kind in North America.

LEED Zero: The first school and the third project overall to receive the certification (2017).

LEED Gold: Awarded in the new construction category (2018).

Passive Systems [98]:

- High thermal mass was achieved through the use of insulated concrete forms (ICF).
- The terraced building section allows daylight to penetrate deep into the building.
- Roof terraces maximize space for photovoltaic (PV) panels.
- Airtightness was prioritized. The building's air leakage rate was measured at 2.19 m^3/h per m^2, which is 80% better than standard requirements.

Key Feature of the Project:

- This is the first elementary school designed in the 21st century for Arlington Public Schools. Built to accommodate rapidly growing student enrollment, the project was designed to meet a broader goal: to demonstrate what is truly possible with a new public school facility.
- Two key design process criteria guided the project: challenging the tendency toward low expectations and putting children first. The resulting primary design objective was to provide a joyful and engaging environment for learning. The secondary goal was to design a building that not only used fewer resources but also made a regenerative contribution to the well-being of its occupants, the community, and the world at large—particularly in response to the climate crisis [98].

[98] https://worldgbc.org/case_study/discovery-elementary-school/

7.1. Case Study 1 – Net-Zero Energy Buildings

Discovery Elementary School:

Renewable Energy System:

- The roof hosts 497 kW of PV panels. Since its construction, the building has generated more energy than it consumes, sending an annual surplus of 100,000 kWh to the grid—enough to power an average of 7.5 homes in Virginia for a year [99].

Lighting Systems [98]:

- The lighting design complies with IECC 2009 standards.
- Strategies were chosen to discourage occupants from using excessive lighting.
- Most areas include fully dimmable daylight zones with individual controls.

Smart Systems [98]:

- In later designs, autonomous daylighting systems were added due to the ease and low cost of new standalone digital room systems.
- Occupancy sensors are installed throughout the building.

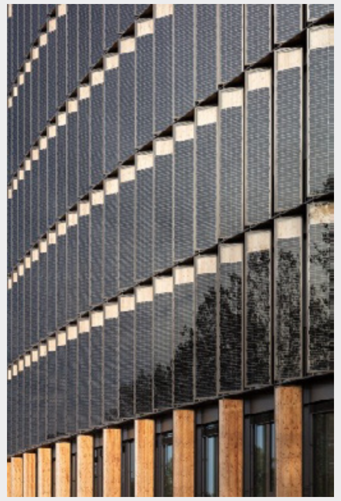
[99] https://www.usgbc.org/projects/discovery-elementary-school

Görseller: https://www.usgbc.org/projects/discovery-elementary-school

7.1. Case Study 1 – Net-Zero Energy Buildings

Freiburg Town Hall

Project Firm: Ingenhoven Architects	**Construction Year:** 2017
Location: Freiburg, Germany	**Area:** 26,115 m²
DGNB Climate Positive: Net Zero Operational Carbon	



Key Feature of the Project [100, 101]:

- Currently, it is Europe's largest innovative municipal building that produces surplus energy.
- The overall energy concept of the building enables it to effectively utilize renewable energy sources and produce more energy than it consumes for heating, cooling, ventilation, and lighting. This is primarily due to the photovoltaic units generating more electricity than the building needs. Additionally, the building can respond to grid demands by feeding excess electricity back into the grid.

Sustainable Building Systems [100, 101]:

- The structure features outstanding thermal insulation, allowing for low-temperature heating and high-temperature cooling.
- To minimize energy demand, the building is equipped with a ventilation system that uses heat recovery.
- Heating and cooling are efficiently managed using energy from groundwater. A heat pump operates the heating system, while a plate heat exchanger is used for cooling.
- The roof and the sun-exposed parts of the façade are fitted with high-performance solar panels, which not only generate energy but also provide shading.

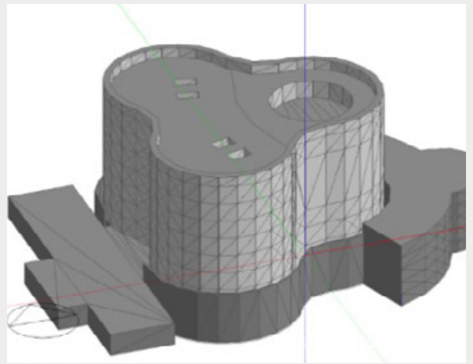
[100] https://worldgbc.org/case_study/city-hall-freiburg/

[101] https://www.archdaily.com/885885/freiburg-town-hall-ingenhoven-architects

7.2. Case Study 2 – Green Office Project

Küçükçekmece Municipality Building

Architect: Mutlu Çilingiroğlu	**Project Year:** 2014
Energy and Green Building Consultants: EKOMIM and TURKECO	**Site Area:** 15,000 m²
Location: Istanbul, Türkiye	**Construction Area:** 40,000 m²



Main Feature of the Project:

- During the design process of the Küçükçekmece Municipality Building, its public function played a key role. The project was envisioned as a potential catalyst for transforming the developing district and as a reference point for the public it serves, introducing “new concepts” across the municipality.
- This is Türkiye’s first public building to receive a BREEAM certification. In the project, BREEAM-Bespoke criteria were applied, and BRE Global developed custom-tailored criteria specifically designed for this project’s climate and building type [102, 103].

Green Design and Sustainability:

- Use of a double façade and atrium space enabling a high degree of passive climate control and natural lighting,
- Three circular building forms designed with equal distance from the center to all directions for uniform daylight distribution,
- Integrated lighting automation,
- Efficient water usage with 54% greywater reuse,
- Waste control and selection of recyclable materials,
- Rainwater harvesting and green roof application,
- Use of A+ and A++ energy class mechanical equipment,
- Trigeneration system providing heating, cooling, domestic hot water, and electricity,
- Ice storage system supporting cooling needs [103, 104, 105].

Building Energy Performance Analyses:

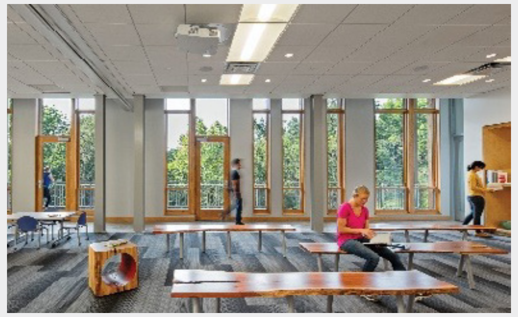
- Under the BREEAM-Bespoke framework, the building received energy consultancy services. Feasibility studies were conducted on energy, daylighting, and low-carbon renewable energy systems. As a result of these studies, 21.3% energy efficiency was achieved [106]. Designed in line with BREEAM standards, the building was awarded the BREEAM Very Good certification.

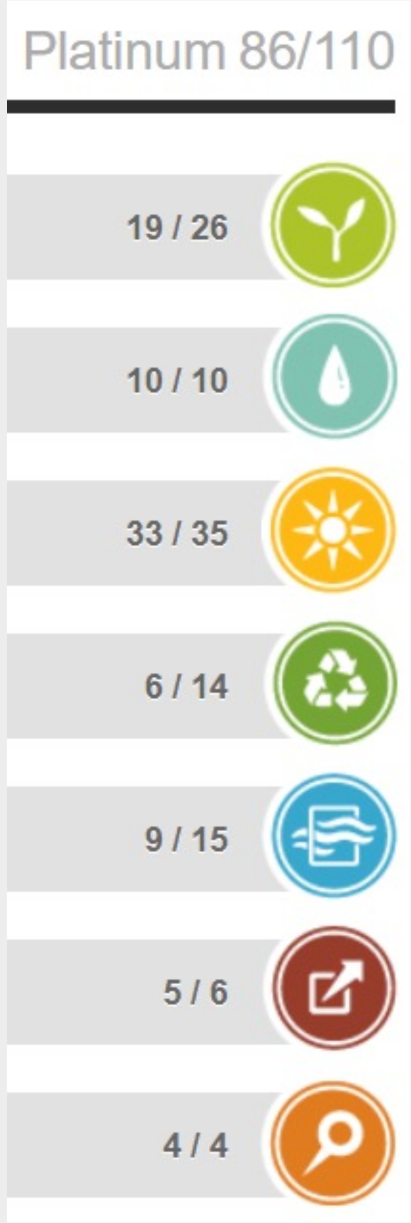
[102] https://www.ekoyapidergisi.org/ornek-bir-belediye-binasi-kucukcekmece-belediyesi
[103] https://www.arkiv.com.tr/proje/kucukcekmece-belediyesi-yeni-hizmet-binasi/2351
[104] https://www.ekoyapidergisi.org/kucukcekmece-belediyesi-nde-btm-yesil-cati-sistemleri-kullanildi
[105] https://www.ankaraaluminyum.com.tr/tr/projelerimiz/kucukcekmece-belediye-binasi/

7.2. Case Study 2 – Green Office Project

Frick Environmental Center

Architect: Patricia Culley	**Project Area:** ~ 1400 m^2
Location: Pennsylvania, USA	**Year of Construction:** 2014





Features of the Project:

- The Frick Environmental Center is a joint project of the Pittsburgh Parks Conservancy and the City of Pittsburgh. It is a sustainability-focused building that holds both LEED Platinum certification and the Living Building designation. The center offers experiential environmental education for individuals of all ages and hosts educational programs while integrating with the surrounding natural areas.
- In terms of energy efficiency, the center consumes 40% less energy compared to similar buildings and meets its entire energy demand through 161.7 kW photovoltaic panels. The indoor temperature is passively regulated through a natural ventilation system and geothermal heating and cooling technologies. The rainwater collection system fills a 15,000-gallon tank, supplying water for the toilets, landscape irrigation, and the historic fountain located within the park. The materials used in construction have been carefully selected, sourced from recycled or local materials. Notably, locally salvaged black locust wood for cladding and furniture has been integrated into the design of the center as a symbol of respect for the region's natural fabric [107, 108, 109].

[106] Yılmaz, A. Z., Kalaycıoğlu, E., Akgüç, A., & Bayraktar, M., Enerji Etkin ve Yeşil Bina Tasarımında Dinamik Enerji Modellemenin Önemi, X. Uluslararası Yapıda Tesisat Teknolojisi Sempozyumu, 2012.

[107] https://pittsburghparks.org/frick-environmental-center/

[108] https://gbdmagazine.com/leed-platinum-buildings/

[109] https://www.usgbc.org/projects/frick-park-environmental-center?view=scorecard

7.3. Case Study 3 – Green Housing Development Project

Trudo Vertical Forest

Architect: Stefano Boeri Archetti	**Number of Floors:** 19
Location: Eindhoven, The Netherlands	**Apartments per Floor:** 8
Year of Construction: 2017 - 2021	**Total Social Housing:** 125

Green Terraces and Biodiversity:

- Over 70 different plant species
- 4 m² terrace: 1 tree and 20 shrubs
- Approximately 8,500 plants in total

Combating Air Pollution

- Absorption of CO_2 and fine dust particles

Rainwater Harvesting:

- Four 20,000 L tanks located beneath the building supply water for the terrace areas.

Main Features of the Project:

- This tower in Eindhoven primarily offers low-rent, high-quality living spaces targeted at students and young professionals.
- The project presents an opportunity to address the significant challenge of the environmental crisis while meeting the need for affordable housing in contemporary cities [110].

Urban Renewal, Cost Efficiency, and Sustainable Transportation: :

- The structure is part of a redevelopment plan for a former site owned by Philips Electronics. This area is being transformed into a new creative hub in Eindhoven.
- To reduce construction costs, prefabricated concrete modules have been utilized.
- The project is strategically located near public transportation systems, encouraging a reduction in the use of private vehicles [110].

It should be noted that the implementation of sustainable buildings is a process that offers long-term environmental and economic benefits. For a successful application, planning, technical expertise, collaboration, and coordination are of great importance. Thanks to innovative technologies and multidisciplinary approaches, sustainable buildings will become more widespread in the future and significantly reduce the ecological footprint of cities..

[110] https://www.stefanoboeriarchitetti.net/en/project/trudo-vertical-forest/

Fotoğraf: https://www.theplan.it/eng/award-2023-Housing/trudo-vertical-forest-a-living-green-heart-stefano-boeri-architetti

7.3. Case Study 3 – Green Housing Development Project

Eisbärhaus Bauteil (Polar Bear House)

DGNB

DGNB Certificate in Platinum
Year of construction: 2019
Valid to: August 2022

Award Climate Positive*
Year of the award: 2019
Valid to: September 2020

Architect: Matthias Bankwitz	**Number of Floors:** 3 floors + roof
Year of Construction: 2009	**Gross Area:** 3,478 m²
Location: Baden-Württemberg, Germany	**Net Area:** 2,948 m²

DGNB Certified and Climate Positive Awarded:

- Components A and B were evaluated by DGNB in 2019 and received platinum and "Climate Positive" awards. The addition of Component C brought the occupancy rate to 95.6% for DGNB certification, making the Polar Bear House "the world's most sustainable building" [111].

Main Features of the Project:

- The Polar Bear House, consisting of components A, B, and C, is a four-story complex that incorporates innovative construction solutions aimed at limiting climate change to 1.5 degrees. The building, which includes commercial spaces, apartments, and an architecture office, is inspired by polar bears adapted to the cold with their thick fur. It meets passive house standards with exterior walls that are approximately 60 cm thick and insulated. Built with a wood frame structure and cellulose insulation, the building efficiently provides heating to offices and living spaces via a heat pump powered by energy from six geothermal drilling wells. Photovoltaic modules on the roof generate renewable energy, while ventilation systems with an over 85% heat recovery rate ensure a comfortable indoor environment. Exhaust air is used to pre-heat the underground parking area, and automatic textile blinds on the exterior block 85% of solar radiation. The sustainably designed building's surroundings harmonize with the natural ecosystem, using region-specific plants and silver fir cladding from the Black Forest [111, 112].

[111] https://www.ubm-development.com/magazin/eisbaerhaus-bankwitz/#:~:text=Die%20Bauteile%20A%20und%20B%20wurden%202019%20von%20der%20DGNB,CO%E2%82%82%2DNeutr%C3%A4lit%C3%A4t%20im%20Betrieb%20best%C3%A4tigt.

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