Development of a Roadmap to integrate Sustainable Consumption and Production within the Housing and Construction Sector for Turkey

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EXECUTIVE SUMMARY

Global climate change, which has gained vital importance in the last two decades, is an issue that necessitates the responsibility of all segments of society, from individuals to governments. To overcome this issue, which is the most difficult challenge of our times, international agreements and conventions have been signed, required legislation has been enacted, programs have been developed, committees have been convened, and numerous scientific activities have been held. Herein, the main source of the problem, the human being, with the unquenchable hunger for development, and the never-ending consumption frenzy that comes with it, are the main issues that must be dealt with absolutely. Considering all these, the Sustainable Consumption and Production (SCP) strategy is constantly emphasized at the international level to overcome these global concerns.

The construction industry, which is predominantly responsible for the generation of greenhouse gases that lead to climate change, continues to expand rapidly year after year to accomplish the fundamental requirements of the world's rising population, including housing, health, education etc. The world is one step closer to irreversible results every second that concrete steps are not taken at the point of the sector's exploitation of natural resources and major damage to nature with each of its constituent components. Given the estimated projections of a growing global population, including billions of new middle-class customers, it is vital to formulate more practical & strategic action plans for the construction industry. For the world of the future to be livable for humanity, the linear economic paradigm of "buy-make-sell," which depletes natural resources and erodes biodiversity, should evolve into a more sustainable and circular structure.

The circular economy model is regenerative and provides long term economic opportunities. The model considers wastes as valuable resources and necessitates traditional beliefs about waste transformation. Being proactive in sustainability benefits organizations, including lower input costs, the increased value of waste products, and improved appearance with regulators, investors, and consumers.

Given current global and regional activities, the necessity for a well-founded roadmap for Turkey on behalf of SCP is obvious. To that end, an essential step must be a comprehensive overview of the current situation of the housing and construction industry, the country's high-impact sector. In this regard, the objective of this report is to serve as a baseline study that can provide a sustainable and circular framework to the Turkish construction sector.

To this end, the current report outlined the requirements for a sustainable and circular economy, following which the current situation of the national housing and construction sector was evaluated. The assessment considered the region's characteristics, including geographical features, seismic risk, economic situation, demographic structure, and immigrant population. The most significant consideration in evaluating the current situation is the impact of each component of the value chain of the housing and building industry on people, the environment, and the economy. Furthermore, the paper presents the best accessible technology (BAT) and best environmental practices (BEP) in the nation and throughout the globe, which may serve as a model for the Turkish housing and construction industry in achieving a sustainable, circular economy identity.

As a result of the detailed study, a road map was created to be both original and inclusive at the international level and achieve the most efficient results in the shortest time possible with the available resources. Finally, after summarizing all the context in conclusion, the final section of the report summarizes the detailed recommendations.

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Overview of Turkish Housing and Construction Sector

PART A: OVERVIEW OF TURKISH HOUSING AND CONSTRUCTION SECTOR

1. OBJECTIVE STATEMENT

As population and per capita consumption reach record levels, global resource demand and environmental pressures have increased sharply [1]. In order to meet these global challenges, the Sustainable Consumption and Production (SCP) strategy has been repeatedly emphasized at the international level, especially since the 1992 Rio Summit. After adopting the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns (10-YFP) at the Rio+20 summit in 2012, the main objective was to suggest that global sustainable development can be achieved by changing the model of society's consumption and production [2]. Subsequently, SCP was adopted as one of the Sustainable Development Goals (SDGs) in 2015 [3], as it had been identified as a key and encompassing aim of sustainable development [4]. In addition to all these concrete steps taken regarding SCP, the Mediterranean Action Plan – Barcelona Convention (UNEP/MAP) has the most crucial role in creating a more sustainable consumption-production pattern in critical sectors through local and national actions and bringing SCP to the plane of reality.

With the adoption of the 2030 Agenda for Sustainable Development and, in particular, the Sustainable Development Goal (SDG) 12, the Turkish government has declared its commitment to work for a sustainable world at every opportunity. The Paris Agreement entered into force in Turkey on Nov. 10 intending to boost the country's international standing in the fight against climate change.

Besides, Turkey, one of the parties to the Barcelona Agreement, has submitted its commitments to the "Sustainable Consumption and Production Regional Action Plan for the Mediterranean," which is built around: "By 2027 a prosperous Mediterranean region is established, with non-pollutant, circular, socially inclusive economies based on sustainable consumption and production patterns, preserving natural resources and energy, ensuring the well-being of societies and contributing to clean environment and healthy ecosystems that provide goods and services for present and future generations." [5]. The SCP Regional Action Plan has been implemented under regional programs like the EU-funded SwitchMed Programme; however, Turkey could not participate in such regional programs and only be integrated as an observer. In addition, although Turkey has a variety of policy instruments, including strategies and measures to reduce the adverse influences of high-impact sectors resulting from carbon-, energy-, waste-intensive current consumption and production techniques, indicator 12.1.1 of SDGs, "Countries with sustainable consumption and production (SCP) national action plans or SCP mainstreamed as a priority or a target into national policies" still has not reached a satisfactory level.

Considering current actions on the global and regional scale, the requirement for a well-grounded roadmap for Turkey on behalf of SCP is quite evident, to this end, a detailed analysis of the current situation of the construction industry, as the country's high-impact sector, is the most critical step that has to be taken. With this regard, this report is intended to be a baseline study to provide a sustainable and circular structure to the construction industry of Turkey. In this context, the requirements of a sustainable and circular economy were defined in the first part of the report, and then the current situation of the national housing and construction sector was evaluated from

this perspective. The evaluation was carried out by taking into account the characteristics of the region, such as geographical features, earthquake risk, demographic structure, and immigrant population. Another focus at evaluating the current situation is the impacts of each component that constitutes the value chain of the housing and construction sector on humans, nature, and the economy. The current situation analysis has been carried out with a gender-disaggregated approach to the extent possible. Besides, the best available techniques (BAT) and best environmental practices (BEP) in the country and the world, which can serve as an example for the Turkish housing and construction sector to gain a sustainable, circular economy identity, are presented within the report. As a result of the comprehensive analysis carried out, a road map was designed, which is aimed to be nationally authentic-globally inclusive, and that will enable to achieve the most efficient outcomes with the available resources as earliest as possible.

1.1 Circular Design in the Housing and Construction Sector

Both investors and developers' focus shifted to sustainability aspects of the projects. The cost benefit relationship of sustainability is under discussion now which was ignored in the past. This topic is no longer the exclusive domain of environmentalists and visionaries in the construction sector but is being advanced bit by bit as part of building requirements. Currently, over twenty jurisdictions around the world have developed or are in the process of developing national or regional sustainable taxonomies [6]. China and the EU adopted their respective taxonomies into legislative frameworks of these jurisdictions. A green taxonomy is an essential building block for a sustainable financial system. It is a tool to help direct capital flows to green, sustainable projects. However, enabling the flow of capital into green, sustainable projects worldwide requires interoperability. If interoperable, taxonomies can help investors' direct capital across borders more efficiently, for instance, by reducing the costs of verifications/due diligence. Further, given that taxonomies can support other tools such as benchmarks and labels, the interoperability of taxonomies is conducive to creating better consistency across the range of tools in the market. An overview of disclosure requirements until 2024 can be followedfollowed from Figure 1.

Figure 1. Overview of Disclosure Requirements (Eurosif, 2021)

The focus of financing sustainable growth is based on the following three main criteria, which are also part of the Cradle to Cradle (C2C) concept [7]:

1. low-CO_2 solutions

2. recyclable solutions

3. healthy solutions

This leads to the fact that investments in real estate must be increasingly oriented towards sustainability aspects. This is already evident in the stock market, where equity funds with sustainable orientation have increasingly higher shares.

It is evident that the current legal requirements – also those that represent standards focus on sustainable solutions are far off from a complete closed-loop circular economy and only represent the first step towards this direction. Therefore, it is crucial to think about how construction products are designed and contribute to this development.

The challenge that most stakeholders in the construction sector face today is that you can manage what you can measure; as for now, there are almost no standardized forms of measuring the circularity and sustainability of the built environment. For this reason, real optimization in the direction of a circular economy is not even initiated or results in isolated solutions that emphasize individual measures but at the same time disregard other vital aspects. Besides, the challenge in rating products for circularity is that there is no harmonized or regulated way of doing so. Not even the underlying data – so, for example, the information about recycled content of products - is harmonized and therefore often is not disclosed at all or not even known by the manufacturers themselves. Therefore, for a realistically sustainable housing and construction sector, it is vital to develop a sustainability approach that considers the life cycles of all components, from material scale to structure scale, covering all elements of the value chain.

1.2 Sustainability in the Housing and Construction Sector

Sustainable development necessitates an adaptive framework that considers both environmental and economic problems. As defined by the United Nations (UN) Brundtland Commission in 1987, sustainability is defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs. As can be seen from the definition itself, the basis of sustainability is people and their consumption behaviours. The urban population is expected to reach 6.5 billion people by 2050, with the developing world contributing to 90% of the growth [8]. The rapid increase in population and the resulting rapid growth of cities bring various economic, environmental, and social challenges. In this context, to ultimately accomplish sustainable development, the way cities are created and administered should be developed with a sustainable approach in every stage of its life cycle, with each component. As a multidimensional process that harmonizes environmental, economic, social, and cultural dimensions, sustainable (urban) development [9] is building cities that are constantly growing economically, creating job opportunities, providing social opportunities, eliminating poverty, protecting ecosystems and reducing climate change. The discussion of sustainable housing has mainly focused on the ecological and economic components; however, the other dimensions of sustainable development, social and cultural sustainability, are equally important as stated by UN Habitat: *"Housing is where successive generations find shelter to keep healthy, develop, socialize, be*

educated and prepare for fulfilling adult lives. In this sense, housing speaks to every dimension of personal human development, hopefully generating a double sense of identity and social belonging. Both are essential to sustainable cities and their participatory governance. If the "emerging futures" of our cities are to become sustainable, then the housing conditions of one billion slum residents must become sustainable, too." [10] Consequently, a sustainable housing and construction sector should address the main issues related to urbanization, climate change, affordable housing, clean energy, and poverty reduction with a holistic approach. Establishing a housing and construction sector in which all components of the sector's value chain gain an ecologically, economically, socially, and culturally sustainable identity is a critical situation for both Turkey and the world.

2. CURRENT STATE OF THE TURKISH HOUSING AND CONSTRUCTION SECTOR

2.1 Current Demographic Situation of Turkey

The population of Turkey is 83 million 614 thousand 362 people. As of 31 December 2020, the population residing in Turkey increased by 459,365 compared to the previous year and reached 83,614,362. While the male population was 41,915,985, the female population was 41,698,377. According to the "Address Based Population Registration System" results, the foreign population residing in Turkey decreased by 197,770 compared to the previous year and became 1,333,410. 49.7% of this population was male, and 50.3% were women [11].

The population growth rate was 5.5 per thousand. While the annual population growth rate was 13.9 per thousand in 2019, it became 5.5 per thousand in 2020, as shown in Figure 2 [12].

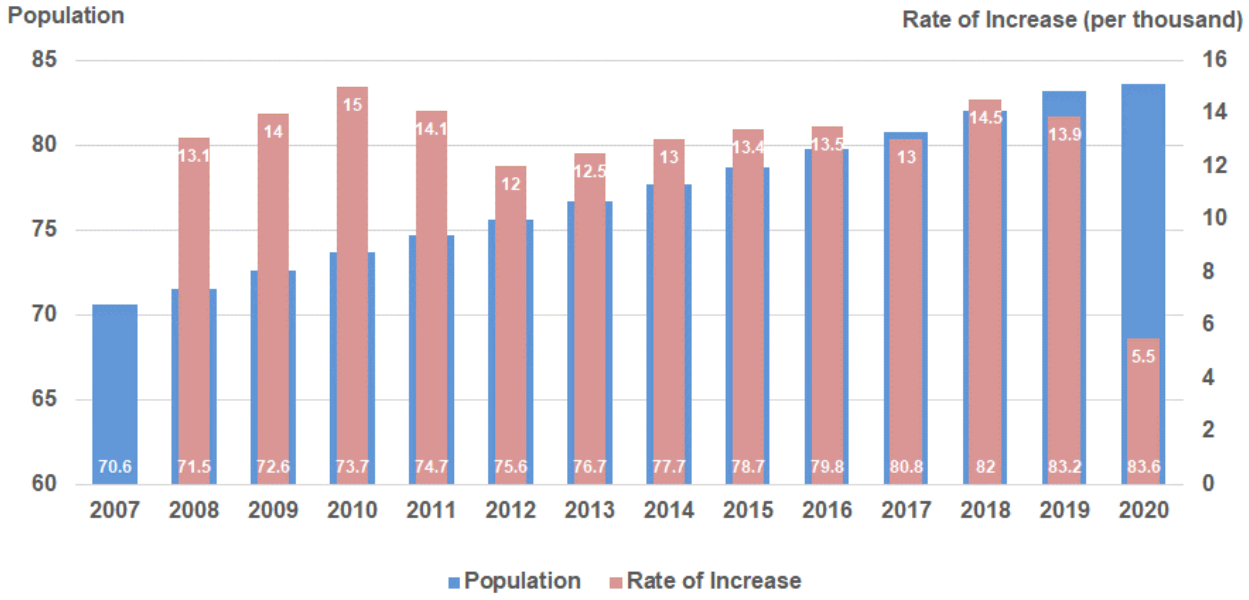


Figure 2. Population and annual growth rate, 2007-2020. (TURKSTAT)

International migration statistics reveal that in 2019 677,042 people immigrated to Turkey from abroad. The number of people who migrated to Turkey from abroad increased by 17.2% in 2019 compared to the previous year and reached 677,042 people. 54.4% of the migrating population was men, and 45.6% was women. Of the population coming from abroad, 98,054 were citizens of the Republic of Turkey (T.C.), and 578,488 were foreign nationals. Iraqi citizens made up 14.5% of the foreign population who came to Turkey, as shown in Figure 3 [13].

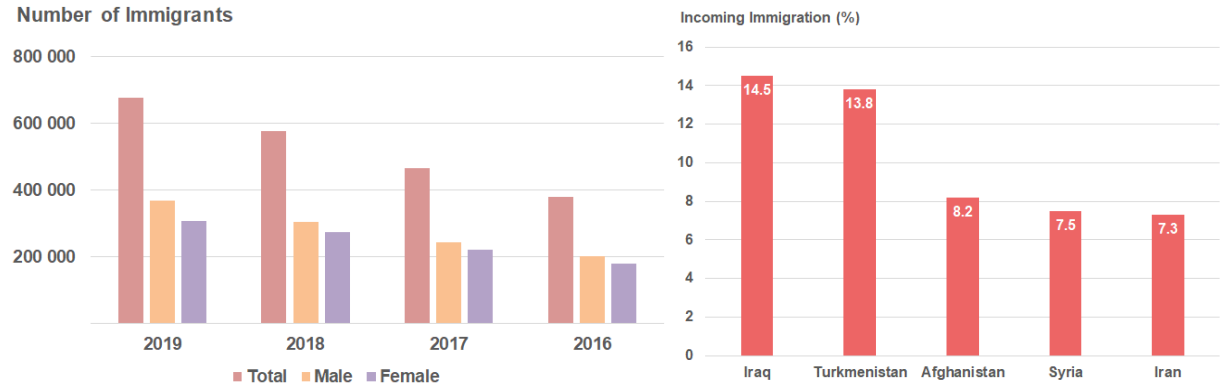


Figure 3. Total number of immigrants and the five countries with the highest number of immigrants 2019 (TURKSTAT)

Iraqi citizens ranked first among the foreign nationals who came to Turkey in 2019 with 14.5%. Iraq was followed by the citizens of Turkmenistan with 13.8%, Afghanistan with 8.2%, Syria with 7.5% and Iran with 7.3% [12].

2.2 Demographic and Socio-cultural Factors/Lifestyle Changes

2.2.1 Current building and housing stock

Several different datasets were used to find current building stock numbers [13]. The first data set used the Building Census statistics in 2000. Building occupancy permits between the years 2000-2001 and between 2002-2017 were used by taking the statistics of TURKSTAT.

In this study, the total number of buildings is given according to the following building types:

- Single Digit Housing
- Multi-Digit Housing
- Office
- Education
- Public
- Hospital
- Other

The analyzes in the rest of the study were carried out according to these building types and the numbers obtained.

The number of existing buildings according to climatic zones and building type is as follows:

Table 1 Current Building Stock [13]

New and Existing Total								
	Single Digit Housing	Multi-Digit Housing	Office	Education	Public	Hospital	Other	TOTAL
1. Climate Zone	1.245.949	311.828	81.263	8.998	8.186	253	112.083	1.768.560
2. Climate Zone	2.254.180	716.698	155.555	25.879	14.594	880	227.195	3.394.982
3. Climate Zone	1.251.297	333.514	90.018	12.573	18.014	440	169.471	1.875.327
4. Climate Zone	435.397	75.154	46.936	9.410	923	198	64.556	632.574
TOTAL	5.186.823	1.437.194	373.773	56.860	41.717	1.770	573.306	7.671.443

In addition to this, the new and additional buildings to be built according to the building permit issued by TURKSTAT are as follows[Table 2]:

Table 2. Construction permits, New buildings and additions by type of investor [14]

Year	Parameter	Total	Private sector	Construction cooperative	Public sector
2018	Number of building	104 509	94 028	1 891	8 590
	Floor area (m²)	149 438 529	119 179 672	3 220 392	27 038 465
2019	Number of building	55 718	49 386	695	5 637
	Floor area (m²)	73 305 535	57 751 276	1 609 957	13 944 302
2020	Number of building	96 012	89 811	1 157	5 044
	Floor area (m²)	112 303 850	94 579 684	2 653 068	15 071 098
2021	Number of building	94 019	87 607	807	5 605
	Floor area (m²)	99 180 358	83 827 213	1 410 926	13 942 219

The floor area of the buildings for which construction permits were granted increased by 36.4%. In the construction permits issued by the municipalities in the January-September period of 2021, the number of buildings increased by 59.5%, the floor area increased by 36.4%, the value increased by 86.3%, the number of flats increased by 33.4%, compared to the same period of the previous year [14].

57.6% of the total floor area was a residential area. While the total floor area of the buildings, for which the municipalities gave construction permits in the January-September period of 2021, is 99.2 million m²; of this, 57.2 million m² was residential, 23.2 million m² was non-residential and 18.8 million m² was everyday use area [14].

Buildings with two or more flats had the highest share with 69.9% according to the purpose of use. In the buildings for which construction permits were given in the January-September period, residence buildings with two or more flats had the highest surface area with 69.3 million m² according to their intended use. This was followed by one flat residential buildings with 7.7 million m² [14].

In parallel with the rapid increase in the world population, the increase in urbanization and the need for agricultural and industrial activities have resulted in the misuse of lands. The areas lost as a result of the use of the land in an inappropriate way for activities such as urbanization, agriculture, industry, etc., should also be taken into account. The increase in the population and the number of buildings also causes the misuse of agricultural lands. Housing construction on fertile agricultural lands is also one of the critical issues to be addressed. Misuse of agricultural lands is one of the most important factors that negatively affect the sustainability of these lands and thus agricultural production. Due to the problems experienced in the implementation of the relevant legislation and the policies followed in Turkey to date, the misuse of agricultural lands still maintains its existence as an essential problem area. The intensification of the misuse of agricultural lands, especially in areas where fertile agricultural lands exists, increases the importance of the issue even more.

The areas where the misuse of agricultural lands are most common are shown in Figure 4 as housing, industry, other, energy, tourism, transportation, education and health-purpose public investments, respectively.

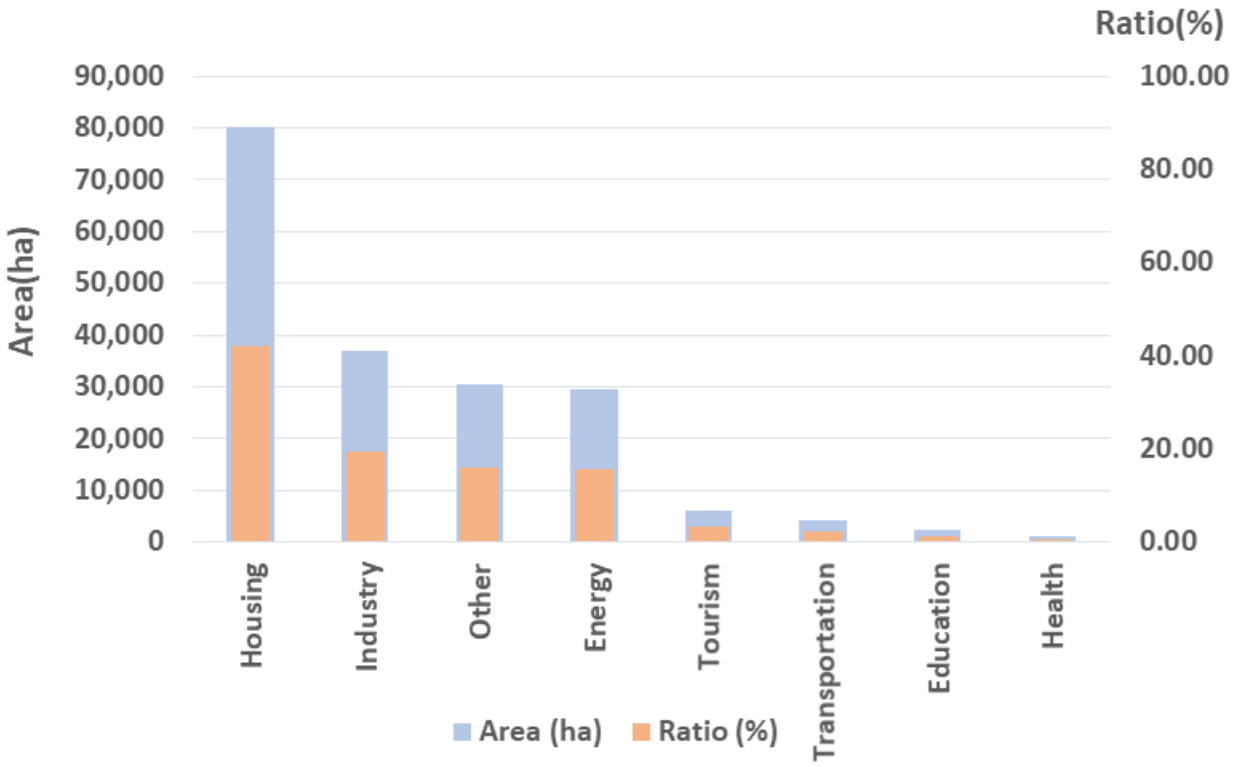


Figure 4. Sectoral distribution of the lands excluded from agriculture (2011-2016) [15]

Each new earthquake code that comes into force requires that most existing buildings either be retrofitted or demolished as the case may be. When we look at the history of earthquake regulations in Turkey, the chronological order we encounter is as follows: 1940, 1947, 1953, 1961, 1968, 1975, 1997 (in terms of content, 1996 and 1998 were gathered under one year), 2007 and 2018. The dates of the last three earthquake regulations, when taken as a basis show that a new earthquake regulation is published in our country approximately every ten years. With each new

regulation published, the need for reinforcement arises in some of the buildings (between 30 and 50%) designed following the previous regulation.

Accordingly, it can be predicted that the design and construction works related to civil engineering will continue intensively in our country for at least the next 60 years. In other words, the construction sector will continue to live as important lifeblood of our country in the coming years.

In Turkey, 137,401 houses were sold in October 2021 [16]. Housing sales across Turkey increased by 14.9% in October compared to the same month of the previous year and became 137,401. Istanbul had the highest share in house sales with 26,041 house sales and 19.0%. According to the number of sales, Istanbul was followed by Ankara with 13,466 house sales and 9.% share, and İzmir with 8218 house sales and 6.0% share. The provinces with the lowest house sales were Hakkari with 22 houses, Ardahan with 45 houses and Bayburt with 84 houses, respectively. Housing sales decreased by 15.2% in January-October compared to the same period of the previous year and amounted to 1,086,539. Housing sales to foreigners increased by 12.1% in October compared to the same month of the previous year and became 5,893. The share of house sales to foreigners in total house sales was 4.3%. Istanbul took first place in house sales to foreigners with 2,464 houses. Istanbul was followed by Antalya with 1,385 house sales and Ankara with 359 house sales, respectively.

2.2.2 Current situation of migrants and refugees

As the bridge between Europe and Asia, Turkey has historically been a country of origin, transit, and destination for immigrants. Due to its geopolitical position on the route from the Middle East to Europe and the ongoing conflicts in neighbouring Iraq, Iran, and Syria, Turkey is home to one of the largest immigrant populations in the world. Ten years ago, the first Syrian refugees fleeing conflict and violence in their home country began arriving in Turkey. What began as a trickle soon became an influx. Today, Turkey is home to more than 3.9 million Syrian refugees, who constitute the vast majority of over 4 million refugees and asylum seekers currently living in the country, making Turkey the world's most prominent host of refugees [17]. Besides, Afghan nationals have been the leading International Protection applicants in Turkey since 2019 [18]. The economic weight of meeting the shelter, nutrition, health and education needs of Syrians is increasing day by day for Turkey.

The size of the refugee influx is not at a level that Turkey is preparing for and can easily bear. With as many as 98.5% of Syrians under temporary protection (SuTPs) now living out of camps in many cities and towns that were already facing significant development obstacles, providing adequate services and support - such as infrastructure, education, housing, and employment - for millions of additional people has been a monumental challenge.

The fact that most Syrians prefer to stay in the houses they rent, especially in the border provinces, instead of staying in the camps, has led to an increase in the prices of rental houses in the settlements where they are concentrated. It has become complicated to find rental houses in border provinces. Since the Syrians living outside the camps do not have a large budget for accommodation, they settle in the outskirts of cities and districts. Local people, who want to earn rental income from Syrians, make additions to their houses without a project or permission. This situation increases unplanned urbanization and slums [19].

The Government of Turkey (GoT) estimates the total number of registered Syrians under Temporary Protection (SuTPs) at 2,225,147 according to a new Policy Note prepared by the World Bank, Turkey's Response to the Syrian Refugee Crisis and the Road Ahead. The policy note collates existing publicly available material on the situation of SuTPs in Turkey and summarizes the strategy and principles of Turkey's unique response to its displacement crisis and the challenges in managing the socioeco-nomic dimensions of displacement. The note also highlights remaining critical policy issues and the road ahead for Turkey, and what lessons could be drawn from the Turkish hosting experience for other countries' refugee response efforts [20].

According to the policy note, there are two key characteristics of the Turkish response effort (i) that it adopts a non-camp; and (ii) government financed approach—which strongly differentiates the response from many refugees hosting countries, where the tendency is to direct the refugees into camps supported by humanitarian agencies.

Three key policy questions should then guide the next steps:

a) How to mitigate the potential negative socio-economic impact of the refugee presence on host communities?
b) How to maximize the social and economic benefits of the refugee presence for host communities and the Turkish economy as a whole?
c) How to support SuTPs to be self-reliant until they can return?

2.3 Financial Overview of the Turkish Construction Sector

2.3.1 Turkish economy and construction sector

The economic metrics of the industry are one of the most significant points to obtain an overview of Turkey's housing and construction sector. According to economic metrics, it is possible to obtain information on the sector's volume, comprehend current trends, and anticipate s future. The turnover of the construction and real estate sector is increasing every year. Although the pandemic conditions somewhat suppressed the 2019 total asset increase, this situation recovered at the end of 2020, and the total assets of the two sectors reached around 1669 billion TL (Figure 5).

Figure 5. Total assets of Construction Sector and real estate activities of Turkey [21]

The construction and real estate sectors have amassed substantial debt in the last ten years, and borrowing continued to rise through April 2020 [22, 23]. The total outstanding debt of construction and real estate development activities amounted to 692 billion TL (Turkish Lira) in April 2020, including residential mortgage loans, representing 15.6% of GDP (Figure 6). The sector's external debt amounted to 24.3 billion USD in April 2020. The TL-denominated loans increased by 40% and 8% in 2017-2019 and in the first 4 months of 2020 (24% annualized). The state-owned banks supplied about 70% of the new construction-related loans in the first quarter of 2020 [22]. The government also started to offer subsidized mortgage loans through the state-owned banks, which increased their mortgage loans by 8%.

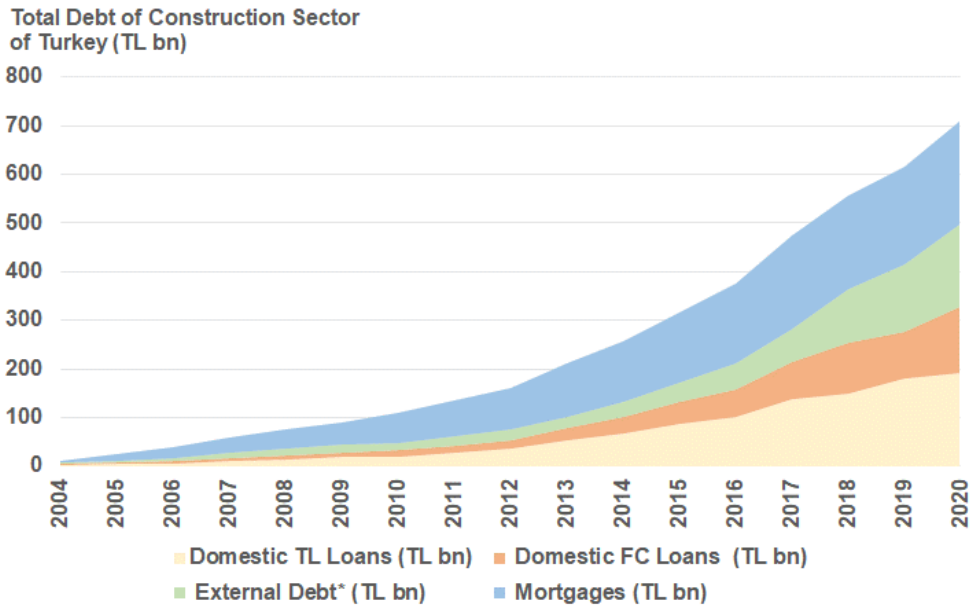


Figure 6.Total Debt of Construction Sector of Turkey (TURKSTAT)

Almost half the construction sector's total debt is denominated in foreign currency. The construction sector's foreign currency (FC) denominated loan was 60% of the sector's total debt in April 2020. The Public-Private Partnerships projects contributed significantly to the increase in FC debt of the sector. The exponential increase in the sector's indebtedness can be mainly attributable to the Public-Private Partnerships projects, which amounted to 50.6 billion USD in 2010-2019. Assuming a debt-equity ratio of 20/80 (in some cases 10/90), it is estimated that the total amount of debt utilized in these projects is estimated in the range of 40-45 billion USD [22].

In general terms, the current situation of the country is as follows, item by item [24]:

- The pandemic in 2020 and the support policies implemented for the adverse conditions of the pandemic adversely affected the economy, construction and housing sectors.
- With the expansionary policies implemented in the economy, the growth was 1.8%% in 2020. National income decreased from 761 billion dollars to 717 billion dollars.
- 1.27 million jobs were lost in 2020. However, as the labour force participation rate decreased, the unemployment rate was realized as 13.2%%.

- With expansionary policies implemented in the economy, inflation increased rapidly, and consumer prices rose to 14.60%% annually. Producer prices, on the other hand, increased by 25.15%%.
- In 2020, with the effect of the conditions created by the pandemic, exports decreased, but imports increased. The foreign trade deficit increased by 69.0%% and reached 49.86 billion dollars.
- As a result of the increasing foreign trade deficit and decreasing service revenues in 2020, the current account balance again gave a deficit of 37.3 billion dollars.
- Turkey's gross external debt stock increased by 14 billion dollars in 2020 and reached 450 billion dollars. Its ratio to national income increased to 62.8%%.
- In 2020, the budget deficit was above the projected level and was realized as 172.7 billion TL. The ratio of budget deficit to national income increased to 3.4%%.
- In 2020, fixed capital investments increased by 22.8%% and amounted to TL 1.37 trillion.
- The industrial sector grew by 2.2%% in 2020. Industrial growth was positively affected by the increase in demand in the second half of the year.
- The Turkish Lira continued to depreciate significantly in 2020.
- The construction sector shrank again in 2020. Despite the support for the sector, there was a 3.5%% shrinkage in 2020.
- In 2020, construction expenditures increased by 8.1%% at current prices and amounted to 628.2 billion TL.
- The construction sector's share in national income decreased by 0.3 points to 6.2%% in 2020.
- Construction costs increased by 25.0%% in 2020. Labour costs increased by 13.7%% and material costs increased by 30.3%%.

2.3.2 Employment and working conditions in the Turkish construction sector

Construction sector employment has been hit severely due to the economic downturn in 2018-2019. Total employment in the construction sector declined by 19.6% in 2018 from its peak at 1.73 million in 2017 (Figure 7). At its peak, construction jobs represented 7.5% of total employment in Turkey, which declined to 5.5% by the end of Feb 2020 [25]. On the other hand, temporary workers accounted for about 80% of total employment in the construction sector by the end of 2017, which has fallen by 50% by the end of March 2020, representing all of the job losses in the sector (Figure 8) [26, 27].

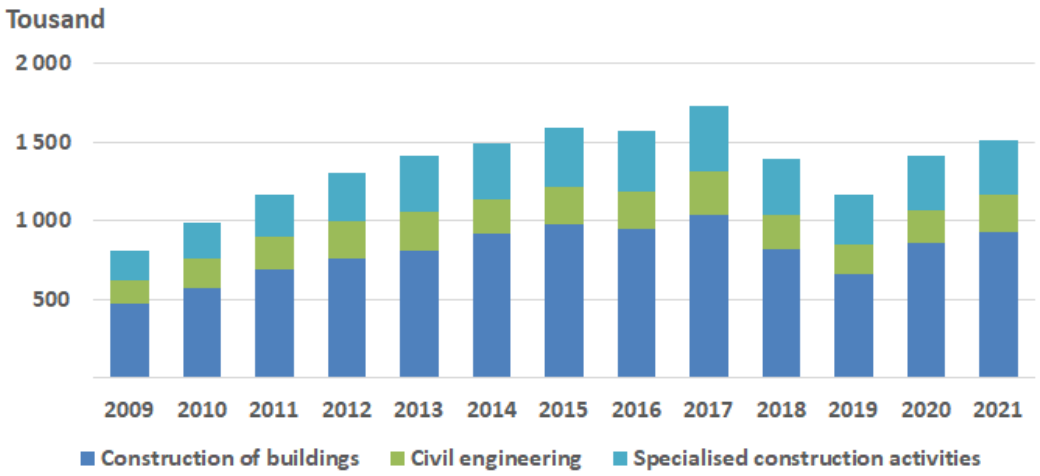


Figure 7. Paid employee statistics of construction sector [28]

With the onset of the Covid-19 pandemic, the employment expectations in the construction sector dipped in April, falling 40% monthly. However, the employment expectations recovered sharply by 40% monthly by the end of May 2020, mainly due to the government's decision to lift the pandemic related restrictions in June 2020. As a result of this improvement, the total number of employees in the sector reached 1.5 million in September 2021 [28].

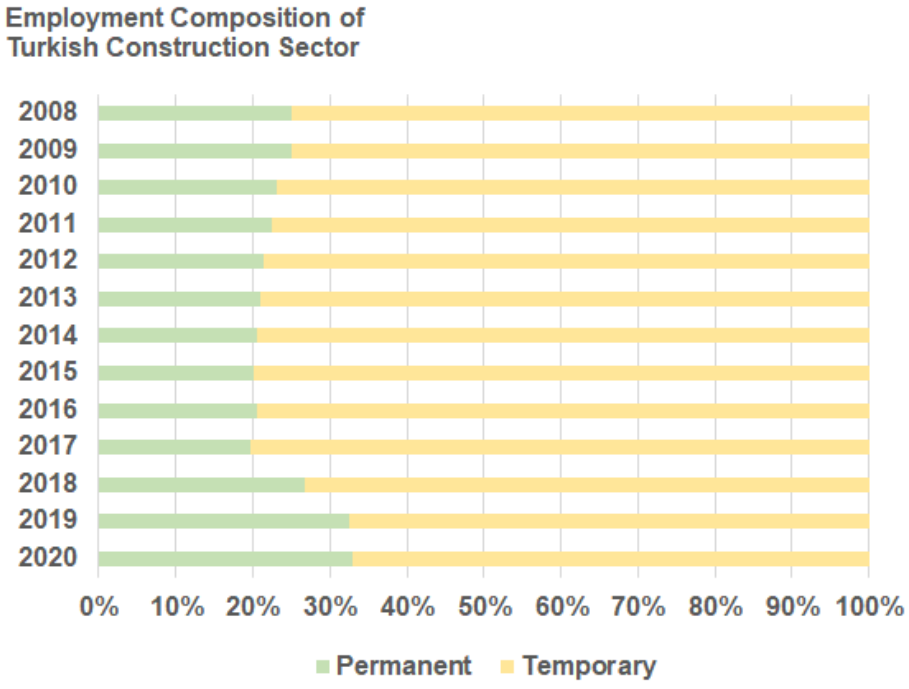


Figure 8. Total Debt of Construction Sector of Turkey (TURKSTAT)

National Income Per Capita Decreased To 8,599 Dollars. The per capita income, which started in 2013, continued to decline in 2020 and can be seen from Figure 9. With the new national income calculation, per capita national income, which was measured as 12,480 dollars for 2013, started to decline. Although the economic growth achieved in the following years, per capita income is

declining in dollars. Economic fluctuations and the depreciation of the Turkish Lira are the main determinants of the decline in per capita income. In 2020, per capita income decreased to 8,599 dollars. Thus, per capita income declined below the 2010 level.

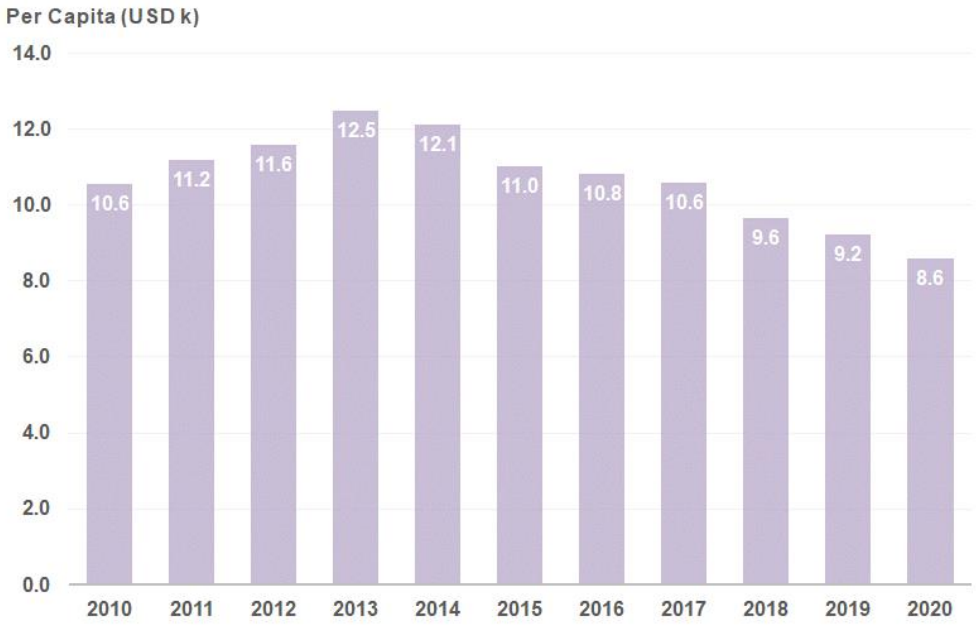


Figure 9. Turkey's Per Capita National Income; Dollar (TURKSTAT)

Construction Sector Closed 2020 With 3.5% Contraction. Despite the support given to the sector by the government, the construction sector shrank by 3.5%% in 2020. The real estate sector, on the other hand, grew by 2.6% in 2020. The real estate sector has grown despite the impact of the Covid-19 outbreak. Total construction expenditures increased by 8.1% in 2020 and amounted to 628.2 billion TL. The total building permits obtained in 2020 increased by 48.7%% based on the area and reached 110.98 million square meters. Housing construction licenses obtained in 2020 increased by 69.6% based on the area and reached 86.84 million square meters. Non-residential building permits In 2020, it increased by 3.0% and reached 24.14 million square meters. The total building permits obtained in 2020 decreased by 18.9% based on the area and decreased to 122.01 million square meters (Figures 10 and 11) [24].

In 2020, construction materials industry exports decreased by 1.5% compared to 2019 and decreased to 21.16 billion dollars. On the other hand, imports of construction materials increased by 3.5% in 2020 compared to the previous year and amounted to 7.03 billion dollars. Industrial production of construction materials grew by 9.1% in 2020 compared to the previous year. In 2019, construction materials industry production contracted by 13.0%. The domestic market of construction materials grew by 8.1% in 2020 compared to 2019 and reached 408.3 billion TL. Construction materials prices increased by 30.48% in 2020. In 2019, construction materials prices increased by 5.12% annually. Construction labour costs increased by 13.96% in 2020. In 2019, the increase was 25.70% [24].

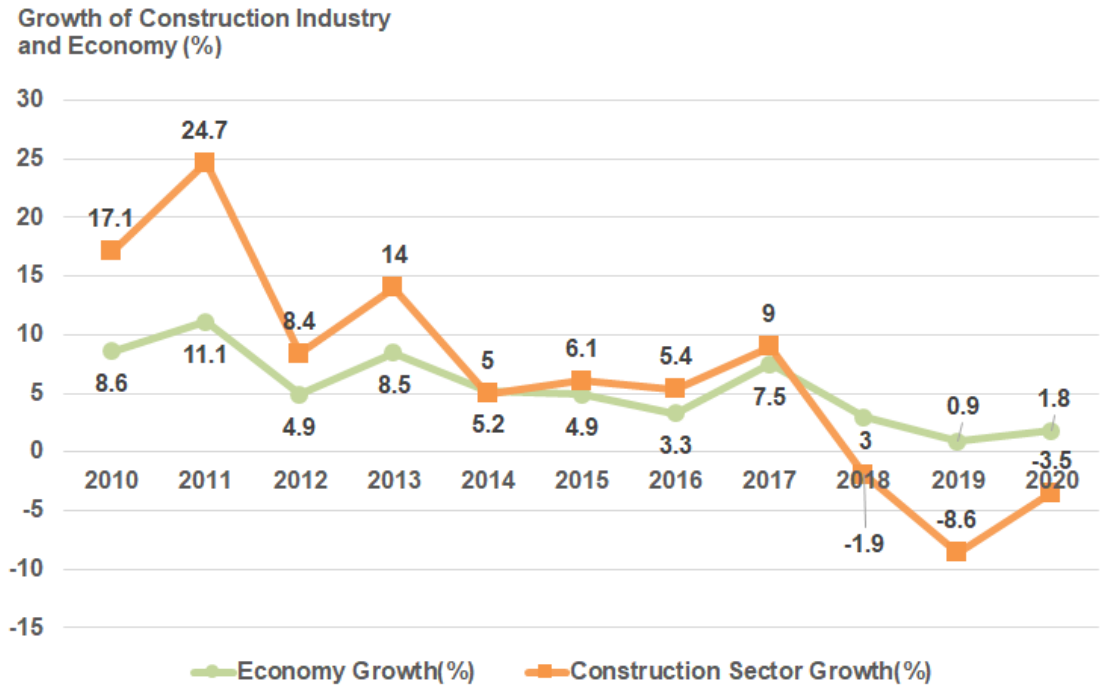


Figure 10. The Relationship between the Construction Industry and Economic Growth (TURKSTAT)

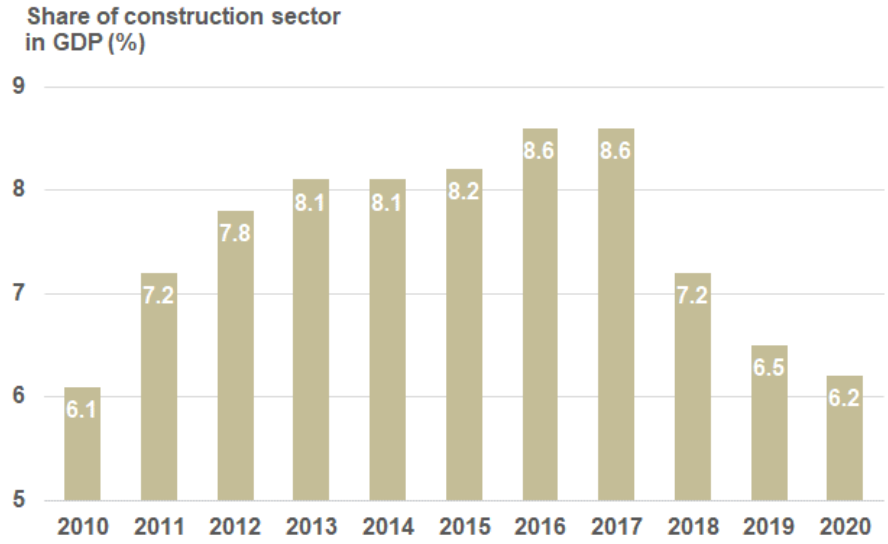


Figure 11. Share of construction sector in gross domestic product, Percent (TURKSTAT)

2.3.3 Construction materials Industry of Turkey

Construction material industry production increased by 9.1% in 2020. The construction materials production industry in Turkey has a significant role in the economy. The construction materials industry largely comprises of medium-skill and technology intensive sectors such as steel, cement, glass, and other construction-related materials production. Turkey ranked 12th in the global construction materials exports market in 2018 [29]. Total sales of the industry stood at 500 billion TL, accounting for 12% of Turkey's GDP and 20% of total industrial sector turnover by the end of

2019. The exports of construction materials stood at 21.5 billion USD in 2019, which represented 13% of Turkey's total merchandise exports.

The economic downturn had a significant impact on the construction materials production industry. The sharp fall in the construction activity in 2018-2019 took a heavy toll on the construction materials industry, where industrial production index (IPI) of the sector has contracted by about 25% by the end of 2019 from its peak in September 2017. The total domestic sales of the construction materials sector fell by 10% annually to 377 billion TL in 2019 which was partially offset by exports that held steady in 2018-2019 largely due to a weaker TL. Production in the sector picked up significantly, as construction activity started to recover in the second half of 2019, albeit hovering at depressed levels relative to the peak levels seen in 2017. The latest IPI data (March 2020) reveal a limited fall in the sector's production levels (down 1.1% monthly) compared to the 6.4% monthly decline70 in the overall industrial activity in Turkey.

The construction material production activity index hints at a deeper contraction in the aftermath of the pandemic in April 2020. The industrial activity index published by IMSAD fell further by 6% monthly at the end of April 2020, after falling 3% monthly in March. According to a recent poll conducted by IMSAD [24] among its members about the impact of the Covid-19 pandemic, there were a significant increase in order cancellations both in the domestic and export markets. Also, about 55% of the participants expected revenue losses in excess of 20% in 2020.

Cement production increased by 28.4%, ready mixed concrete production increased by 25.9%, ceramic coating materials production increased by 25.4%, and the production of armature faucets, valves and valves increased by 24.8%.

In the construction materials industry, the increase in the production of metal industry materials remained limited. The production of bars and profiles made of iron and steel grew by 6.0% and the production of iron and steel construction products by 2.3%. Production in construction glass and plastic construction materials grew by 1.8% and 0.6%.

Construction materials exports decreased by 1.5% in 2020 and decreased to 21.16 billion dollars. With the pandemic in 2020, there were two separate periods in exports. First of all, in the first quarter of the year, the increase in exports started to gain momentum due to the optimism in global trade. In the second quarter, there was a sharp contraction in exports due to the effects of the pandemic. As we entered the second half of the year, exports started to recover again.

With the support of governments and other measures in export markets, the construction sectors have started to revive. Accordingly, exports recovered in the third quarter. In the last quarter of the year, the increase in exports of construction materials accelerated significantly. With the availability of vaccines in the markets and the increasing optimism about the following periods, the demand for construction materials has started to increase. Again, in the second wave of the pandemic, supply concerns also brought many orders forward.

Due to these developments during the year, exports of construction materials remained below expectations and decreased by 1.5%. Exports managed to stay above 21 billion dollars as can be seen from Figure 12 [24].

Figure 12. Turkey's construction materials exports, billion dollars (Calculated by Economy and Strategy Consultancy Services from TURKSTAT data)

In 2020, Turkey's share in world construction materials exports increased to 2.38%. In 2020, both Turkey's and the world's construction materials exports declined. While the world's construction materials exports shrank by 2.8%, Turkey's exports remained below this and shrank by 1.5%. Thus, Turkey's share in world construction materials exports increased to 2.38% as shown in Figure 13.

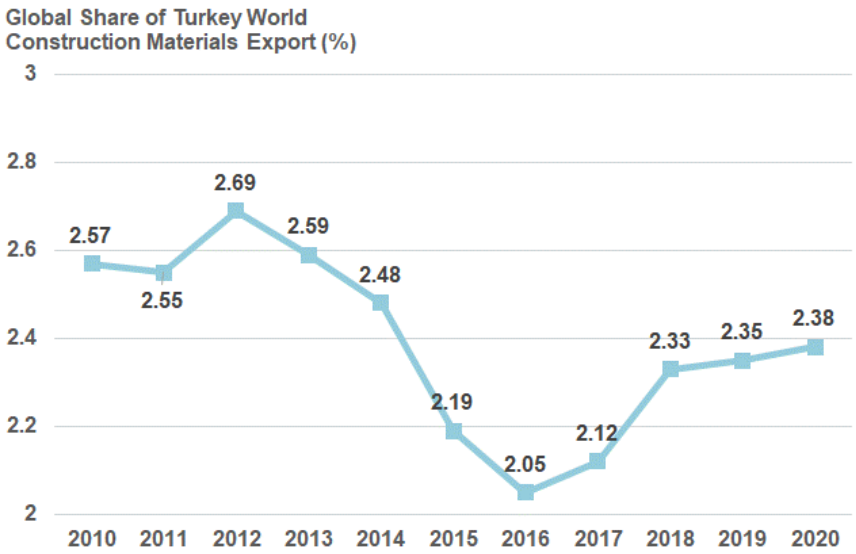


Figure 13. Turkey's Share in World Construction Materials Export,% (Economy and Strategy Consultancy Services)

2.3.4 World Construction Materials Industry

World Construction Materials Market Contracted By 5.8% In 2020, Reaching $5.86 Trillion. The world construction materials market moves in parallel with the developments in the world construction expenditures. Construction expenditures include construction expenditures on public-private, infrastructure, residential and non-residential building investments. The growth in the world construction materials market is shaped by the demand arising from construction expenditures. In

2018, with the recovery, especially in developed countries, the construction materials market grew by 3.2% and reached 6.07 trillion dollars. Developing countries also contributed to the growth in the construction materials market in 2018. The slowdown in the global construction industry in 2019 also affected the construction materials market. In 2019, the construction materials market grew by 2.6% and reached a size of $6.23 trillion.

In 2020, the contraction experienced in the global construction sector due to the Covid-19 pandemic also negatively affected the construction materials market. In 2020, the construction materials market shrank by 5.8% and regressed to $5.86 trillion. The construction materials market experienced contractions in both developed and developing countries.

World Exports of Construction Materials Contracted by 2.8% in 2020. Nearly 20% of the demand in the world construction materials market continues to be met through imports. Two main factors determine the world's construction materials exports in this context. The first is the material demand, which is created by the growth in construction expenditures. The second is the prices of materials subject to exports.

In general terms, the current situation of the construction material industry is as follows, item by item [24]:

- In 2020, with the effect of the pandemic, the construction materials market shrank by 5.8% and regressed to 5.86 trillion dollars.
- In 2020, world exports of construction materials contracted by 2.8% and decreased to 887.9 billion dollars.
- China continues to be the largest exporter country in the world's construction materials exports. China's exports increased to 219.8 billion dollars.
- Turkey has risen two places in 2020 with its exports of 21.16 billion dollars and has become the 9th exporter country of the world.
- As of 2020, the largest importer or export market is the USA with 106.4 billion dollars. Imports of the USA decreased by 7.7% in 2020.
- Turkey is the 33rd largest market or importer with an import of 7.03 billion dollars in 2020 and has increased 4 places compared to 2019.
- Turkey's construction materials industry production increased by 9.1% in 2020 compared to 2019. Industrial production grew significantly with the increase in domestic and foreign demand in the second half of the year.
- The domestic market of construction materials grew by 8.1% at current prices in 2020 and amounted to TL 408 billion.
- Exports of construction materials decreased by 1.5% in 2020 and amounted to 21.16 billion dollars. The decline in exports remained limited despite the pandemic.
- The USA has been our largest export market in 2020. Israel and Germany followed suit.
- Export unit prices were 0.42 dollars/kg in 2019, while it was 0.35 dollars/kg in 2020. Import unit prices, on the other hand, were $2.68/kg in 2019, while it became $2.65/kg in 2020.

2.4 Urban Transformation

In Turkey, internal migration has occurred due to natural disasters, social, cultural, economic, etc. reasons from rural areas to cities. This situation brought along the need for shelter, which is one of the most essential needs of humanity, and there has been an increase in the number of buildings

that do not meet the requirements of the public housing laws and earthquake code in most of the cities that receive immigration.

Turkey is located in the Alpine-Himalayan orogenic belt in respect of its location. The majority of Turkey was formed in the third geological time, and it continues to take its current form in the fourth geological time, so it is a young country in terms of its structure. This situation has made Turkey one of the most critical countries in the world in terms of plate tectonics and has caused Turkey to be located in a vital earthquake zone.

The existence of more than 500 active faults is known in Turkey, and %92 of the current population lives in the cities where these active faults are located [30]. On the other hand, Turkey is the third most crowded country in Europe with an 84 million population. Due to the rapid urban growth and development, the cities have become increasingly unsustainable, vulnerable and insecure. Therefore, achieving sustainability and resilience for existing and future citizens is critical.

Urban transformation is the intervention of an urban area for regeneration due to ageing, run-down and disaster risk. Urban transformation is the whole of the strategies and actions applied to improve the urban space's economic, social, physical and environmental conditions, which has collapsed and/or deteriorated, with comprehensive and integrated approaches.

Turkey is an earthquake-prone country. The North Anatolian fault zone, East Anatolian fault zone, and Western extension zone all encircle the nation, as seen in Figure 14. Furthermore, each major earthquake results in the loss of life and money. Thus, 6-7 million dwelling units need to be demolished or strengthened in the existing building stock. In addition to the poor building stock, the reasons such as the lack of infrastructure, lack of social reinforcement and the preservation of the historical texture are among the factors that necessitate the transformation.

Several regulations have been enacted following the disasters that have struck Turkey in recent years to ensure that required precautions are taken before disaster strikes. Some of those are Law No. 7269 on Precautions to be taken due to Disaster Affecting Public Life and Assistance to be Provided, Slum (“Gecekondu”) Law No. 775, Zoning Peace Law No. 2981, Mass Housing Law No. 2985, Law no.5366, Law no.5393 and Law no. 5104.

When the damages caused by earthquakes are considered in conjunction with the aforementioned difficulties, it becomes clear that immediate urban transformation is required to avoid loss of life and mitigate economic losses. In this context, the General Directorate of Infrastructure and Urban Transformation Services was established with the Decree Law No. 644 on the Organization and Duties of the Ministry of Environment and Urbanization, which was published on 4/7/2011.

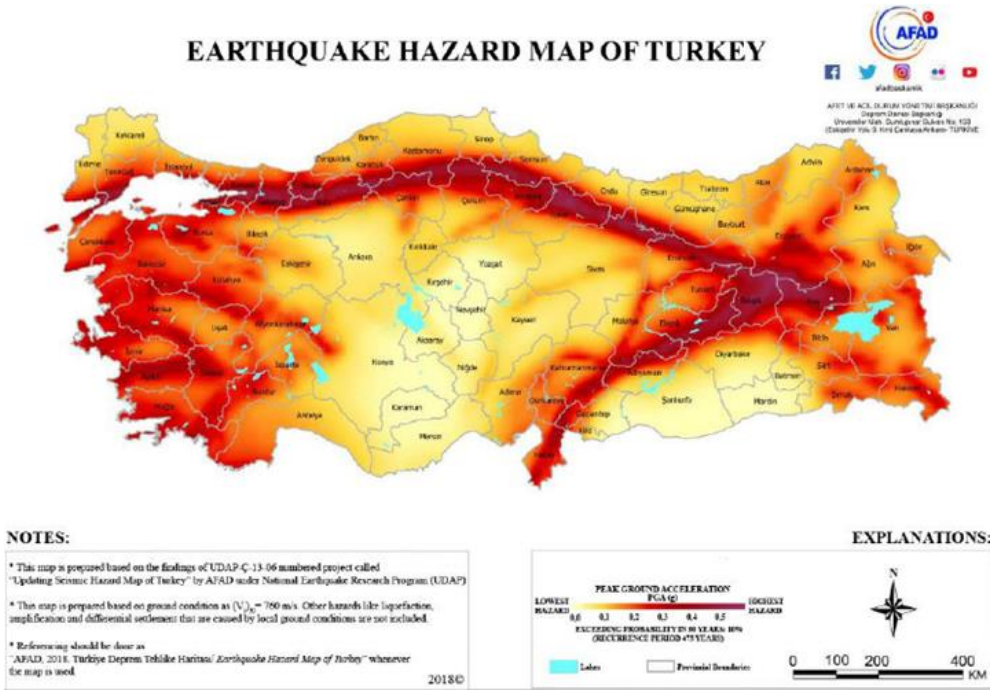


Figure 14. Earthquake Hazard Map of Turkey [31]

Following the severe earthquakes of recent years, including the Van Earthquake in 2011, Law No. 6306 on Transformation of Areas Under Disaster Risk was drafted and signed into law on May 31, 2012, to expedite and successfully perform the transformation works in Turkey.

According to the Law document, the law's goal is to designate the principles and procedures of rehabilitation, prevention areas, and renewal for achieving safe and healthy living environments that are compatible with science and art norms and standards, within disaster-prone areas and on plots and lands where risky buildings have been constructed [32].

In achieving this target, three implementation tools are defined in the law as;

1. Implementations in risky areas,

2. Implementations for risky buildings and

3. Implementations in reserve area for constructions.

The legislation was passed on May 16, 2012, and the following definitions are found in the initial version of the law and its regulations:

• *The Ministry*: Ministry of Environment and Urbanization,

• *Administration:* Municipalities in the adjacent areas, in the outside of adjacent areas Provincial Administrations in the metropolitan cities the metropolitan municipality and if it authorized by the Ministry the district municipality,

• *Reserve Area:* The areas which will be used for development following this law that is designated by the Ministry, upon the proposal of the *Administration* or TOKI or on its motion, with taking the official opinion of the Ministry of Finance,

• *Risky Area:* Areas under disaster risk that can cause deaths and losses due to ground conditions or conditions of the buildings within the area are designated by the Council of Ministers and proposed by the *Ministry* based on the proposal of the *Ministry or Administration* and taking the official opinion of the Disaster and Emergency Management Presidency (AFAD),

• *Risky Building:* Buildings within or outside of the *Risky area,* where the risks due to fulfilling its lifespan or carrying the risk of collapse or heavy damage is determined by scientific and technical data,

• *Related Institution: The Ministry, Administration or TOKI* that is responsible for the implementation of a regeneration project in the *Implementation Area*

• *Implementation Area:* The Risky Area designated by the Council of Ministers, Reserve Area designated by the Ministry or the area including the Risky Building(s) [33].

The identification of risky structures can be at the owners' request, associated NGOs, government agencies and institutions, or at the Ministry's request. However, according to the Ministry of Environment and Urbanization, compliance with Law No. 6306 is first and foremost voluntary.

Between 2012 and 2020, 701,710 dwelling units and 213,533 buildings in every part of Turkey are identified as risky [30] as shown in Table 3. On the other hand, 372,269 dwelling units and 72,829 buildings are labelled as risky in İstanbul where is the most crowded city in Turkey, and its earthquake risk level is labelled as high. 590,000 dwelling units labelled as risky were demolished [34].

The level of safety and vulnerability of structures depends on how they are designed and built according to current earthquake codes. If the minimum safety levels determined by the regulations are fully complied with, it will be possible to be sure of the safety of the buildings. However, it is clearly understood from the damages observed in the earthquakes that occurred in Turkey in previous years that the structures were not built according to the regulations. Determination and reduction of earthquake risks in existing structures is one of the essential policies. At the same time, it is vital to minimize the risks by applying earthquake regulations with strict supervision in new construction.

Table 3. Statistics on identification of risky buildings [33]

	All over Turkey	İstanbul
Number of dwelling units as risky	701.710	372.269
Number of buildings as risky	213.533	72.869
Number of dwelling units demolished	596.337	316.514

Minister of Environment and Urbanization stated that 6.7 million dwelling units in Turkey are risky [35]. He also said that there are 5.9 million dwelling units in Istanbul. 1.5 million of them are risky and 300 thousand are buildings that need to be transformed immediately.

On the other hand, there are approximately 22 million dwelling units in Turkey, and one-third of them are considered risky. Between 2012 and 2020, only 702 thousand of dwelling units were identified as risky. The number of risky dwelling units' identifications per year is 78 thousand, so, according to those official figures, 6.7 million risky houses could be renewed in 86 years, which is

a long time to reduce disaster risk. As a result, preventive steps should be adopted to avert loss of life and property, and the urban transformation process should be accelerated.

2.5 Transformation of Slums

As stated in Turkey's report prepared within the scope of the Implementation of the New Urban Agenda [36], it has adopted housing policies with all its social and economic dimensions as a priority policy area for low-income households, which has prevented slums and informal settlements and contributed to household income and living standards in the last two decades. A province-based Urban Transformation Strategy was also developed in order to improve the resilience of informal settlements and slum areas, the majority of which are vulnerable to disasters. Policy measures and authorities for the relocation and strengthening of buildings constructed in violation of the law, slum areas and disaster-prone areas, and the construction of new settlement places, as well as for the production of houses and lands, were transferred to Housing Development Administration of Turkey (TOKI) with the Metropolitan Municipal Law No. 5216 enacted in 2004. As part of sustainable urbanization policies, the TOKI has developed a series of strategies to ensure that everyone, especially low-income and disadvantaged groups, has access to adequate, livable, durable, safe, inclusive and economically affordable housing with basic transportation facilities. These strategies can be listed as Housing Chapter Urban Transformation Action Plan, Provincial Urban Transformation Strategies, Priority Transformation Programs of the 10th Development Plan, Competitiveness and Social Cohesion Enhancing Urban Regeneration Program.

According to Implementation of the New Urban Agenda Report [36], in 61 provinces and 146 districts, 164 thousand houses were tendered in collaboration with local governments between 2002 and 2020, ensuring reconciliation with rights holders. Most of these residences have been finished and delivered over to their rightful owners. Plans and initiatives for 88 thousand new residences are still in the works. Between 2012 and 2018, TOKI implemented slum improvement and urban transformation projects in 60 cities and 143 districts, resulting in the construction of 193,365 houses across 228 projects totaling 56,267,445 m^2. In 2019, 40 projects with a total of 76,334 houses were completed. As of June 2019, within the scope of the large scale urban transformation program initiated in cooperation with local governments, 158 projects are ongoing, and the construction of 146,804 houses within the scope of the urban transformation project. Within this framework, 83,171 houses have been built, with another 700,000 planned until 2023.

According to the Presidential Annual Program for 2020, the total housing deficit has been rapidly decreasing due to increased housing supply in recent years; however, there are 2.5 million poor households, indicating that low-income and disadvantaged groups continue to prioritise obtaining housing. Although a significant decrease has been observed in the number of slums in Turkey thanks to TOKI's efforts, according to World Bank data, 8.6% of the total population still lives in slums in 2018 [37]. Since this amount was estimated to be 700 thousand persons based on demographic data in 2018, given that Turkey hosts an excessive number of immigrants and refugees due to its geopolitical location, this number may have risen to severe levels today.

2.6 Assessment of Construction and Demolition Waste

Many types of buildings have been built from the past to the present in terms of the period and technology. Especially in the last century, with the extraordinary developments in technology and the increase in the world's population, the building stock has reached more serious figures than ever before in the history of humanity.

Except monumental buildings, the buildings are designed for a particular economic life. To give an example from Turkey's earthquake regulation, a usual residence built in today's conditions is designed with a 10% probability of an earthquake exceeding the design load in 50 years. In other words, the economic life of this structure is 50 years. In addition, due to the differentiation of human needs, the performance criteria and functionality expected from the building also differ considerably. Approximately 30-50 % of the demolition wastes in the buildings are used for renovation, renovation, etc., resulting from the transactions. For these reasons, the structures are completing their economic life, and a new building is built to meet the needs by demolishing them.

Today, the recycling issue has become very common, with demolition companies realizing that the resulting waste has a material value. In Turkey, the construction and demolition (C&M) wastes that have emerged so far have been sent to landfills. The culture of recycling construction and demolition waste is not developed yet to take advantage of C&D waste fully. However, the rapid consumption of available resources in the world, the decrease in waste disposal areas and the emergence of increasingly more significant problems for local governments make recycling C&M waste a necessity. All these reasons show that the demolition activities encountered today cannot always be done with traditional methods.

Considering the current developments in demolition waste in the world, i.e., in Germany, building dismantling has become a necessity, and the studies carried out under selective demolition ensure that the wastes have an economic value at high rates. When demolition activities are evaluated in terms of economic and environmental effects, the selective demolition option, which has been widely used in developed countries recently, stands out as an environmentally friendly approach. For these reasons, it is necessary to examine the parameters that will bring the demolition sector to better levels in Turkey.

The focus should shift now to recycling raw materials into the building cycle and supporting the recycling process to reduce the quantities to be disposed of as much as possible. Today in countries like Germany, many new buildings or renovation measures are preceded by deconstruction. However, in planning practice, this is often not yet taken into account. In order to consistently close material flows, promote a higher value of the building stock and establish solutions in line with the circular economy on all levels involved, a systematic look at the planning of deconstruction measures is required. It is a matter of protecting and preserving the building stock and valuing the materials.

2.6.1 The economic and environmental Importance of construction and demolition waste

The natural resources in the world are decreasing day by day due to the increasing population and consumption. There is no doubt that these resources will one day run out if the necessary precaution are not taken. In our world, where resources are limited, and consumption is increasing rapidly, one of the issues that have been given great importance in recent years is construction and demolition (C&D) waste. Many different types of waste are recycled, and the waste can be

reused as a raw material. Since 1980, when large amounts of construction/demolition waste are encountered, reducing the effects of construction/demolition wastes during the construction and demolition of buildings, minimizing construction/demolition wastes. Continuous work has been done to prevent the uncontrolled use of natural resources, developed countries have developed some methods for the recovery and reuse of wastes to solve energy crises in the world. However, compared with other developed countries, Turkey is quite behind in the economic evaluation of construction wastes in the construction sector.

According to the statistics of 2020, Turkey is the leader in cement production in Europe. Approximately 72 million 300 thousand tons of cement was produced in 2020 [38]. Production of this scale brings environmental, social and economic problems. In some countries, asphalt, concrete, aggregate, wood, etc., building materials are recycled and converted back into raw materials. Thus, the harmful effects on the economy and the environment are minimized. Recycling is the collection of wastes to reuse, obtain energy (incineration, etc.) or obtain a new product by physical or chemical processes. Resource and waste management approaches applied during construction activities have essential environmental effects. For countries to benefit from their natural resources in the long term and in the most effective way, they should put an end to waste wastage and research methods of recovering and reusing materials with economic value. Due to the increase in population in Turkey, especially the demolition wastes have increased and the construction wastes. It has become a problem that requires careful attention and immediate solution to the construction wastes.

It was not possible to talk about a concept such as the life cycle of structures in the past. The buildings were demolished at the end of their economic life, and the remaining wastes were either left idle or used as filling material. However, due to today's social and economic factors, using these materials in creating new products becomes inevitable.

In the past 20-30 years, many important earthquakes have occurred in Turkey and serious loss of life and property has been experienced in these earthquakes. The most critical earthquakes that occurred in this process are Erzincan (1992), Dinar (1995), Adana (1998), Marmara (1999-August), Düzce (1999-November), Çankırı (2000), Afyon (2002), Bingöl (2003), Elazığ (2010), Van (2011) earthquakes. It works in the parts of the buildings damaged in these earthquakes where possible before they collapse, and the materials (structural steel, all steel and aluminium composites, bathroom and kitchen equipment, roof tiles and joinery, grating iron railings, door and window frames and equipment, etc.) are dismantled, and then demolition is done with the help of construction machinery, and the remaining wastes are taken to landfills or some of them are lakes etc. It is known that natural resources such as In Figure 15, it is seen that the demolition wastes that occur after natural disasters and the significant damage they cause to the environment.

(a) (b) c)

Figure 15. Improper storage of demolition wastes (a) demolition waste, (b) rubble heaps, (c) Construction site after demolition

2.6.2 Characteristics of construction and demolition wastes

All processes related to the construction sector are shown as a cyclical process, as shown in Figure 16. From a sustainable point of view, it is clear that this cycle can be completed by aiming to recycle construction and demolition wastes close to 100%. Today's construction and demolition waste is based on building materials applied 50-100 years ago.

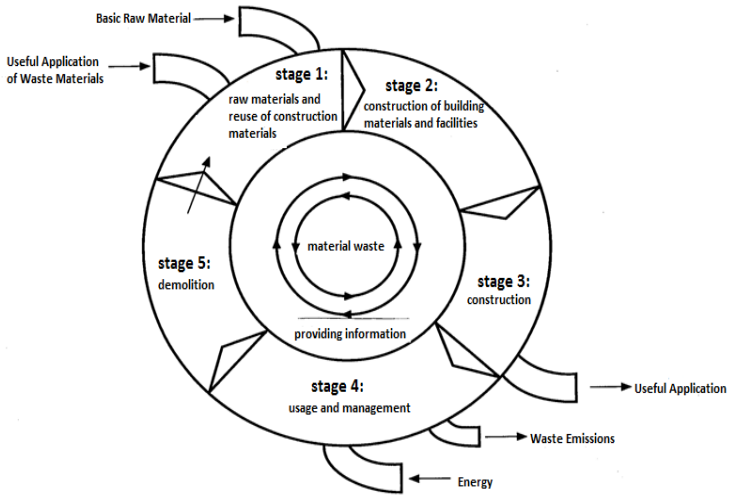


Figure 16. The cyclical process of a sustainable, ideal construction industry [39]

Construction wastes are liquid and non-hazardous wastes, and mostly heavy waste means solid waste generated during the construction and demolition processes of bridges, roads and all building types (with or without residential areas). Construction waste is primarily due to design errors, incorrect planning, ineffective materials and unexpected changes during the design of the building.

Considering that the construction sector is one of the sectors where raw materials are consumed the most, it is necessary to try to minimize the inputs in the manufacturing processes, to reduce the use of raw materials, energy consumption, emissions and space usage as much as possible while conducting effective waste management. Materials such as concrete, asphalt, wood, aluminium and iron are the leading materials consumed in this sector. These materials can be encountered as construction or demolition wastes during the construction process.

With the increasing population in our country, the total amount of solid waste has reached large dimensions. For this reason, the investment, maintenance, operating expenses, storage and recycling costs of the vehicles used for the collection and transportation of solid wastes are constantly and rapidly increasing. As a natural result, the costs of collecting solid wastes and transporting them to certain distances have reached very high levels. When we consider the demolition waste, it consists of soil, gravel, concrete, plaster, plates, plaster, briquettes, sand, and porcelain. Wreckage wastes are not homogeneous. The composition of this type of waste generated during the demolition of buildings depends on the content of the building, the material used in the building, its age, design style and size. Natural disasters, especially wastes generated after earthquakes, require the control, recycling or disposal of excessive amounts of debris and the crisis environment. Construction debris waste constitutes the most prominent waste component globally. For example, construction/wreckage waste in China has reached 30-40% of the total generated waste due to rapid urbanization and city rebuilding. This example of re-urbanization in China shows a close resemblance to the urban transformation process for our country. The sources of construction and demolition wastes are given in Table 4.

Table 4. Sources of construction and demolition waste [40]

Categories	Waste Types
Road Construction and Maintenance Materials	Asphalt, concrete, cover soil
Excavation Materials	Soil, stone, gravel
Construction Demolition Waste	Concrete, mixed rubble, steel, brick, iron, timber
Building Renovation and Work Zone Materials	Wood, roofing materials, pipe, plastic, glass, metal, insulation materials

As can be expected from the studies carried out, it is seen that there is a small but significant amount and variety of construction wastes compared to the demolition wastes. Besides, it is known that very large amounts and types of waste are generated as a result of natural disasters. Our society's idea to get rid of extraordinary situations as quickly as possible, the unplanned and immediate removal of these wastes in general, incineration or storage, means that the adverse effects of the existing waste problem are postponed in a way. In addition, demolition waste has become a subject that needs to be emphasized much more during a new construction in our country, such as urban transformation. With the urban transformation works, there will be a serious increase in construction demolition waste. However, complete and accurate data on this subject cannot be produced throughout the country. The data can be obtained mainly from a few cities such as Istanbul, Kocaeli, Sakarya.

Depending on their source, these wastes can be classified as follows:

Waste from partial or complete destruction of buildings and/or construction infrastructure: These materials; soil, gravel, construction materials of the clean water system, concrete pieces, ceramics, paints (primers), bricks, coating plates, tiles, plaster, sand, stones, sanitary fittings, etc. it could be. Wreckage waste materials are often heterogeneous and result from the complete or partial (selective) demolition of buildings or other civil engineering infrastructures. Waste compositions

vary depending on type, shape, age, use, size and base material of the building or construction infrastructure. Demolition materials can also be metals, paints, adhesives, resins, cables, insulation materials, etc. may also contain.

Waste from the construction of buildings and/or construction infrastructure: These materials; Concrete, wood, plastic, paper, ceramics, bricks, tiles, plaster and all materials originating from construction site applications consist of repair, buttress, sedimentation (accumulation), expansion or restoration activities.

Soil, rock and vegetation originating from land levelling, excavation, civil works and/or general foundations: This category; includes excavated soil, sand, gravel, rock and clay. Waste materials from excavations are caused by almost every construction activity, especially underground construction and ground works that cause a large amount of waste from building and other related activities. The composition of these materials depends on the local geological characteristics and the type of construction work.

Materials arising from road maintenance activities or related to road planning: These materials; It can be asphalt, sand, gravel, metal and materials resulting from road dismantling and renewal, as well as all pavement materials. These materials can also be created during underground hydraulic and electrical work in cities and repair activities.

2.6.3 Activities that should be given priority in terms of environmental and economic impact in construction wastes

Reuse and recycling of concrete wastes obtained from construction and demolition wastes may provide environmental and economic benefits. There are several issues that need to be prioritized while performing these operations; These stages are shown in Figure 17. While the construction is in production, it is necessary to take some precautions and set a series of targets in order to reduce waste. These targets are an essential factor in preventing and reducing the generation of waste. In order to keep construction and demolition waste to a minimum, building materials can be used within the construction site as much as possible, creating an area reserved for wastes in the construction or demolition area and suitable for storage facilitates waste management. Ordering the right amount of materials prevents material waste. Scrap materials from demolition areas can be used as filling material in the following construction. For the reuse of the construction material, the wastes generated during and after the construction must be of reusable quality. Doors, windows, cabinets, tiles, electrical materials etc. Many materials such as can be reused in another construction. Reusing these types of materials not only reduces the amount of waste to be

produced but also prevents excessive consumption of natural resources. In summary, the factors that affect the excellent evaluation of construction demolition waste are:

- Site plan covering the selective demolition issue,
- Choosing the right equipment,
- To know the environmental and safety regulations,
- Employees who are conscious of waste,
- Secondary market information,
- Technical specifications,
- Legal incentives.

Figure 17. Waste Management Pyramid

The waste management pyramid includes the issues that should be prioritized from the bottom to the top. Considering from top to bottom, the waste management pyramid should be the first to prevent the emergence of waste, and if it is not possible to prevent it, the waste should be minimized in the second place, that is, the waste should be kept at a minimum level after this sequence comes to the reuse of waste. If it is not possible to reuse, it is aimed to recover the material by recycling using energy. Disposal management, defined as storage and incineration, which is in the last place, should be applied when the above-mentioned methods are inconclusive.

2.6.4 General evaluation of construction and demolition waste

With the increase in the population in our country in the medium and long term, the demand for land and housing will continue to increase. With these developments, selective destruction will be among the crucial issues in the future. With more efficient selective demolition activities, the need for dump sites will be reduced. The main point to be considered in selective demolition is that structures should be considered as integrated systems. Environmental responsibility should be widely considered in building design. The consumption of natural resources and the increasing importance of environmental decomposition affect economic development in the long run. The main problem is society's view of the change in this regard. Considering the returns of the selective demolition technique, the demands of society in terms of materials in the construction industry are constantly changing. Environmental problems include very current problems and stand out as issues related to politics. The most significant barriers to unconventional construction and demolition techniques are cost and habits. It is pretty challenging to replace traditional, tried-and-true techniques today. For selective demolition activities to work effectively, structures must be made of recycled materials. In today's construction economy, the use of high-quality products

increases the costs of the buildings. Selective demolition practices must change not only material flows but also mindsets. The materials in used buildings should be considered raw materials, not waste materials. Storing and reusing economically valuable and usable materials means creating new products for the seller, supplier and manufacturer.

In general, it is observed that ecological factors are ignored in the applications made in the landfills. Especially in the storage facilities near water basins, no measures have been taken against leakages to groundwater. It is a fact that construction demolition wastes, excavation soil and sometimes even domestic wastes are stored in the same areas. The reason is that even a simple application such as a preliminary control or visual inspection regarding the content of the waste coming to the facility are not performed. Sometimes, municipalities may direct the excavation soil to relevant areas for filling certain areas or for pre-construction elevation. In addition to its environmental disadvantages, this process creates debris, etc., in the excavated soil. The use of demolition wastes in this process in a mixed way will have significant effects on the stability of the structure (consolidation, differential settlement, etc.) from a technical point of view.

Although the current regulations in our laws provide some main conditions, there are still deficiencies in the content and implementation of waste management plans. The inadequacy of waste disposal facilities and their inability to meet the requirements of the times, the inadequacy of penal sanctions in improper waste storage and disposal practices, the absence of clear and encouraging elements in the legislation on waste recycling, and the failure to support the "polluter pays" principle with effective regulation and implementation mechanism are our main shortcomings.

With the enactment of the Law on Transformation of Areas Under Disaster Risk in 2012, the construction industry in our country gained a serious momentum. There has been a serious movement in the transformation of existing poor-quality buildings. The amount of construction and demolition waste generated also progresses in parallel with these increases.

Demolition practices seem to be the biggest obstacle to implementing selective demolition. As we have summarized, there is an essential sector for waste materials obtained from demolished buildings in our country, and the demand is increasing day by day. However, the technical inadequacies of demolition contractors and the lack of a comprehensive legal infrastructure to supervise them are serious shortcomings.

Demolition activities proceed haphazardly, ignoring occupational health and safety rules. During the process, sufficient attention is not given to the issues necessary for evaluating and separating wastes. Therefore, the structures are demolished quickly and it is not possible to separate the wastes that arise. The resulting demolition wastes are transported mixedly and directed to the sanitary landfills due to the demolitions made without considering specific techniques and separation priority. Hazardous wastes are also stored in these mixtures without being treated, making it difficult to implement selective destruction. It is inevitable to make regulations on the management of demolition practices in the current legislation and strictly implement them.

It should be known that the main problem experienced in demolition processes is not the evaluation of the material to be revealed in the demolition, but the fact that the demolition is not carried out within the scope of a specific plan and technical requirements.

2.6.5 Studies conducted in Turkey

Within the scope of the "2013K080040 Construction and Demolition Waste Evaluation Project" carried out between Gazi University Earthquake Engineering Application and Research Center and the Ministry of Environment and Urbanization General Directorate of Infrastructure and Urban Transformation Services on 14 May 2015 in Istanbul (Green Park Hotel/Pendik), the "National A Joint Service Implementation Protocol on the Research and Application of Full, Partial and Selective Demolition Techniques for the Demolition Management System" was signed and a "Workshop" was held. In addition to the workshop, meetings were held with the officials of the Turkish Chamber of Engineers and Architects, the Chamber of Civil Engineers, the Chamber of Environmental Engineers, the Chamber of Mining Engineers, the Chamber of Geological Engineers, the Turkish Cement Manufacturers' Association and the Turkish Ready Mixed Concrete Association, on the subject of demolition in Turkey.

In the Opening Workshop event, evaluations were made on the issues required by a planned, safe and environmentally friendly demolition management, such as selective demolition and separation at source, demolition techniques, demolition occupational health and safety, disposal of hazardous materials, and preparation of the demolition plan and project, which will constitute the scope of the demolition legislation. In this workshop, the current situation of the demolition sector in Turkey, its advantages and disadvantages compared to developed countries, problems and solutions were discussed in detail.

Within the scope of the workshop, the “Workshop Questionnaire” was presented to the participants to fill out. The number of people participating in the survey was 41. 27% of the respondents are employees of the Ministry of Environment and Urbanization and Labour and Social Security, 22% are companies from the demolition sector, 20% are participants from different municipalities, 17% are universities and R&D centers, 12% are dangerous companies related to construction demolition wastes and 2% represent the insurance sector.

As a result of this survey;

i. It is necessary to develop an accreditation system for companies that will work in demolition works, as well as to develop incentives and standards for the use of products that will occur as a result of selective demolition,
ii. Separation of dismantling, which is the basis of demolition and selective demolition. Developing a unit price system, including the dismantling and disposal of hazardous materials, for this type of work in tenders,
iii. Organizing training organizations for owners, engineers, architects, operators and workers working in demolition and all related fields,
iv. It has been determined that most of the organizations working in the current demolition sector are demolitionists, and it is seen that the demolition activities they have carried out are not based on any scientific and technical data, but only on experience. Companies operating in the demolition sector should appoint expert engineers in demolition and related fields,
v. There are very different practices within the scope of demolition activities in different cities and municipalities,

vi. Before the demolition companies begin the demolition of the structures to be demolished, a comprehensive plan should be prepared on selective demolition, disposal of hazardous materials, demolition method, and occupational and worker health, and demolition licenses should be obtained/applied based on this plan, results are out.

2.6.6 Regulation on demolition of buildings

"Regulation on Demolition of Buildings" was published in the Official Gazette on 13 October 2021 by the Ministry of Environment and Urbanization.

The following matters are included in the demolition plan to be prepared in accordance with the regulation.

1-Information on the Building to be Demolished

(a) Sketch, location, photograph and satellite image of the building to be demolished, purpose of use, total construction area and total number of floors including basements, amount and type of material to be removed,

(b) Architectural and/or static project (If not available, the builder's survey is prepared),

(c) A plan showing the relationship of the building subject to demolition with its immediate environment, such as the road, retaining structures, infrastructure facilities and neighbouring structures that may be affected by the demolition.

2-Demolition Technique and Its Effects

(a) Detailed application information regarding the demolition technique to be applied and the order of demolition,

(b) work schedule,

(c) Information and documents regarding the number, qualifications and duties of the personnel to be involved in the demolition,

(d) Information and documents regarding the machinery and apparatus and operators to be used in demolition activities,

(e) the demolition activity; evaluations that show the impact and possible risks on the supporting structures and adjacent structures,

(f) Transport, traffic, lighting, communication, field safety, occupational health and safety and emergency response measures,

(g) Due to demolition activity; environmental protection and security measures to be taken against the risks that may arise from the demolition site, employees and third parties.

3-Annexes of the Demolition Plan

(a) Waste management plan

(b) Measures to be taken to control dust emission: Dust emission sources and measures to prevent the spread of dust emissions, taking into account demolition techniques

(c) Selective destruction

(d) Detection and removal of asbestos and other hazardous wastes in demolition

(e) Noise and vibration management

(f) Use of waste codes

2.7 Energy Consumption and Production-Main Policies Related to Energy Efficiency and Current Situation

The growing construction sector (including residential and non-residential sectors) in Turkey has an important place in the final energy consumption of the country. The housing stock alone is expected to grow by more than 50% in total by 2050 [13]. Therefore, the construction industry in Turkey is one of the most important pillars for Turkey to achieve the national climate protection targets set in the National Declaration of Contribution.

The most recent analysis from the IEA's Energy Technology Perspectives concludes that the global average per capita energy use in buildings must be reduced to at least 10% by 2025 to achieve the net zero emissions target by 2060. Accordingly, significant reductions in energy use are required through energy efficiency actions in OECD countries where energy demand is generally stagnant. At the same time, considering the increasing demand for energy services, energy efficient and low carbon construction technologies should be deployed without delay in non-OECD countries [42].

In December 2015, the world marked a historic milestone: The Paris Agreement (PA), which provides a universal agreement, was signed to continue efforts to limit the global temperature rise in the current century to 1.5°C. Since the beginning of November 2016, when the PA entered into force, the climate negotiations focused mainly on the procedures to make the PA applicable.

Within the scope of the Climate Action Tracker, an independent scientific assessment that tracks emissions, countries' commitments and actions, 10 necessary short-term steps to be taken in key sectors have been identified in order to reach the 1.5°C limit in the world [13]:

• Electricity: Maintaining the growth rate of renewable resources and other zero and low carbon energy by 2025, increasing it to 100% by 2050

• Coal energy: Not to build new coal power plants and to reduce emissions from existing coal power plants by at least 30% by 2025

• Road transport: Ending the sale of fossil fuel vehicles by 2035

• Aviation and shipping: Developing and agreeing on a vision in line with the 1.5°C target

• New buildings: By 2020, all new buildings are almost zero-energy buildings [43]

• Building renovation: Increasing annual rates from less than 1% in 2015 to 5% by 2020

• Industry: All new facilities in emission-intensive sectors will be low carbon after 2020, and material efficiency will be maximized

• Land use, land use change and forestry: reduce emissions in forestry and other land use areas to 95% below 2010 levels by 2030 and stop net deforestation by the 2020s.

• Commercial agriculture: keeping emissions at or below current levels, establishing and disseminating regional best practices, and increasing research

• Reducing CO_2: Starting research and planning for negative emissions [44]

2.7.1 General assessment of national climate and energy policies

Turkey has been a party to the United Nations Framework Convention on Climate Change (UNFCCC) since 2004 and signed the Kyoto Protocol in 2009. Since then, it has developed policies, strategies and action plans to advance and adapt to mitigate climate change while improving energy security.

Within the framework of international climate negotiations, Turkey presented its climate targets in 2015 through the National Intent for Contribution (INDC). This section provides a summary of the energy efficiency policies that contribute to Turkey's climate goals and provides an overview of the country's key climate policy documents.

• National Climate Change Strategy Document (2010)

• National Climate Change Action Plan (2010)

• National Climate Change Adaptation Strategy and Action Plan (2011)

• Tenth Five-Year Development Plan (2014)

• INDC (2015)

• National Energy Efficiency Action Plan (2017-2023)

National Climate Change Strategy (UIDS): One year after signing the Kyoto Protocol, Turkey developed and approved the national climate strategy, which has become the main policy document to guide the development of climate policies. This strategy was developed in multi-stakeholder consultations conducted by the Climate Change Coordination Board. UIDS covers and defines short, medium and long term strategies in the energy, waste, transportation, industry, land use, agriculture and forestry sectors. In addition to these, it determines strategies in greenhouse gas control, adaptation to climate change, technology development and transfer, financing, training, capacity building and institutional framework, and finally, monitoring technology transfer. On the other hand, within the scope of Energy Strategies for buildings, various short-term strategies such as implementing energy identity certificates and increasing energy efficiency in public buildings are specified.

National Climate Change Action Plan (UIDEP): Turkey developed the National Climate Change Action Plan in 2011 to implement the UIDS and submitted it to the UNFCCC in 2012. The National Climate Change Action Plan is a climate implementation roadmap covering approximately 540 mitigation actions across all sectors. The most prominent actions are energy efficiency, renewable energies, promoting clean technologies and awareness-raising campaigns to reduce GHG emissions. It is essential to consider that the actions determined in the National Climate Change Action Plan do not include qualitative objectives and stages and it is difficult to determine priority areas for each action. Although the requirements for quantitative data are lacking, the construction industry is represented by 11 action plans. The Ministry of Energy and Natural Resources and the Ministry of Environment, Urbanization and Climate Change are responsible for most of the actions. Particular emphasis was placed on energy efficiency and the integration of renewable energies in buildings.

Tenth Development Plan (2014-2018): Turkey has prepared its development plan in accordance with the targets included in the Vision 2023 in the National Climate Change Action Plan. Since a road map for the strategy and policies of the Ministry is created in the Development Plan, actions aimed at reducing the effects of climate change are implemented directly or indirectly with this plan. For example, the importance of renewable energy for other sectors is underlined and efficient use of energy is also a key issue for the development plan.

Although not clearly stated, measures for energy efficiency are also included in the development plan. It also refers to the sustainable city approach, urban renewal programs, smart buildings and construction materials.

Implementing energy efficiency policy actions is critical to achieving long term climate goals and saving energy in the construction, industry, and transport sectors. Therefore, energy efficiency is considered to be of central importance for implementing the 2010 UIDS (2010-2020) and the 2011 National Climate Change Action Plan (2011-2023).

National Energy Efficiency Action Plan (UEVEP): In the National Energy Efficiency Action Plan, which entered into force after being published in the Official Gazette dated January 2nd, 2018 and numbered 30289, the measures regarding buildings are listed below:

1. Identification of best practices regarding materials and technology used in the construction industry

2. Creating a database containing energy usage information in buildings

3. Defining energy saving targets for public buildings

4. Increasing energy efficiency in municipal services

5. Rehabilitation of existing buildings and improvement of energy efficiency

6. Encouraging the use of central and district heating/cooling technologies

7. Increasing the energy performance certificate ownership rate of existing buildings

8. Encouraging the certification of sustainable green buildings and settlements

9. Promoting energy efficiency in new buildings

10. Increasing energy efficiency in existing public buildings

11. Expanding the use of renewable energy and cogeneration systems in buildings

12. Energy efficiency study programs for SME buildings and resource allocation for studies.

2.7.2 Legal framework for energy efficient buildings in Turkey

This subsection provides basic information about the legal framework of energy efficiency.

2.7.2.1 Development of policies over the years

Emphasizing the urgency of energy efficiency, reducing dependence on fossil fuels and natural gas and implementing energy efficiency measures in all sectors, UIDS has become an important milestone in realizing the targets set in the National Climate Change Action Plan, Energy Efficiency Strategy and UEVEP.

Turkey has aligned energy efficiency legislation, standards and labels in the construction sector with the EU framework; however, the EU has not fully implemented the Energy Efficiency Directive. Part of the harmonization is the transposition of the EU ecodesign and labelling directives, which oblige some equipment to provide information on their energy consumption and minimum energy performance standards (MEPS) via labels (they have been partially applied to some items to avoid overall low-quality imports). Figure 18 shows the development of policies implemented to promote energy efficiency in Turkey over the years.

Figure 18. Development of energy efficiency policies over the years [45]

2.7.2.2 National Energy Efficiency Strategy Document

The National Energy Efficiency Strategy Document aims to reduce energy consumption per gross domestic product by at least 20% compared to 2012 level until 2023. Therefore, the National Energy Efficiency Strategy Document has developed a roadmap for energy efficiency activities in Turkey and determined responsibilities for institutions to increase cooperation between non-governmental organizations (STK) and the private sector to achieve their energy efficiency goals. Its scope includes the following areas: industry, electrical system, private/public sector buildings, electrical products and transportation. Since strategies for the whole economy are determined in this strategic document, individual supra-sectoral issues are addressed. Since the National Energy Efficiency Strategy Document is not a binding document, it should be evaluated as a roadmap for sectors and Ministries. This document includes strategic goals, objectives and activities, and stakeholders. Table 5 presents an overview of the strategic objectives for buildings and their sub-objectives.

Table 5. Overall assessment of proposed strategic objectives for buildings, including sub-targets, based on the National Energy Efficiency Strategy [46]

Strategic objectives (SP)	Goals	Topic
SP-01: Reducing energy intensity and energy losses in industry and service sector	Within ten years following the publication of this document, energy intensity will be reduced by at least 10% in each sub-sector of the industry, at rates to be determined through intra-sector cooperation.	Reducing energy intensity in the service and trade sectors (and other)
SP-02: To reduce the energy demand and carbon emissions of buildings, to promote sustainable environmentally friendly buildings by using renewable energy sources	In 2023, thermal insulation and energy efficient heating systems that meet the current standards will be installed in all commercial and service buildings with a total usage area of over 10,000 m^2, including residences. By 2023, at least ¼ of the building stock (of 2010) should be made sustainable.	Insulation and efficient heating systems and commercial and service buildings >10,000 m^2 Sustainable buildings at the rate of 25% among all buildings (in 2023)
SP-03: Ensuring market transformation of energy efficient products	Market transformation will be completed based on the minimum energy efficiency class of lamps, coolers and electric motors; however, the market transformation of heating/cooling systems and other energy efficient products will be carried out in accordance with EU practices.	Minimum energy efficiency of products
SP-06: Using energy effectively and efficiently in the public sector	Annual energy consumption of public institution buildings and facilities will be reduced by 10% until 2015 and 20% until 2023.	Reduction of energy consumption in public buildings by 10% (2015) and 20% (until 2023)
SP-07: Strengthening institutional capacity and cooperation, increasing the use of cutting-edge technology and awareness activities, developing financing mechanisms other than public finance institutions	Institutional structures, capacities and joint cooperation of implementing institutions will be strengthened. The number of certified energy managers will be increased to at least 5,000 and the number of energy efficient consulting companies experienced in industrial sectors will be increased to 50 throughout the country. The number of original designs and/or products to be produced based on domestic R&D results will be at least 50 until 2023 in the fields of energy efficiency and renewable energy resources.	Capacity development

2.7.2.3 Energy efficiency legal infrastructure in Turkey

The framework regulating the implementation of energy efficiency measures is set in the Energy Efficiency Law (EVK). With EVK, it is aimed to reduce energy intensity and overall energy costs in the economy. In addition, this law provides a basis for receiving subsidies for the implementation of energy efficiency projects in the electricity and industrial sectors. However, it does not set a binding energy saving target. EVK also arranged energy audits (Item 2, 4, 5, 11, 12), energy management services (Item 4) and voluntary agreements (Item 18-20).

This law forms the basis for the following regulations:

• Energy Performance Regulation in Buildings (2008)

• Regulation on Increasing Efficiency in the Use of Energy Resources and Energy (2011)

• Regulation on Environmentally Responsible Design of Energy-Related Products (2010)

• Energy audits for buildings with the following characteristics in the public and service sector:

o Buildings in the public sector: Buildings with a total built area of more than 10,000 m^2 and an annual energy consumption of more than 250 TEP (tons of oil equivalent)

o Buildings in the service sector: Buildings with a total built area of more than 20,000 m^2

• Energy audits should be carried out every 10 years for buildings in the public sector and every 4 years for buildings in the service sector.

• Energy consumption in public buildings should be reduced by at least 20% by 2023 compared to 2010 levels.

• Lighting, washing machine, dishwasher, TV set, refrigerator, air conditioner, dryer, etc. household appliances such as must have a specific energy label.

The EVK includes legally binding actions, including:

• Thermal insulation and energy efficient heating systems must be installed in all commercial and service buildings with a total built area of more than 10,000 m^2.

• Central heating should be installed in new buildings with a built area of more than 2.000 m^2.

Thermal Insulation Regulations in Buildings, TS 825

It was enacted in 2000 after being enacted in 1999. Revised and republished in 2008; major changes included improvement of thermal conductivity coefficients and maximum energy consumption levels per degree-day zones.

TS 825 divides Turkey into four climate zones. The TS 825 standard also determines the recommended U values according to the climate zone and the building envelope section. The U-value expresses the heat transmittance obtained by dividing the rate of transfer of heat in a structure (can be a single material or a composite) by the temperature difference in the entire structure. The better the structure is insulated, the lower the U-value will be.

Thermal insulation systems are directly related to the developments in the construction industry. Therefore, the growth or contraction in the construction sector also affects the thermal insulation materials sector.

According to Heat Water Sound and Fire Insulators Association (İZODER)'s Turkey Heat and Water Insulation Market Report, the total size of the heat and water insulation market in 2018 was 19.6 billion TL.

In this context, in 2018, the size of the thermal insulation market, including services and auxiliary materials, was 12 billion TL, and the size of the waterproofing market was 7.6 billion TL.

The total consumption of products used for thermal insulation in Turkey, excluding exports, was 17.5 million m^3 in 2018. Accordingly, per capita consumption of thermal insulation material was 0.213 m^3. In the European Union, where 270 million m^3 of thermal insulation products were used

in 2018, the per capita consumption was 0.526 m^3. In other words, per capita consumption in the EU was 2.5 times higher than the per capita consumption in our country [47].

90% of the 17.5 million m^3 thermal insulation products used in the domestic market in Turkey were used in the insulation of the buildings, and the rest in the installation insulation. In general, when compared to 2016, there was a 9% shrinkage in thermal insulation and 6% in the waterproofing market in 2018. The stagnation in the construction sector, the lack of purchasing power, the decrease in the number of new constructions and the inability to complete the existing constructions were effective in this shrinkage.

With the increase in production and production quality, Turkey's import of insulation materials has stagnated. In 2017, 89,848 tons of insulation materials worth $161.9 million were imported. In 2018, imports decreased to 83.424 tons, but due to the increase in exchange rates, the value increased again to 173.2 million dollars [47].

The closest official data on the breakdown of domestic market demand in terms of materials belongs to 2013. Accordingly, approximately 50% of the demand in the domestic market was EPS, 20% was glass wool, 12% was XPS and the rest was rock wool, polyurethane and other materials [49].

It is thought that, in the last 7 years, after the developments in fire regulations, the usage rate of EPS decreased, instead the usage rate of XPS and rock wool increased. The most basic basis of this assumption is the rapidly increasing stone wool and XPS production capacity in recent years.

Naturally, it is complicated for the insulation materials industry to operate at full capacity again before the construction industry rises to a certain level again. Therefore, it is necessary to return to urban recycling activities. The potential is vast because more than 50% of Turkey has been transformed in the current situation, but financial difficulties are likewise very limiting factors.

One crucial aspect is the better implementation of building inspections. Otherwise, wrong practices that lead to unfair competition and that are done with less cost, become the direction of the sector.

Energy Performance Regulation in Buildings

The purpose of the Regulation on Energy Performance in Buildings, which came into force after being published in the Official Gazette dated 05/12/2008 and numbered 27075, is to regulate the procedures and principles regarding the effective and efficient use of energy and energy resources in buildings, the prevention of energy waste and the protection of the environment.

With this regulation, Energy Performance Certificate was introduced and put into practice. In accordance with the Energy Performance Regulation in Buildings, it is obligatory to obtain an Energy Identity Certificate for existing and new buildings. Energy Performance Certificate is the official document in which the energy consumption and greenhouse gas emissions of the building are modeled and classified according to the relevant methodology and approach, defined within the scope of the Regulation on Energy Performance in Buildings. It is a document that is mandatory for new buildings, and mandatory for existing buildings in sales and rental businesses as of 2020. According to the Regulation on Energy Performance in Buildings, new buildings must be at least C class and above.

According to the Regulation on Energy Performance in Buildings, every building over 50 m^2 must obtain an Energy Performance Certificate. Buildings under 50 m^3, greenhouses, workshops and warehouses, arsenals, warehouses, barns, barns, etc., which are built individually and do not need to be heated or cooled. buildings are outside the scope of this regulation.

Other Principles of Regulation on Energy Performance in Buildings

The principles stipulated in this Regulation are taken into account in the design of new buildings, in major renovation projects that require project changes of existing buildings, and in changes in mechanical and electrical installations, according to the characteristics of the building.

Building permits are not issued by the relevant administration for the buildings whose projects do not comply with the Regulation on Energy Performance in Buildings. Building occupancy permit is not issued by the relevant administration for the buildings whose projects are not implemented in accordance with the Regulation on Energy Performance in Buildings.

Architectural Project Design and Implementation

The location of the building; Considering the effect of sun, humidity and wind, heating, cooling, ventilation and lighting facilities should be utilized at the highest level. The use of renewable energy sources should be investigated.

Architectural application project and system details should provide integrity with the materials and point details in the thermal insulation project, and include roof-wall, wall-window, wall-floor and floor-floor-wall composition details to ensure continuity in thermal insulation.

Heating and Cooling Systems Design and Application Principles

In new buildings; In case the total usage area, which is the basis of the building permit, is 2.000 m^2 and above, a central heating system is installed. In buildings using gas fuel with an individual heating system with an area of use of 250 m^2 and above, in independent sections or in detached buildings; condensing type heater devices or devices with integrated economizers are used. Central cooling system designs are made in non-residential buildings with a cooling need greater than 250 kW. The refrigerants to be selected in the design of cooling systems must comply with TS EN 378 series standards. It is necessary to make the correct settings according to the operating characteristics and energy economy of the cooling systems.

Ventilation and Air-Conditioning Systems Design and Application Principles

TS 3419 and related European standards are used in a design, and TS 5895 is used in operation and maintenance. Ventilation and Air-Conditioning systems, under the responsibility of the building owner, manager or energy manager, must be subject to the periodic control, test and maintenance required by the system specified in the relevant standards and reported.

2.7.3 General evaluation of energy consumption and building sector

The energy delivered to the final consumer's door for all energy uses is referred to as final energy consumption. It's determined as the total of all sectors' final energy consumption. Industry, transportation, residential, and the service sector are among them.

It shows the trend in final energy consumption by sector, as well as the progress made in lowering energy consumption and the various end-user sectors' environmental implications (household,

transport, industry, service). It's also used to track the effectiveness of key programs aimed at reducing energy usage and increasing efficiency.

Data on ultimate energy consumption aids in the calculation of energy use's environmental impact. The nature and magnitude of energy-related environmental stresses are determined by both energy sources (and how they are used) and total energy consumption. Using less energy as a result is one approach to minimize energy-related environmental concerns.

Turkey's overall final consumption amounted to 103 Mtoe (million tonnes of oil equivalent) in 2018, accounting for 71% of total primary energy supply (Figure 19) [41].

Industry consumes the most energy, accounting for 36% of total final consumption in 2018, followed by transportation (27%), residential (20%), and services (17%), which includes agriculture and fisheries [41].

Since 2001, Turkey's energy demand has climbed in all sectors, with the exception of industry, which has decreased somewhat in 2018. Energy consumption in transportation climbed by 86%, in industrial by 60 %, and in services and residential by 12 % and 2%, respectively, between 2008 and 2018 [41].

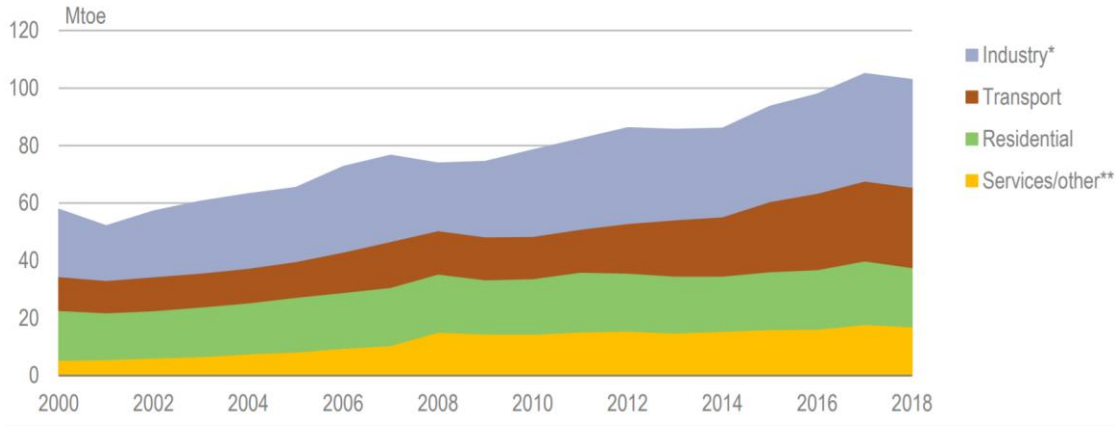


Figure 19. Total final consumption by sector, Turkey, 2000-2018

* Industry includes non-energy consumption.
** Services/other includes commercial and public services, agriculture, and forestry.
Note: Mtoe = million tonnes of oil equivalent.
Source: IEA (2020), IEA World Energy Statistics and Balances (database), www.iea.org/statistics

Energy Efficiency

The National Energy Efficiency Action Plan (NEEAP), which runs from 2017 to 2023, intends to cut Turkey's main energy consumption by 14% by 2023 by implementing 55 activities divided into six categories: buildings, energy, transportation, industry and technology, agriculture, and cross-cutting areas. By 2023, it is expected to save 23.9 Mtoe, with USD 10.9 billion invested in the process. At 2017 pricing, cumulative savings by 2033 are predicted to be USD 30.2 billion, with the effect of particular savings expected to last until 2040 [41].

Turkey agreed to reduce greenhouse gas (GHG) emissions by up to 21% from business-as-usual levels by 2030, in compliance with the United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties framework (including land use, land use change and forestry). Turkey's increasing economy and degree of development limit its capacity to reduce emissions

from current levels, forcing the government to choose a business-as-usual baseline that allows some emissions growth from present levels. Increasing renewable energy sources, such as solar and wind, is essential to attaining the targets.

Turkey does not intend to reach a peak in its emissions anytime soon. The "Capacity Building and Monitoring Project for Achieving the Greenhouse Gas National Contribution Target," led by the Ministry of Environment and Urbanization, will influence efforts to update Turkey's INDC, including measures implemented after 2015. The 2010 National Climate Change Approach 2010-2023 and its implementing plan, the 2011 National Climate Change Action Plan (NCCAP) 2011-2023, explain the country's domestic CO_2 reduction strategy. The NCCAP's primary ideas include increasing energy efficiency and expanding renewable energy sources. By the end of 2023, Turkey will need to revise its NCCAP and National Climate Change Strategy. The study to modernize the NCCAP will begin in 2020, with a goal of finishing it in three years. Policy and strategy choices for the long term (2030-50) will also be considered.

Turkey does not have a carbon tax, but it is examining carbon pricing options as part of the Partnership for Market Readiness Project, which might include the implementation of an emissions trading program. Turkey imposes an environmental cleaning fee on houses, companies, and other structures based on the amount of water they consume to reduce water consumption. Value-added tax and SCT-special consumption tax (SCT) tax reductions for energy efficient products were introduced in 2018 and terminated in June 2019.

CO_2 emissions resulting from energy use

CO_2 emissions in energy-related sectors were predicted to be 374 Mt CO_2-eq in 2018, up 86% since 2000. (Figure 20). Emissions in 2018 were somewhat lower than the previous year. The major generating industry is electricity and heat generation, which accounted for 39% of total emissions in 2018. The rest was emitted by transportation (22% of total emissions in 2018), industry (19%), residential (9%), services (7%), and other energy sources (4%). In the last few decades, emissions have increased in all industries, with a particularly high increase from 2013 to 2017 [41].

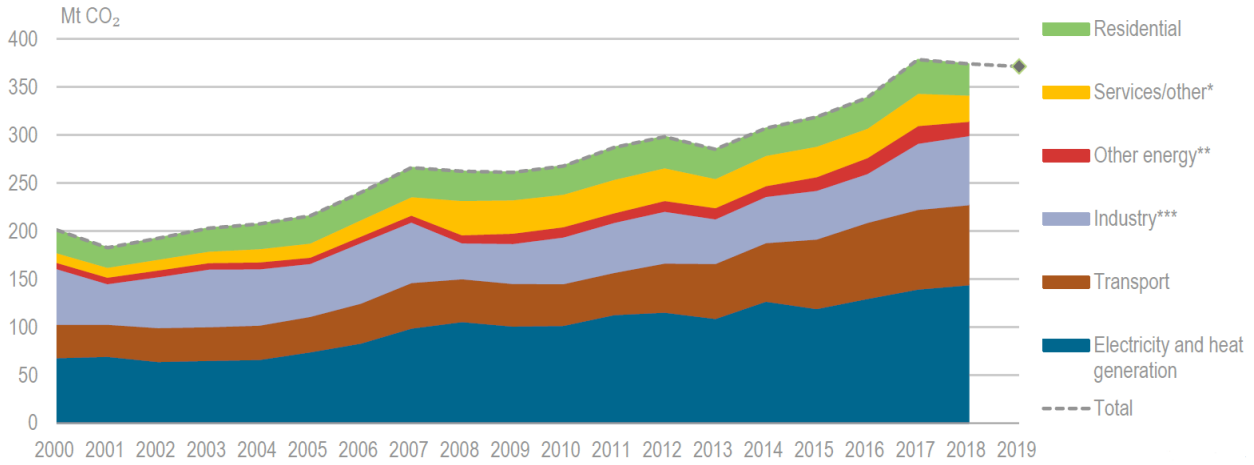


Figure 20. Energy-related CO_2 emissions by sector, Turkey, 2000 -2019

* Services/other includes commercial and public services, agriculture/forestry, and fishing.
** Other energy includes emissions from coal, oil and gas extraction, oil refineries, blast furnaces, and coke ovens.
*** Industry includes CO_2 emissions from combustion at construction and manufacturing industries.

Notes: Mt CO_2 = million tonnes carbon dioxide. Data for 2019 are estimates.
Source: IEA (2020), CO_2 Emissions from Fuel Combustion 2020, www.iea.org/statistics.

Carbon intensity and CO_2 drivers

Population growth and economic development (GDP/capita), as well as changes in the energy intensity of the economy (TPES/GDP) and carbon intensity of the energy supply (CO_2/TPES), all influence total CO_2 emissions from fossil fuel combustion in a country.

Turkey's GDP per capita climbed by 88% between 2000 and 2018, but its population expanded by 27%. Meanwhile, the carbon intensity of the energy supply has remained essentially consistent, while the economy's energy intensity has only marginally dropped. Between 2000 and 2018, energy-related CO_2 emissions increased by 86% as a result of these trends (Figure 21).

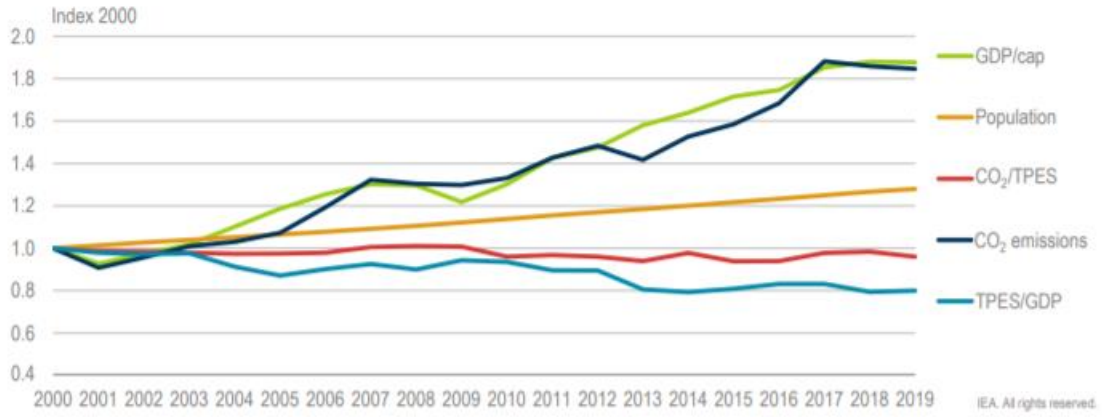


Figure 21. Energy-related CO_2 emissions and driving factors, Turkey, 2000-2019

* GDP data are in billion USD 2015 prices and purchasing power parities (PPPs).
Notes: GDP = gross domestic product. TPES = total primary energy supply. Data for 2019 are estimates.
Source: IEA (2020), CO_2 Emissions from Fuel Combustion 2020, www.iea.org/statistics.

Buildings

Energy consumption in residential buildings

In 2018, the residential sector utilized 20.5 million tons of oil equivalent (Mtoe), accounting for 21% of total final consumption (TFC). Natural gas is primarily used by Turkish households, accounting for 51% of total energy consumption in 2018. (Figure 22). Electricity (23%), bioenergy (8%), coal (8%), geothermal (6%), solar (3%), and oil (3% each) accounted for the remainder (1%). In recent decades, there has been a significant change in domestic energy usage from biofuels and oil to natural gas and electricity. Bioenergy usage, in particular, has decreased dramatically since 2008, falling by 76%. In the meantime, natural gas usage has more than quadrupled, and electricity consumption has more than doubled. While natural gas is the primary source of heating in houses, appliances consume the majority of power [41].

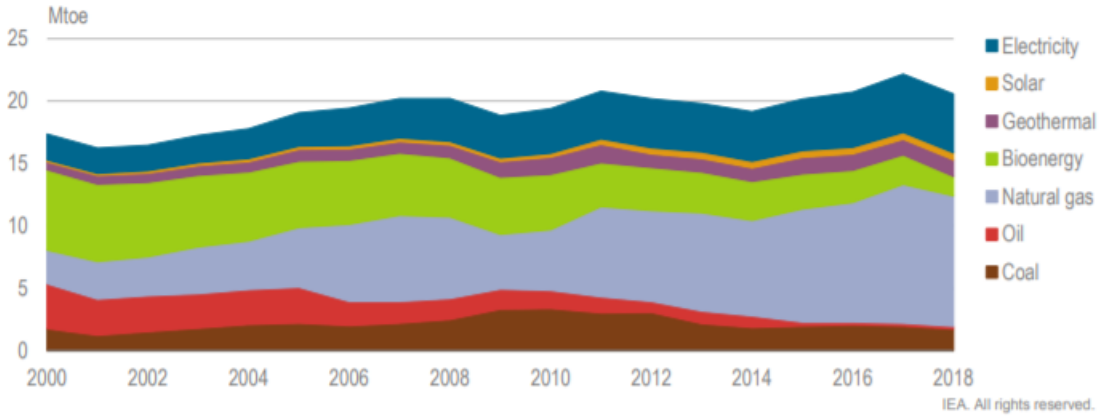


Figure 22. Energy consumption in the residential sector by fuel, Turkey, 2000 -2018

Note: Mtoe = million tonnes of oil equivalent.
Source: IEA (2020a), IEA World Energy Statistics and Balances (database), www.iea.org/statistics.

Residential water heating and appliance energy usage have more than doubled since 2000. However, water heating and appliance use per capita was remained among the lowest in the IEA. Residential cooking, unlike other industries, has seen a reduction in energy intensity as a result of the transfer from oil to natural gas and electricity. The building sector will be supported by the Eleventh Development Plan, which includes the following measures:

-support will be provided to enhance energy efficiency in existing buildings

-buildings that are more energy efficient and self-sufficient will be expanded

- the establishment of a National Green Building Certificate System

According to the 2018 energy balance table prepared by the Ministry of Energy and Natural Resources, the Housing Sector ranks 3rd with a share of 20%, after the Industry and transportation sectors. Figure 23 and Table 6 below gives the distribution of 2018 final energy consumption by sectors, announced by the Ministry of Energy and Natural Resources. According to the same statistics, the total energy consumption of the housing sector in 2018 was 21.3 million TEP (Ton Equivalent Petroleum) [50].

Table 6. 2018 National Energy Balance Table

Sectors	Thousand TEP
Industry	36.155
Transportation	28.441
Housing	21.313
Trade and Services	11.985
Agriculture and Livestock	4.581
Other Non-Energy	6.296

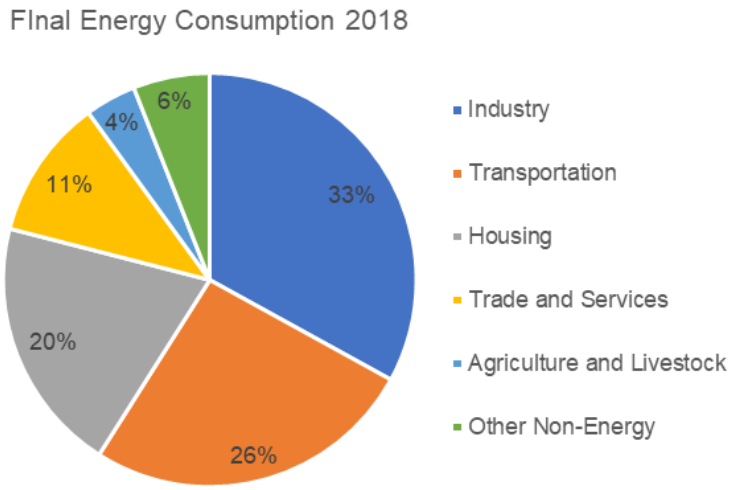


Figure 23. Final energy consumption by sectors

3. METHODOLOGICAL APPROACH OF ASSESSMENT

Due to the high relevance of sustainable housing in the context of SCP in Turkey, this study aims to assess the current state and trends in this field. The study focuses on the analysis of the building life cycle, identifying trends and priority issues for each stage of the building value chain with a particular focus on:

i) Policy environment
ii) Standards, guidelines & rating systems and
iii) Access to finance.

The second part of the study addresses overarching topics that guide and impact the situation of Turkey's on sustainable housing. These topics concern Turkey's targets within the scope of the SCPs and SDGs for the building sector, the national policies for affordable housing and the concepts for district development. Figure 24 provides a schematic overview of the assessment structure and linkages. Together, the findings of these analyses highlight potential thematic key areas, gaps and trends for further promoting SCP in support of Sustainable Housing.

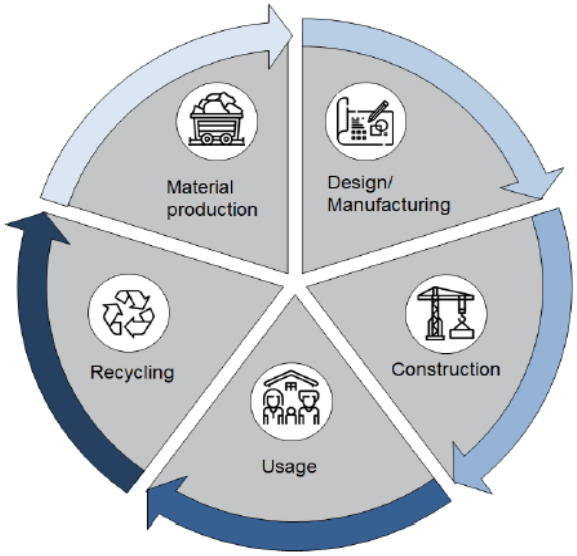


Figure 24. Building life cycle stages as considered in the assessment

This part of the study provides a comprehensive overview of material issues and emerging issues of sustainable housing in SCP, with a particular focus on Turkey. Turkey's leading trends in this regard are presented in this section.

The structure of this chapter is considered within the scope of each predefined focus areas: the national policy environment; standards, guidelines and rating systems; and access to finance. Under these scopes, it follows the different lifecycle stages of buildings, i.e. material production, design and manufacturing, construction, usage and recycling. Research has been conducted on the country's specific laws and regulations pertaining to the different stages of the building's value chain, allowing for a better understanding of these issues in the legal situation regarding SCP in sustainable housing. Other focus areas focus on standards, guidelines and rating systems, energy building codes, green building rating systems, standards and labelling schemes, and other requirements of the country for the building sector. Finally, the focus is on access to finance,

designing financial support opportunities for the implementation of measures within the value chain.

3.1 Value Chain Stages of a Building

3.1.1 Material Production

The value chain of a building starts with the material production stage, which involves extraction of raw materials, their transformation into construction materials and transportation to the construction site. Environmental impacts generated due to the activities of this whole process comprising depletion of natural resources, consumption of large amounts of energy, the emission of greenhouse gases to the atmosphere, the release of pollutants to the environment, loss of biodiversity and deforestation is generated.

The construction sector is responsible for almost %40 of the global consumption since it is dominated by fossil fuels, particularly coal. The CO_2 emission from the fossil fuels and raw material extraction processes makes the industry sector the second largest emitting sector with 8.7 Gt CO_2 today, after power generation. According to the projections which shows to what extent the announced ambitions and targets, including the most recent ones, are on the path to deliver emissions reductions required to achieve net zero emissions by 2050, the demand for industrial products like iron and steel, cement and primary chemicals rises by around 10-30% till 2030. However, the projections fall behind the Net Zero Emission plans, and there is a 2.8 Gt CO_2 emissions difference. CO_2 emissions from cement and steel production correspond to more than half of CO_2 release [51].

Iron and Steel Production

Iron and steel production is an energy-intensive process since it uses coal as the main energy source. For every tone of steel produced, 1.8 tonnes of CO_2 are emitted on average [52], which corresponds to 3.3 Gt CO_2 in a year [53]. Thus, steel production is responsible for 7-9% of the emissions from the global use of fossil fuel [54]. The iron and steel industry has the largest share in the difference between CO_2 emissions of Net Zero Emission plans and current projections with 0.9 Gt [51]. In order to track the "2°C pathway", the emissions could be halved and the "1.5°C pathway" could mean a reduction by %80. On the other hand, the energy consumption of steel varies in different countries between 19-26 GJ/t rude steel [55]. By considering the statistics, it is obvious that the steel demand must be reduced to reach the objectives in 2050. Table 7 shows the current and projective energy demand and CO_2 emissions globally.

Table 7. Energy demand and CO_2 emissions for iron-steel productions globally, with projections to reach Net Zero Emission [54]

Year	Energy Demand (EJ)	CO_2 Emissions (Mt)
2019	36	2507
2020	33	2349
2030	37	1778
2040	36	859
2050	32	220

In Turkey, according to the report of the Ministry of Industry and Technology of Turkey, as of 2019, the Turkish Steel Industry ranks 8th in the world and 2nd among steel producers in Europe after Germany [56]. Table 8 shows the steel production statistics of Turkey from 2017.

Table 8. Crude steel production in Turkey (million tons)

Year	Steel production (million tons)	CO_2 equivalent emissions (million tons) [57]	Estimated CO_2 equivalent emissions (million tons)*
2017	37.5	11.5	67.5
2018	37.3	12.5	67.1
2019	33.7	10.6	60.6
2020	35.8	-	64.4

Resource: Turkish Steel Manufacturers Association *: Estimated CO_2 emissions rates are calculated by considering CO_2 rate as 1.8 tons due to the production of one ton of steel [52].

Most of the liquid steel produced in Turkey is produced in integrated iron and steel plants with Blast Furnace Basic Oxygen Furnace (BOF) producing from ore, and Electric Arc Furnace (EAF) plants producing from scrap. As of 2019, there are 3 BOF plants producing from iron ore and 32 IF (Induction Furnace) and EAF plants producing from scrap in Turkey [56]. Table 9 shows the energy consumption and Table 10 shows the crude material consumption of the iron-steel facilities.

Table 9. Energy supply distribution of cement production in Turkey, in 2020 [58]

Fuel Type	Unit	Energy Supply Distribution
Coal	(thousand ton)	1,615
Lignite	(thousand ton)	28.53
Petroleum coke	(thousand ton)	4,635.65
Derived gases	(thousand TEP)	499.61
Blast furnace gas	(thousand TEP)	108.67
Coke oven gas	(thousand TEP)	350.21
Steel plant gas	(thousand TEP)	40.73
Coal tar	(thousand ton)	18.09
Petroleum products	(thousand ton)	30.88
Petroleum coke	(thousand ton)	20.01
Fuel oil	(thousand ton)	0.08
Diesel	(thousand ton)	10.66
Gasoline	(thousand ton)	0.02
LPG	(thousand ton)	0.11
Natural gas	(10^6 Sm^3)	1,754.49
Bioenergy and waste	(thousand ton)	1.75
Waste	(thousand ton)	1.75
Other heat	(thousand TEP)	270.80

Table 10. Raw Material Consumption of Iron and Steel Facilities

Crude Material Consumption	BOF Facilities (1 ton of crude steel)	EAF Facilities (1 ton of crude steel)
Scrap (kg)	-	1150
Ore (kg)	1500	-

Resource: Ministry of Industry and Technology of Turkey

Cement Production

The cement industry is the second largest contributor to the gap between the current projections and Net Zero Emission plans. According to the research conducted to determine the CO_2 emission of production of one ton of cement, 0.7-0.9 tons of CO2 is emitted due to the production of cement depending on the clinker-cement ratio and other factors [60], [61]. Around 8% of global CO_2 emissions are sourced by cement production [62]. Two-thirds of emission are process emissions generated from carbon released from the raw materials used, this emission cannot be eliminated by changing fuel or increasing energy efficiency since it is released through a chemical reaction (calcination). According to the research conducted by Kara et al., [63] to present the emission rates of the clinker and cement production processes, clinker emissions are roughly corresponding to more than half of the total emissions released due to the cement production activities. A further 40% of emissions come from burning fossil fuels to heat kilns for the calcination process and the last 10% come from the fuels needed to mine and transport the raw materials [62]. Hence, the most emission-intensive ingredient of the cement is clinker and attempts to reduce the clinker-to-cement ratio, and thus reduce the emissions, deliver around 40% of emission savings in 2030 compared with 2020 [64]. Table 11 shows the energy demand and CO_2 emissions of the cement productions globally with projections.

Table 11. Energy demand and CO_2 emissions for cement productions globally, with projections to reach Net Zero Emission [64]

Year	Energy Demand (EJ)	CO_2 Emissions (Mt)
2019	12	2461
2020	16	2334
2030	11	1899
2040	11	906
2050	10	133

As of 2019, Turkey ranks first in cement production in Europe and fourth in the world and there are 55 integrated facilities and 22 grinding facilities in the sector [65]. Table 12 shows the cement and clinker production statistics of Turkey from 2017. Cement and clinker production rates and corresponding CO_2 emissions are shown in Figure 25.

Table 12. Cement and clinker production in Turkey (million tons)

Year	Cement production (million tons)	Clinker production (million tons)	CO_2 emissions (million tons) [57]	Estimated CO_2 emissions (million tons)*
2017	80.5	70.8	37.2	68.4
2018	72.5	70.3	37	61.6
2019	56.9	57.7	-	48.4
2020	72.2	71.7	-	61.3

Resource: TürkÇimento *: Estimated values are calculated since the CO_2 rates given by TURKSTAT are only due to the calcination process in cement production. Estimated CO_2 emissions rates are calculated by considering average CO_2 rate as 0.85 tons due to the production of one ton of cement.

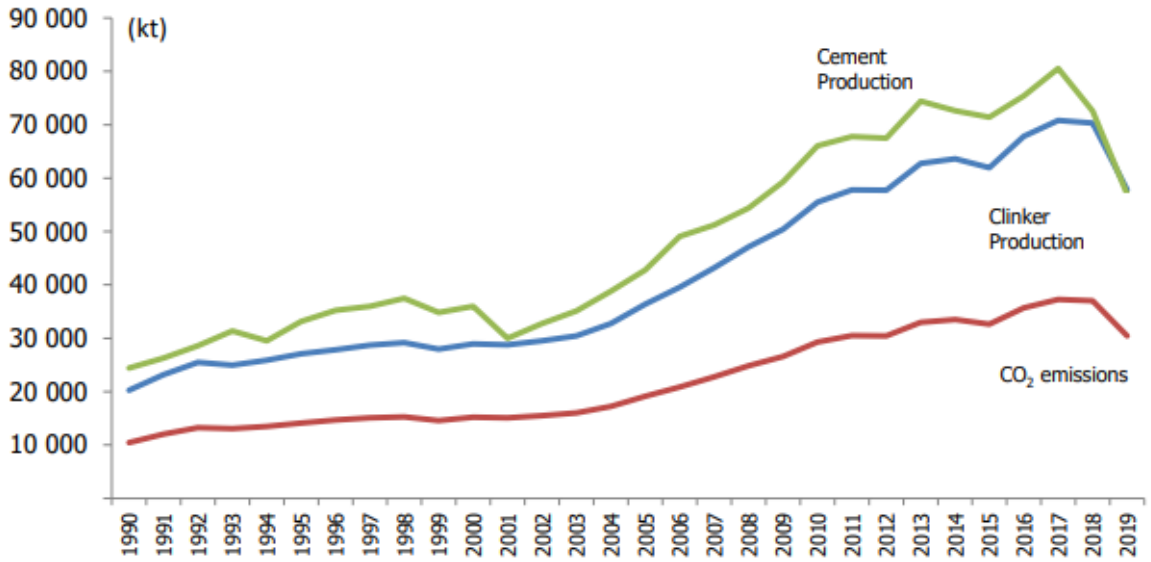


Figure 25. Cement and clinker production rates and corresponding CO_2 emissions [57]

The share of the cement sector in the total energy industry consumption was measured as 17.5% it is the second most energy consuming industry after the iron and steel industry. The chemical and drying processes carried out during cement production occur at high temperatures, which requires intense energy use. For this reason, fossil fuels are largely used in energy production, and many wastes that are difficult to dispose of and various biomass wastes can also be used as alternative fuels. Table 13 shows the energy distribution of cement production in Turkey.

Table 13. Energy supply distribution of cement production in Turkey, in 2020 [58]

Fuel Type	Unit	Energy Supply Distribution
Coal	(thousand ton)	2,701
Lignite	(thousand ton)	1,075
Asphaltite	(thousand ton)	1
Petroleum products	(thousand ton)	4,257
Petroleum coke	(thousand ton)	4,152
Fuel oil	(thousand ton)	11
Diesel	(thousand ton)	92
Gasoline	(thousand ton)	1
LPG	(thousand ton)	1
Natural Gas	(10^6 Sm^3)	276
Bioenergy and wastes	(thousand ton)	1,335
Wastes	(thousand ton)	1,335
Electricity	(GWh)	7,978
Other heat	(thousand TEP)	43

When the cost components of the sector are analyzed, fuel expenditure with a slice of 38% constitutes the main expenditure item of the cement sector. As can be seen from the table, the cement industry can be defined as being dependent on fossil fuels at present. Almost all (92%) of the fossil fuels used extensively in production are imported [66].

Aggregate Production

Aggregate, in addition to being the most important raw material of concrete plants, is used in different fields of industry with different quality properties. Mainly used as raw materials in the processes filling, ballast, plaster, asphalt etc. Aggregate has a very important economic and technical position in concrete production. Since the aggregate cost is quite low compared to cement, it is accepted as a filling material used in concrete. Aggregate production in Turkey is given in Table 14 for in 2020.

According to their source, aggregates are collected in two groups as natural and artificial aggregates. Natural stone aggregate is obtained from terraces, rivers, seas, lakes and quarries. The composition of natural aggregates used as building materials is rocks and minerals. Minerals are natural formations with a defined chemical composition and a special crystal structure. Rocks, on the other hand, are formed by the combination of these minerals.

In a report prepared by the Aggregate Manufacturers Association (AGMA); it was stated that 80 tons of aggregates are needed for the construction of a flat, 3,000 tons for the construction of a school, 300,000 tons for the construction of a stadium, 30,000 tons for the construction of one kilometer of road, and 9,000 tons for the construction of one kilometer of railway.

Table 14. Aggregate production in Turkey, in 2020

Year	Aggregate production (million tons)
2017	480
2018	430
2019	220
2020	270*

Resource: AGMA *: Estimated value

Considering the production scales of natural and artificial aggregates, it is seen that non-renewable natural aggregate resources are being destroyed irreversibly. In this way, along with the rapid consumption of a natural resource, the problem of deterioration of the natural contours/structure arises during their removal from the source.

3.1.2 Design/Manufacturing

Sustainable design is concerned with creating new, added value, eco-efficient products or services that can stimulate the economic competitiveness of industries, while contributing to more sustainable forms of consumption and lifestyle scenarios [67]. A practical product development strategy that meets sustainable development goals encompasses ecodesign by improving solutions throughout the product life cycle, promoting dematerialisation and increasing the eco-efficiency of products [68].

The product design and manufacturing process is a complex process. The sustainability and circularity of a product are defined not in the development phase but in the embryonic one design. The manufacturing industry on the other hand processes raw materials and materials into semi-finished goods and products. There are many opportunities within the manufacturing industry like:

- High-quality recycling, so that there is no outflow of materials, including critical raw materials;
- Optimizing use, so that products can be used for longer;
- Developing new business models, so that the focus of propositions is not on the product, but on the function.

Products, components and materials have untapped value potentials of the traditional take-make-dispose value chain. So if the construction products are designed and manufactured with circularity principles and architects select the right kind of materials, a Circular economy is about turning inefficiencies in linear value chains into business value.

3.1.3 Construction

Within the value chain, the construction stage involves all the phases starting from the transportation of the manufactured components to the construction site to the end of the construction. Within this process, excavation works, transportation of the excavated material, manufacturing, and installation of the components, etc. involves major impacts of the whole value chain such as releasing of wastes, emissions and pollutants that have impacts on soil, water and atmosphere; deforestation, large-scaled energy consumption etc. During this stage, the CO_2 equivalent of the whole greenhouse gas emissions is 6,132,940 tons [59].

3.1.4 Usage

After construction stage is completed, the stage of usage refers to daily operation and maintenance process of the building. During this stage, the consumed energy for maintaining comfort conditions and day-to-day maintenance of the building is referred to as operational energy. Heating and ventilation, air-conditioning, lighting, electro-mechanic systems, other miscellaneous areas, and repairing or replacing building assemblies are involved by the usage stage. The stage of usage is usually the most prolonged phase along the value chain, and many significant urban environmental challenges are related to it, for instance, the lowering of groundwater table as well as pollution of the soil and water bodies.

The global emissions sourced by the usage stage of the buildings have been increasing by % 1 per year since 2010. However, in 2020, it has reduced to 9 Gt because of the lower activities of the service sector due to the Covid-19 pandemic. Nevertheless, this emission rate is not a signal of reducing trend. The fastest-growing building end uses – space cooling, appliances, and electric plug-loads – are driving building sector electrification. While electricity accounted for one-third of building energy use in 2019, fossil fuel use also increased at a marginal annual average growth rate of 0.7% since 2010. Table 15 shows the energy demands and CO_2 emissions of the buildings with both current statistics and projections of Net Zero Emissions [69].

Table 15. Energy demand and CO_2 emissions for buildings globally, with projections to reach Net Zero Emission

Year	Operational energy demand of buildings (EJ)	CO_2 emissions of buildings (Mt)
2019	129	3007
2020	126	2860
2030	99	1809
2040	89	685
2050	86	122

Resource: Net Zero by 2050

In order to achieve net zero emissions in 2050, all new buildings and 20% of the existing building stock would need to be zero carbon-ready as soon as 2030. In other words, building sectors energy intensity needs to drop five times more quickly over the next ten years than it did in the past five to be in line with the Net Zero Emissions by 2050 scenario [69]. Table 16 shows the fuel consumption and combustion emissions from the residential sector.

Table 16. Fuel consumptions and combustion emissions from the residential sector [*57*]

Year	Fuel consumption (TJ)	CO_2 equivalent emissions (kt)
2017	705 283	42 571
2018	636 194	38 826
2019	717 860	43 653

3.1.5 Recycling

At the end of the usage stage, the recycling stage refers to the dismantling or demolishing of the building. The components dismantled can be reused or demolished materials can be recycled. Recycling of construction demolition wastes has a crucial importance in sustainable land use. Additionally, recycling eliminates the raw material extraction processes, thus the emissions, energy consumption and other environmental impacts are also eliminated. Dismantled components such as windows, doors etc. can be directly reused or recycled onsite.

3.1.5.1 construction and demolition waste

According to 2020 data, Turkey ranks first in Europe in ready mixed concrete production with 542 ready mixed concrete companies, 1032 production facilities and 95 million m^3 ready mixed concrete [70]. Production of this scale causes many environmental, social and economic problems in the process after the demolition of the building, as in all value chain processes. Since construction demolition wastes are increasing rapidly due to population growth in Turkey, recovery of demolition wastes is of critical importance due to the destruction of natural resources, the high rates of emissions and energy consumption, and the rapid increase in investment, maintenance, operating expenses and storage costs of the vehicles used for the collection and transportation of wastes.

According to a report by the World Bank in 2012, globally, cities generate 1.3 billion tons of solid waste every year. This volume is expected to increase up to 2.2 billion tons every year by 2025. Building material accounts for half of the solid waste generated every year worldwide [71].

The U.S. generated over 600 million tons of construction-related waste in 2018. C&D concrete was the most considerable portion at 67.5%, followed by asphalt concrete at 17.8%. C&D wood products made up 6.8%, and the other products accounted for 7.9% combined. Demolition represented over 90% of total C&D debris generation. Construction, on the other hand, represented under 10% [72].

In Europe, construction and demolition activities are responsible for generating 850 million tonnes of construction and demolition waste (CDW) per year. The construction sector in the EU is the highestproducer of waste when compared with other economic sectors,accounting for 35% of the total waste generation [73]. The recovery rate of C&D waste in the EU is 88% from 2018 [74].

In Turkey, it has been determined that information on C&W waste is still not kept regularly in many cities. TURKSTAT and the relevant unit of the Ministry of Environment and Urbanization do not have C&W statistics.

3.1.5.2 Hazardous Wastes

Due to the thermal and acoustic properties of asbestos minerals, it is widely used to produce construction materials. After determining the harm of asbestos to human health, many countries worldwide have banned the use of asbestos in building works. However, since most of the existing buildings contain asbestos, those working in the construction industry cannot be isolated from the danger of asbestos. Asbestos exposure in the construction industry typically occurs during the following work stages that contain asbestos:

- Demolition or dismantling works in buildings

- Changing the location of materials or moving them to a closed area
- Change, maintenance, repair or renewal processes of buildings or infrastructures
- Cleaning of rubble and waste
- Transportation, loading, placement, storage, control and recovery of products at the construction site

Proper disposal of these materials is critical, as exposure to toxic substances such as lead, mercury, etc., in addition to asbestos, may occur during the demolition of buildings.

In Turkey, according to statistics of the Ministry of Environment and UrbanizationUrbanization, waste declarations were made by 66,478 facilities in 2018. It has been declared that 1,513,624* tons of hazardous and 15,068,633* tons of non-hazardous waste are generated throughout our country.

Within the scope of the Waste Management Regulation (AYY), annual hazardous and non-hazardous waste declarations are made by the waste producers using the Waste Management Practice/Waste Declaration System (TABS) of Ministry of Environment and Urbanization.

According to Ministry of Environment and Urbanization statistics, in 2018, 84.99% of the total hazardous waste was sent to waste processing facilities for recycling, and 13.26% to sterilization, landfill and incineration facilities for disposal. 64.70% of the total non-hazardous waste was sent to waste processing facilities for recycling, and 21.31% to landfills and incineration facilities for disposal. It is seen that most waste generation belongs to the manufacturing sector/basic metal industry. It has been declared that 360,824 hazardous waste and 3,185,300 tons of non-hazardous waste are generated in the facilities in this sector. In the ranking, the basic metal industry sector is followed by the "manufacturing of chemicals and chemical products" sector in hazardous waste, and the activities in the non-hazardous waste "electricity, gas, steam and ventilation system production and distribution" sector.

According to TURKSTAT data, as of 2018, 1395 out of 1399 municipalities in Turkey provide waste services. In order to provide waste management, the Turkish Ministry of Environment and Urbanization have been conducted Zero Waste project. Within this project, it is stated that 58 tons of paper, 14 tons of plastic, 3 tons of glass, 1.5 tons of metal have been collected and by this way greenhouse gas emissions are reduced by 11 tons. 32 million tons of municipal waste was collected in 2018 [59]. Table 17 shows the disposal/recovery methods and percentage of each method in total amount of municipal waste in 2018. As it can be seen from the table, large amount of waste is delivered to landfill sites which have important environmental impacts. On the other hand, recycled municipality waste amount is considerably low relative to the overall disposal methods.

Table 17. Disposal/recovery methods and amount of municipal waste [59]

Waste disposal and recovery methods	Waste delivered to municipality's dumping site	Waste delivered to controlled landfill sites	Burning in an open area	Lake and river disposal	Burial	Other disposal methods	Waste delivered to composting plants	Waste delivered to other recovery facilities
Amount (thousand tons)	6 521	21 644	6	0.5	2	65	123	3 848
%	20.2	67.2	0.019	0.002	0.006	0.2	0.38	11.9

4. ANALYSIS OF SUSTAINABLE HOUSING ALONG THE LIFE CYCLE OF BUILDINGS

4.1 Policy Environment

The construction sector has an enormous potential for a circular economy given the scale of material use, the value contained in buildings, labour intensiveness, and the long term effect of measures. Overall, the construction sector employs 18 million people directly and accounts for around 9% of the EU's GDP. Buildings are responsible for over 40% of energy consumption and 36% of CO_2 emissions in the EU, making them Europe's single most significant energy user; thus, greater material efficiency might save up to 80% of those emissions, according to estimates [75]. Buildings also account for almost one-third of total water use. Construction and demolition waste (CDW), which contributes for over 35% of all waste generated in the EU, has major life cycle impacts, especially throughout the extraction and processing stages. The degree of recycling and material recovery of CDW varies significantly amongst EU Member States (between less than 10% and more than 90%) [76]. On a worldwide scale, the housing and construction industry has great significance in mitigating global climate change since households consume 29% of global energy and generate 21% of CO_2 emissions. At the European level, construction is identified as a key for the value chain in the new Circular Economy Action Plan of the European Commission. Moreover, the urbanization rate in the Mediterranean coastal areas is expected to grow to 72% by 2025, bringing an unbearable burden on the environment. The emerging housing sector causes unlimited extraction of raw material and production of construction material directly associated with the deterioration of the natural landscape, with atmospheric emissions (dust, NO_x, SO_2, CO_2, etc.), noise and vibrations. Therefore, housing and construction are regarded as having a strong potential for generating a considerable and cost-effective GHG emission reduction and have been identified as one of the priority sectors in the Regional SCP Action Plan. Besides, the SDG target 12.2 calls for sustainable management and efficient use of natural resources, and green buildings may certainly help this aim. However, there are no direct references from the SDGs to this sector. Regarding material consumption, the Hot Spot Analysis for SCP (SCP-HAT) showed that the construction industry has the most significant raw material consumption in Turkey, with 61.3%. In this perspective, it is vital to make housing and construction more sustainable and to integrate them into the circular economy framework.

Table 18 depicts European regulatory, economic, communicative, and voluntary policy tools addressing key environmental concerns throughout the housing and construction value chains. The EU has built a legal framework to improve the energy performance of buildings, which comprises the Energy Performance of Buildings Directive (EPBD) (2010/31/EU) and the Energy Efficiency Directive (2012/27/EU). As part of the Clean Energy for All Europeans package, both directives were revised in 2019, and the EU member states have 1-2 years to implement the new directives into national legislation. The EPBD mandates new public buildings to be Nearly Zero-Energy Buildings (NZEBs) as of January 2019, each new building in the EU to be an NZEB by the end of 2020, and building stock decarbonization by 2050. In this regard, Turkey has committed to a less decisive short-term goal by joining the Zero Carbon Buildings, which proposed making new buildings carbon-neutral by 2030 and existing buildings carbon-neutral by 2050 through the aims of the national and municipal policies. Table 19 depicts Turkey's regulatory, economic, communicative, and voluntary policy instruments. Besides, the hotspots of the national housing

and construction sector value chain (i.e. the environmental aspects that have the highest priority to tackle) were defined according to information obtained from stakeholders through workshops and online surveys [77]. Determined hotspots are as presented in Figure 26. It has to be noted that the stakeholder composition was not representative of the whole housing and construction chain. A more comprehensive consultation has to be carried out.

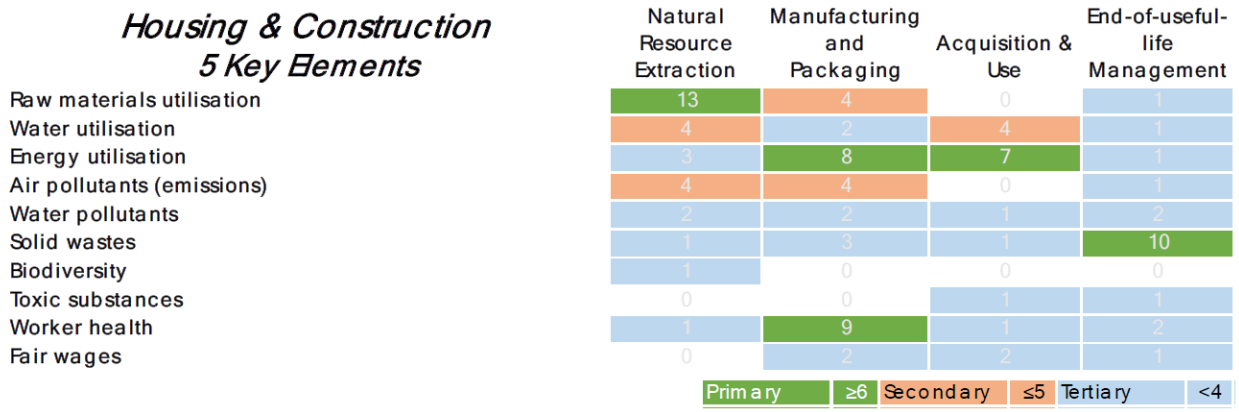


Figure 26. Hotspots within housing and construction value chains [77]

Table 18. Existing and upcoming EU policies enabling circular economy business models within the housing and construction value chain

Policy Instruments	Extraction Of Natural Resources	Manufacturing and Packaging	Acquisition & Use	End-of-life
Regulatory Instruments		(i) Environmental Impact Assessment of the effects of certain public and private projects on the environment (2011/92/EU);	(i) The revised Energy performance of buildings directive (EPBD) (2018/844) and the revised Energy efficiency directive (2018/2002) include specific provisions and measures to support national governments achieve a decarbonized building stock by 2050. (ii)The EPBD requires that all new buildings must be Nearly Zero-Energy Buildings (NZEB) as of 31 December 2020. The low amount of energy that NZEB require comes mostly from renewable energy sources.	(i) Directive (EU) 2018/851 revising waste, Revised waste legislative framework (2018) reinforced rules and new obligations on separate collection of construction and demolition waste (ii) President-elect Von der Leyen also announced plans for a "New Circular Economy Action Plan" which would focus on the sustainable resource use, "especially in resource-intensive and high-impact sectors such as textiles and construction".
Economic Instruments	(i) Funding for Research & Demonstration and innovation, such as the Horizon 2020 programme for Energy Efficiency, which has Buildings as one of the main areas. *For example,* The H2020 Funded project "Bioclimatic approaches for improving energy performance in buildings in Africa and Europe" aims to study the performance of a selection of European and		(i) Under the EPBD, EU countries can provide a list of national measures for funding opportunities to finance renovations that make buildings energy efficient. (ii) EU countries have to submit long term renovation strategies (LTRS) that foster investments in the renovation of buildings. These strategies will as of 2019 form a key part of EU countries' integrated national energy and climate plans (NECPs).	

	African bioclimatic building designs, local construction materials and techniques to determine how they could be utilized to increase the energy performance, living quality and sustainability of buildings. The project seeks to enable adaptation of local materials and techniques to current building design and construction practices, and to investigate how sustainable supply chains of local materials could be established to cope with fast construction paces.		(iii) The Union's European Structural and Investment Funds (ESIFs) and the European Fund for Strategic Investments (EFSI) seek to improve the availability of finance for energy efficiency investments. (iv) One-stop-shops (OSS) offer holistic renovation solutions for building owners. They have been advocated by the European Commission through both the 'Smart financing for smart buildings' initiative and the recast EPBD, where they are expected to become key tools for the energy transition. (v) H2020 includes Smart Buildings as one of their R&D topics, such as the project "Enabling next-generation of smart energy services valorising energy efficiency and flexibility at demand side as energy resource"
Communicative Instruments	(i) The European Climate Foundation commissioned a report to assess different pathways to reduce CO_2 emissions from the cement and concrete industry.	(i) This year's World Green Building Week aims to raise greater awareness of the carbon emissions from all stages of a building's lifecycle, and therefore encourage the construction industry to decarbonize all the supply chain, instead of focusing only on the operational phase emissions.	(i) The Building Stock Observatory was established in 2016 and aims to provide stakeholders with comprehensive knowledge on Europe's building stock. It contains a database, a data mapper and factsheets for monitoring and statistics on the energy performance of buildings across Europe. (ii) Energy performance certificates provide information for consumers on buildings they plan to purchase or rent. They include an energy performance rating and recommendations for cost-effective improvements. Under the Energy Performance of Buildings Directive (2018/844) all EU countries have established independent

			control systems for energy performance certificates and inspection.	
Voluntary or Procedural Instruments	(i) ECTP is a construction stakeholders-led European Technology Platform. In its publication "Energy Efficient Buildings Public-Private Partnership Project Review 2018" they present the progress of a portfolio of 168 projects which demonstrate scientific and technological excellence across the whole value chain. The section "Advance materials and nanotechnology" presents 5 projects with new materials that reduce operational energy and pollution (p. 14). - In Europe, the most common labels for sustainable wood materials are the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC).	(i) Level(s), the first framework of indicators for measuring sustainability of buildings, is being tested in more than 130 projects through Europe and it will be launched around summer 2020. It focuses on six 'hotspots' for environmental impact through the whole building life cycle: greenhouse gas emissions, resource efficiency, water use, health and comfort, resilience and adaptation to climate change, and cost and value. The report: "Taking action on the total impact of the construction sector" details the impact achieved so far and presents some good practices. (ii) Voluntary commitments and procedures, such as the EMAS Sectoral Reference Document on Best Environmental Management Practices (BEMPs) for the building and construction sector (2012), which	(i) Build Up is the European portal for energy efficiency in buildings. The web portal targets professionals working in the building sector (public or private) to exchange best working practices and knowledge and to transfer tools and resources. (ii) The European innovation partnership on smart cities and communities (EIP-SCC) is an initiative supported by the European Commission that aims to improve urban life through more sustainable integrated solutions and addresses city-specific challenges from different policy areas such as energy, mobility and ICT. Several policies and initiatives are in place to tackle energy challenges. The development of SmartBuildings, with technologies enabling demand side management of energy is growing and will be key to improve energy efficiency. (ii) At the global level, the Zero Carbon Buildings for All Initiative unite leaders across sectors in a strong international coalition to decarbonize the building sector by 2050, same target than the EU. (vi) The "Buying green – Handbook on GPP" (2016) includes buildings as one of the key sectors. (v) New/revised EU Green Public Procurement criteria (2016) integrating circular economy	(i) Industry engagement has led to the adoption of the EU Construction and Demolition Waste Protocol and Guidelines (2018). (ii) Voluntary industry-wide recycling protocol for construction and demolition waste (2016). Dissemination actions have been implemented in order to assist Member States and private practitioners in adopting it in their construction market. (iii) See examples of Public-Private Partnerships concerning End-of-life in page 17 of the EeB PPP Project review (2018).

		according to EMAS website, is currently following the legal process for its adoption by the European Commission. (iii) Construction 21 is a social networking platform that started as part of an EU project. Its objective is to help professionals discover and develop new ways of sustainable building.	requirements for office building design, construction and maintenance. Recommended criteria can be found at the GPP Working document and the Procurement practice guidance document. Other relevant GPP criteria concerning paints, sanitary tapware and furniture can be found here. (vi) The LEIPZIG CHARTER on Sustainable European Cities, where Member States commit to improve energy efficiency of buildings. "This concerns both existing and new buildings. The renovation of housing stock can have an important impact on energy efficiency and the improvement of a resident's quality of life" (2007, page 4).	

Table 19. Existing national policies enabling circular economy business models within the housing and construction value chain

Policy Instruments	Extraction Of Natural Resources	Manufacturing and Packaging	Acquisition & Use	End-of-life
Regulatory Instruments	(i) Construction Products By-Law (305/2011 / EU) (10.07.2013, 28703) (ii) By-Law on Occupational Health and Safety in Construction Works (05.10.2013, 28786) (iii) Mining Law (15.06.1985, 18785) (iv) Mining By-Law (21.09.2017, 30187) (v) By-Law on Substances that Deplete the Ozone Layer (07.04.2017, 30031) (vi) By-Law on Fluorinated Greenhouse Gases (04.01.2018, 30291) (vii) Persistent Organic Pollutants By-Law (14.11.2018, 30595) (viii) By-Law on Registration, Evaluation, Authorization and Restriction of Chemicals (23.06.2017, 30105) (ix) Turkey Earthquake Building Regulations (18.03.2018, 30364) (x) By-Law on Fire Protection of Buildings (19.12.2007, 26735)	(i) Construction Products By-Law (305/2011 / EU) (10.07.2013, 28703) (ii) By-Law on Occupational Health and Safety in Construction Works (05.10.2013, 28786) (iii) By-Law on the Construction Products Criteria (26.06.2009, 27270) (iv) Law on Building Control (13.07.2001, 24461)	(i) Construction Products By-Law (305/2011 / EU) (10.07.2013, 28703) (ii) By-Law on Waterproofing in Buildings (27.10.2017, 30223) (iii) By-Law on Energy Performance of Buildings (05.12.2008, 27075) (iv) By-Law on Green Certificate for Buildings and Settlements (23.12.2017, 30279) (v) By-Law on Fire Protection of Buildings (19.12.2007, 26735) (vi) By-Law on the Noise Protection of Buildings (31.05.2017, 30082) (vii) Green Buildings and Green Building Certificate	(i) By-Law on Control of Excavation, Construction and Demolishing Wastes (18.03.2004, 25406)
Economic Instruments	(i) Mining Law (15.06.1985, 18785)		(i) Fines arising from Customs Union Agreement (ii) Law on the Amendment of Some Law and Law Decree for the Development of Industry and Supporting Production (01.07.2017, 30111)	

Communicative Instruments	(i) Electronic Mining Operations Management Information System (EMining)			
Voluntary or Procedural Instruments	(i) İstanbul Mineral Exporters' Association (İMİB) (ii) Turkish Miners Association (TMD) (iii) Turkish Association of Economic (iv) Geologists (MJD)		Green Procurement	

4.2 Standards and Rating Systems

4.2.1 General standards about environmental management of value chain of a building

TS EN ISO 14001

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). TS EN ISO 14001 – "Environmental management systems — Requirements with guidance for use" standard is described as; "ISO 14001:2015 specifies the requirements for an environmental management system that an organization can use to enhance its environmental performance. ISO 14001:2015 is intended for use by an organization seeking to manage its environmental responsibilities in a systematic manner that contributes to the environmental pillar of sustainability.

ISO 14001:2015 helps an organization achieve the intended outcomes of its environmental management system, which provide value for the environment, the organization itself and interested parties. Consistent with the organization's environmental policy, the intended outcomes of an environmental management system include:

- enhancement of environmental performance;
- fulfilment of compliance obligations;
- achievement of environmental objectives.

ISO 14001:2015 is applicable to any organization, regardless of size, type and nature, and applies to the environmental aspects of its activities, products and services that the organization determines it can either control or influence considering a life cycle perspective. ISO 14001:2015 does not state specific environmental performance criteria." in the website of ISO. It is published in 2015-09 and it has been in operation since 2015-10 in Turkey. This standard contributes to the following Sustainable Development Goals (SDGs) [78];

TS EN ISO 14040

TS EN ISO 14040 – "Environmental management — Life cycle assessment — Principles and framework" standard is described as; "ISO 14040:2006 describes the principles and framework for life cycle assessment (LCA) including: definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and conditions for the use of value choices and optional elements.

ISO 14040:2006 covers LCA studies and life cycle inventory (LCI) studies. It does not describe the LCA technique in detail, nor does it specify methodologies for the individual phases of the LCA.

The intended application of LCA or LCI results is considered during the definition of the goal and scope, but the application itself is outside the scope of this International Standard."

This standard is published in 2006-07 and it has been in operation since 2007-06. The SDGs contributed by this standard are [78];;

TS EN ISO 14044

TS EN ISO 14044 – "Environmental management — Life cycle assessment — Requirements and guidelines" standard is described as; "ISO 14044:2006 specifies requirements and provides guidelines for LCA including: definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, relationship between the LCA phases, and conditions for use of value choices and optional elements." In official website of ISO. It is published in 2006-07 and it is in operation from 2007-06 in Turkey. The SDGs contributed by this standard [78];

TS EN ISO 12270

TS EN ISO 12270 – "Sustainability in buildings and civil engineering works — Guidelines on the application of the general principles in ISO 15392" standard is described as; "ISO/TS 12720:2014 provides guidance for the application of the general principles of sustainability in buildings and civil engineering works elaborated in ISO 15392. It shows the different actors involved with the construction works how to take these principles into account in their decision-making processes in

order to increase the contribution of the construction works to sustainability and sustainable development." in official website of ISO. This standard was published in 2014-04 and it has been I progress since 2016-02. This standard contributes to the SDGs [78]

4.2.1.1 Material Production

TS EN ISO 14067

TS EN ISO 14067 – "Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification" standard is described as; "This standard specifies principles, requirements and guidelines for the quantification and reporting of the carbon footprint of a product (CFP), in a manner consistent with International Standards on life cycle assessment (LCA)" in the official website of ISO. It was published in 2018-8, and it is in operation from 2018-11 in Turkey. The SDGs contributed by this standard [78];

TS EN ISO 21930

TS EN ISO 21930 standard is described as; "ISO 21930:2017 provides the principles, specifications and requirements to develop an environmental product declaration (EPD) for construction products and services, construction elements and integrated technical systems used in any type of construction works. It establishes a core set of requirements to be considered as core product category rules (PCR) to develop an EPD for any construction product or service. In addition, this standard, as the core PCR document for construction products, construction elements and integrated technical systems:

a) includes the rules for calculating the life cycle inventory analysis (LCI), the predetermined environmental indicators and the life cycle impact assessment (LCIA) results that are reported in the EPD;

b) describes which life cycle stages are considered in a particular type of EPD, which processes are to be included in the life cycle stages and how the stages are subdivided into information modules;

c) defines rules for the development of scenarios;
d) includes the rules for reporting relevant environmental and technical information that are not covered by LCA;
e) defines the core elements to be included in an EPD;
f) establishes the structure of a project report;
g) defines the conditions under which construction products can be compared, based on the information provided by an EPD;
h) provides requirements and guidelines on PCR for sub-categories of construction products;
i) includes mandatory and unalterable requirements for any PCR based on this document."
This standard was published in 2017-07 and it has been in operation since 2021-02 in Turkey and it contributes to the SDGs below [78];

4.2.1.2 Design/Manufacturing

TS EN ISO 14006

TS EN ISO 14006 – "Environmental management systems — Guidelines for incorporating ecodesign" standard is described as; "This standard gives guidelines for assisting organizations in establishing, documenting, implementing, maintaining, and continually improving their management of ecodesign as part of an environmental management system (EMS)." in the official website of ISO. This standard was published in 2020-01, and it has been in operation since 2020-3 in Turkey. The SDGs contributed by this standard [78];

TS EN ISO 16813

TS EN ISO 16813 – "Building environment design - Indoor environment - General principles" standard is described as "ISO16813:2006 establishes the general principles of building environment design taking into account healthy indoor environment for the occupants, and protecting the environment for future generations. ISO16813:2006 promotes an approach in

which the various parties involved in building environmental design collaborate with one another to provide a sustainable building environment.
The unique features of the design process are articulated by the following aims:
a) to provide the constraints concerning sustainability issues from the initial stage of the design process, including building and plant life cycle together with owning and operating costs to be considered at all stages in the design process,
b) to assess the proposed design with rational criteria for indoor air quality, thermal comfort, acoustical comfort, visual comfort, energy efficiency and HVAC system controls at every stage of the design process,
c) to make iterations between decisions and evaluations of the design throughout the design process.

ISO16813:2006 is applicable to building environment design for new construction and the retrofit of existing buildings.

This standard was published in 2006-05 and has been in operation since 2015-02 in Turkey and contributes to the SDGs below [78];

4.2.1.3 Construction

TS EN ISO 15392

TS EN ISO 15392 – "Sustainability in buildings and civil engineering works - General principles" standard is described as "This standard identifies and establishes general principles for the contribution of buildings, civil engineering works and other types of construction works (hereinafter referred to collectively as construction works) to sustainable development. It is based on the concept of sustainable development as it applies to the life cycle of construction works, from inception to the end-of-life. This standard is applicable to new and existing construction works, individually and collectively, as well as to the materials, products, services and processes related to their life cycle. This standard does not provide performance levels (benchmarks) that can serve as the basis for sustainability claims." in the official website of ISO. This standard was published in 2019-12 and it has been in operation since 2021-02 in Turkey. SDG's contributed by this standard are [78];

4.2.1.4 Usage

TS EN ISO 21931-1

TS EN ISO 21931-1 – "Sustainability in building construction — Framework for methods of assessment of the environmental performance of construction works — Part 1: Buildings" standard is described as "ISO 21931-1:2010 provides a general framework for improving the quality and comparability of methods for assessing the environmental performance of buildings and their related external works.

It identifies and describes issues to be taken into account in the use and development of methods of assessment of the environmental performance for new or existing buildings in their design, construction, operation, maintenance and refurbishment, and in the deconstruction stages." in official website of ISO. This standard is published in 2010-06 and it has been in operation since 2016-02. The SDGs related to this standard are [78];

4.2.1.5 Recycling

TS EN ISO 21929-1

TS EN ISO 21929-1 – "Sustainability in building construction — Sustainability indicators — Part 1: Framework for the development of indicators and a core set of indicators for buildings" standard is described as "This standard establishes a core set of indicators to take into account in the use and development of sustainability indicators for assessing the sustainability performance of new or existing buildings, related to their design, construction, operation, maintenance, refurbishment and end-of-life. Together, the core set of indicators provides measures to express the contribution of a building(s) to sustainability and sustainable development. These indicators represent aspects of buildings that impact on areas of protection related to sustainability and sustainable development." in official website of the ISO. This standard is published in 2011-11 and it has been in operation since 2016-02 and the SDGs contributed by this standard are [78];

4.2.2 Rating systems

In order to provide the sustainable buildings to be prevalent, one of the most effective ways is rating and certification systems. In Turkey, LEED (Leadership in Energy and Environmental Design, USA), BREEAM (Building Research Establishment Environmental Assessment Method, UK), Energy and Environmental Design (LEED) and EDGE (Excellence in Design for Greater Efficiencies, International Finance Corporation) certification systems are used. The assessment criteria for each of the certification systems are given in Table 20. B.E.S.T. is developed by ÇEDBİK but only completed a pilot multi-dwelling project.

Table 20. Assessment criteria of widely used rating systems in Turkey (IMSAD, 2020)

LEED	BREEAM	B.E.S.T	EDGE
1. Integrated process 2. Location and transportation 3. Sustainable land use 4. Water efficiency 5. Energy and atmosphere 6. Materials and resources 7. Indoor air quality 8. Innovation 9. Regional priority	1. Worksite and building management 2. Health and comfort 3. Energy efficiency 4. Water efficiency 5. Land use and ecology 6. Transportation 7. Material use 8. Waste management 9. Pollution 10. Innovation	1. Integrated green project management 2. Land use 3. Water use 4. Energy use 5. Health and comfort 6. Material and resource use 7. Life in building 8. Operation and maintenance 9. Innovation	1. Energy efficiency 2. Water efficiency 3. Resource use

As of December 7, 2021, as can be seen from Figure 27 there are 449 LEED certified buildings (LEED Country Report, 2021). There are 75 BREEAM certified, 4 EDGE New Certified projects with 400 homes (Table 21), and 1 BEST certified New Constuction (NC) multi-dwelling project (pilot). The numbers of LEED certified projects as can be seen from Figure 27 includeboth existing, new and commercial interiors certifications. The numbers of BREEAM include the existing buildings as well as new buildings.

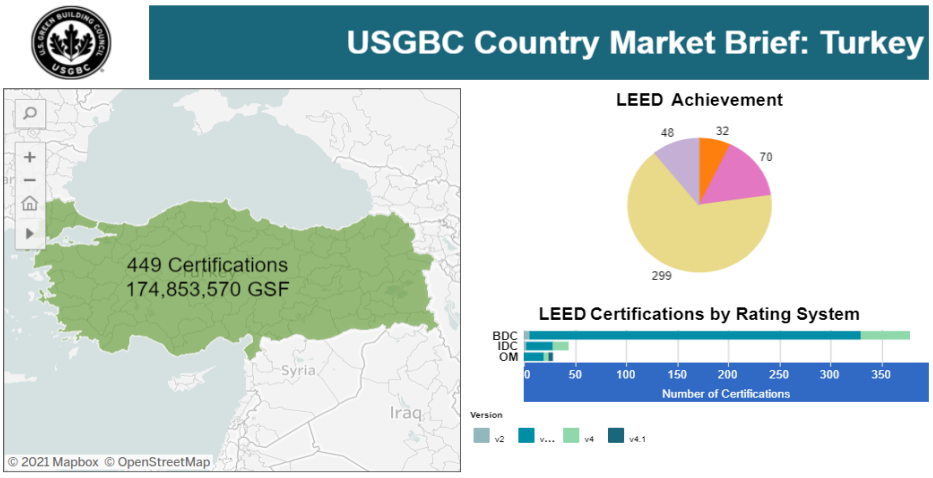


Figure 27. Total LEED certifications as of December 7, 2021 [86]

Table 21. Edge certification numbers in Turkey (December 2021)

Floor Space Registered	Floor Space Final Certification	CO_2 Savings Certified	Number of Certified Homes
12,830 m^2	263,089 m^2	2,285 (tCO_2/year)	400

Considering the number of buildings certified globally, the number of certified buildings in Turkey are minimal. The green transition in Turkey when it comes to buildings, communities and cities have to increase dramatically.

The National Green Certificate System (YeS-TR)

The National Green Certificate System (YeS-TR) has been developed in order to popularize energy efficient and environmentally friendly building and settlement practices at the national and local level in Turkey. With YeS-TR, certificates will be given to buildings and settlements by authorized institutions.

The Ministry of Environment and Urbanization necessitates the construction of environmentally friendly green buildings in the construction sector due to reasons such as global warming and climate change, decrease in water resources, environmental pollution and rapid consumption of natural resources. Within the scope of sustainable development, since 1990, various green building certifications have been established in many countries in the world, especially in developed countries, to support the construction of buildings that consume less energy, use natural resources less and pollute the environment less.

In this context, a "National Assessment Guideline" was issued on February 26, 2016 between the Ministry of Environment and Urbanization and Istanbul Technical University (ITU) for the purpose of evaluating and certifying buildings and settlements that are suitable for climate data and the region, consume energy and water as much as they need, and use renewable energy resources. development protocol was signed. Then, in 2018, a "Certificate System Guide" was prepared within the framework of the main categories of "building" and "settlement" specific to Turkey, in order to disseminate building practices that evaluate the building within the framework of its life cycle from land selection to demolition, that are compatible with nature, that are sustainable, and that use the geographical features of the location. Within the framework of the guide, the National Green Certificate System (YeS-TR) software infrastructure was created on November 8, 2019, and work began.

The Green Certificate Implementation Communiqué for Buildings and Settlements was published in the Official Gazette on June 9, 2021. Experts from the Ministry and 31 academicsfrom six universities participated in the study, which was carried out in line with the request of the Ministry of Environment and Urbanization and under the coordination of ITU. This certification specific to Turkey has essential differences from the certifications in other countries. Unlike other certification systems, YeS-TR also has evaluation criteria for disaster management.

During the implementation process, authorizations are made by the ministry by providing training to the relevant institutions. In the system, which is based on volunteerism and is not required by the administrations, it is aimed to create certificates of "acceptable", "good", "very good" and "national superiority" certificate degrees for authorized institutions for sustainable green buildings and green settlements. Hopefully, through YeS-TR, it will be ensured that a sustainable green building certification system, which is a brand value unique to Turkey, will be created by disseminating energy efficient and environmentally friendly building practices at national and local level, promoting renewable energy technologies and reducing carbon dioxide emissions.

Evaluation and certification of buildings and settlements designed with a holistic approach, which are compatible with nature, evaluate the building within the framework of its life cycle from land selection to demolition, are suitable for climate data and the region, consume energy and water as much as they need, use renewable energy resources, have waste management and carbon emissions can be monitored. A building, an island formed by buildings, a site or a city can apply for the certificate. New buildings can also apply for this certification, but it is mostly aimed to improve existing buildings.

4.3 Access to Finance

4.3.1 Urban Transformation

Law No. 6306 provides some financial benefits to right owners. According to sentence "…Provisional housing or workplace allocation or rent assistance may be granted to the owners, tenants and limited real right owners provided that they reside in the structure." at Article 5 of the Law No.6306 Ministry of Environment and Urbanism provides rent support to the right owners. Right Owners According to Article 5 of the Law No. 6306 are:

- Owners
- Tenants
- Limited Real Right Owners

Period of rent support to the owners is maximum 18 months for risky buildings and maximum 36 months for risky areas and reserve building areas. Please note that monthly rent price is updating according to consumer price index published by Turkish Statistical Institute every year.

At risky buildings, tenants who live or run a business at risky building receive twice amount of the rent support price for once, limited real right owners who live or run a business at risky buildings receive five times the amount of the rent support price for once, right owners whose structure expropriated with agreement under the Law no. 6306 receive twice amount of the rent support price for once.

As of January 2020, totally approximately 4 billion TL has been paid as rent support at risky buildings and risky areas. It is crucial to state that same person is not receiving both rent support and interest support from Ministry at the same time. On the other hand, approximately 16 billion TL has been spent for the purpose of urban transformation until 2021 [34].

The principles about the interest support provided to the loans used by right owners who wish to build or acquire their house and/or workplace with their own resources within the scope of the third paragraph of Article 6 of the Law no. 6306 published at 13.10.2012 dated and 28440 numbered Turkish Official Gazette. In scope of Regulation on Energy Performance in Buildings,

support rate on interest rates increases by 50 basis points for buildings with Class B Energy Performance Certificate (EPC) and 100 basis points for buildings with Class A Energy EPC. Interest support varies from 300 to 400 basis as shown in Table 22.

Table 22. Interest Support for Urban Transformation

Loan Type	Rate of interest Support	Maximum Grace Period (year)	Maximum Period (year)	Upper limit for loan principal amount
Reinforcement Loan	400 basis point	2	10	80,000 TL
Housing Construction Loan	400 basis point	2	10	200,000 TL
Housing Acquisition Loan	400 basis point	1	10	200,000 TL
Workplace Construction Loan	300 basis point	2	7	200,000 TL
Workplace Acquisition Loan	300 basis point	1	7	200,000 TL

The fees and taxes that should not be charged according to Article 16 of the Implementing Regulation of Law no. 6306 are as follows:

- Notary Fee
- Land Registry and Cadastral Fees
- Fees Received by Municipalities
- All fees such as Stamp Tax, Inheritance Tax, Revolving Fund Fee and Banking and Insurance Transactions Tax taken by institutions and organizations under the name of revolving fund fee.

4.3.2 Green mortgage approaches in Turkey

Green Finance is an important and developing trend that is increasing investments into environmentally and socially responsible projects while reducing financial risk to those lending for those projects. This concept creates a tremendous opportunity to positively transform the health and environmental performance, quality, comfort and financial viability of Europe's new and existing housing stock.

SMARTER Finance for Families is a Horizon 2020 project to implement ambitious yet practical Green Homes & Green Mortgage programs in 12 European countries that includes the collaboration and

participation of 17 expert green building, green energy, research and other organizations. Organizations from Belgium, Bosnia-Herzegovina, Bulgaria, Czech Republic, Denmark, Georgia, Greece, Ireland, Italy, Poland, Romania, Slovakia and Ukraine are participating in this comprehensive project. Turkey is also part of this Project (www.surdurulebilirkonut.com) [79].

Turkey's first green mortgage-covered bond has been launched by Garanti Bank in cooperation with the EBRD and IFC, delivering $150 million in green financing for energy efficient property purchases. The Green Mortgage program was prepared considering the importance of urban transformation for Turkey, which is located in an earthquake zone and needs to renovate a large part of its buildings, and the importance of energy efficiency in the renovation process of buildings and the transformation of new buildings into green buildings. In this program in addition to making the interest rates advantageous, credit 50% discount was applied in the allocation fee. Customers who prefer to buy houses with "Energy Identity Certificate" class A or B and obtain the document benefit from the Green Home Loan. Apart from Garanti Mortgage, Vakıfbank and Halkbank, as public banks in Turkey, launched their green mortgage programs for eligible green homes projects. Despite the fact that the green banks mean are only energy efficient projects with EPC ratings i.e. A and B, in the long run, they may change the definition to describe whole building design not only energy efficiency.

4.3.3 Budget finance with bond Issues and green, social and sustainable bonds

4.3.3.1 Budget financing with bond issuance

Bond is a written promissory note issued in the capital markets in order to borrow money in order to meet the financing needs of state or corporate enterprises, which can yield interest at various rates in certain periods. Coupon is a security that is based on the payment of the coupon (interest) during the payment periods and the principal when due, by the debtor (the issuer) to the bond holder (investor).

Government Domestic Debt Securities (GDDS) can be issued in domestic markets by the Ministry of Treasury and Finance on behalf of the Republic of Turkey, based on the current year's budget law, for the purpose of financing budget deficits and the public, as well as foreign debt instruments (Eurobond) in foreign currencies in international capital markets.

Bonds issued in international capital markets and project loans received from International Financial Institutions (World Bank, European Investment Bank, etc.) are also important, especially in terms of providing FC financing to Turkey. Bond is a budget financing instrument and differs from project loans. Although both debt instruments have a certain maturity and interest/coupon rate, the most significant differences between them are as follows:

- While the amount provided by the project loan is used to finance a specific project, the amount provided by the bond issuance can be used to finance any expenditure to be made from the general budget.
- While the repayments of the project loan are made with the revenues generated by the project in question, the bond repayments are made from the general budget.
- While the repayment of the project loan is in the form of paying the sum of the principal and interest in equal installments at certain intervals (monthly, semi-annually, annually, etc.), the

repayment of the bond is in certain periods (semi-annually, annually, etc.) only by paying the coupon and at the end of the maturity. in the form of repayment of the principal.

- While the financial conditions of the project loan are determined as a result of the negotiations of the parties, the financial conditions of the bond are determined according to the market conditions. In project loans, financing can be provided by International Financial Institutions for certain sectors/projects at much more favorable terms than market conditions. The financial conditions of the bonds issued in international capital markets on behalf of Turkey by the Ministry of Treasury and Finance vary according to the global financial conditions at the time of issue and Turkey's credit risk.

4.3.3.2 Green, social and sustainable bond market

In the bond market, as in other markets, new debt instruments are developed for changing demands over time. With the importance of sustainable investment in the early 2000s, Environmental, Social and Governance (ESG) criteria began to be effective in investment decisions, and the ESG debt instruments market was formed within this framework. The main debt instruments in the bond leg of the ESG market are green bonds, social bonds and sustainable bonds.

Green bonds are bonds issued to finance projects and/or expenditures aimed at creating positive effects on the environment and climate. Green bonds were started to be issued for the first time by International Financial Institutions in 2007-2008, and these bonds have started to be more popular since 2013.

Social bonds aim to provide the necessary capital from investors to fund a social program or project. Considering the issuances realized in 2020, it is seen that the social bond issuances, which were realized in very limited volumes in the previous years, have caught up with the green bond issuances with a great increase. For example, the European Union (EU) issued a social bond of 17 billion Euros on 20 October 2020 to finance social supports (employment, etc.) to be provided within the scope of the fight against COVID-19, and the said bond received a record high demand from investors [80].

Sustainable bonds are debt instruments used to finance green and social projects/expenditures. In other words, it is the type of bond in which green and social bonds are issued together. In 2020, with the effects of the COVID-19 pandemic, sustainable development has become the focus of many investors, and thus the sustainable bond market has grown significantly.

Increasing sensitivity and awareness among investors, especially on climate change, in international markets, causes many savings fund managers to direct their savings to investment/saving tools that will contribute to the fight against climate change, reducing carbon footprint or social development projects. Therefore, the strong demand from investors in this direction gave a strong impetus to the development of the sustainable bond market in 2020. While there was a slowdown in standard borrowing activities due to the impact of the COVID-19 pandemic, the sustainable bond and loan market continued to grow.

Many international institutions, especially the EU, the EU Commission and the European Central Bank, include policies supporting green and social bonds in their agendas. Green bond purchases, including the asset purchase strategies of Central Banks, especially by investors/funds/banks

looking for alternative investment vehicles to the bonds of companies with high carbon emissions and using intense fossil fuels, have increased visibly in 2020, and are sustainable in 2021 and beyond. The bond market is expected to maintain its momentum.

Sustainable bond developments in question are important not only for institutional structures, but also for countries. Countries such as the United Kingdom, China, and Saudi Arabia, especially EU countries, quickly include project/program expenditures that will constitute a framework for issuing green or sustainable bonds into their budget items. It also begins to take steps to reorganize public expenditures in areas such as investment and financing decisions, saving habits, determining production and trade standards, the future of climate change projects, afforestation, forestry and supporting village life. Program targets such as reducing the carbon footprint to zero, determining production and trade standards, and digitalization are also included in the country agendas one by one.

In addition to the above, the Ministry of Treasury and Finance announced that it has prepared a framework document on sustainable bond issuance in its first quarter public finance report. Thus, it is thought that the Ministry may make its first issuance before the end of the year, depending on the market conditions.

4.4 Housing Programmes Targeting Minorities - Affordable Housing

4.4.1 The National Housing Development Administration of Turkey (TOKI)

The National Housing Development Administration of Turkey (TOKI) is the primary public institution in Turkey's housing sector to improve housing supply for low-to-middle-income people. TOKI has based its strategy on the fact that existing slums will expand and new slums will emerge. As the world becomes more urbanized, many families will have few options but to reside in slums, which will contribute to a variety of issues such as urban exclusion, poverty, environmental degradation, and the depletion of natural resources. In this context, TOKI's main objectives are as follows:

- Develop a blueprint for high-quality, low-cost homes
- Avoiding low-quality materials from being used in the construction of low-margin houses that can be resulted in real estate speculation
- Increasing the housing production in regions in Turkey where the private sector does not operate
- Providing low- and middle-income groups with the necessary opportunities to finance their own homes
- Provide rural housing options to reduce the demand on migration to metropolitan regions
- Development of urban transformation projects in cooperation with local governments
- Generating financial opportunities for social housing initiatives that creative income-sharing projects with the business sector.

TOKI plans to meet between 5% and 10% of Turkey's housing demand by developing low- and middle-income housing on TOKI-owned land. Social housing beneficiaries make a down payment and enter into a loan agreement with a bank, which has low interest rates and longer payback

terms. TOKI has also been working on slum upgrading since 2003. The strategies used are temporary resettlement of occupants, followed by resettlement in newly built houses, or resettlement with the site given to TOKI for development. Another strategy of TOKI is the 'Revenue-Sharing model', a type of project in which private developers re-invest in low-income projects with certain profit rates on the land they took from TOKI.

As stated in the news published on TOKI's official website, 11 million 320 thousand residences were built in 1 million 173 thousand buildings in 2003-2019 [81]. In the past nine years, the transformation of 2.5 million residences has been completed with urban transformation projects. Within the scope of the ongoing works for 258 thousand residences with an investment cost of 30 billion TL in 122 projects carried out in 61 provinces for the purpose of urban transformation, it has been reported that 10 thousand residences have been delivered, 63 thousand residences are under construction, and the remaining ones are at the project stage.

Financial constraints and affordability

Although the affordable housing strategy is implemented, TOKI housing is out of reach for many low- and even middle-income families. The most significant impediments to the affordable housing strategy are the high unit costs and the lack of financing options available to consumers. According to Habitat International [82], the problem in Turkey is not so much a lack of affordable housing as it is a lack of affordable house loans. Furthermore, concerns have also been raised about who benefits from the implicit subsidies. It indicates that the majority of those who obtain housing are middle-income workers and public servants rather than the truly economically disadvantaged people. Similarly, eviction and resettlement of slums on development sites appear to be problematic. The Advisory Group on Forced Evictions [83] reported during a mission in Istanbul, 2009 that forced evictions to the city, citing significant population growth, social inequities, and a desire to transform Istanbul into a "Global First Class City."

As of September 1, 2016, 43.14% of the social housing projects carried out by TOKI consists of low- and middle-income groups. 20.61% of the projects (lowest 20%-40% income bracket) are projects for the lower-income group. The monthly household income of the applicants is expected to be at most 3,200 TL in the applications for low-income group residences. The income limit has been determined as 3.700 TL for Istanbul [84].

TOKI's experience in Turkey highlights the necessity of affordable and readily available housing finance. It is not enough to simply build finished housing units on a large scale; they must be affordable and have appropriate financing mechanisms to allow households access to housing units. Turkey, like many other Asian countries, urgently needs enhanced housing finance markets to promote house production for the middle- and lower-income groups. If the situation continues like this, private developers will stop building houses they can't sell. To promote housing construction, predictable sources of finance for potential homebuyers are required for all income groups; however, flexible finance alternatives for the low-income population are particularly vital. Furthermore, Turkey exemplifies the difficulties of governments providing direct housing provision. To reach low-income households, targeted and purposeful measures must be applied; otherwise, direct housing support would not reach low-income households, and the government will finish building and subsidizing houses for the middle- and upper-income groups. Turkey needs to incentivize green and affordable housing and there are many best practices as public-private

partnership models and public procurement norms. (Menes, 2020). For example Kenya's Department of Housing and Urban Development is providing free land o developers of affordable housing wih green criteria. That kind of approach would result in tremendous benefits to homeowners.

5. CONCLUSION AND RECOMMENDATIONS

The circular economy, one that operates through 'designing out waste and pollution, keeping products and materials in use, and regenerating natural systems' as defined by Ellen MacArthur Foundation. It is becoming increasingly commonplace and in its simplest form it describes how products and materials can continue to be used again once they have reached the end of their 'first' life; as such they are no longer viewed as a waste but as a resource. Materials therefore move in loops within the activities of reuse, remanufacture and recycling. The circular economy is the opposite of the 'take-make-dispose' linear economy model. A key principle is that materials should be utilised at the highest value possible, avoiding down-cycling. However, currently, much of the waste the construction sector produces is down-cycled. Achieving more value from products, can also be achieved through increasing a product's longevity and ensuring it performs in-use, so it is not replaced earlier than required. This is also highly applicable for buildings which can be adapted and refurbished and therefore continue to be used rather than demolished.

To enable products and buildings to become more circular, it is important to consider how they are designed. Important considerations for products include designing for disassembly, the potential for standardisation and modularity, the use of secondary materials, avoiding the use of hazardous materials and composite materials which may hinder reuse and recycling opportunities. The actual approach will depend on the type of product, for example a high-value, shorter lived product such as M&E equipment may be more suitable for reuse, than a lower-value, longer-lived product such as concrete. Architects have a key role in specifying; for example, requiring products that are either reclaimed or have recycled content within and products that can be reused and/or recycled at the end-of-life.

Underpinning the move to a circular economy is the need for more data, such as the material composition of products, the residual value, test results and warranties and in-use data where relevant, which may reduce any potential risk from reuse. This data is starting to be collected through the development of material passports. At the building level, BIM is a means to also collect this product data as well as information on disassembly. There is no legislation or standard yet for circular economy in buildings.

The circular economy, one that operates through 'designing out waste and pollution, keeping products and materials in use, and regenerating natural systems'[82] is fast rising up the business and political agenda. However, few construction clients are yet specifying zero waste in their procurement tenders or project briefs. Despite recent growth rates, offsite manufacturing - which can result in significant waste reductions on site - still represents a very small proportion of the market. That is partly because it is a challenge to convert the circular economy from a neat theory into replicable practice.

The Circular Economy Strategy aims to minimize material waste and maximize benefits to local community members. Successful implementation of this approach requires input from everyone involved; project management team, designers, contractors, supply chain partners, community members and local businesses. It is recognized that there are strong links between the Circular

Economy, Social Value and return on investment and therefore all project partners are expected to contribute to the implementation of Circular Economy principles. In addition, existing standards are often not enforced or adhered to, and financing options are rare, especially for low-income groups. Through the comprehensive analysis performed, material issues that have hitherto received little attention in the current SCP discussion on sustainable housing, but which are critical for promoting sustainable development along the entire building value chain, have been identified.

The aim of this study is to analyze the current situation of the value chain and the efforts needs, in particular at the policy level, to adopt a housing, construction and demolition approach that is environmentally friendly and in line with SCP models. In the report, first of all, the current situation of Turkey was evaluated. The increasing population and the arrival of refugees in addition to this population and Turkey's refugee problem are discussed. This situation brought along the need for shelter, which is one of the most important needs of humanity, and there has been an increase in the number of buildings that do not meet the requirements of the mass housing law and earthquake regulations in most cities. In addition, the number of buildings in Turkey, the number of houses and their ratios to the population are given under the title of changing lifestyle.. Due to rapid urban growth and development, cities have become increasingly unsustainable, vulnerable and unsafe. Therefore, it has been crucial to achieve sustainability and resilience for current and future citizens. And this has made urban transformation necessary. Three implementation tools are defined in the relevant law;

i. Implementation in risky areas
ii. Implementation for risky buildings and
iii. Implementation in the reserve area for constructions

Afterwards, Turkey's economy and the construction sector were evaluated. While Turkey was struggling with the negative effects of the epidemic in the economy in 2020, on the other hand, its financial fragility increased significantly with the expansionary policies implemented.

Although it closed the year with growth, macro balances deteriorated and the Turkish Lira depreciated significantly. In the epidemic year of 2020, 1.8% growth was achieved in the economy. However, despite this, the construction sector shrank by 3.5% in 2020. The shrinkage was caused by the problems experienced in the construction sector and related to its own dynamics. Total construction expenditures increased by 8.1% in 2020 and amounted to 628.2 billion TL. In 2020, house sales increased by 11.2% compared to 2019 and amounted to 1,499,316 units. Housing sales to foreigners decreased by 10.3% in 2020 and amounted to 40,812. Prices of construction materials increased by 30.48% in 2020. In 2019, construction materials prices increased by 5.12% annually. While the share of the construction sector in national income has increased since 2010, a significant decrease was experienced in the share in 2018 for the first time. The share of the construction sector in GDP decreased to 7.2%. The contraction continued in 2019 and the share of the construction sector decreased to 6.5%. The decrease in the share taken from GDP in 2020 lasted and was realized as 6.2%.

Then, the construction and demolition waste part was evaluated and its economic and environmental importance was revealed. In the past, it was not possible to talk about a concept such as the life cycle of structures. The buildings were demolished at the end of their economic

life, and the remaining wastes were either left idle or used as filling material. In the last 20-30 years, many important earthquakes have occurred in Turkey and serious loss of life and property has been experienced in these earthquakes. It is clearly seen that the demolition wastes that occur after natural disasters and the great damage they cause to the environment. Due to today's social and economic factors, it becomes inevitable to use these debris wastes to create new products. Due to the increase in population in Turkey, construction wastes as well as especially demolition wastes have increased. Construction waste has become a problem that needs attention and an urgent solution. The sources of construction and demolition waste are given and the cyclical processes of an ideal, sustainable construction industry are explained.

Waste management pyramid has been created and includes the issues that should be prioritized from the bottom up. Considering from the bottom up, the waste management pyramid should be in the first place to prevent the emergence of waste, if this cannot be avoided, waste should be minimized in the second place, that is, waste should be reduced and kept to a minimum. After this sequence comes the reuse of waste. If it is not possible to reuse, it is aimed to recover the material by recycling using energy. Disposal management, which is defined as storage and incineration, which ranks last, should be applied when the above-mentioned methods are inconclusive.

The building demolition regulation in Turkey is included and information about the building to be demolished, demolition technique and its effects are explained. In addition to the demolition plan; waste management plan, measures to be taken to control dust emission, selective demolition, detection and removal of asbestos and other hazardous wastes during demolition, noise and vibration management are given.

Then in energy consumption and production part, within the framework of international climate negotiations, Turkey presented its climate targets in 2015 through the National Intent for Contribution (INDC). In this section, a summary of the energy efficiency policies that contribute to Turkey's climate goals is given and an overview of the country's key climate policy documents is presented.

- National Climate Change Strategy Document (2010)
- National Climate Change Action Plan (2010)
- National Climate Change Adaptation Strategy and Action Plan (2011)
- Tenth Five-Year Development Plan (2014)
- National Energy Efficiency Action Plan (2017-2023)

The framework regulating the implementation of energy efficiency measures is set in the Energy Efficiency Law (EVK). With the EVK, which entered into force in 2007, it is aimed to reduce energy intensity and general energy costs in the economy. Moreover, this law provides a basis for receiving subsidies for the implementation of energy efficiency projects in the electricity and industrial sectors. This law forms the basis for the following regulations:

- Energy Performance Regulation in Buildings (2008)
- Regulation on Increasing Efficiency in the Use of Energy Resources and Energy (2011)
- Regulation on Environmentally Responsible Design of Energy-Related Products (2010)

The study then focuses on the analysis of the building lifecycle, identifying trends and material issues for each stage of the building value chain, with a particular focus on:

i. Policy environment,
ii. Standards, guidelines and
iii. Access to finance.

In this context, it follows the different life cycle stages of buildings, namely material production, design and manufacturing, construction, use and recycling. Research has been conducted on the country's specific laws and regulations pertaining to different stages of the building's value chain, allowing for a better understanding of these issues in the legal situation regarding SCP in sustainable housing. Other focus areas focus on standards, guidelines and rating systems, energy building codes, green building rating systems, standards and labelling schemes, and other requirements of the country for the building industry. Finally, the focus is on accessing finance, designing financial support opportunities for the implementation of measures across the value chain.

The construction industry is responsible for approximately 40% of global consumption due to the dominance of fossil fuels, primarily coal. CO_2 emissions from fossil fuels and raw material extraction processes make the industrial sector the second largest emitter of 8.7 Gt of CO_2 today, after electricity generation. The CO_2 emission amounts in the iron and steel industry are given, it is explained that for each ton of steel produced, an average of 1.8 tons of CO_2 is emitted, which corresponds to 3.3 Gt of CO_2 per year. The same process was carried out for cement production, and it was stated that one ton of cement production produces 0.6 tons of CO_2 on average, and about 8% of global CO_2 emissions originate from cement production.

A table showing the map of Turkey's regulatory, economic, communicative and voluntary policy instruments has been prepared. Identified based on information obtained from stakeholders through workshops and online surveys, as well as hotspots of the national housing and construction sector value chain (i.e. environmental issues with the highest priority to be addressed).

Then, general standards related to environmental management of a building's value chain are given and these are explained in detail. These; TS EN ISO 14001, TS EN ISO 14040, TS EN ISO 14044, TS EN ISO 12270, TS EN ISO 14067, TS EN ISO 21930, TS EN ISO 14006, TS EN ISO 16813, TS EN ISO 15392, TS EN ISO 21931- 1, TS EN ISO 21929-1.

The ideal roadmap for the implementation of circular economy is increasing the number of green buildings. Despite the fact that Turkey’s construction market met with the certification systems since 2007, the rise of the numbers are minimal. The reason for this can be attributed to lack of incentives in the market as well as the high cost of international certification. Turkey’s local system can be a saver for those builders who can nor afford the high cost of certification especially if it is supported by government incentives.

Recommended Actions/Findings for Roadmap Planning

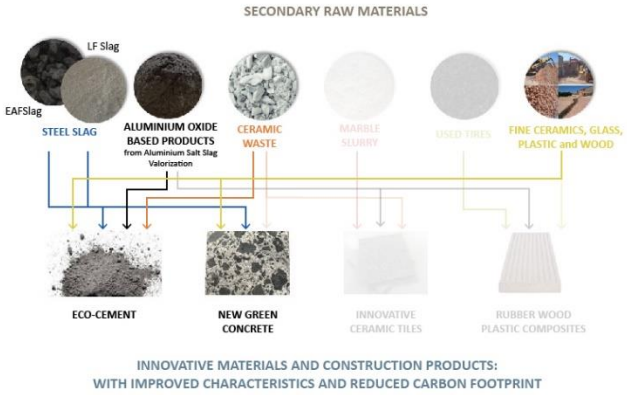
Within the scope of this study, the following Circular Economy approaches can be suggested in Turkey:

- Policies that promote sustainable practices during the design and construction phase, such as mandatory requirements for building components
- Waste and recycling concepts such as digital platforms to reuse all kinds of waste materials, smart collection points/recycling stations for construction and household waste, waste-to-energy approaches
- Energy building codes, green building rating systems and green building materials certification for high-level sustainability practices in the residential sector; in particular to consider effective measures for enforcement, compliance and enforcement
- Eco-friendly materials and technologies for material production and construction, such as fly ash, manufactured sand and semi-open mining method for limestone production
- LCA, environmental criteria, etc. for architects and developers, guides/directories to compare products using
- Concessional financing mechanisms for green construction such as soft loans, grants, revolving funds, energy performance contracts; combination of financial incentives with building standards
- Separation of waste material streams to maximize recycling value
- Extensive use of recycled and natural materials that can be recycled at the end of their life
- Developing a waste design strategy by working with the design team
- Identifying a network of local businesses and community groups to maximize the reuse and recycling of construction and demolition waste
- Ensure proper storage is provided for waste separation in buildings and homes and agree on a waste collection and service strategy

6. BEST PRACTICE EXAMPLES FROM TURKEY AND AROUND THE WORLD

Example 1: Fostering Industrial Symbiosis for a Sustainable Resource Intensive Industry across the extended Construction Value Chain (FISSAC) https://fissacproject.eu/en/case-study-2/

Autoclaved aerated concrete (AAC) wall blocks with standard dimensions (Length: 60 cm, width: 25 cm, thickness: 15 cm) were produced in G2/350 class by using ceramic waste, electric arc furnace (EAF) slag and ladle furnace slag (LF) as secondary raw materials supplied by regional providers (Çanakkale Ceramic and Ekinciler Iron and Steelout the consortium) in order to ensure the replicability. The objective of the Case Study 2 of FISSAC is to manufacture Autoclaved aerated concrete (AAC) blocks at industrial scale, with standard dimensions in order to build a wall (360 units). The project runs from September 2015 until February 2020 in Izmir, Turkey.



AAC is manufactured in six steps:

1) Preparation of raw materials.
2) Mixing.
3) Pre-curing.
4) Cutting.
5) Autoclave curing.
6) Packing.
7) On site Installation.

The FISSAC project involves stakeholders at all levels of the construction and demolition value chain to develop a methodology and software platform, to facilitate information exchange, that can support industrial symbiosis networks and replicate pilot schemes at local and regional levels. The model will be based on three sustainability pillars:

- Environmental (with a life cycle approach)
- Economic
- Social (taking into consideration stakeholder engagement and impact on society).

The ambition of the project is the model that was created can be replicated in other regions and other value chain scenarios. FISSAC aims to demonstrate the effectiveness of the processes, services, and products at different levels.

Example 2: TECLA https://buildbetternow.co/exhibition/

TECLA (Technology + Clay), designed by Italy's leading architecture studio Mario Cucinella Architects (MC A), is the first 3D printed eco-sustainable housing made entirely of raw earth. It has been chosen as one of seventeen building projects from around the world showcasing pioneering zero carbon construction for Build Better Now, a virtual exhibition at the COP26 Built Environment Pavilion.

TECLA was selected for the exhibition as a globally important exemplar of how to address the reduction of the construction industry's environmental impact which is significant as buildings currently consume over a third of energy produced and are responsible for 40 per cent of carbon emissions.

TECLA is not only a key creative contribution from the built environment sector but also an impactful illustration of the UK-Italy COP26 partnership. It is a truly ground-breaking step towards rethinking how ancient, natural and abundant building materials can be made to work using the latest technologies. TECLA houses are created entirely from recyclable materials, mostly soil from the earth around and beneath them. A team of just two people is needed to work on the 3D printed structures that consume an average of six kilowatts of energy during the construction process. The time to print a footprint of 60 sqm takes only 200 hours, so the model has real potential for emergency housing as well. TECLA was conceived in partnership with WASP (World's Advanced Saving Project) who are global leaders in 3D printing technology.

Mario Cucinella says, "TECLA is an innovative habitat prototype that integrates research into vernacular construction practices, climate studies, and bioclimatic principles, together with the use of natural and local materials finding an answer for the Earth in the use of earth."

Example 3: Holistic Innovative Solutions for an Efficient Recycling and Recovery of Valuable Raw Materials from Complex Construction and Demolition Waste (HISER) http://hiserproject.eu/

The main objective in HISER is to develop and demonstrate novel cost-effective holistic solutions (technological and non-technological) for a higher recovery of raw materials from ever more complex construction and demolition waste (C&DW) by considering circular economy approaches throughout the building value chain (from End-of-Life Buildings to New Buildings).
Within the HISER project it has been demonstrated in Hoorn, the Netherlands at industrial scale (100 t/h) that Advanced Dry Recovery (ADR) technology is effective in producing high-quality aggregates from concrete waste which is the result of a detailed design and built engineering.
One of the main environmental challenges in the construction industry is a strong social force to decrease the bulk transport of the building materials in urban environments. Considering this fact, applying more in situ recycling technologies for C&DW could be the key. To achieve this goal, a new low-cost classification technology, called ADR has been developed.
Advanced Dry Recovery (ADR) technology is effective in producing high-quality aggregates from concrete waste. The advantage of ADR is also the fact that it can be applied on site of demolition works.

ADR performs purely mechanically and in the moist state, i.e. without prior drying or wet screening. It uses kinetic energy to break the bonds that are formed by moisture and fine particles and can classify materials almost independent of their moisture content. This choice reduces process complexity and avoids problems with dust or sludge. ADR is applied to remove the fines and light contaminants with an adjustable cut-point of between 1 and 4 mm for mineral particles. ADR separation has the effect that the aggregate is concentrated into a coarse aggregate product and a fine fraction which includes the cement paste and contaminants such as wood, plastics and foams.
With this technology, 3 material fractions can be obtained: 1) a cement-rich fine fraction (<1 mm); 2) an intermediate sand fraction (1-4 mm) and 3) a coarse high-grade concrete aggregate fraction. These coarse aggregates are used in the production of high-grade structural concrete.

Example 4: Circular Retrofit LAB (CRL) https://www.bamb2020.eu/

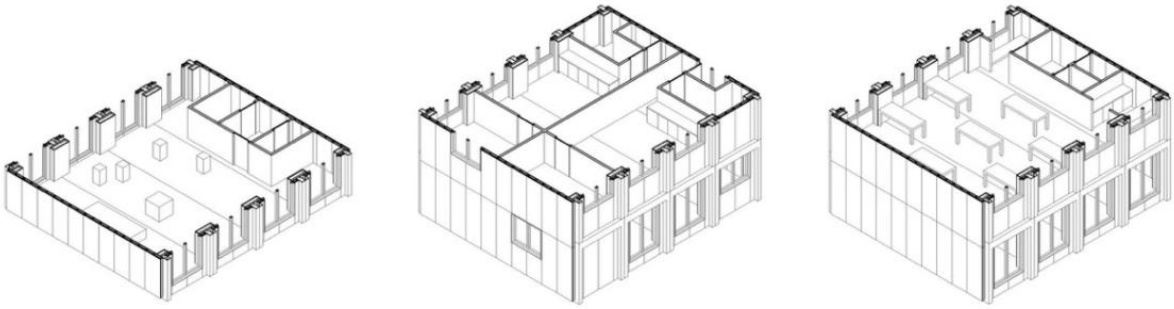
FULL RENOVATION OF PREFABRICATED STUDENT HOUSING MODULES FOR MULTIPLE USES

The circular refurbishment tested dismountable, adaptable and reusable solutions for maximizing waste reduction. The pilot developed a co-creative process all along the (re) design, (re) build, (re)use, repurpose or dismantling phases. This necessitated a close collaboration with all the value network stakeholders and future users in the early development phase.

The university organized several round tables with industry stakeholders where design solutions were debated and improved, as well as hands-on workshops with students where solutions were tested.

The CRL pilot project applied a step-by-step innovation strategy based on products available on the market. This strategy thus incrementally improves products that are already technically and commercially viable.

Selected products, such as partition walls, had a high initial potential to reach circularity objectives. Together with the manufacturers, the team sought to add new product capabilities, such as new functionality (ex. from a facility partition wall to a living room separation), reversible connections, etc.



The development of the Circular Retrofit Lab as an experimental lab for innovative reversible and reusable building solutions creates new opportunities for collaborations between the academic sector, the research sector and private partners.

These collaborations are an added value to the pilot's objectives and ambitions. The expertise of private partners of the construction sector enabled to set larger goals and to integrate findings from the current building sector. The contact and collaboration with industrial partners also exposed new unknown reversible building systems and new opportunities.

Example 5: Tracking system for construction and demolition waste (TRACIMAT) https://www.tracimat.be/

TRACIMAT, a non-profit construction and demolition waste (CDW) management organization was founded by the HISER partner - the Flemish Construction Confederation (VCB), together with the Federation of Producers of Recycling Granulates (FPRG), the Belgian Demolition Association (CASO) and the Organization representing the engineering and consultancy companies (ORI). Tracimat certifies the selective demolition, thereby assuring the processing company of the quality of the construction and demolition waste.

Through an elaborate traceability system Tracimat monitors and supervises the selective demolition process. The tracking procedure starts with an identification of the materials that come free during the deconstruction and demolition of the building, and follows up on what happens with these materials during the selective demolition works. Environmental risks during deconstruction and demolition will consequently be limited, hazardous waste materials will be correctly and –more importantly– safely removed, which will result in purer waste streams.

Based on intermediate inspections at demolition sites and desk control of the discharge certificates/processing documents, Tracimat will check if its traceability system has been applied correctly and will deliver the necessary documents and certificates.

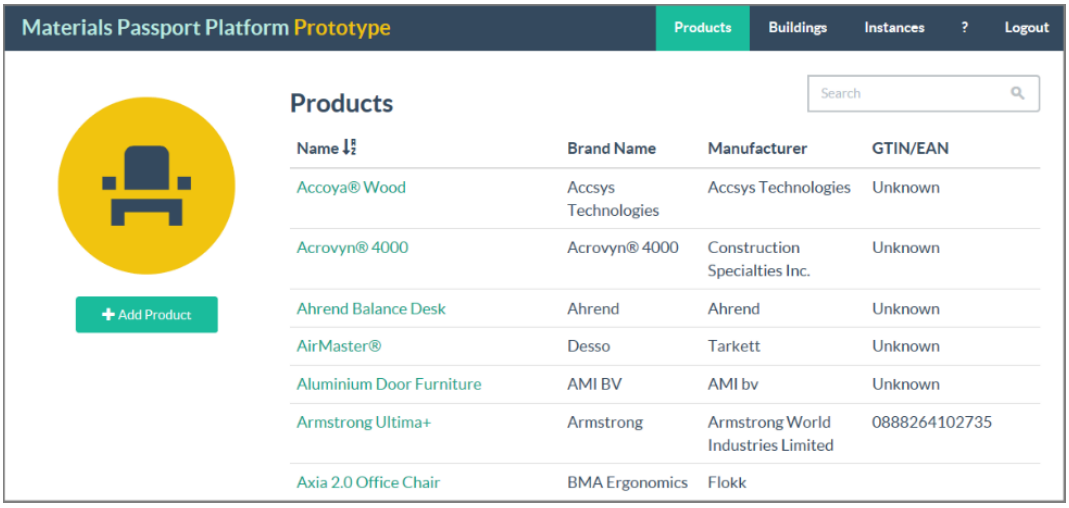
In order to enhance the quality of recycled aggregates, a more pure stony fraction is needed at the gate of the producers of recycled aggregates. Hence the necessity for a traceability system that guarantees the selective collection of stony waste, that traces the waste from its point of origin down to the gate of the processing company, and as such assures the processing company of the environmental quality of the input (selectively collected) stony waste.

Purer waste streams will not only lead to high-quality recycled aggregates, but will also create a greater upcycling potential. This in turn opens up opportunities for incorporation into more high-quality applications than today's current practice. As the demolition waste comes with a certificate issued by a recognized and independent organization, this will enhance trust, not only in the quality of the waste material, but also in the quality of the demolishing company. Furthermore, it will boost trust in the recycled product, resulting in an improved and more widespread marketing of recycled aggregates.

Tracimat is incorporated in the Flemish environmental legislation (Vlarema) and operates in feedback with the Common Regulation for Recycled Aggregates (ER), allowing it to trace construction and demolition materials down to the producer of recycled aggregates. In the ER, the regulation which establishes the requirements that need to be met by crushers and aggregates in Flanders, a significant amendment has been introduced which requires crushers to distinguish materials with a low environmental risk (LMRP) from materials with a high environmental risk (HMRP) at the time of acceptance. The ER also provides that LMRP streams can be processed more cheaply than HMRP streams. Demolition waste from a selective demolition monitored and certified by Tracimat can be accepted as low environmental risk.

Example 6: Material Passports https://www.bamb2020.eu/

Material Passports provide the necessary information about materials, products and components for a circular use of building materials, products and components whilst supporting reversible design.
The mission of BAMB is to enable the shift to a circular building sector. Effective recovery and reuse of components, products or materials in buildings requires that the right information is easily accessible. This information is also crucial for choosing materials, products and components that later can be reused.
The electronic Materials Passports developed in BAMB aim to be a one stop shop for material information. Materials Passports developed in BAMB are sets of data describing defined characteristics of materials in products that give them value for recovery and reuse.



BAMB Materials Passports aim to:

- Increase the value or keep the value of materials, products and components over time
- Create incentives for suppliers to produce healthy, sustainable and circular materials/building products
- Support materials choices in “Reversible Building Design” projects,
- Make it easier for developers, managers and renovators to choose healthy, sustainable and circular building materials,
- Facilitate reversed logistics and take back of products, materials and components.

Within the project more than 300 Materials Passports for various products, components or materials are developed together with a software solution. The software will facilitate the appropriate accessibility of information for different stakeholders at specific stages in the process.
Different Materials Passports might take into account different levels of abstraction, ranging from materials and components of products and systems making up a building, to the building stock for a certain region. For materials, passports can define their value for recovery, while for products and systems they can include design-for-disassembly aspects and specifics of a single product or system, for example, how products relate to a building – location, connections, etc. – is essential to understanding their reuse potential.
Information requirements span the complete lifecycle of a building and the products and materials inside it. These include physical details, ranging from tensile strength for steel beams to ease of maintenance of flooring or doors; biological information on treatments or biodegradability; and chemical properties of materials used, together with process-related information on the design and production of building products, the building construction process, use phase aspects and dismantling approaches.

Example 7: Reuse of construction materials in a temporary construction site (London 2012 Olympic Park)

https://www.bioregional.com/resources/how-reclaimed-building-materials-were-used-for-the-london-olympic-park

The Olympic Delivery Authority (ODA) set demanding sustainability targets for the Olympic Park demolition, including an overall target of at least 90% by weight of demolition material to be reused or recycled. The ODA's overall target was exceeded by 8.5%, with less than 7,000 tonnes landfilled. The key lessons learned from this project include:

1. Undertake a pre-demolition audit and include a reclamation survey.
2. Use this data, and consultations with reclamation specialists, to set headline targets for reuse and reclamation for key materials before issuing tenders, ideally linked to carbon targets.
3. Include clear reclamation and reuse targets as separate and additional to the overall recycling target and state them clearly in the tendering process and in contracts. Make explicit the responsibility for demolition.
4. Incentivise use of specialist contractors and achieving of reuse targets.
5. Require the project to measure the total carbon impact of the demolition process and the new construction on the site.
6. Require reuse to be entered into a materials database and included in Site Waste Management Plans.
7. Design team workshops and communication with other local regeneration projects are recommended; regular site visits are vital.
8. Include use of site-won reused materials in the design and construction contracts for the new build.
9. Sufficient storage space is vital to enable reuse of construction products.

Example 8: Design considerations for circular buildings https://www.futurebuilt.no/

Embodied carbon of a building's materials is largely decided by design decisions and is later much more difficult to avoid. Up to now, buildings have been material-consumers rather than material stocks, and are conventionally built that way. If the use of materials and products that can be recycled is not taken into account at the planning stage of a renovation or a new building, this cannot be made up for. Retrofitting to improve resource efficiency is not feasible. Optimized use of space and occupancy efficiency as design considerations can avoid the material, cost and carbon for underutilized spaces. Consider setting carbon as a criterion for design competitions or even incrementally introducing emissions limits for construction projects city-wide, by setting maximum carbon emissions and/or embodied carbon per square meter (according to building or material type). Further key design considerations for circular buildings are summarized below.

Strategies	Solution/measures
Robust material selection	• Minimize the number of different materials and components • Choose homogeneous materials (mono-materials), where all components consist of the same material • Use **durable** materials that can be reused in several generations of buildings • Avoid the use of substances that are harmful to health and the environment (even if the amount of substances is within permissible limit values), and avoid surface treatments where this is not necessary to reduce wear or degradation of the materials • Use **modular** design, standard dimensions and low complexity of components and building parts
Flexible connections	• Use reversible connections between components and between building parts, e.g. screws and bolts. Avoid welding, glue, putty and sealants / foam • Minimize the number of different connectors, and plan for the use of common tools • Use components and building components with adapted tolerances for repeated disassembly and reassembly • Project the construction systems as independent, and arrange them according to the expected service life of the components
Available information	• Label materials and component types • Mark attachment points and make sure they are visible and accessible • Require a **digital material passport** (to include information about products and materials, including EPD and maintenance advice, as well as information about the building system with disassembly instructions) • The geometry of the building is documented through open BIM
Manufacturer agreements	• Leasing agreements with manufacturer / supplier instead of purchasing, e.g. for lighting, furniture or technology systems • Take back schemes or **extended producer responsibility** with material manufacturer / supplier

Example 9: List of C&D materials that need to be removed from the building before demolition - example of the Austrian standard ÖNORM B3151

https://shop.austrian-standards.at/action/de/public/details/532055/OENORM_B_3151_2014

C&D materials representing or containing dangerous substances:

- Loose artificial mineral fiber (if hazardous)
- Components or parts containing mineral oil (such as an oil tank)
- Smoke detectors with radioactive components
- Industrial smoke stacks (for ex., fireclay boxes, bricks or lining)
- Insulating material made up of components containing Chlorofluorocarbon ((H)CFC) (like sandwich elements)
- Slags (for ex., slags in inserted ceilings)
- Oil-contaminated or otherwise contaminated soils
- Fire debris or otherwise contaminated debris
- Isolations containing polychlorinated biphenyl (PCB)
- Electrical properties or equipment with pollutants (for ex., vapor discharge lamps containing mercury, fluorescent tubes, energy efficient lamps, capacitors containing PCB, other electrical equipment containing PCB, cables containing insulation liquids)
- Cooling liquid and insulations from cooling devices or air-conditioning units containing Chlorofluorocarbon ((H)CFC)
- Materials containing polycyclic aromatic hydrocarbon (PAH) (like tar bitumen, tar board, cork block, slags)
- Components containing or impregnated with salt, oil, tar, phenol (e.g. impregnated wood, cardboard, railway sleepers, masts)
- Material containing asbestos (for ex., asbestos cement, sprayed asbestos, night storage heaters, asbestos flooring)
- Other hazardous materials.

Example 10: Programme for Asbestos Abatement in Poland 2009-2032

https://www.bazaazbestowa.gov.pl/en/about-asbestos/asbestos-in-poland

The aims of the Program for Asbestos Abatement in Poland 2009-2032 are:

1. Removal and disposal of products containing asbestos;
2. Minimizing adverse health effects caused by the presence of asbestos in Poland;
3. Eliminating negative effect of asbestos on the environment.

The program groups together the activities scheduled for the implementation at a central, regional area (or province) and local level in five subject areas:

a. Legislative activities;
b. Education and information activities addressed to children and youth, trainings for employees of government and self-government administrations, development of training materials, promotion of technologies for the destruction of asbestos fibers, organization of national and international trainings, seminars, conferences, congresses and participation therein;
c. Activities related to the removal of asbestos and products containing asbestos from the constructions, public amenities and sites of former asbestos products producers, cleaning the premises, building landfills;
d. Monitoring of the program implementation by means of electronic spatial information system;
e. Activities in the area of exposure assessment and health protection.

Example 11: Wood recycling into wood-based panels www.europanels.org

Wood can be recycled into particle boards. In 2014, the European particle board industry in the EPF member countries consumed 18.5 million tons of wood raw material. The average share of recovered wood was 32%, the other raw material categories being processed round wood (29%) and industrial by-products (39%). Recovered wood continued to be used as the major raw material source in Belgium, Denmark, Italy and the United Kingdom. Austria, Germany, Spain and France also used important quantities of recovered wood for particle board manufacturing, reflecting the encompassing problem of wood availability. Other European countries still use primarily roundwood and industrial residues due to the lack of an efficient collecting system or thanks to less pressure from the incentivized bioenergy sector. The share of CDW in the recovered wood fraction used for panel production is currently rather low but rising with the improvement of appropriate source separation and collection from C&D sites.

Example 12: Circular economy: The Municipality of The Hague, Netherlands https://www.denhaag.nl/

The project that flow from the Green Deal, is the tender for the construction of a waste and recycling center, which was sustainable, partly reused material was used. In using such material, the municipality also wanted to stimulate the center's users to start thinking about the reuse of raw materials.

The construction of the waste and recycling center was awarded according to MEAT (Most Economically Advantageous Tender) using the award criteria of price, design, sustainable material use and action plan. The sort of reused materials in the construction, including their volume percentage and origin, is known exactly per component (roof, façade, walls). The façades are largely constructed from plates from the automotive industry and the sheet piling is also reused. As well as using recycled and reusable materials, the building will also be energy and water neutral.

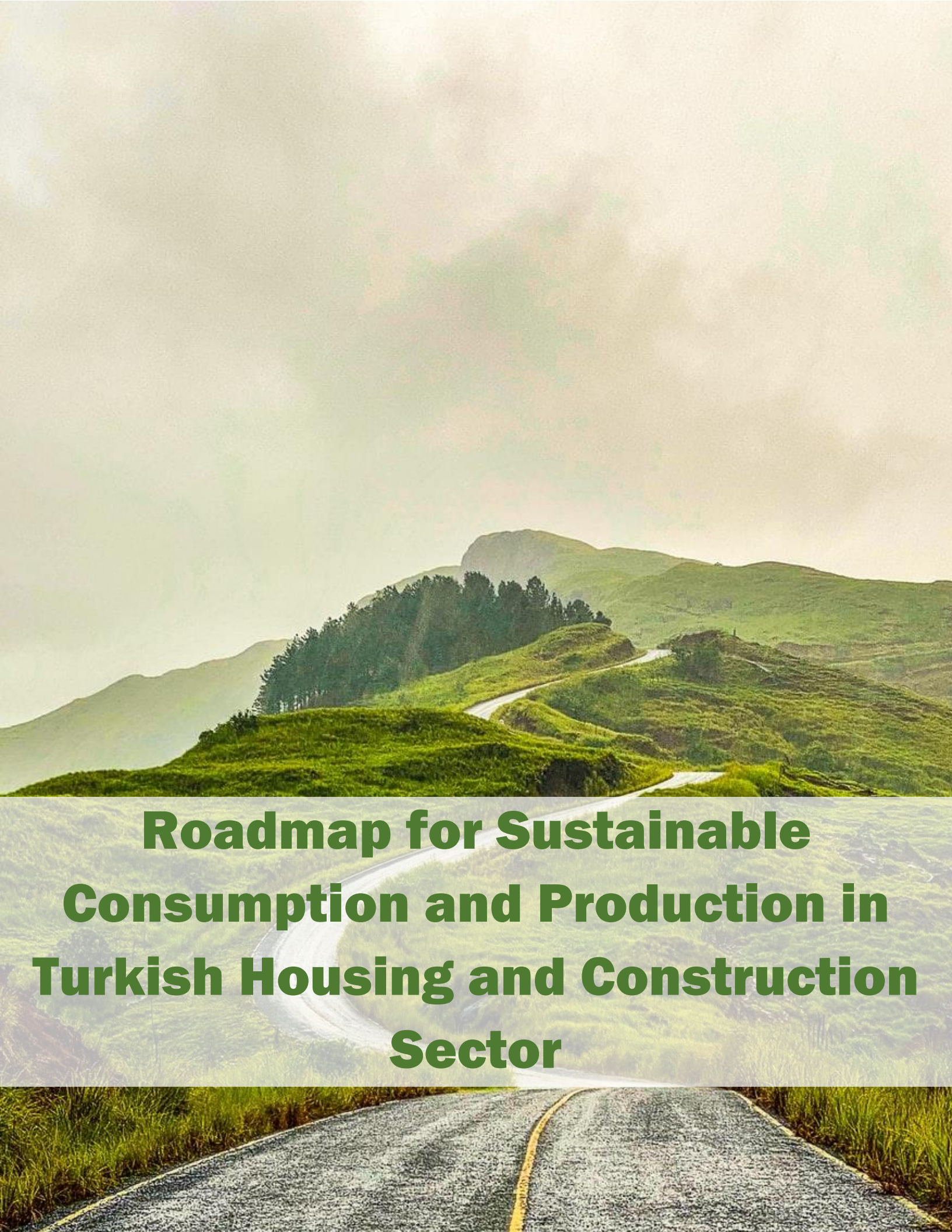
Lessons learned

- Consider the assessment system carefully in advance to prevent that certain aspects influence the score more than intended.
- It is important to know the market possibilities and which parties are interested: factories, retailers, construction or installation companies.
- Assessment method for types of sustainable material was constructed as follows:
    1. Reuse of household waste,
    2. Reused materials,
    3. Renewable materials,
    4. Recycled materials,
    5. Non-renewable materials.
- As yet, a self-sufficient energy supply building is not interesting for the construction market.
- The bar can be raised somewhat regarding sustainable material use, by making a distinction in visible components and non-visible components (e.g. construction and floor) with an adapted rating scale.

Example 13: Erzincan-Çarşı Quarter Urban Renewal Project, Turkey

Erzincan-Çarşı Quarter Urban Renewal Project was developed by Housing Development Administration of Turkey (TOKI) and implemented in cooperation with Erzincan Municipality. The aim of the project, which includes the demolition of the slums in the central district District of Erzincan and the relocation of the beneficiaries to alternative residences built in other part of the city, is replacing the collapsed and illegal construction area with the urban renewal policies.

The Upgrading Project of Erzincan-Çarsı Quarter, one of the first urban upgrading projects of TOKI initiated in 2003, received ''the good practice award'' of the United Nations Human Settlements Programme (UN HABITAT) and the Municipality of Dubai in 2008



Roadmap for Sustainable Consumption and Production in Turkish Housing and Construction Sector

PART B: ROADMAP FOR SUSTAINABLE CONSUMPTION AND PRODUCTION IN TURKISH HOUSING AND CONSTRUCTION SECTOR

1. What do we truly require, and how aware are we?

Continuing its development in every field without slowing down, Turkey also exerts significant efforts to place this development in an environment- and climate-sensitive framework. However, the ever-increasing population, geography surrounded by active faults, and climate-related natural disasters bring a high demand for housing, which creates excellent pressure on the natural and economic resources of the country. Every year more raw materials are extracted, higher energy is consumed, and greenhouse gas emissions are rising all over the world, clearly, the world is depleting and suffering as it happens. At this point, every precaution that can be taken, every step taken, and every action to be taken is the obligation of all humanity, regardless of who it is. Integrating the circular and sustainable economy to live in prosperity within the boundaries set by our planet can only be achieved by smart choices and the proper steps.

There are two essential questions to be addressed in Turkey's transition to a circular and sustainable economy; What are the deadlock points in the current mainstream? What is the most inclusive option to disentangle these points? For the former, many examples can be listed at first glance; in addition to its natural increase, the population increasing with migrant flows, the constant increase in demand for housing and the danger of risky building stock, the production of materials that cause high carbon emissions, energy-inefficient production technologies, and old housing stock, the monitoring of compliance with current legislation, a significant portion of society's unawareness on the point of sustainability. For the latter, however, this is not the case. While the awareness and motivation for the steps to be taken are high, the path to be walked remains uncertain. To overview the current situation, the 2nd Volunteer National Reviews report presented by Turkey at the High Level Political Forum in 2018 can be briefly summarized [88]:

I. For 'SDG 12: Responsible consumption and production', directly related to the sustainable production and consumption approach, only 10% progress has been made.

II. In addition, attention was drawn to the access to indicators, quality, regularity, and priority of the indicators for monitoring the SDGs at the national level, and it was reported that the current situation in this regard is not at the targeted level.

III. The problems in coordination with the international monitoring system were highlighted, it took time to include the indicators submitted or verified by the UN agencies responsible for global indicators (custodian agencies) into the UN SDG database; thus, it has been reported that this situation overshadows the accuracy of the evaluation reports to be prepared with the data to be obtained from this database.

IV. A systematic evaluation process specific to SDGs has not been defined to evaluate progress. Considering the preference to follow the SDGs by reflecting them in development plans, it is reported that the need to strengthen evaluation mechanisms suitable for this structure and national processes continue.

According to the SDG Index [89], an assessment of each country's overall performance in the 17 SDGs and where each objective is given equal weight, Turkey ranks 70th out of 165 countries with a score of 70.4 out of 100. In addition, 2021 SDG dashboards (levels and trends) for OECD countries [89] show that 'Significant challenges remain and data flow cannot be provided' for Turkey within the scope of SDG 12. For 'SDG 13: Climate Action', the indicators for Turkey demonstrate that 'Major challenges remain and actions have decreased'. Besides, policy efforts and commitments on Turkey's transformation into 'Energy Decarbonization and Sustainable Industry' are presented in Table 1.

Table 23. Policy efforts and commitments on Turkey's transformation into Energy Decarbonization and Sustainable Industry [89]

UN Climate Ambition Alliance Signatory[1]	N/A
Policy- or NDC-based commitment to reach net-zero emissions by 2050[2]	N/A
1.5°C Paris-agreement compatible climate action[3]	Critically insufficient
Unconditional fossil fuel subsidies[4]	167

[1]March 2020, UN; [2]March 2020, Energy & Climate Intelligence Unit; [3]November 2020, Climate Action Tracker; [4]USD per capita, April 2021, Energy Policy Tracker

The construction of a sustainable and circular structure for Turkey in every field and in every aspect can only be achieved by solutions with a holistic approach to fundamental points such as population migration, affordable housing, risky housing stock, urban transformation, poverty reduction, climate change, clean energy, and over-consumption/-production. Particularly establishing a housing and construction sector in which all components of the sector's value chain gain an ecologically, economically, socially, and culturally (i.e. four pillars of sustainability strategy human, social, economic, environmental) sustainable identity is a critical situation for both Turkey and the world.

2. The approach of circularity in a build environment

The circular economy idea in the built environment can be divided into three different layers as follows: (i) macro-level, which evaluates a system of cities or urban agglomerates, (ii) meso-level, which considers the scale of the structures, (iii) and on a micro-level, which focuses on the material dimension [90]. The macro-level is addressed by using the circular economy concept at the urban level via the 'urban mining approach,' which considers the systematic management of anthropogenic resources such as material, waste, water, and energy fluxes stored in the urban environment [91]. The meso-level, on the other hand, is concerned with accelerating the implementation of circular economy principles at the building level by considering buildings as material banks [92, 93]. The micro-level is concerned with the exchange of by-products and wastes in various industry sectors (industrial symbiosis), significantly developing new products using recycled components [94].

Although the applicability of the circular economy idea for each level is possible to a certain extent, the interoperability and full integration of different levels are essential to strengthen this applicability. This approach can be possible by providing solid ties between each level rather than an approach where different levels cover each other. In other words, the

sustainability of all components that comprise a city must be assured down to the micro elements that constitute those components. Conversely, the ability of micro-elements to be sustainable must meet the requirements of both meso-level and macro-level. Hence, to actualize a sustainable and circular housing and building sector, 'helix of the circular sustainability' in which all levels engage in a wholly integrated framework should be established (Figure 24). In this approach, inspired by a DNA helix, the aim is to match the components of the helix at different levels of sustainability and to provide this in a cyclical framework. It is desired that all the knowledge we have gained by transforming the genes of the Turkish housing and construction sector into a sustainable and cyclical structure will be successfully transferred to the Turkey of the future.

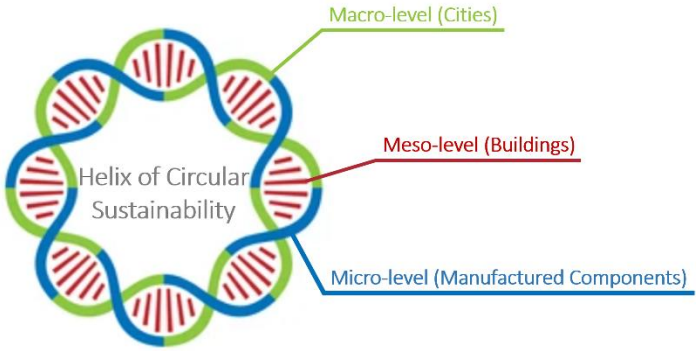


Figure 28. Helix of the circular sustainability

3. How Do We Accomplish?

The roadmap for Turkey's "Sustainable Consumption and Production (SCP) in the housing and construction sector" should mandate the country's development toward no emissions, no waste without overconsumption. Carbon neutrality refers to a country with no emissions. A country with no waste does not generate waste for landfills; instead, the waste is recycled. A country that avoids overconsumption uses natural resources to the maximum extent possible within the boundaries of the planet's capacity. The proposed roadmap follows three pillars, whose goals and actions support each other. These are:

- SCP at Macro-Level (Cities)
- SCP at Meso-Level (Buildings)
- SCP at Micro-Level (Manufactured Components)

3.1 Goals and actions of the roadmap

The desirable scenario for each lane of roadmap towards a sustainable life has been outlined to guide Turkey's housing and construction sector in the proper direction. The main topics for sustainable consumption and production at macro-, meso- and micro-levels are given below.

SCP at Macro-Level (Cities)

- Energy consumption and energy sources
- Renewable energy sources
- Fossil fuels

SCP at Meso-Level (Buildings)

- Building supply and demand
- Inequality in purchase power

- Irregular distribution of buildings
- Architectural design approaches
- Training of people who will work in sustainable projects

SCP at Micro-Level (Manufactured Components)

- Waste management
- Recycling facilities
- Design of wastes
- Standardization of the obtained material
- Material passport

3.1.1 Sustainable Consumption and Production at Macro-Level (Cities): Energy Consumption and Production

Construction processes and material selections are becoming increasingly important as energy efficiency improves. Given this, it is evident that we must invest not only building energy efficiency and renewable energy sources but also building layout and construction materials. By 2050, it is conceivable to reduce emissions from construction materials by up to 38% using circular economy methods [95].

Most greenhouse gas emissions come from energy production and consumption. The roadmap aims to produce emission-free electricity and heating, gradually abandoning coal and turning to renewable energy sources such as solar energy. Building heating accounts for a significant portion of greenhouse gas emissions. The amount of energy used can be reduced by remodeling existing buildings to make them more energy-efficient and creating renewable energy on-site.

Commencement of energy renewals requires a unanimous decision from housing associations and adequate funding. Some of the actions are related to the maintenance of buildings and can be carried out cost-effectively. The most important measures are to increase the information available to property owners by providing advice on energy usage and financial incentives. The city can improve energy efficiency by collaborating with various parties while renovating old neighborhoods. To improve energy efficiency, new financing solutions for energy renewals, the creation of financial incentives, and the removal of legal barriers are required.

The Energy Sector Action Plan has three goals: strengthening institutional changes and regulatory framework, promoting clean energy technology and harnessing potential resources, and reducing carbon footprint. Turkey has enormous potential for long-term energy production by balancing the energy generation mix among oil, gas, hydro, coal, nuclear, solar, wind, and biomass, considering its indigenousness, economic feasibility, scalability, risk assessment, and environmental impact. The plan also emphasizes the need for public-private partnerships in renewable energy generation and the implementation of investment-friendly financial regulations. It is recommended that energy efficiency devices, appliances and gadgets with energy performance labels should be distributed and used in residential, public, and commercial settings. Revising and implementing the National Energy Conservation Policy and formulating guidelines for establishing climate-resilient energy infrastructure in development sectors, including tax rebates and soft loans, and introducing public procurement rules and regulations in line with SCP principles are necessary actions need to be addressed. The

proposed changes will help Turkey improve its energy and security while also putting it on a low-carbon growth path.

National Action Plan on SCP at Macro-level: Cities

Objective 1: Strengthening of relevant institutions, policies, rules and regulations, financial mechanisms, innovative and accessible energy efficiency resources are all needed		
Short term	Medium term	Long term
Developing SCP skills in the energy sector through hands-on training, refresher courses, staff exchange programs, and collaboration with local and international academia and technical institutions.	Introduce investment-friendly incentives and financially appealing renewable energy regulations.	Using public-private partnerships, develop in-house technology capacity for manufacturing renewable energy generation in the country.
Boost investment in energy-efficient urban infrastructure through public-private partnerships.	With the help of SCP, review and streamline Public Procurement laws and regulations to integrate energy efficiency requirements.	
Formulate guidelines for establishment of climate resilient energy infrastructure.	In provinces, establish energy resource and information centers.	
Energy-efficient appliances, equipment, and machinery are eligible for a tax credit.	Enacting and enforcing energy conservation regulations and auditing requirements is a top priority.	
	Give IPPs (Independent Power Producers) priority status and tax incentives for investing in sustainable energy in the power sector.	

Objective 2: Reduce the carbon footprint by promoting energy efficiency		
Short term	Medium term	Long term
Promote solar water heaters to expand the use of direct solar energy for water heating.	Establish certification criteria for energy-efficient heating and cooling appliances, equipment, and machinery.	Improve refining operations and quality of oil products to reduce GHG (Greenhouse gas) emissions
In public and open areas, streetlights, buildings, factories, and commercial establishments, replace incandescent lighting with energy efficient bulbs. In	Introduce energy performance labeling, disclosure, and benchmarking of appliances and systems and create standards for the most energy-efficient technologies available.	

order to increase efficiency, sensors should be installed.		
	Using a Public-Private Partnership, provide incentives for local renewable energy generation equipment production.	

Objective 3: Promote clean energy R&D (research and development) in Turkey, and take advantage of the country's vast potential for indigenous and renewable resources and technologies such as micro-hydel, bio-fuel (biogas), solar, wind, geothermal, and hydrogen energy		
Short term	Medium term	Long term
Prepare primary data on wind, solar, biogas, hydrogen, and geothermal energy potential.	Improve technological knowledge and transfer in order to implement clean coal technology.	Creating a center to investigate the potential and alternatives for power generation using innovative and clean energy technologies.
Provinces will be paid a royalty for using their energy resources to generate electricity.	Plants that generate electricity from municipal trash should be installed.	Widely using geo-thermal energy
	Encourage the development of small and medium-sized hydropower potential (HPP) at suitable locations.	

Objective 4: Enhance key institutions capacity to design and administer Sustainable and Green Cities		
Short term	Medium term	Long term
Encourage the private sector to participate in delivering services and infrastructure for smart city development.	Using responsive urban land use, tight zoning enforcement, and targeted legislation, prevent the intrusion of fertile agricultural and forest areas.	
Ensure that existing laws and policies are followed.	Ensure planned urban development through updating land use planning and governance legislation.	
	Increase green areas and begin programs to green the road network to improve air quality.	

Objective 5: Develop integrated waste management policy, legal framework, and governance, as well as promote best practices and technology for waste management efficiency		
Short term	Medium term	Long term
Compile a solid waste management plan for the province, focusing on improving energy output.	Launch public awareness campaigns and programs to raise national understanding about garbage management.	Establish a monitoring and reporting system for waste collection, transportation, and disposal to guarantee that the service is reliable and satisfactory.
Enforce rules and regulations to prevent open rubbish burning.	Equip local governments with the human and technological resources they need to handle solid waste collection, transportation, and disposal.	Install plants for waste to energy conversion.
Coordinate and integrate national urban planning, land-use planning, and waste management strategies. It is necessary to ban landfills or impose high taxes on landfills. These measures can increase the recycling process, especially through recycling. It is important to enable upcycling and reuse processes within the circular economy.	Develop training programs for communities, hospitals, and businesses around the country on handling, transporting, and disposing of garbage in a safe and environmentally sound manner.	
	Locate nationwide regional dump sites and convert them to designed landfills.	

3.1.2. Sustainable Consumption and Production at Meso-Level (Buildings): Building Supply - Demand and Architectural Design Approaches

Globally, the built environment consumes around half of all materials produced each year. In 2010, the total material consumption of the world's cities was 40 billion tonnes. By 2050, this volume is expected to reach 90 billion tonnes. As a result of this development, carbon dioxide emissions from construction will account for nearly half of new building emissions [95].

There is a rapid urbanization process in our country depending on natural increase and migration, whose population is increasing rapidly, and this situation brings the housing issue to the forefront. Aside from the problems of immigration and housing shortage in our country, issues related to existing housing and unplanned housing and urbanization are increasingly appearing. Our cities are filled with poor-quality shanty houses and shanty apartments without a well-organized architectural plan. While the houses where our people live become uninhabitable, the problems of our cities increase as a result of unplanned multi-story construction and rapid concretization, and as a result, they take on an ugly appearance.

In developing countries such as Turkey, the inability to provide the services provided in cities in proportion to the rate of urbanization has resulted in "distorted and unhealthy urbanization". It is possible to summarize the problems related to the characteristics of the houses as follows: The most prominent housing problems are slums, illegal construction, and unplanned urbanization. Secondly, vertical architecture can be mentioned: the problem of green space and infrastructure, and the problem of concretization, which emerged from the apartment building and dense-high construction. However, it is a matter of curiosity how the housing need of the increasing population without vertical architecture will be met through the efficient use of areas.

So, how can unplanned urbanization be prevented? Buildings must be planned and should be placed in an order, not haphazardly. It should be ensured that the buildings constructed have car parks and gardens. Parks and gardens with plenty of greenery should be created in places open to urbanization. In addition, the development and dissemination of green and environmentally friendly transportation methods is an essential factor at this point. A determination commission should be established in cooperation with municipalities regarding buildings that have completed their economic life, and a comprehensive study should be carried out. As a result of this study, planning based on years should be made, and an inventory list of buildings that have completed their economic life should be prepared.

In the meantime, it is necessary to emphasize the inequality in income distribution. Within the framework of this inequality, we can start with the data on homeownership obtained from the Turkish Statistical Institute (TurkStat). The rate of people living in a house of their own was 57.8% in 2020, with a decrease of 1.0 points compared to the previous year. The rate of those living in rent was 26.2%, the rate of those living in lodgings was 1.2%, and the rate of those who did not live in their own house and did not pay rent was 14.7% (Those who live in public housing without rent, such as lodging, and others) [96].

Income distribution inequality is a phenomenon experienced by many countries worldwide, which harms economic growth. The widening of the gap between the rich and the poor affects not only economic growth but also the social structure of society. The increase in the difference observed in many points, from the access opportunities of the upper and lower percentiles to social services and tax liabilities, leads to maintaining the income distribution inequality over future generations. For healthy and sustainable economic growth, countries should follow policies that will reduce income inequality, and these policies should be designed to cover the lower percentage as well as the upper percentage. Considering that some people have more than one house and some have difficulties in finding a place to stay, a taxation system can be established in direct proportion to the number of houses bought by a single person, especially in the purchase of housing. In order to protect the free market economy for people from the upper income group, certain discounts on taxation can be provided in the case of house sales and rentals to people in the low income group.

Everyone should have access to adequate, safe, affordable housing and essential services. A real estate valuation system based on objective criteria should be developed to increase the effectiveness of urban transformation, expropriation, consolidation, and zoning practices under the title of sustainable urbanization and construction and ensure a healthier functioning of the market.

For the last ten years, Turkey has been bringing new legal regulations, revising existing laws, and implementing new standards and regulations regarding the use of energy-saving and renewable energy resources, within the process of harmonization with the European Union, with similar approaches to the European Union Countries. The most important of these legal regulations is the "Energy Performance in Buildings (BEP) Regulation", which repealed the "Heat Insulation Regulation in Buildings". In line with the framework directive of the European Union numbered 2002/91/EC, the Regulation on Energy Performance in Buildings was published in the Official Gazette on December 05, 2008, and entered into force on December 05, 2009.

The purpose of the BEP Regulation is to determine the calculation rules that will enable the evaluation of all energy uses of a building and to classify it in terms of primary energy and carbon dioxide emissions for new and existing buildings to be significantly renovated. The classification considers the external climatic conditions, indoor requirements, local conditions, and cost-effectiveness. It aims to regulate minimum energy performance requirements for the building, evaluate the applicability of renewable energy sources, control heating and cooling systems, limit greenhouse gas emissions, determine performance criteria and application principles in buildings.

The action plan on energy efficiency in buildings within the scope of SCP consists of the following: establishing a database containing data on building energy use, setting energy-saving targets for public buildings, existing building rehabilitation and energy efficiency improvements, promoting the use of central and district heating/cooling systems, and increasing the percentage of existing buildings with energy performance certificates.

The approach to constructing buildings in layers

The concept of building in layers considers each distinct building layer's intended lifespan while designing adaptive and flexible structures, optimizing building lifetime and material renovation at end-of-life. This approach considers the anticipated lifespan of each building's "Layer" – site, structure, skin, services, space layout, and items (Figure 25). Different layers can be renovated, improved, or replaced as required without affecting the adjacent layers by designing each layer to be as independent as feasible. This contributes to constructing buildings that are easier to maintain, flex, or modify, and it allows the components to be more easily reclaimed at the end of their life. A building can be designed to optimize building, component, and material lifetime and flexibility by recognizing the intrinsic long-life of the structure and understanding the short, high maintenance/replacement cycles of the services, space plan, and items. This method has several advantages. The value of the materials and elements used in the constructions is maximized, and the simplicity of maintenance is enhanced. It also provides significant benefits to householders and renters by allowing for little disturbance during maintenance, allowing future upgrades of building services to ensure buildings are as effective as feasible and supporting adaptability of the internal layout to match changing householders' demands.

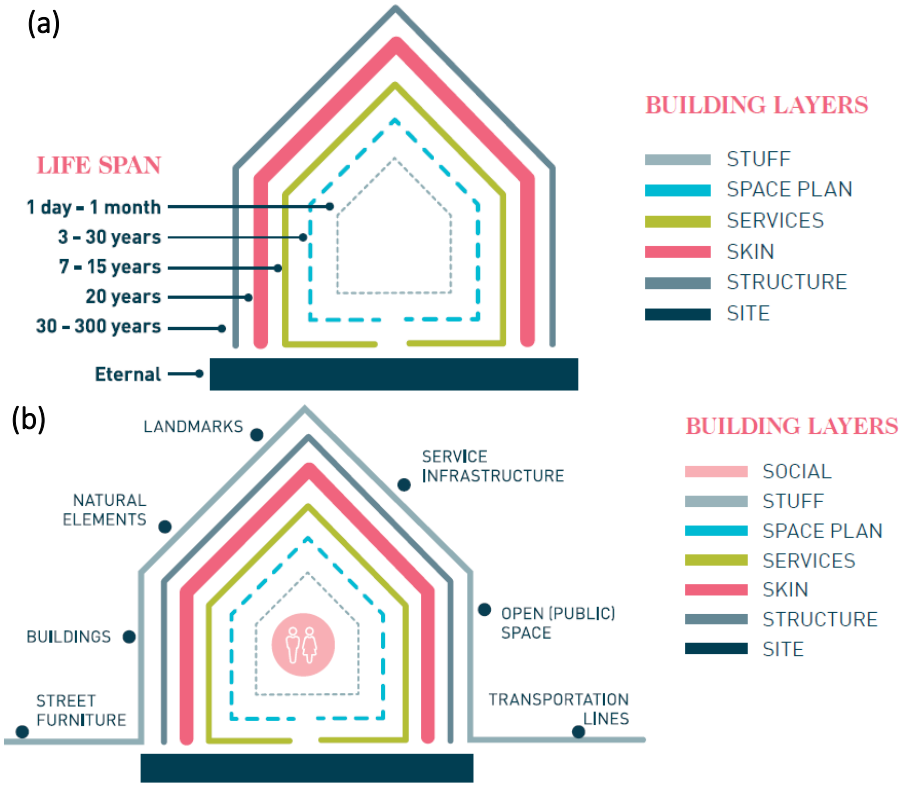


Figure 29. Building in layers (a) and adapted building in layers (b)

National Action Plan on SCP at Meso-level: Buildings

Objective 1: Developing Sustainable, Smart and Green Buildings and aligning policy and legal frameworks		
Short term	Medium term	Long term
Initiate programs for building the capacity of key organizations and launching physical actions to include SCP principles to fully realize the potential of planned urbanization.	Ensure strict adherence to building by-law rules to develop resilient structures and infrastructure.	A real estate valuation system based on objective criteria should be developed to increase the effectiveness of urban transformation, expropriation, consolidation and zoning practices under the title of sustainable urbanization and construction, and to ensure a healthier functioning of the market.
In purchasing a house, it should be considered that some people have more than one house and some people have difficulties in finding a place to live, and a limitation should be imposed on having too many houses on the same person.	To design flexible, adaptable, and simpler to maintain buildings, allowing components to be more readily replaced at the end of their useable life without damaging surrounding components. To identify building elements that are generally	If the horizontal architecture is combined with the projects that give importance to green areas, it can save the future of cities by preventing agglomeration at one point of the city, ensuring that the population, residential and

	replaced before the end of their design life and establish more robust alternatives to reduce maintenance costs and waste.	business areas are distributed evenly over a wide area.
	Ensuring everyone has access to adequate, safe and affordable housing and essential services, and improving slum areas.	Adopting the concept of "building in layers" as a principle to support future maintenance, renovation and reuse.
	To reduce heating costs and the consequences of GHG (Greenhouse Gas) emissions, promote green building design by inserting provisions for insulation and thermally efficient windows, as well as renewable energy technology, into building by laws.	
	Concessional financing tools for green development, such as soft loans, grants, revolving funds, and energy performance contracting; Combining financial incentives with building requirements; Community-based savings and lending programs, such as settlement improvement funds; Regulatory and fiscal incentives, such as tax/import duty reductions/exemptions for green building materials, subsidies for green construction and retrofits, upgrading to energy-efficient appliances, resource efficiency off-grid applications, and tax/import duty reductions/exemptions for green building materials.	Adopting BIM is necessary to create a continuous flow of information. From early planning and design to construction, operation, maintenance and final recycling, every stage of the construction process is digitally recorded. This opens up new possibilities for better efficiency, accuracy, collaboration and collaboration between the parties involved in the construction process.
		BIM has the potential to drastically reduce carbon emissions during the construction process. A quantity take-off based on a 3D BIM model, instead of 2D drawings, provides far more accurate results. Architects and contractors will be able to properly describe the exact

		quantity of building materials necessary as a result of this. When this estimate is correct, the pre-bid budget will be closer to the actual budget, and material waste will be reduced significantly.
		The government should implement a green procurement policy. The policy should include: Local businesses that are reputable and certified should be used. Choose certified environmentally friendly products that are manufactured entirely of biodegradable, compostable, or post-consumer materials and do not include caustic or harmful chemicals. When purchasing biodegradable products, make sure there is a collection facility available, as biodegradable materials require special processing. Choose ethical items that promote good working conditions, worker health and safety, and economic development in the community. Look for ethical certificates and fair trade brands. When possible, avoid using plastic products because many of them are non-recyclable and can break down into microplastics that endanger wildlife and human health. Select eco-friendly products that reduce waste and save natural resources. Think ahead and make a plan on how to handle product disposal.

Objective 2: Actions to increase energy efficiency in buildings		
Short term	Medium term	Long term
Setting energy saving targets for public buildings	Establishment of a database containing data on building energy use.	Increasing the percentage of existing buildings with energy performance certificates.
Updating, developing and promoting legislation on the use of central and district heating/cooling systems	Existing building rehabilitation and energy efficiency improvements	

Objective 3: Retrofitting and maintenance of existing intensive energy buildings stock is being conducted		
Short term	Medium term	Long term
Identify establishments with high energy use	Select priority establishments to conduct retrofitting	Identify establishments with high energy use
	Conduct feasibility studies for the selected establishments to demonstrate cost effectiveness of measures	Conduct mandatory energy audits for industrial and commercial sector buildings with high energy use.

Objective 4: Awareness of green buildings and sustainable life styles in using buildings is increased		
Short term	Medium term	Long term
Increase awareness of households on SCP: a) on the importance of Retrofitting and maintenance of existing buildings b) on access to finances for green building elements, retrofitting, and maintenance of existing buildings c) advantages and cost savings potentials for green buildings d) Replacement of materials examples: efficient lighting and day-lighting; more efficient electrical appliances and heating and cooling devices; improved insulation; passive and active solar design for heating and cooling; alternative refrigeration fluids	Develop and implement a capacity building program targeting construction companies on green buildings a) program for technicians: b) program for engineers Note: topics to be covered: sustainability, waste management, environmental aspects of construction, how to develop, implement, monitor and report for construction, construction aspects related to energy and water conservations, renewable energy installation.	Increase awareness of municipalities on green building, energy efficient building and new codes of construction and access to finances for municipal buildings for public use.
The absence of experienced operators capable of disassembling and storing the	Increase awareness of construction	

materials to be reused is what prevents the activation of sustainable circular practice at the building level. These discrepancies result in high human labor expenses and logistical challenges. In this context, training programs should be started urgently in order to train personnel with high experience.	companies on green building elements and associated standards (green, energy)	

3.1.3. Sustainable Consumption and Production at Micro-Level (Manufactured Components): Waste Management

In the conventional building, life-cycle waste is generated, processed, and disposed of at each stage of the building life cycle. This waste significantly loses economic and social value while significantly increasing environmental degradation (Figure 28).

The building life-cycle stages have been evaluated through the circular economy principles. This evaluation has led to the determination of some key interventions that aim to reduce waste generation and materials consumption at all building life-cycle stages while maximizing social value creation and economic return on investment. Construction procedures can also be improved, reducing construction waste generated by erroneous operations (design error, site operation, materials scraps), which can be prevented with a BIM design, which improves communication, efficiency, and decreases errors.

Pre-demolition audits assist maximize the value of items recovered from the demolition process and reduce waste transportation for off-site processing or disposal by identifying resources for potential reuse, refurbishment, or recycling. Although the demolition process may take longer and involve more planning, there should be financial benefits in the form of lower waste disposal costs and the creation of materials for future construction projects.

On inner-city sites, space for salvaged materials storage and on-site recycling is a prevalent issue that must be considered from the start of the project design process. Actions for waste management, sorted according to environmental preferences, should be taken. It is aimed to reduce waste generation and material consumption, create social value and maximize the economic return on investment at all stages of the building life cycle.

It should be intended to maximize the value and quantity of materials recovered for potential reuse and recycling during demolition. Thus; targeted separation improves the quality of demolition materials and maximizes the potential for material reuse and on-site recycling, saving project savings and reducing waste disposal costs.

Well-separated materials are more likely to be recycled by off-site Material Recovery Facilities rather than being incinerated or sent to landfill. At the same time, high recycled content must be specified in products to create a demand-side driver for increased recycling of materials and

investment in new recycling procedures by product manufacturers. And it is necessary to introduce economic incentives in this direction.

A list of standardized items should be made, such as a material passport. Teams should evaluate this list and decide which standard components to include in the design before starting the project. The design team should be briefed on the requirements.

Figure 30. Waste hierarchy pyramid

National Action Plan on SCP at Micro-level: Manufactured Components

Objective 1: Demolition for maximum recovery value (During demolition, maximize the value and quantity of items rescued for possible reuse and recycling)		
Short term	Medium term	Long term
Conduct a site survey with the design team to discover potential salvageable or on-site recyclable materials.	Request that the demolition contractor conducts a pre-demolition audit to precisely quantify waste streams and create a deconstruction statement outlining how the structures will be disassembled to maximize the value of waste material resources. All waste streams should have their further reuse, recycling, or disposal routes detailed in the deconstruction statement, along with the associated quantity. Local recycling and recovery facilities that have been audited for legal compliance should be given preference.	At the very least, demolition companies should save natural stone, bricks, good-quality furniture, wood, and top soil. Plasterboard, carpets, vinyl flooring, concrete, asphalt, and mixed masonry should all be meticulously separated to maximise recycling possibilities.
Locate prospective storage and reprocessing locations for rescued demolition wastes.		Direct agreements with innovative waste reprocessing companies, rather than disposing of waste via a waste contractor,

		can support the establishment of new recycling business models.

Objective 2: Designing out waste (To encourage efficient use of materials by applying lean design principles, using reclaimed materials and components, and substituting high replacement cycle materials with more robust materials.)		
Short term	Medium term	Long term
Develop design proposals responding to the existing site topography to minimize cut and fill.	Consider how the building could be deconstructed in future to allow beneficial in-situ reuse of long life-span items such as the foundation and frame of a building and maximize salvage and recyclability of other building components	Communicate design initiatives to reduce waste to the contractor and supply chain to promote more efficient procure
Review the existing site to identify potential materials that may be salvaged and incorporated into the design, including materials from earlier demolition phases.	Provide a designing out waste statement including a refurbishment and deconstruction statement within the design report to demonstrate how principles have been incorporated.	BIM may be a valuabletool in designing waste and quantifying the benefits of design initiatives. Construction techniques can also be improved by avoiding construction waste caused by incorrect operation (design error, site operation, material scraps) that can be avoided with BIM design.
Record actions are taken to design out waste.		

Objective 3: Specify high recycled content in products (To provide a demand-side driver for increased material recycling and product producers' investment in novel recycling procedures.)		
Short term	Medium term	Long term
Detail recycled materials within design proposals and reports. As a minimum, designers should review the following opportunities: • Engineered fill (up to 100% recycled content) • Concrete (at least 7% recycled content, and/or 40% cement replacement)	Include specific reference to the minimum recycled content in key specifications.	Implement monitoring and reporting procedures to ensure contractors and their supply chain partners realize opportunities.

• Blockwork and concrete paving (at least 50% recycled content) • Insulation (at least 50% recycled content) • Plasterboard (at least 95% recycled content) • Carpet tiles (at least 50% recycled content) • Asphalt roads (at least 40% recycled content)		
	It is necessary to introduce economic incentives, this is essential to overcome economic barriers: for example, incentives can be introduced for building renovations using reused/reusable materials or recycled/recyclable materials.	

Objective 4: Create a standardization plan that includes off-site/modular elements. (To promote standardization of key elements across projects, supporting efficient product procurement, installation and maintenance. To reap the benefits of off-site modular building, such as faster construction timelines, fewer waste, and less disruption to the community.)		
Short term	Medium term	Long term
Develop a list of standardized components such as a material passport. Before starting the project, teams should review this list and agree on which standard components will be incorporated into the design. Requirements must be instructed to the design team.	Any agreements made with a modular fabricator must be communicated to the competing contractors at the earliest contract award stages.	The contractor and supply chain should review the transportation and construction details of modular components as early as possible to determine if low carbon solutions are available.
The design team and project managers should undertake a modularization review to identify design elements that could benefit from off-site fabrication. These elements may include bathroom pods, risers and mansard roofs.	Procurement models for standardized components should be reviewed with the preferred contractors and take the form of a centralized material purchase and issued to the sub-contractor	

Designers must consider modularity in design and identify 'specials' on design drawings.		

Objective 5: Excellence in construction waste management (Using best-practice material handling techniques, reduce the total quantity of construction trash created on-site. To maximize construction waste segregation on-site to enable local waste material reuse and improve the grade of recyclable materials. To make the waste management supply chain more transparent.)		
Short term	Medium term	Long term
The project managers will identify potential space for the storage of reusable materials and allocate appropriate space to allow extensive segregation of waste materials.	Integrate and coordinate national plans of urban planning, land-use planning with waste management plans/policies and strategies	The principal contractor will develop a comprehensive Site Waste Management Plan (SWMP), one month before starting on site. The SWMP must detail actions and initiatives to reduce construction waste and ensure the legal disposal of waste. The SWMP should include: • How BIM and associated quality management procedures will be used to order materials and minimize rework accurately; • Identification of key supply chain partners that could be approached to develop re-usable packaging solutions and supplier takeback and recycle schemes • How key sub-contracts will be managed to incentivize waste reduction and segregation; • Detail how site waste will be managed to maximize segregation at the site; • Identify how reusable materials will be stored and distributed • Detail off-site waste recycling, disposal routes and how legal waste disposal will be verified; • Set project waste targets, • State the method of reporting and monitoring, including responsibilities and frequency of reporting.

Objective 6: Construction demolition waste inspection guidelines and legislations		
Short term	Medium term	Long term
To encourage the reuse and upcycling of materials, more ambitious regulation is required. First and foremost, it is critical to increase market demand for secondary materials, including in the building industry, by enacting rules prohibiting the extraction of primary resources (e.g. to forbid the opening of new quarries).	'Guidelines for waste inspections before demolition and renovation of buildings' can be applied. These initiatives can improve waste identification and certification through better separation and collection, waste logistics through better traceability of the waste stream, waste processing through an efficient recycling process, and quality management through the introduction of quality labeling.	
A database should be established to monitor CDW quantities. Because when analyzing current CDW management, the first obstacle to sustainable waste stream management is the lack of a database to monitor CDW quantities and not knowing who should control and monitor waste management.	A pre-demolition audit can be an available valuable tool for improving collaboration and communication between designers, demolition companies, and waste managers.	

4. How will we monitor shortcomings, progress, and requirements?

The most crucial aspect for the housing and construction sector to ensure a circular economy-based SCP is the comprehensive and robust establishment of the monitoring system. A successful monitoring system to be established is vitally essential in terms of presenting current situation analysis, taking measures earlier, detecting malfunctions in operation, and providing a healthy data flow. In addition, while ensuring the continuity of motivation, it allows decision-makers to make effective decisions. Considering these points, it will contribute to developing universal indicators by establishing an effective monitoring system and obtaining more data.

At this point, it is important to establish a unit in the Ministry of Environment, Urbanization and Climate Change of the Republic of Turkey in order to establish and actively operate this monitoring system and coordinate between different stakeholders from industry, government and research councils. This unit should be responsible for the development and implementation of roadmaps, action plans, legislations necessary for circular economy and sustainable production and consumption in the housing and construction sector as well as in other important industries of the country. Besides, the unit will ensure a tremendous contribution as long as the unit to be established monitors the implementation of SCP national action plans in close cooperation with other public bodies, information institutions, stakeholders, and legal entities. The monitoring system to be established for implementing SCP effectively is as follows.

Material monitoring	Life cycle analyzes of materials at each step of the value chain of the housing and construction sector at all levels of sustainability
Emission monitoring	Identifying GHG emissions at each step of the housing and construction sector's value chain at all levels of sustainability
Waste monitoring	Detection of waste produced by each component of the housing and construction sector and determination of their recycling, upcycling and reusing potentials
Energy monitoring	Determining the energy consumption in each step of the value chain of the housing and construction sector at all levels of sustainability
Social foundation monitoring	Comprehensive and up-to-date analysis of indicators that provide information about a society's general welfare, such as housing, income and wealth inequality, and health

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