TURKEY'S DECARBONIZATION ROADMAP

Towards Net Zero by 2053

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Introduction

Turkey became a party **to the Paris Agreement** in 2021 and announced its goal of reducing greenhouse gas emissions to net zero **by 2053**. However, the target set in the updated National Determined Contribution (**NDC)** in 2022 to reduce greenhouse gas emissions by 41% by 2030 compared to the reference scenario is not consistent with this long-term goal. Under the Paris Agreement, countries must update their contributions to climate action and reduction targets every five years, and in accordance with this rule, Turkey, along with other countries, will submit its new NDC to the UN this year (2025).

It is an important principle that climate action and reduction targets cover all relevant sectors of the economy and that priority is given to sectors and measures where reduction is easiest. Accordingly, emissions must be reduced gradually and with the most appropriate curve possible in each sector until the year when they reach net zero. This reduction pathway is generally determined through bottom-up or hybrid modeling studies, taking into account existing and emerging technologies. These studies compare one or more reference scenarios and reduction scenarios that reflect the current trajectory of the economy and are consistent with the net-zero target.

As a result of modeling studies initiated by Sabancı University**'s Istanbul Policy Center (IPC)** before Turkey became a party to the Paris Agreement, three reports published between 2021-2023, which outline Turkey's decarbonization roadmap to 2050, the cost-benefit analysis of policies to be followed to achieve net-zero carbon dioxide emissions between 2020 and 2030, and the geographical distribution map of the energy transition, which is the most important component of the roadmap. These independent scientific studies, the first of their kind in Turkey, have guided discussions on what the transformation should look like as Turkey implements its climate policies.

The preparations for the new Decarbonization Roadmap, which was prepared by the IPM as a scientific background study for discussions on the 2053 net zero target and the new NDC that will include the 2035 targets, and whose results are presented in this new report, took approximately one year. The model study underlying the new roadmap takes a bottom-up approach, covering all relevant sectors of the Turkish economy (**electricity, industry, buildings, transportation, agriculture, waste)** and all greenhouse gases (**carbon dioxide, methane, nitrous oxide, and F-gases)**.

The roadmap models two scenarios for the possible paths Turkey's greenhouse gas emissions may follow. The Reference Scenario shows how energy demand and greenhouse gas emissions would evolve if the economy's current trajectory were to continue until 2053, without any additional intervention in the economy or ambitious climate policies to reduce emissions to net zero. The Reference Scenario assumes that important climate policy transformations, such as the transition to renewable energy and electric vehicles, and electrification in industry and buildings, will continue at their average rate in recent years under current policies and economic structures.

In the Net Zero Scenario, it is assumed that the necessary interventions are made in the economy to achieve net zero emissions by 2053 (e.g.**, rapid transition to renewable energy, gradual phase-out of coal, rapid transition to electric vehicles, gradual technological transformation in industry and electrification of buildings,** etc.) and how energy demand and emissions will evolve. It is assumed that these interventions will be implemented at a reasonable additional cost that will not compromise the country's energy security or harm the economy. The assumptions prioritize interventions that are technologically established and economically effective today. Technologies that are not yet sufficiently developed, whose effectiveness is questionable, and that are very expensive (such as *CCS*) have not been used in the scenarios or have been used to a very limited extent.

The carbon budget, which remains the most important constraint in changing the course of the economy towards reducing emissions, has been used in the Net Zero Scenario. The maximum amount of carbon emissions that can be made in order for the world economy to reach net zero in the 2050s, in line with the Paris Agreement's goal of limiting global warming **to 1.5-2°C**, constitutes the remaining global carbon budget. When calculating Turkey's share of the global carbon budget, Turkey's low historical responsibility and its right to development were taken into account.

The report calculates the differences between the Net Zero Scenario and the Reference Scenario, as well as the percentage reduction in the country's total emissions **in 2035 and 2053 compared to 2021** if the Net Zero Scenario is followed. It also calculates the additional cost that this transformation will create for the decade **between 2025 and 2035**. **These potential reduction scenarios shed light on Turkey's new Nationally Determined Contribution (NDC) for 2035 and its Long-Term Strategy targeting 2053.**

Methodology

The general framework of the methodology used in the study and the data flow between models are presented in Figure 1. The study models five sectors that account for the majority of Turkey's greenhouse gas emissions: **industry, transportation, buildings, agriculture, and electricity.** In addition, **the waste sector and F-gases** are addressed independently.

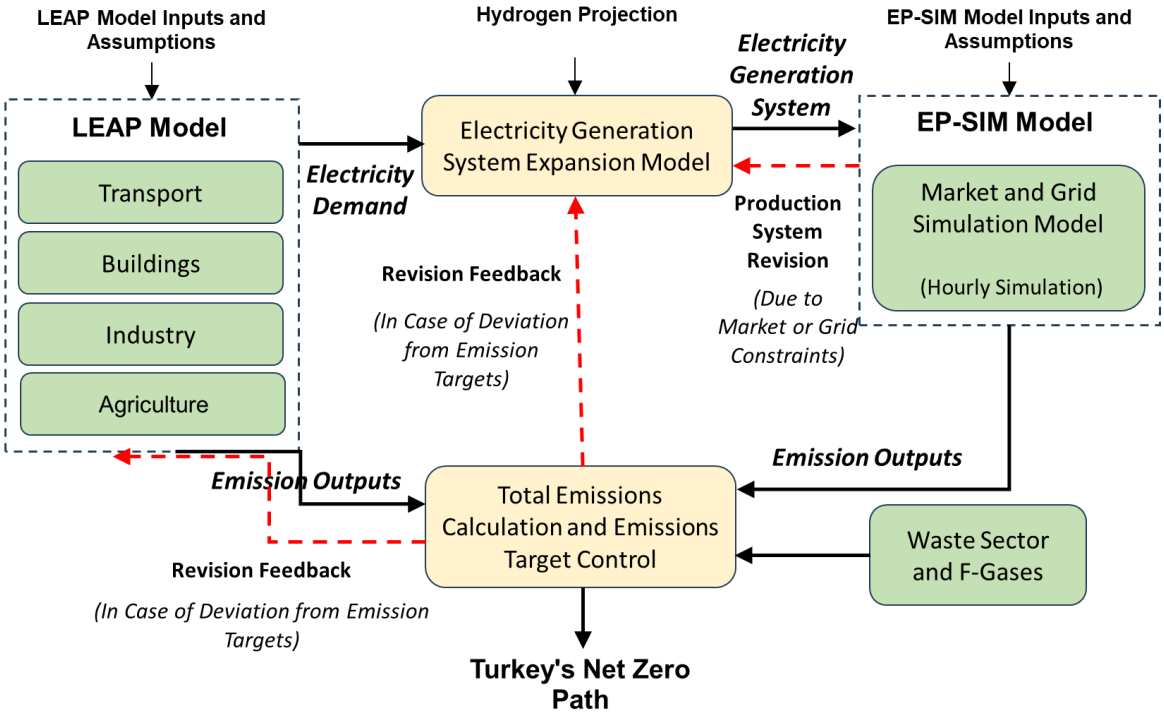

Figure 1 - General framework of the proposed methodology

Two modeling tools were used together in the study: **LEAP and EP-SIM.**

LEAP (Low Emission Analysis Platform) is an integrated software system for planning for energy, climate change, and air pollution reduction. Developed by **the Stockholm Environment Institute (SEI)**, LEAP has been used by approximately 60 countries to assist in the development of NDCs. It is also used by academia, NGOs, and consulting firms, in addition to public institutions. LEAP allows for different methodologies, such as simple accounting-based models and least-cost capacity expansion optimization modeling.

EP-SIM is a platform developed for electricity market and grid simulation. By defining inputs such as demand projections, current production capacity, and system constraints, market behavior and grid behavior can be analyzed realistically. The model developed by **EPRA-Energy** uses mathematical algorithms, optimization methods, and machine learning approaches to produce outputs such as production distribution, capacity factors, market

exchange prices, and grid reliability. In this respect, it evaluates not only the economic dimension of the market but also technical elements such as grid flexibility and security. EP-SIM offers the opportunity to examine the integration of renewable sources, flexibility options, and the effects of different scenarios on the market and the grid. Thus, it contributes to the more realistic and feasible design of reference and net-zero scenarios.

In the study, each sector was modeled in a data-driven manner, taking into account technological developments, efficiency gains, and macroeconomic assumptions. The results of sectoral energy demand were reflected in the electricity generation system; at this stage, generation capacity planning, technology transformation, and investment requirements were analyzed. The electricity system model was also integrated with the market and grid simulation model, and hourly simulations were conducted to examine the supply-demand balance, system reliability, and flexibility needs.

All greenhouse gases published in the inventory, namely carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), were included in the model. F-gases were also considered separately and included in the calculations.

Two main scenarios were developed in the study:

- ***Reference Scenario****:* Unlike the traditional "business as usual" (BAU) approach, the current trajectory of the economy has been projected to 2053, incorporating the most reasonable and acceptable trends for technological developments and sectors. The base year is 2023, calibrated to reflect post-pandemic economic and social conditions.
- ***Net Zero Scenario:*** Designed in line with Turkey's net zero emissions target for 2053. This scenario shows how greenhouse gas emissions would evolve if the necessary policies and measures were implemented, while maintaining the current economic structure and growth expectations.

The greenhouse gas emissions calculated in this study were evaluated comparatively with national-level carbon budgets. The carbon budget calculation approach is based on the methodology developed in the **Decarbonization Roadmap** study published by IPM in 2021 and has been adapted to current data. The global carbon budget was taken **from the IPCC's Sixth Assessment Report (AR6)** and updated taking into account emissions between 2020 and 2023. Accordingly, the remaining carbon budget is calculated as **370.8 $GtCO_2$** to limit the climate to 1.5 °C with a 50% probability after 2023. Under the same probability level, this figure rises to **720.8** $GtCO_2$ for 1.7 °C and **1,220.8** $GtCO_2$ for 2.0 °C.

Turkey's share of this global budget has been calculated using the **Paris Equity Check (PEC) Cumulative Per Capita Equity (CPC)** approach. This method is based on a fair distribution principle for countries with relatively low historical responsibility and higher development rights. According to this approach, Turkey's carbon budget compatible with the 1.5°C target corresponds to **1.37% of** the global total.

This percentage is higher than Turkey's current share of carbon emissions (approximately **1.2%)** and corresponds to a national budget **of** approximately 5**.08** **GtCO$_2$** as of 2023. This national budget is distributed among sectors in the project. Sectoral carbon budgets are calculated based on the cumulative emissions

projected for each sector under the baseline scenario. This reveals how Turkey's share of the remaining global carbon budget, required to limit global temperature increase to **1.5°C, 1.7°C, and 2°C with a 50% probability**, is distributed among sectors based on their current trends. The comparative results of the global and Turkey-specific carbon budgets are presented in Figure 2 and Figure 3. (Note that the global carbon budget is given in GtCO2 – billion tons – and Turkey's carbon budget is given in MtCO2 – million tons – in the graphs.)

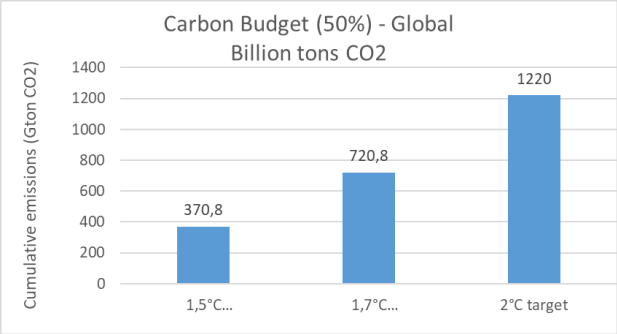

Figure 2 - Global carbon budget (GtCO2)

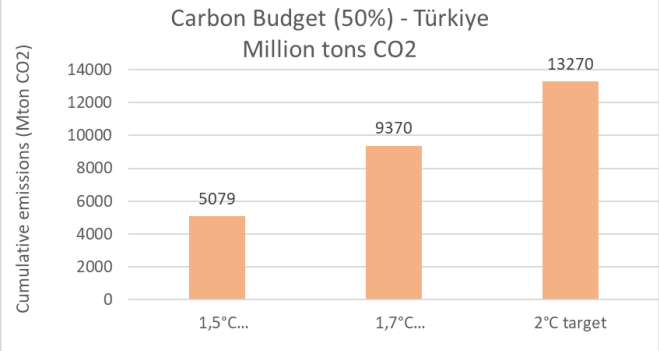

Figure 3 - Turkey-specific carbon budget (MtCO2)

Decarbonization Pathways for Sectors

INDUSTRIAL SECTORS

The industrial sector is one of the major sources of greenhouse gas emissions in Turkey and has been modeled in the study under six sub-sectors: **iron and steel, aluminum, cement, fertilizers, chemicals, and other industrial sectors.** The iron and steel, aluminum, cement, and fertilizer sectors are modeled based on mass-based production due to their homogeneous outputs; chemicals and other sectors are modeled based on the added value they create in the economy. "Other industrial branches" include sectors with relatively low emission intensity, such as textiles and machinery.

In the Reference Scenario, sectors are projected based on **current growth rates, productivity increases**, and **technological developments**. In the Net Zero Scenario, **process-based transformations, efficiency improvements**, and **electrification** steps have been implemented. While the main source of transformation in the iron and steel and aluminum sectors is changes in process technologies, catalytic purification technology is envisaged for nitric acid production in the fertilizer sector. In the cement sector, the reduction of process emissions is quite limited, and reducing the clinker ratio and using alternative raw materials are the only options that stand out. In the chemical and "other" industrial sectors, transformation through electrification is targeted.

Modeling results show that the industrial sector is undergoing a significant transformation on the net-zero pathway. Compared to the Reference Scenario, the Net Zero Scenario creates approximately 11% more electricity demand in the industrial sector. This increase is mainly due to electrification in the chemical and other industrial sectors. However, efficiency gains and demand reductions in many sectors balance out total energy consumption.

By 2053, there will be **69.7 $MtCO_2e$ of** residual emissions in the industrial sector under the Net Zero Scenario. Approximately two-thirds of this amount consists of process emissions, about 78% of which originate from the cement sector. This result reveals that technological limitations in the industrial sector make emission reductions particularly difficult in sectors such as cement. The Net Zero Scenario reduces cumulative emissions by almost half compared to the Reference Scenario. However, this transformation requires approximately **$8.65 billion** in additional investment by 2035.

Throughout the 2025–2053 period, industrial emissions increase by an average of 2.5% annually in the Reference Scenario, while emissions decrease by 2% annually in the Net Zero Scenario. The Net Zero Scenario achieves a 22% reduction in CO_2 equivalent emissions in 2035 compared to 2025, and a 44% reduction in 2053. The trajectory of industrial sector emissions under the Reference and Net Zero scenarios during the 2025–2053 period is presented in Figure 4.

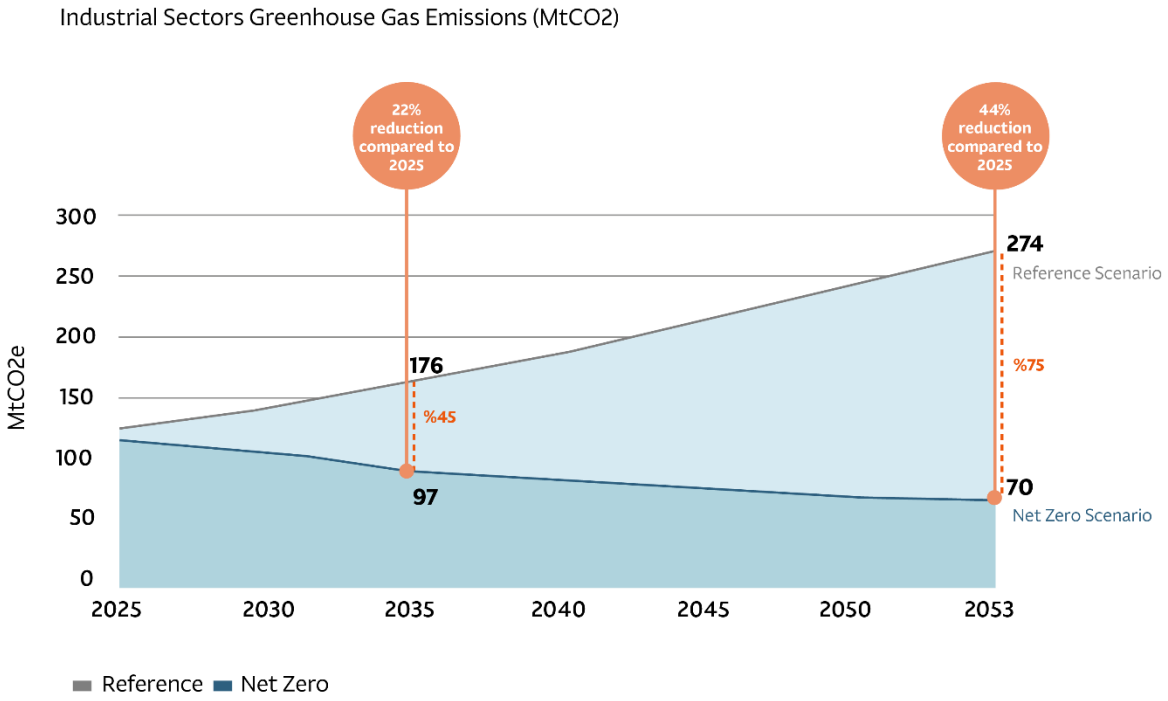

Figure 4 - Industrial Sector - Greenhouse Gas Emissions

BUILDINGS SECTOR

Buildings in Turkey are responsible for approximately 14% of energy-related carbon dioxide (CO_2) emissions. Approximately 76% of these emissions come from residential buildings, while 24% come from commercial and institutional buildings. Looking at long-term trends, emissions from buildings have increased from 1990 to the present. As of 2022, energy-related emissions from residential buildings have risen significantly compared to 1990, and although a decrease of approximately 4.6% was observed between 2022 and 2023, this decline has not reversed the long-term trend.

In this study, residential and non-residential buildings were considered separately for modeling emissions in the building sector, and energy consumption was disaggregated according to **Energy Performance Certificate (EPC)** classes and usage areas. Detailed energy profiles were created for both the residential and service sectors, taking into account sub-usage categories such as space heating, cooling, water heating, cooking, electrical appliances, and lighting.

The reference scenario assumes that new buildings constructed after 2025 will have **at least a C-class EIC**, that the renewable energy usage rate will remain at 10%, and that approximately 90,000 new buildings

will be constructed annually. By 2053, it is projected that the area of use will increase by 55% per residential unit and 51% for non-residential buildings. In the Net Zero scenario, more ambitious policies have been adopted; all new buildings after 2025 will be constructed as **"Nearly Zero Energy Buildings" (NSEB)**, **the use of Renewable Energy Sources (RES)** to increase to 20% by 2040 and 30% by 2050, the gradual demolition and renovation of buildings constructed before 2000, and energy efficiency improvements in existing buildings. Furthermore, the transition from coal to natural gas, and then from natural gas to electricity, aims to completely phase out fossil fuels for heating by 2045.

These measures contribute significantly to reducing emissions. In particular, the transition from fossil fuels to electricity accounts for more than half of the total reduction in the building sector. In line with the emissions budget allocated for buildings under the net-zero scenario, cumulative emissions up to 2053 are estimated to reach approximately 796 $MtCO_2$. This value is below the 825 $MtCO_2$ budget compatible with the 1.5 °C target. However, this transformation requires an investment **of** approximately **$233 billion**, and it is predicted that savings from energy efficiency will reduce this cost to approximately $200 billion.

Figure 5 shows the emission trends under the Reference and Net Zero scenarios for the building sector over the period 2025–2053.

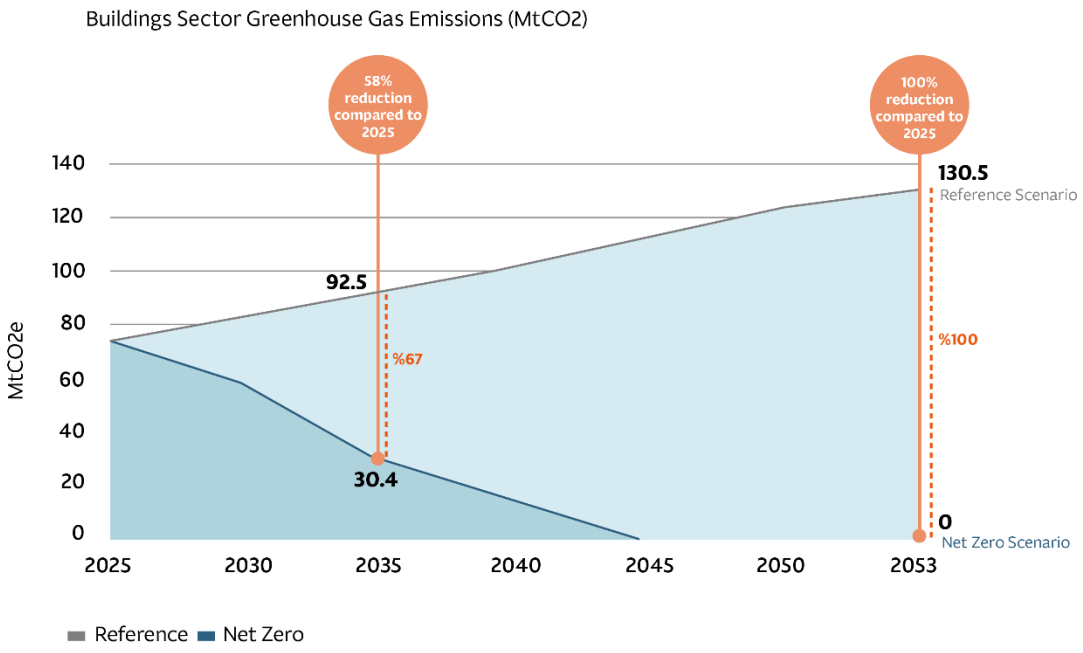

Figure 5 - Buildings Sector - Greenhouse Gas Emissions

TRANSPORTATION SECTOR

The transportation sector in Turkey accounts for approximately 23% of energy-related greenhouse gas emissions, with nearly all of this amount, 94%, coming from road transport. Transport sector emissions increased by 269% between 1990 and 2023, with their share of fossil fuel-related emissions increasing by approximately 3%. Within the scope of this study, emissions were modeled across four main transport modes: **road, air, rail, and sea**. Road transport was examined in greater detail; calculations were made at **IPCC Tier 3** level using vehicle numbers, vehicle kilometer values, and energy consumption coefficients obtained from the COPERT program. For air, rail, and sea transport, the **IPCC Tier 2** methodology was used.

In the Reference Scenario, passenger and freight transport activities are projected based on current trends. Despite increased rail investments, road transport continues to grow at a higher rate and maintains a sector share of approximately 90%. The increasing market share of electric vehicles has been included in the reference scenario: it is projected to **reach 33% in 2035 and 67% in 2053 for cars,** and to have a share of 11% and 28% in the vehicle fleet, respectively. It is assumed that the electrification process in rail transport will be completed by **2045,** with all lines becoming electrified.

The Net Zero Scenario, on the other hand, envisions a more profound transformation in the transportation sector. A shift from road to rail transport for both passenger and freight is targeted, with the share of rail transport projected to increase to 6% for passenger transport and 22% for freight transport, in line with the objectives of the Master Plan for Transportation and Logistics. The electrification of road vehicles has been accelerated, and based on the IEA's accelerated electrification scenario, it is assumed that **the automobile market will be completely electric by 2040**. High-rate electrification is also projected for vans, buses, and trucks, and it is accepted that hydrogen-fueled vehicles will join the system to a limited extent after 2035. In addition, measures such as the shift from passenger cars to buses, increased bicycle and pedestrian transportation, the use of sustainable aviation fuel (SAF) in aviation, **a 2% annual increase in efficiency,** the use of biodiesel in buses, and the start of electrification in maritime transport have been included in the scenario.

According to the modeling results, while the electricity demand for transportation in the Reference Scenario is approximately **47 TWh** in 2053, this figure rises to approximately **176 TWh** in the Net Zero Scenario due to accelerated electrification. However, due to the decrease in fossil fuel use, total energy demand declines from **62 million TEP** in the Reference Scenario **to 35 million TEP** in the Net Zero Scenario. In terms of emissions**,** a **70%** reduction is achieved by 2053 compared to the Reference Scenario, **and** a 52% reduction compared to 2025; thus, emissions decrease from **174** $MtCO_2e$ to **51** $MtCO_2e$.

Cumulative CO_2 emissions in the Net Zero Scenario are 2.2 billion tons, which is slightly above the 2.1 billion ton limit set for

the 1.7 °C target with a 50% probability. While approximately **$75.3 billion** in investment is estimated to be required for the transition by 2035, energy efficiency gains will result in savings **of $111.9 billion**.

Figure 6 shows the trajectory of emissions from the transport sector under the Reference and Net Zero scenarios for the period 2025–2053.

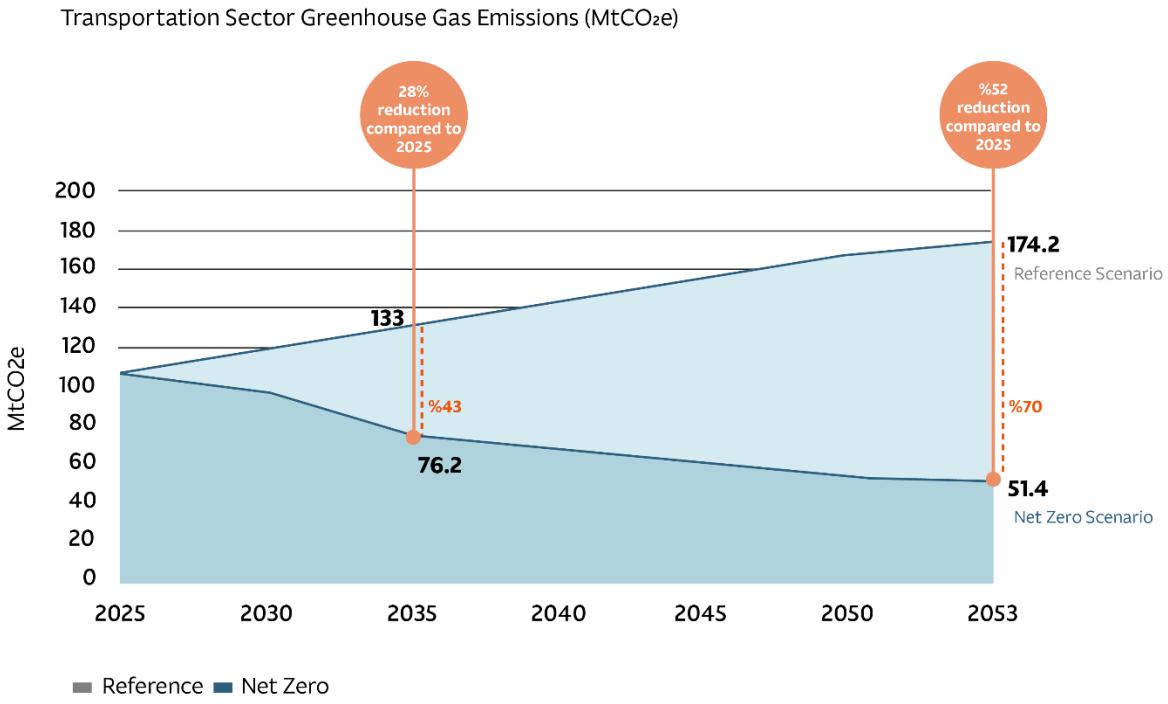

Figure 6 - Transportation Sector - Greenhouse Gas Emissions

AGRICULTURAL SECTOR

The agriculture sector in Turkey is responsible for approximately 13% of total greenhouse gas emissions and holds a critical position in terms of climate goals. Contributing 5.3% to GDP and playing a strategic role in national food security, the sector also contributes the highest amount of methane (CH_4) and nitrous oxide (N_2O) emissions among all sectors. These emissions primarily stem from enteric fermentation, agricultural soils, livestock manure management, energy use, urea application, rice cultivation, and stubble burning. According to 2023 data, the sector's total emissions were calculated as 71.9 $MtCO_2e$ excluding energy use and 82.8 $MtCO_2e$ including energy use.

The study used the LEAP model to create comprehensive greenhouse gas emission

projections for the sector from 2025 to 2053, using 2025 as the base year. The model integrates the two key components of agriculture: fuel combustion and non-energy emissions. In this context, assessments were made under both the Reference Scenario and the Net Zero Scenario.

Under the Net Zero Scenario, a series of strategies are proposed to reduce emissions. These include **reducing diesel fuel consumption** through **the electrification of agricultural machinery** and **no-till farming practices**; **reducing enteric methane emissions in cattle farming through genetic improvement** and **feed additives**; **using animal manure for biogas production,** implementing **legume rotation in agricultural soils**, and **reducing the use of synthetic nitrogen fertilizers and urea**.

Projections show that if current trends continue, agriculture-related emissions will rise to 92 $MtCO_2e$ in 2035. In particular, the expected 16% increase in emissions from enteric fermentation and manure management points to priority areas for intervention in the decarbonization of the sector. When the Net Zero scenario is implemented, emissions decline from 99.1 $MtCO_2e$ in the BAU scenario to 68.1 $MtCO_2e$ in 2053. This represents a reduction of approximately 20 $MtCO_2e$ compared to the 2025 base year. Looking at the impact of the strategies, biogas use can reduce emissions from fertilizers by 66.5%, the electrification of agricultural machinery by 67.6%, and genetic improvement and feed quality improvements in cattle breeding by 14.3%.

A cumulative reduction of approximately 100 $MtCO_2$ is achieved over the projection period, demonstrating that the agricultural sector can contribute to the goal of limiting global warming to 2°C despite its limited policy space. Figure 7 shows the trajectory of agriculture-related emissions under the Reference and Net Zero scenarios for the period 2025–2053.

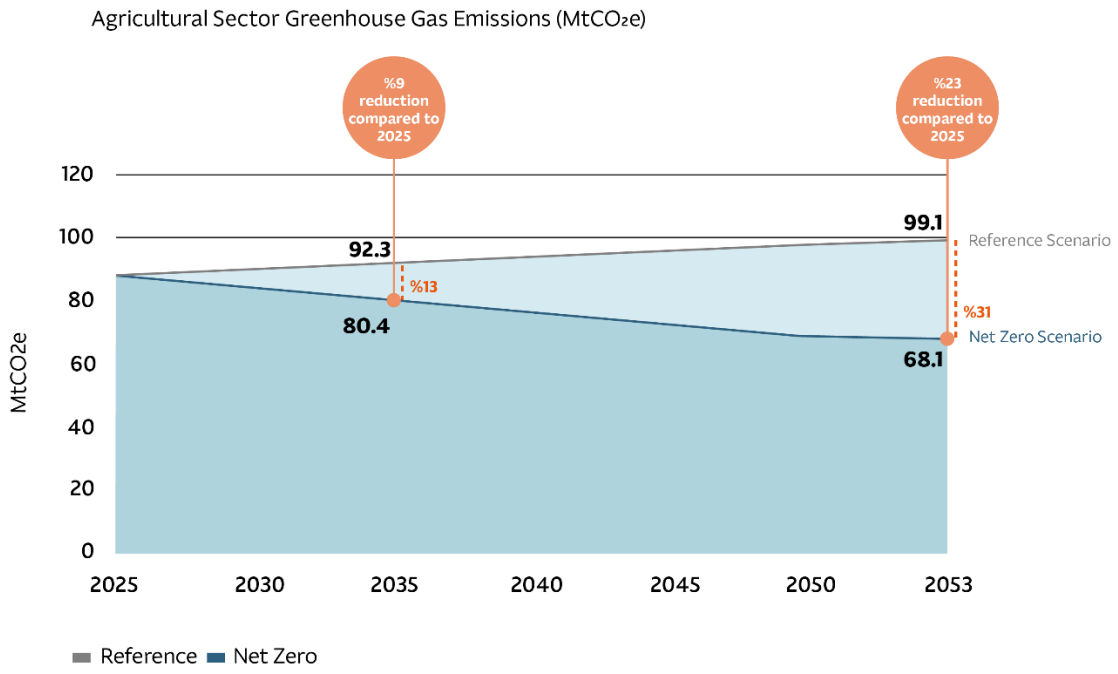

Figure 7 - Agricultural Sector - Greenhouse Gas Emissions

ELECTRICITY SECTOR

As the first step in modeling the electricity sector**, electricity demand from the industrial, building, transportation, and agriculture sectors** was calculated, and a total demand projection was created. In the Reference Scenario for the period 2025–2053, the average annual demand growth is projected to be **2.8%**, while in the Net Zero Scenario, this rate rises **to 3.8%** due to the acceleration of electrification. Projections for total electricity demand are presented in Figure 8. A generation system expansion model was established to meet electricity demand, and capacity investments were defined for different scenarios. In the Reference Scenario, the current composition was maintained, with an increase in natural gas installed capacity only based on demand growth. In this scenario, an additional annual capacity of 2.2 GW for solar energy and 1 GW for wind energy was projected. In the Net Zero Scenario, as a first step, a rapid coal phase-out path has been followed; the total coal installed capacity of 21 GW has been reduced to 7 GW in the 2025–2030 period and will be completely phased out of the system by 2035. During this transition process**, an annual capacity increase of 7.5 GW is planned for solar energy and 2.4 GW for wind energy.** The distribution of installed capacity under both scenarios is presented in Figure 9.

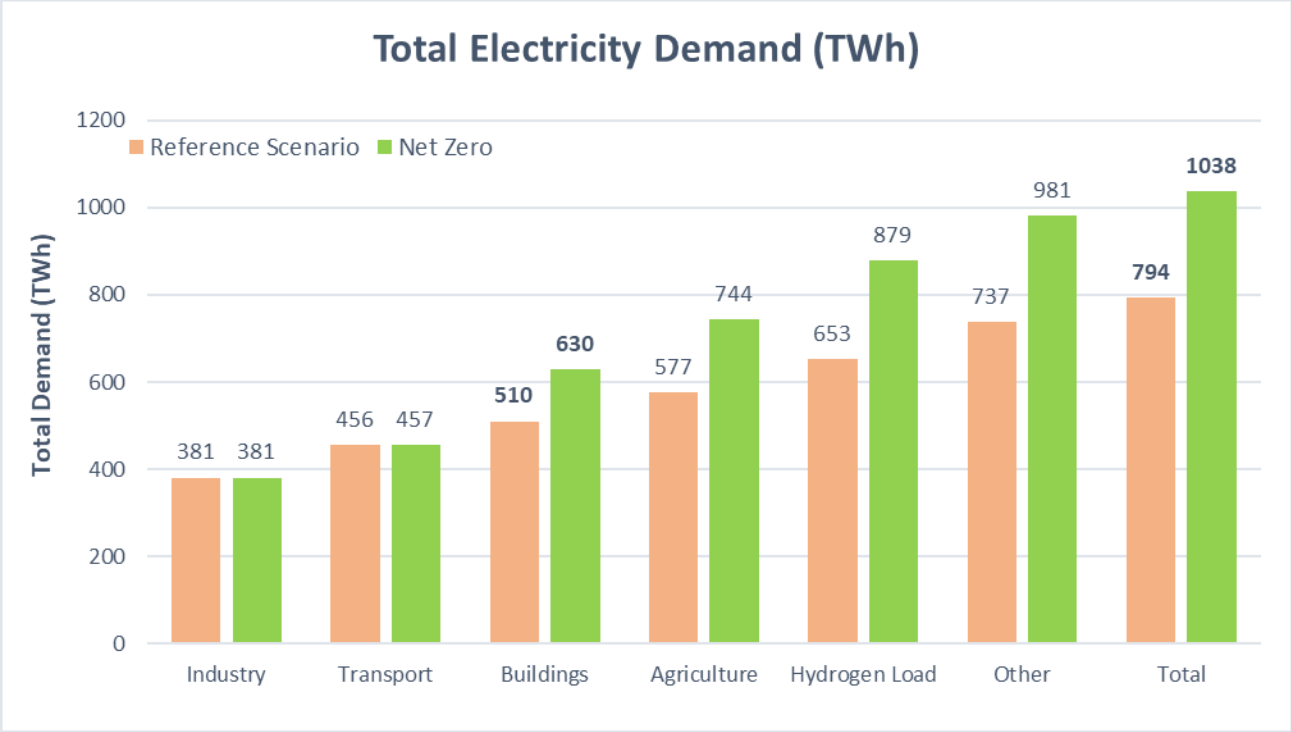

Figure 8 - Projections for total electricity demand

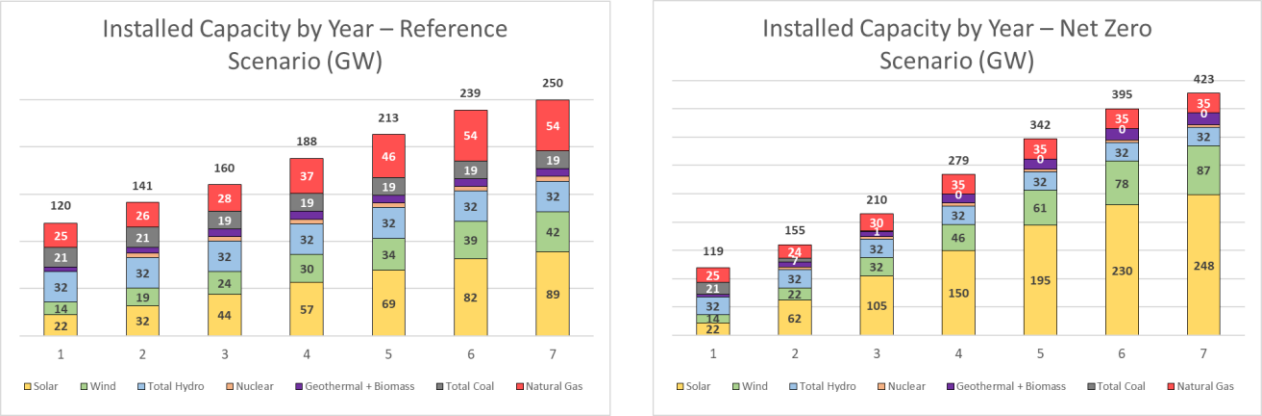

Figure 9 - Distribution of installed capacity under two scenarios

The calculated generation fleet was tested using the EP-SIM model according to market and grid operating conditions. This model considers the total electricity demand from industry, buildings, transportation, and agriculture, hourly load profiles, energy constraints of dammed hydroelectric power plants, historical production data of renewable sources, merit-order scheduling of conventional power plants based on increasing prices, reserve requirements, generator technical constraints, and the current grid model. Market and grid simulations conducted for 2035 and 2053 **show that the share of solar and wind energy in total production will**

reach 38% in the reference scenario and 73% in the Net Zero scenario by 2053. During this process, the capacity factors of conventional power plants remain within the expected range, total YAL/YAT instructions remain below 3% of the load in terms of grid reliability, and renewable production interruptions are less than 3% of the total potential. The EP-SIM model's production distribution outputs for 2035 and 2053 are presented in Figure 10.

In terms of greenhouse gas emissions, **an** average annual **increase of 1.2%** is observed in the Reference Scenario and **an** average annual **decrease of 6.5%** in the Net Zero Scenario throughout the 2025–2053 period. The Net Zero Scenario achieves a **54%** reduction in CO_2 equivalent by 2035 compared to 2025, and an 84% reduction by 2053 compared to 2025. The curves showing the trajectory of emissions related to the electricity sector during the 2025–2053 period under the Reference and Net Zero scenarios are presented in Figure 11.

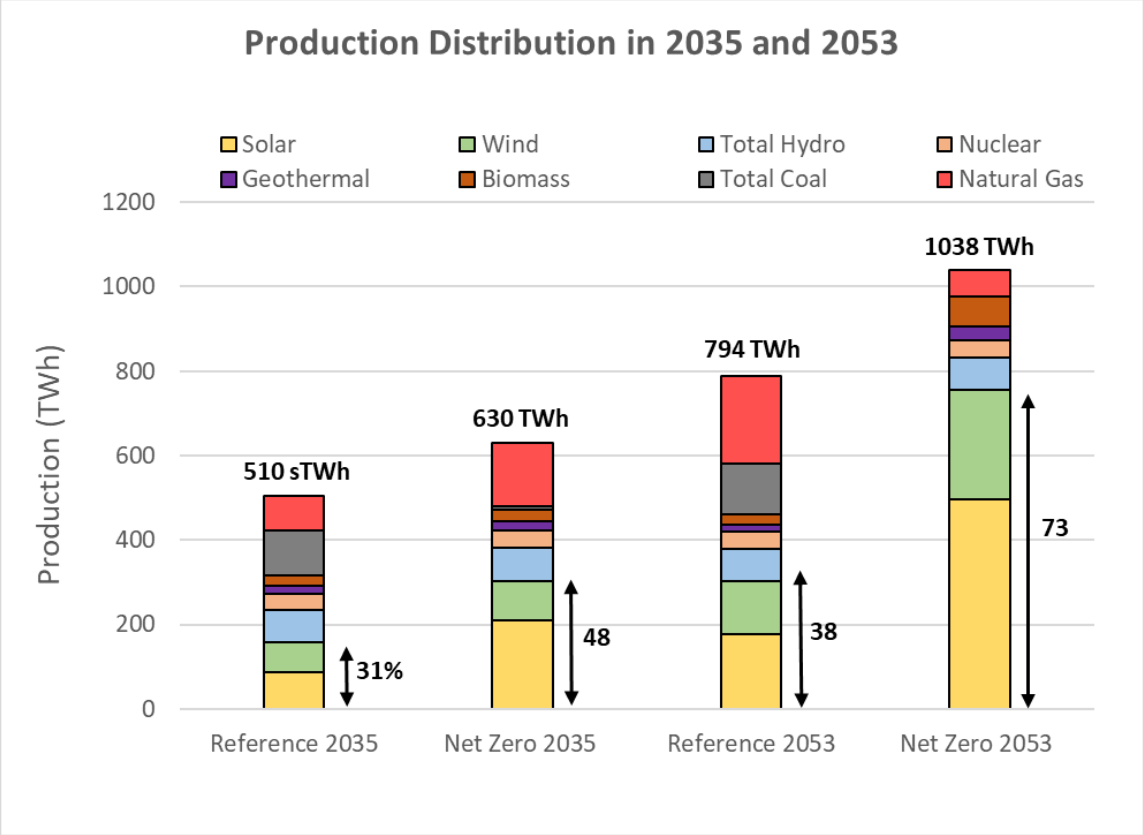

Figure 10 - Production distribution for 2035 and 2053

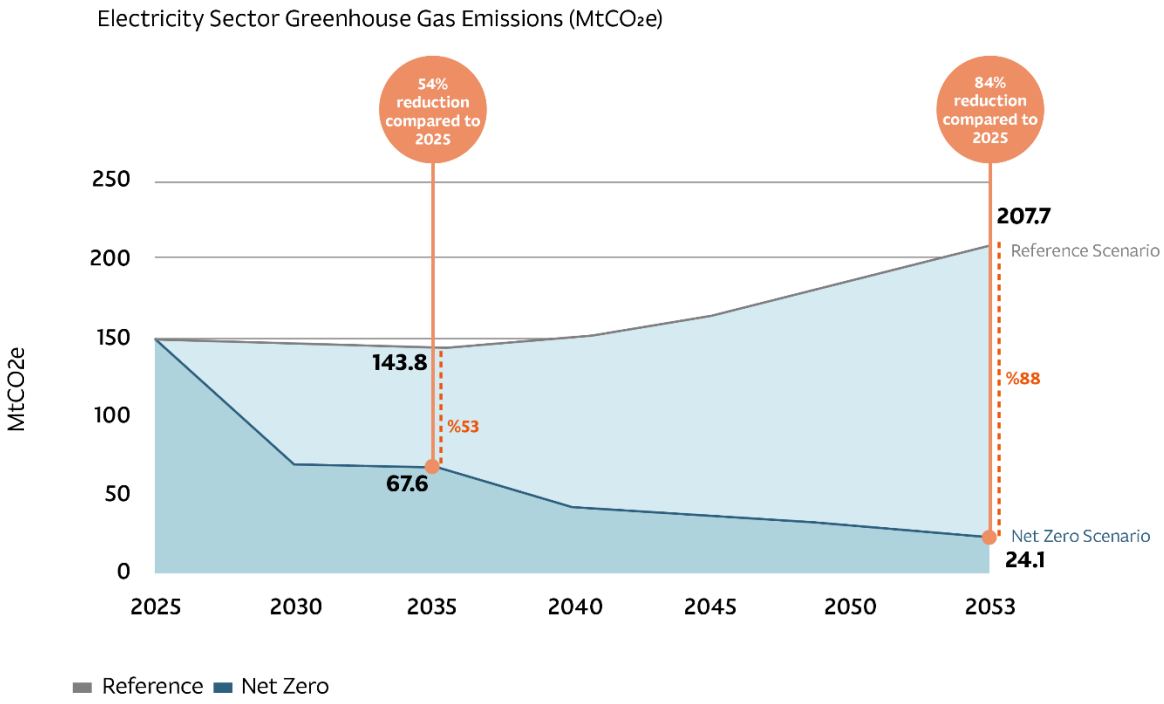

Figure 11 - Electricity Sector - Greenhouse Gas Emissions

The net zero transition cost has also been calculated for the 2025–2035 period. According to this calculation, which includes investment, maintenance, fuel, operation, and network investments, the total cost of the transition **is $80.1 billion.** Among these cost items, power plant investment costs account for the largest share in the emission reduction scenario.

WASTE SECTOR

The waste sector has been modeled using a data-driven linear regression approach, and it is assumed that emissions will decrease linearly from **14 $MtCO_2e$** in 2025 to **8.2 $MtCO_2e$** in 2053. Emission projections for the waste sector are presented in Table 1.

Waste sector - Greenhouse Gas Emissions (MtCO2e)							
Greenhouse Gas	2025	2030	2035	2040	2045	2050	2053
CO2	0,0	0,0	0,0	0,0	0,0	0,0	0,0
CH4	11,9	11,6	10,6	9,6	8,6	7,5	6,9
NOx	2,1	2,1	1,9	1,7	1,5	1,4	1,3
Total	14,0	13,7	12,5	11,3	10,1	8,9	8,2

Table 1 - Waste Sector - Greenhouse Gas Emissions

F-GASES

According to the Greenhouse Gas Inventory, total F-gas emissions, not sector-specific, are **9.9 $MtCO_2e$** in 2023. Under the **Kigali Amendment** to the Montreal Protocol on Substances that Deplete the Ozone Layer, Turkey must reduce its F-gas emissions by approximately 80% by 2045. In the model, a linear reduction was applied, taking into account the reduction trend specified for Turkey in the Kigali Amendment. (Figure 12)

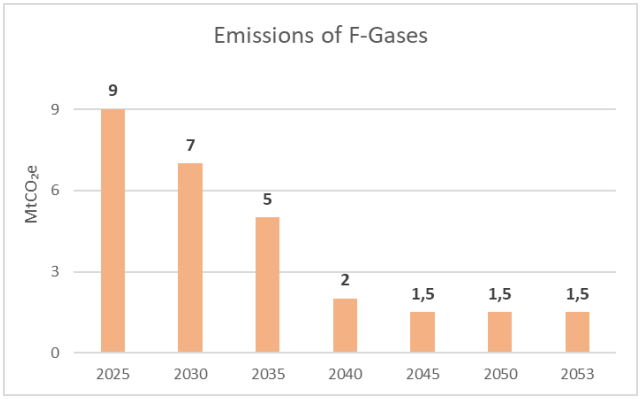

Figure 12 - F-Gas Emissions

Total Emission Reduction Pathway and Cost

In the study, emissions from all sectors were combined, and Turkey's total greenhouse gas emissions were projected for the 2021–2053 period. The results show that the Reference Scenario maintains an upward trend in emissions, while the Net Zero Scenario achieves a sharp decline. As shown in Figure 13, under the Net Zero scenario, total greenhouse gas emissions are projected to decrease by approximately 60% by 2053 compared to 2021. This corresponds to an **average annual** reduction of **approximately 3**%. **Total emissions in 2035 are projected to decrease by 35% compared to 2021.**

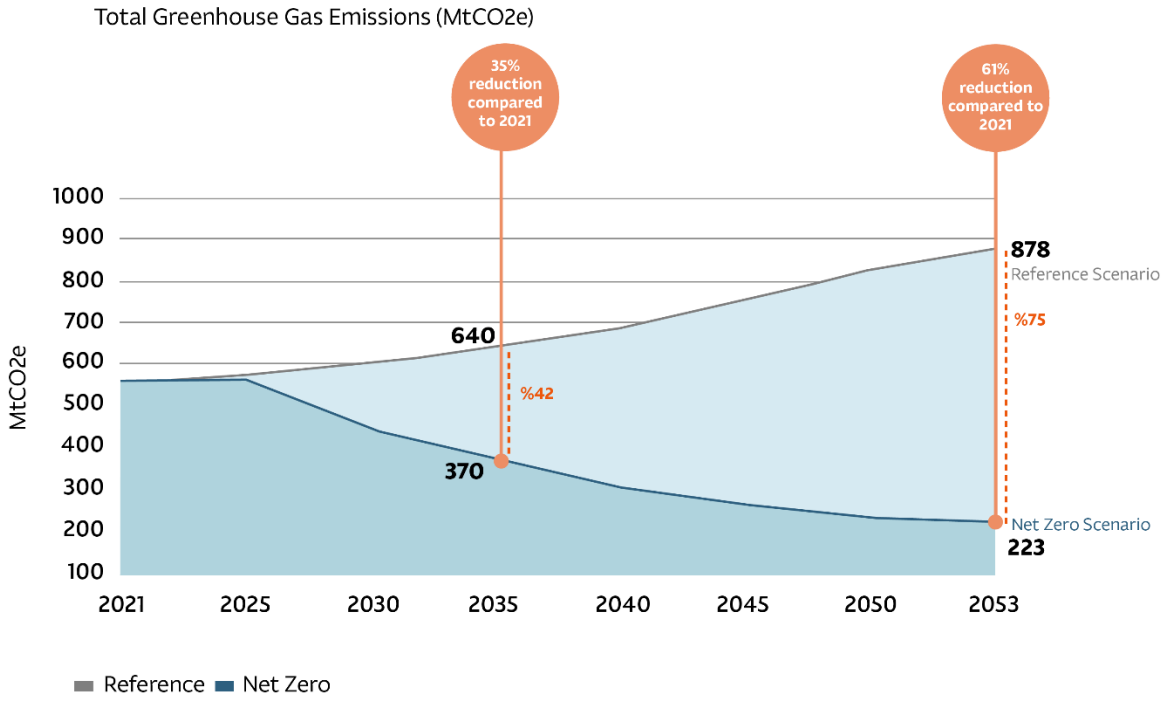

Figure 13 - Turkey's total greenhouse gas emissions

The sectoral distribution presented in Figure 14 shows that the share of the industrial sector in total emissions will increase during the 2025–2035 period, while the share of the electricity sector will decrease significantly thanks to the rapid integration of renewable energy sources. Furthermore, emissions from the building sector are projected to be zeroed by 2040. **By 2053, CO_2 will account for approximately 65% of the remaining emissions, with the remainder coming from methane (CH_4), nitrous oxide (N_2O), and F-gases.**

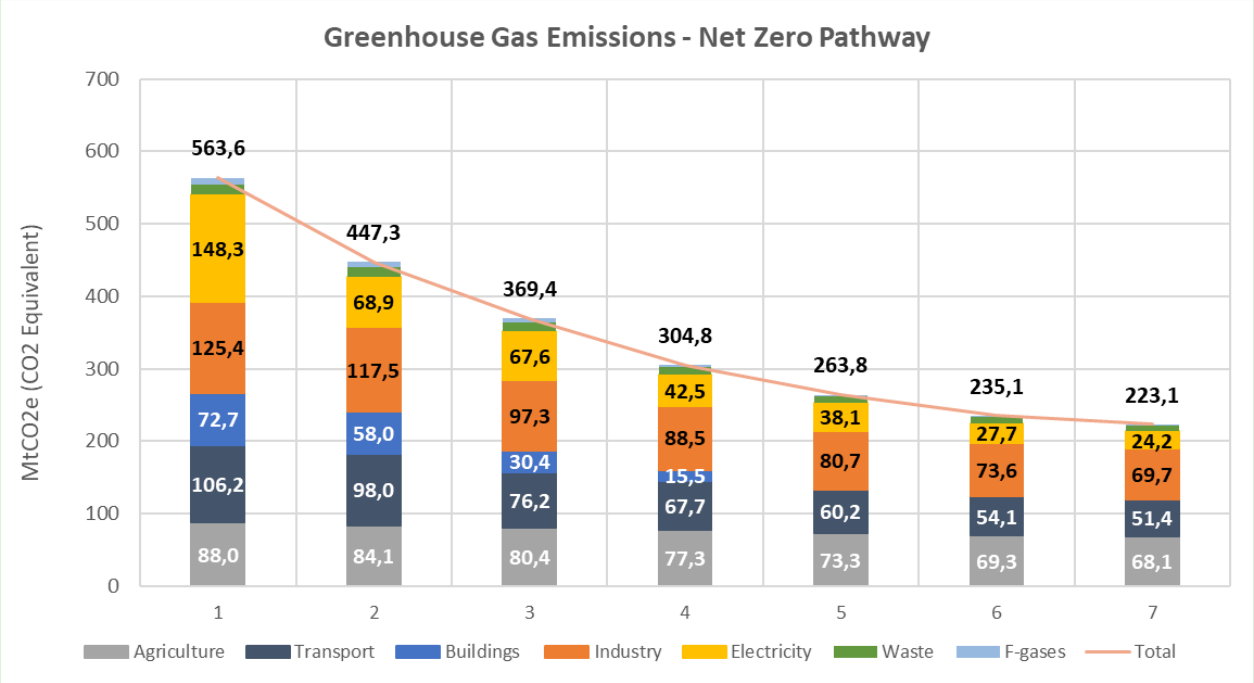

Figure 14 - Sectoral Distribution of Total Emissions – Net Zero Scenario

Figure 15 shows the distribution of reductions achieved in the Net Zero Scenario compared to the Reference Scenario by sector, while Figure 16 shows the contribution of the main measures (electrification, technological transformation, efficiency improvements, and others) to these reductions.

As shown in Figure 17, compared to the Reference Scenario**, the Net Zero Scenario achieves a 40% reduction in CO_2 emissions by 2035 and an 82% reduction by 2053 compared to 2021 levels.** This significant reduction highlights the scale of transformation required for Turkey to achieve its 2053 Net Zero target. The study also outlines the costs of this transformation.

As shown in Figure 18, implementing the Net Zero scenario incurs an additional cost **of $265 billion (or $26.5 billion per year)** compared to the reference scenario. The largest portion of this cost is transformation investments in the building sector.

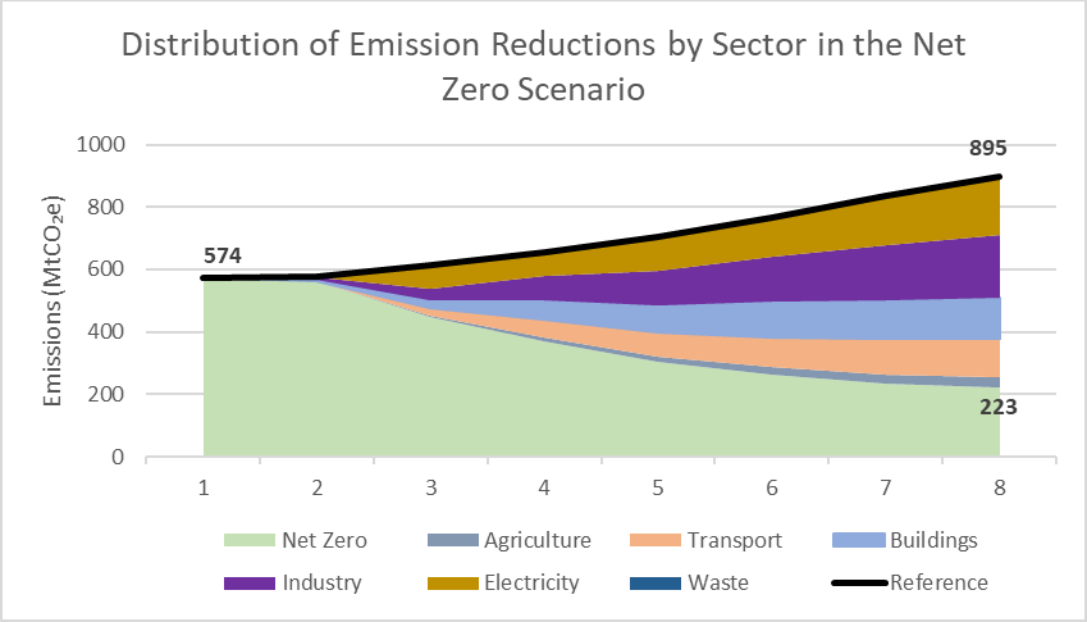

Figure 15 - Distribution of emission reductions by sector in the Net Zero Scenario

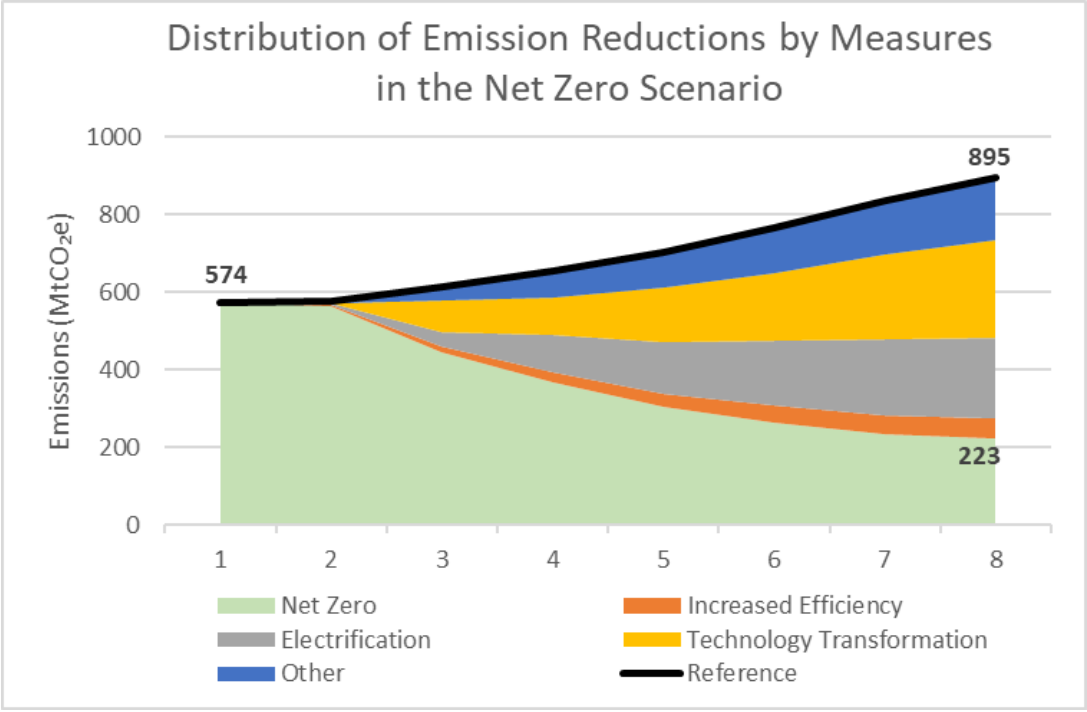

Figure 16 - Distribution of emission reductions by measures in the Net Zero Scenario

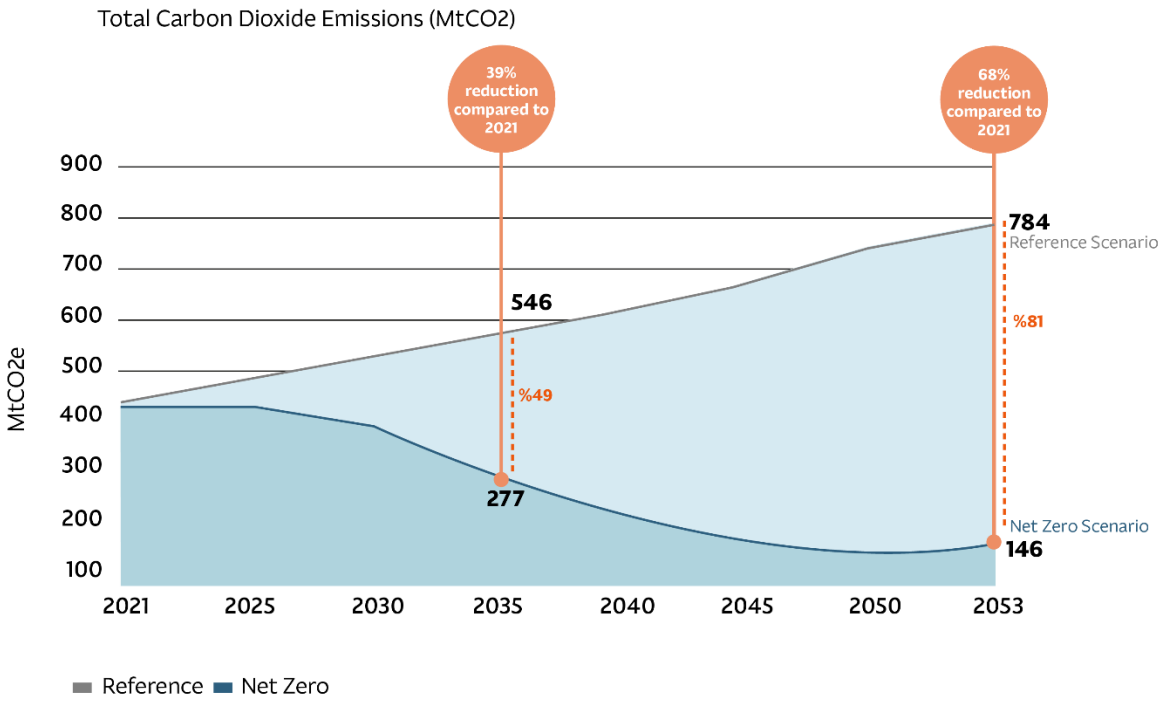

Figure 17 - Total CO_2 emissions

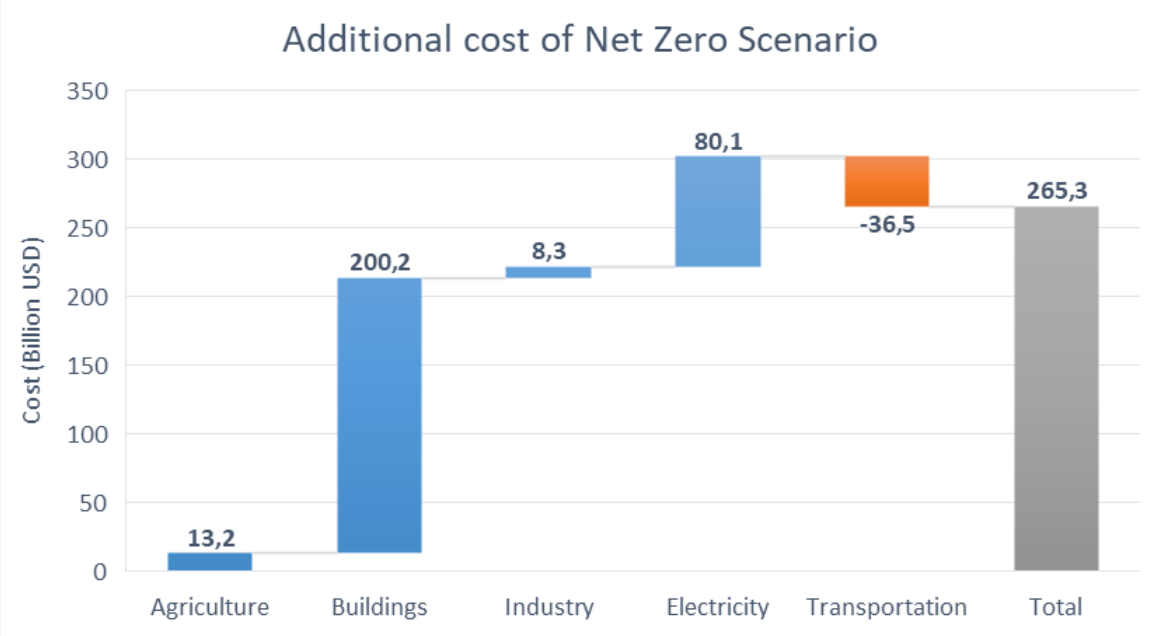

Figure 18 - Net zero transition cost for the 2025-2035 period

Finally, when assessing the compatibility of emissions with Turkey's share of the remaining global carbon budget, it is seen that cumulative emissions remain above the limit set for the 1.5°C target but below the limit set for the 1.7°C target (Figure 19). This situation reveals that Turkey's Net Zero pathway is partially aligned with global climate targets, but more ambitious reduction steps are needed.

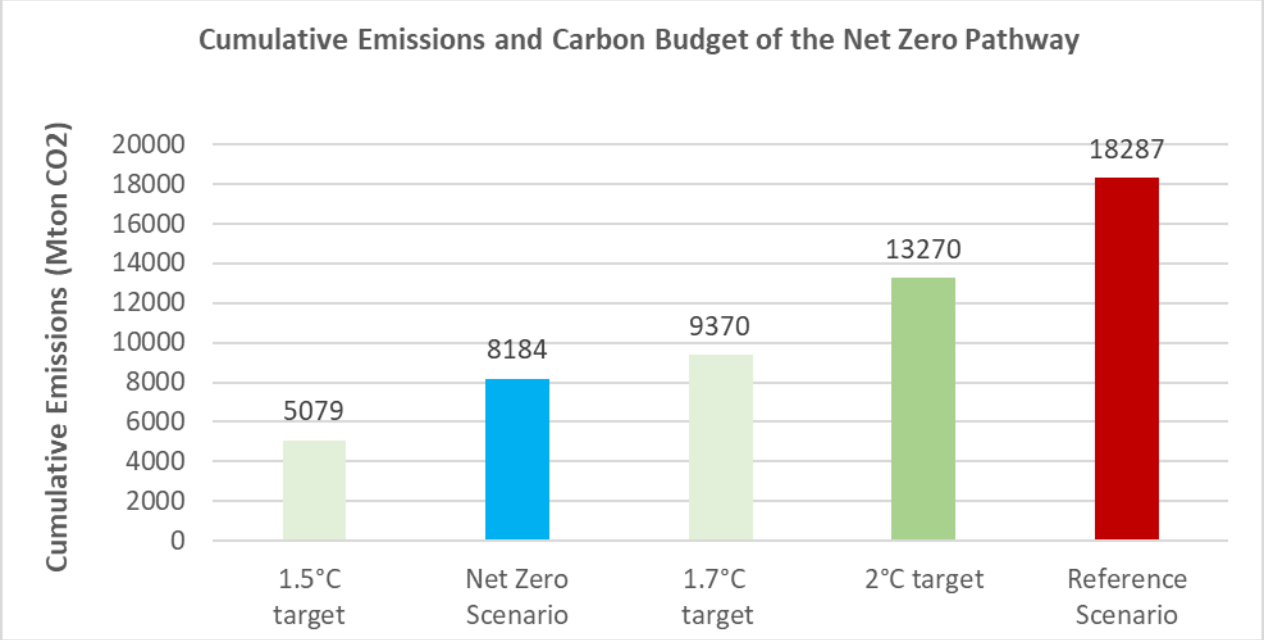

Figure 19 - Turkey's cumulative greenhouse gas emissions and carbon budget until 2053

Conclusion

1- With a planned economy-wide strategy, Turkey **can absolutely reduce its greenhouse gas emissions between 2025 and 2035** and further reduce its emissions by 2053 to approach the net zero target, provided that the current economic structure, growth paradigm, and lifestyle continue and that measures proven to be technologically and economically feasible today are implemented. Achieving the net-zero target by 2053 depends on new technologies that will develop in the coming decades and become more economically viable, as well as the adoption of a more ecological lifestyle and behaviors with lower energy intensity than the current lifestyle.

2- According to the latest GHG inventory prepared by TÜİK and submitted to the UNFCCC by the Climate Change Presidency, **Turkey's emissions peaked at 573.8 $MtCO_2e$ in 2021** and decreased by 3.8% to **552.2** $MtCO_2e$ by 2023, the last year for which emissions were reported. **This decline may be temporary, but** if it is linked to developments that reduce the carbon intensity of the economy, such as renewable energy, along with various reasons related to the structure of the economy, **emissions may have permanently peaked in 2021.** The Reference Scenario included in this study shows that, unless new measures are taken towards the net-zero target, this decline may be temporary based on the current trajectory of the economy, and emissions could increase **by more than 12%** compared to 2021 levels, reaching **655 $MtCO_2e$** by 2035.

3- According to the Net Zero Scenario presented in this study, for Turkey's new NDC to be compatible with the Net Zero target in 2053:

a. **2021** must be maintained as **the peak year for emissions**, and emissions must be rapidly reduced starting in 2025.
b. Turkey's greenhouse gas emissions can be reduced by **35% compared to 2021 levels**, reaching **370 $MtCO_2e$ by 2035**, provided that the necessary policies are implemented. This also means reducing emissions to **pre-2010** levels.
c. Under the net-zero scenario, the reduction in carbon dioxide emissions is faster. Turkey's CO_2 emissions can be reduced by **40% compared to 2021 levels by 2035**, falling **to 277 $MtCO_2$**. This also means that CO_2 emissions could fall back to **pre-2005** levels.
d. This reduction, which can be achieved by 2035, largely depends on the gradual phase-out of coal in the electricity sector and the rapid establishment of new renewable energy power plants. **The gradual phase-out of coal use in the electricity sector could be completed by 2036.** This phase-out is possible with the installation rate of new renewable energy (wind and solar) reaching **approximately 10 GW per year** and **9 GW** of battery investment **by 2035**.
e. Measures to be taken by 2035, including reducing fossil fuel use in buildings and **electrification**, **transitioning to electric vehicles** in transportation, and **increasing efficiency** in industry, will also have a significant impact.

4- The cost of this scenario, which envisions reducing greenhouse gas emissions by more than

one-third over the next decade, is limited to **$8 billion per year** for the electricity sector and **$830 million per year for** industrial sectors. In transportation, reducing fossil fuel use and consequently oil imports yields an **annual** benefit of **$3.6 billion**. The high cost of the net-zero scenario is in the buildings sector, **at US$20 billion per year**, due to the investments required for electrification and raising the energy standards of buildings. Therefore, **the total cost** rises **to US$265 billion**.

5- Although Turkey's net zero scenario aims to reduce greenhouse gas emissions to zero by 2053 in line with its net zero target, the modeling used in this study shows that this reduction cannot be achieved with current technologies and the current structure of the economy. According to the net zero scenario, Turkey's greenhouse gas emissions will decrease by approximately 62% compared to 2021, falling to **223 $MtCO_2e$ in 2053**. This reduction is 75% less than the emissions projected to reach **895 $MtCO_2$** in the reference scenario. Looking only at CO_2 emissions, it is seen that **143 $MtCO_2$** remains in 2053. This means a reduction of approximately 69% compared to 2021. This reduction is 82% less than the CO_2 emissions expected to reach **784 $MtCO_2$** in 2053 in the reference scenario. In the net-zero scenario, the reduction rates in 2053 are significantly lower for greenhouse gas emissions, largely due to the greater difficulty of reducing methane and nitrous oxide gases in the agriculture sector.

6- Of the remaining **223 $MtCO_2e$** emissions in 2053, one-third comes from other greenhouse gases such as methane and nitrous oxide. Most of the remaining **146 $MtCO_2$** emissions also come from process emissions in the industrial sector and fossil fuel-powered vehicles in transportation. Due to the relative ease of decarbonization in the electricity sector, **24 $MtCO_2e$** of residual emissions will continue to be generated from natural gas, primarily due to the need for grid flexibility. To achieve net-zero emissions by 2053, new technologies to prevent process emissions, particularly in the cement sector, and new measures or technologies to accelerate electrification in transportation are required. Additionally, behavioral changes that reduce consumption and promote a more ecological lifestyle, largely overlooked in this modeling, could help emissions reach net-zero.

7- The carbon budget approach used in this study takes into account the carbon inequality between countries. Turkey has less historical responsibility for the emergence of climate change than early industrialized countries such as the US and European countries, and countries that have industrialized very rapidly in recent years, such as China. Nevertheless, as the world's 15th largest emitter of greenhouse gases, a G20 member, an upper-middle-income, industrialized country, Turkey has a much higher reduction responsibility compared to lower-middle-income and less developed countries. In this study, Turkey's share of the global carbon budget is higher than its share of current emissions, taking into account Turkey's right to development. However**,** in this study's Net Zero Scenario**, Turkey's cumulative emissions until 2053 exceed the remaining carbon budget allocated to Turkey to keep the temperature increase below 1.5°C with a 50% probability.** This indicates that the policies that need to be followed to comply with the Paris Agreement's 1.5°C target must be stricter than those adopted in the Net Zero Scenario.