Social and Employment Impacts of Climate Change and Green Economy Policies in Türkiye

Application of the Green Jobs Assessment Model for Türkiye

ABOUT UNDP

UNDP's work on climate change spans more than 140 countries and involves US$3.7 billion in investments in climate change adaptation and mitigation measures since 2008. With the goal to foster ambitious progress towards resilient, zero-carbon development, UNDP has also supported implementation of the Paris Agreement on Climate Change by working with countries on achieving their climate commitments, or Nationally Determined Contributions (NDCs).

ILO

ILO is spearheading a global Just Transition agenda through the Climate Action for Jobs Initiative. The Paris Agreement on Climate Change, adopted in 2015, acknowledges the imperatives of a just transition and the creation of decent jobs in a response to climate change. In the same year, ILO constituents adopted Guidelines for a just transition towards environmentally sustainable economies and societies for all.

ILO GREEN JOBS PROGRAMME

The Green Jobs Programme signals ILO's commitment to act on climate change and promote resource efficient and low-carbon societies. Decent work is a cornerstone for effective policies to green economies for achieving sustainable development. The Green Jobs Programme has, over time, assisted over 30 countries by building relevant ILO expertise and tools.

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Placeholder: Foreword

Climate change is accelerating to the point of no return despite all joint efforts of the global community. Coupled with other environmental problems such as the loss of biodiversity, water pollution and land degradation, global warming has pushed our planet to the brink. Urgent action is long overdue, and we have already run out of time to avoid serious harm. As United Nations Secretary General Antonio Guterres said in June 2022 in addressing the Stockholm+50 conference, "We need to change course – now – and end our senseless and suicidal war against nature."

Responsibility for this shift lies with every individual. But while individual decisions to adopt a more nature-friendly lifestyle can help, a radical policy shift by governments and corporations at all levels is vital to give us any hope of success in protecting humanity from the ravages of climate change.

The appetite for the bold policies that will be needed to achieve sustainability varies from country to country. In this respect, Türkiye took a big step forward at the end of 2022, ratifying the Paris Agreement and committing to the achievement of a net-zero emissions target by 2053. A first measure of the country's ambition will emerge in the Nationally Determined Contribution that is currently under revision for submission during the climate summit in Egypt at the end of this year.

Like other industrialized nations, Türkiye is grappling with the economic and social consequences of the policy changes needed for effective climate action. "Decarbonization" will mean expansion for some sectors, with renewable energy at the forefront, but it also spells trouble for highly polluting industries such as coal and plastics. Concerns about the impact on the labor force of a shift away from fossil fuels are high on the political agenda and can sometimes discourage bold action.

In this context, credible analysis is needed to answer tough questions:

- Are "green jobs" a credible economic option or merely a political slogan?
- Can the renewable energy sector replace the job losses caused by phasing out fossil fuels?
- Will redundant workers be able to transfer to new jobs in more sustainable industries?
- Can the social protection system bear the burden of redundancies and retraining?
- What scale of investment is necessary to ensure a "just transition" in Türkiye?

This report draws on a globally tested model to try to answer these questions. Our research team made a side-by-side comparison of investments of the same size in renewable energy and energy efficiency, on the one hand, and coal-powered electricity, on the other. The results are promising. In pursuing the sustainable option, the model showed, Türkiye could increase GDP by up to TRY45 billion per year; create more than 300,000 new jobs by 2030; and reduce greenhouse gas emissions by 12 percent compared to the 2019 level. This is a win-win-win scenario for the country, showing that environmental protection can go hand in hand with economic growth and social progress.

The International Labour Organization (ILO) and the United Nations Development Programme (UNDP) have joined forces to develop this report to provide a fresh perspective on the idea of "green jobs." Building on the analysis conducted by SINTEF, an independent research organization, we hope to help shift discussion in Türkiye from the question of "whether" ambitious climate action is urgently needed to the "which" of specific policies that are sufficiently bold and timely to address the dire nature of the challenge we face. We look forward to working with government, the private sector, trade unions and civil society to build a strong consensus behind "peace with our planet," and to continue to provide policy advice and practical solutions to make this vision a reality.

Numan ÖZCAN	Louisa VINTON
Director of the ILO Office for Türkiye	UNDP Türkiye Resident Representative

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CO_2	Carbon dioxide
CO_2-eq	Carbon dioxide equivalents
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GJAM	Green Job Assessment Models
ILO	International Labour Organization
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contribution
IO	Input-Output
IOT	Input-Output Table
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land Use, Land-Use Change and Forestry
MEIO	Macro-Econometric Input-Output
NDCs	Nationally Determined Contributions
OECD	Organisation for Economic Co-operation and Development
SDG	Sustainable Development Goal
SNA	System of National Accounts
SUT	Supply and Use Table
UNFCCC	United Nations Framework Convention on Climate Change
VA	Value Added
YEKA	Renewable Energy Resource Areas
YEKDEM	Renewable Energy Support Mechanism

Executive Summary

Türkiye's economy is at a crossroad. To become a higher-income country in the long run and achieve faster economic growth and lower unemployment in the medium term, as set out by the New Economic Program, several structural challenges must be overcome.

Key structural challenges include signs of a middle-income trap which is hindering the move to higher value-added service industries, a widening current account deficit and a negative trade balance, which stood at around USD 50 billion - some 5-6 % of GDP - in the past decade. In addition, Türkiye's current economic structure relies on energy hungry industries for exports, as compared to higher value-added services, and displays a high import dependency, notably on energy and fossil fuels, which further create growing national security and geopolitical risks. The economy's energy dependency makes Türkiye particularly vulnerable as it is reliant on imports for 60% of coal, 93% of oil, and 99% of natural gas.

Similarly, key labour market indicators point to structural challenges in the utilisation of Türkiye's growing population. Labour force participation stands at around 55%, the lowest in OECD countries, with low female participation. Unemployment hovers around 11% and is high for youth while labour under-utilisation is a major phenomenon and concern for more than 40% of those employed, similarly to the high levels of informal employment.

Compounding these structural challenges are increasingly costly climate change disasters and environmental hazards, such as country wide forest fires, flooding or sea-snot, impacting not only the tourism industry but the economy at large including agriculture and manufacturing industries and employment.

Among the policy choices to address the structural challenges, low-carbon and green economy policies have featured importantly in the wake of the Covid recovery. They have been advocated for by the IMF, OECD, G20, EU, ILO and the UN System under the name of 'Building Back Better'. Proponents claim green and low-carbon policies can fast-track a new era of economic development with higher growth rates, increased employment levels, lower environmental risks and augmented energy and national security.

While Türkiye has engaged in green and low-carbon policies in the past, ratified the Paris Agreement on Climate Change and put forward some green and low-carbon policies, a key question is whether fast tracking and augmenting such green policies could further address above structural challenges in an integrated and coherent way, and contribute to Türkiye's vision of a high-income country.

This report sets out to assess Türkiye's structural challenges in terms of its economic, social and environmental outcomes of a swift and comprehensive implementation of green low-carbon policies. First, a macro-economic structural simulation model, named the Green Jobs Assessment Model, was built for this purpose. And second, a green development scenario was applied and compared to a business-as-usual development scenario.

In both scenarios Türkiye's economy grows by around 3-4% per year as projected by the OECD. To satisfy industries' needs, Türkiye's energy and electricity demand need to grow rapidly at 20% by 2025 with a linear trend up to 2030. In the business-as-usual scenario, economic growth follows Türkiye's historic trend and no structural change, other than past observed changes, is assumed. This scenario includes the growth of fossil fuel energy imports and electricity generation from mainly coal power. However, in the Green Scenario, instead of investing into fossil fuels and new coal power plants, Türkiye is assumed to undergo a green structural transition by investing exclusively into renewable and notably wind and solar power to satisfy all future energy needs.

Total additional investments required to satisfy those energy needs are assumed to be the same in both scenarios. They represent the cost of new investments in coal power plants between 2022 and 2029. These investments correspond to 89.5 billion USD for the period (between 9.3 and 12.5 billion USD per year) which amount to 510 billion TRY (in 2019 constant prices). However, the green scenario requires lower investments to satisfy all energy needs because the cost is lower for green technology than investments into coal power plants per GWh of electricity produced. This means that green policy measures are less costly, and that money would be available to invest into further energy security measures, such as grid stability and energy efficiency of buildings.

Comparing results, by 2030, in the green scenario, outcomes are positive in terms of economic growth, employment creation, trade balance, reduced environmental risks and GHG emissions. Compared to the business-as-usual scenario, the green scenario results in additional 10-45 billion TRY (in 2019 constant prices) in annual GDP, over 300,000 extra jobs by 2030, and lead to a decrease of 60,000 Mt CO2-eq, that is, 8% lower than in the reference scenario.

In addition to the economic, employment and environmental gains from a green structural change, the diversification of energy sources makes the electricity system more reliable and resilient from external factors, such as droughts and international fossil fuel prices, which are likely to be affected by geopolitical risks, climate change and climate policies. Increasing domestic energy production further strengthens the security of supply and boosts the economy by creating more economic activity domestically, both in the energy producing industries and in upstream value chains including in manufacturing and higher value-added services, further contributing to the development of a high-income economy.

The positive long-term effects of a policy induced green structural change are due to a combination of economic factors, namely three main conditions. First, the investment in new infrastructure is driving long-term structural changes in the energy and electricity industry which, in turn, increase the demand for goods and services from other industries within the Turkish economy to operate and maintain these new green industries. Second, the operation of renewable electricity generates more jobs than of fossil electricity, due to the distributed nature of wind and solar compared to thermoelectric power plants. And third, the inputs to the current electricity and gas industry comprise of mainly fossil fuel-based coal and natural gas. The coal and natural gas which serve as inputs to thermal electricity are mostly imported. Thus, losses of economic output and jobs from the lower demand from coal affects mostly workers outside of Türkiye. In contrast, the operation and maintenance of solar and wind power plants increases the demand for goods and services produced by Turkish industry, leading to positive indirect impacts on the economy.

Although the Green scenario has a positive net impact on jobs, it is important to identify where and which jobs will be gained, and which jobs will be lost. Anticipating where jobs will be created and where jobs will be lost will allow for the design of policies and strategies to maximise benefits of job creation and growth of decent jobs and alleviate negative impacts from job losses by identifying opportunities for job transitioning for affected communities.

Employment gains in the Green Scenario are widespread in the economy. Out of the 66 detailed industries from the model, only three industries will experience net-losses by 2030. Most jobs lost, as expected, are in the traditional (fossil fuel) electricity industry. The green investment portfolio generates long-term employment opportunities in the manufacturing of electronic and electrical equipment, both industries supplying important inputs for renewable energy technologies. High and professionally skilled employees are in higher demand in the long run green scenario, supporting the transition to a high-income economy, but would need to be trained.

This effects on both, formal and informal employment, as well as jobs typically held by men and by women are positive overall. However, due to the current structure of the labour market more jobs are created for men who are typically formally employed and medium skilled, notably in manufacturing.

In order to enable and further improve on the positive social and employment impacts, comprehensive Just Transition policies are required to accompany the green energy policies. Notably, the modernisation of the Technical, Vocational and Education System to provide for the required skill sets. The expansion of Social Protection to cater for and transition jobs from declining to new industries. And, enabling policies for green enterprise development to stimulate private sector growth. In terms of financing, a fiscal neutral reform to progressively tax richer and carbon intensive households, who are responsible for most carbon emissions as compared to poorer ones, could finance a Just Transition Fund. The fund, in turn, would invest into skills training and education, notably for women, social protection schemes to help transitioning workers and energy poor households and could finance green enterprise development and capital investments.

Green Jobs Assessment Model

Green Job Assessment Models (GJAMs) are a tool to assess the direct and indirect impacts of climate policies on jobs. They are a macro-economic modelling framework based on the official national accounts statistics, combined with employment and other social data from household and labour force surveys, and with greenhouse gas emissions from national inventories. These models can assess alternative climate strategies and provide guidance for policy making and for the revision of Nationally Determined Contributions (NDCs). GJAMs have been so far developed for 14 different countries.

GJAMs are not economic forecasting models. Rather, these models are a tool to inform about possible effects of "what-if" scenarios on emissions and labour demand by industries, given that the remaining structure of the economy remains as it is. The results should be assessed relative to the reference scenario. They indicate the direction and possible size of the effects but should be interpreted cautiously. For example, the actual labour market outcomes also depend on other factors as well as dynamic labour market adjustments, which are not considered here. Nonetheless, these models give an indication on how to design measures and policy goals to maximise the positive and minimise the negative implications of climate policies. The merit of input-output and supply-and-use based models is their ability to assess indirect effects of measures on the entire economy, such as measures aimed at changing production technology, consumer behaviour, or investments. Note, investments are modelled as additional economic activity, not crowding out other investments.

"*The term 'scenario' is often used in decision-making to represent an imagined future*". A scenario aims at being self-consistent and plausible, but is not a prediction of the future[1].

1. Introduction

1.1. Background

The 2030 Agenda for Sustainable Development[2] and the Paris Agreement on Climate Change[3] have highlighted the necessity for a transition to a low-carbon economy, while eradicating poverty and guaranteeing a sustainable socioeconomic development worldwide. This transition requires structural shifts in the global and in national and local economies, transforming different sectors such as energy production and consumption, agriculture, manufacturing industries, and mining. These structural changes cause direct and indirect impacts throughout national and global value chains, affecting workers, income, and communities, particularly those built around declining industries such as coal mining.

Türkiye has recently ratified the Paris Agreement, as a move towards implementing climate policies and reducing greenhouse gas (GHG) emissions. As part of climate policies efforts, Türkiye submitted its first Intended Nationally Determined Contribution (INDC) to the UNFCCC in 2015, pledging to reduce up to 21% of GHG emissions relative to business-as-usual by 2030[4]. However, although it is considered an Annex I country[1], the principle of "common but differentiated responsibilities" means that Türkiye, as a country with small historical contribution to GHG emissions, should prioritise a low-carbon socioeconomic development.

As an upper-middle-income emerging country, Türkiye is going through rapid industrialisation and urbanisation, and its energy demand is growing substantially. Therefore, efforts for climate mitigation should include decoupling energy production and consumption from carbon emissions. Furthermore, climate policies should ensure positive socioeconomic outcomes in order to achieve a just transition to a low-carbon society. Transition to renewable energy systems can be a driver for job creation[5], but it is crucial to anticipate where jobs and income can be created or lost in the energy transition so that policies can be promulgated to maximise benefits and decrease negative socioeconomic impacts. This is all the more relevant in the current context, where the Covid-19 pandemic has disrupted national and international supply chains for the past two years and had negative impacts on employment and income worldwide.

Assessing the impacts of climate policies in the economy and on jobs is essential to identify opportunities and trade-offs in a low-carbon transition. Anticipating the new green jobs created through the economy can assist the development of policies centred on the promotion of decent work, while anticipating job losses are essential to put in place policies to minimise negative impacts and transition affected communities towards new job opportunities. This way, climate policies can provide benefits on several Sustainable Development Goals (SDGs), from *Climate Action* (SDG 13) and *Affordable and Clean Energy* (SDG 7), to *Gender Equality* (SDG 5), *Decent Work and Economic Growth* (SDG 8), *and Reduced Inequalities* (SDG 10).

This report aims to answer the following questions:

- What are the impacts of a green energy transition on the economy, jobs, and GHG emissions in Türkiye?
- What will be the shift in the demand of skilled work throughout the Turkish economy?
- What will be the effects on work that is done by women, 'migrants' and in disadvantaged groups?

To answer these questions, we develop a Green Jobs Assessment Model (GJAM) for Türkiye and analyse the effects of decreasing the share of coal in electricity production and increasing investments in energy efficiency, wind and solar electricity.

Green Jobs Assessment Models (GJAMs) provide a tool to assess the multidimensional impact of climate policies on the labour market. They are a macro-economic modelling framework based on the System of National Accounts (SNA) statistics and Input-Output or Supply-and-Use Tables (IOTs, SUTs), combined with employment and other social data from household and labour force surveys, and with GHG emissions from national inventories. The aim of the GJAM is to assess

[1] Annex I countries include the industrialised countries that were members of the OECD (Organisation for Economic Co-operation and Development) in 1992, plus countries with economies in transition. Annex I countries are subject to additional obligations under the UNFCCC, including emissions reduction, technology and finance transfer, and taking the lead in combating climate change.

and guide policymaking by modelling alternative policy scenarios to compare effects on socioeconomic indicators such as jobs, skills, gender, and income. GJAMs have already been developed for 14 different countries[2].

The philosophy of the model is to represent economic development as simply and transparently as possible, while enabling the identification of employment outcomes of structural economic changes that occur due to climate change mitigation and adaptation policies. Being an input-output model, the GJAM captures both direct effects as well as their indirect impacts on upstream industries, that is, those that supply the industries that will be strongly affected by the structural changes. These results can be used to inform policy design for climate and energy policies, following the ratification of the Paris Agreement in October 2021.

What are Green Jobs?

In this report, **Green Jobs** are those jobs that are created due to green policies. They include:

- Direct jobs created in green industries, such as wind and solar electricity,
- Indirect jobs created in the rest of the economy due to demand of goods and services as a result from the green policies and growth of green industries, and
- Induced jobs created in all industries due to growth of income resulting from the green policies, which boost household consumption.

1.2. An overview of the economy, labour, and greenhouse gas emissions in Türkiye

With a population of 83.6 million people [6], Türkiye's gross domestic product (GDP) per capita was of 8,538 USD in 2020[7], classifying as an upper-middle-income country. In this report, we use 2019 as the base-year for the analysis, focusing on the structure of the Turkish economy before the economic Covid-19 crisis, which disrupted both national and international markets and jobs. This section presents an overview of the economy, labour distribution, and GHG emissions in Türkiye in 2019.

The largest sectors contributing to Turkish GDP[3] (Figure 1, left) were services, followed by manufacturing industries, trade, and transportation and storage. Services also accounted for over half of employment (Figure 1, right), albeit with a high degree of informality. Manufacturing industries accounted for 20% of Türkiye's GDP and 34% of employment in 2019. Together, the production of food products, textiles, and wearing apparel amounted to 35% of manufacturing industries' GDP, but accounted for almost half of all the workers in manufacturing. Energy-intensive industries – chemical industries, refining and processing of minerals and metals, foundries of metal products, machinery, and transport equipment – corresponded to around half of the GDP of manufacturing industries, and these products accounted for nearly two thirds of Turkish exports[8]. Agriculture also has an important role in the Turkish economy. Although it accounted for 7% of value added, agriculture employed nearly 18% of the labour force, and was responsible for 13.4% of total GHG emissions[4]. Food products (including agriculture and food processing industry) accounted for 11.7% of Turkish exports in 2019.

[2] See a complete list of publications in: https://www.ilo.org/global/topics/green-jobs/publications/assessments/lang--en/index.htm

[3] Excluding taxes less subsidies, which accounted for 11.1% of Turkish GDP in 2020[9]

[4] Excluding LULUCF

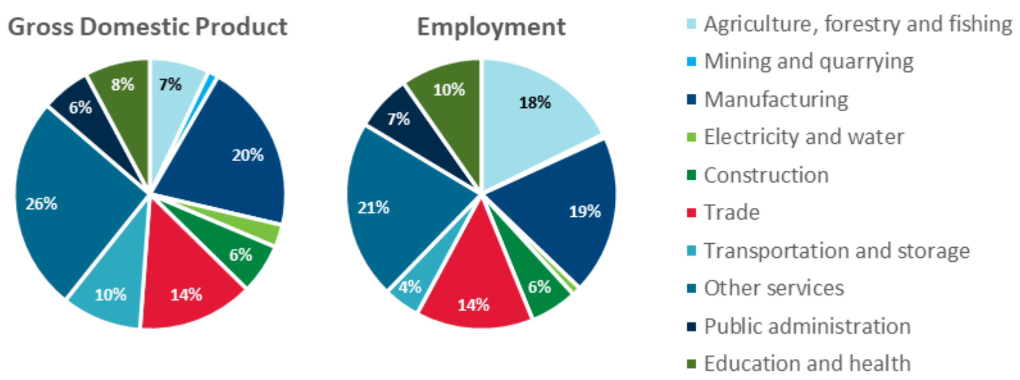


Figure 1 Gross domestic product, excluding taxes less subsidies[9] (left), and employment[10] (right) by economic activity in 2019

The labour market in Türkiye (Figure 2) in 2019 was characterised by a high predominance of male work, with less than one third of workers being women. This gender disbalance was lower in agriculture and in public administration, education, and health, where women corresponded to almost half of the work force. On the other hand, only 4% of construction work was performed by women. Informal work is widespread in the Turkish labour market, with only two thirds of the workers being in formal employment. Most of informal employment happens in agriculture, processing of food products, trade, construction, and accommodations and food services.

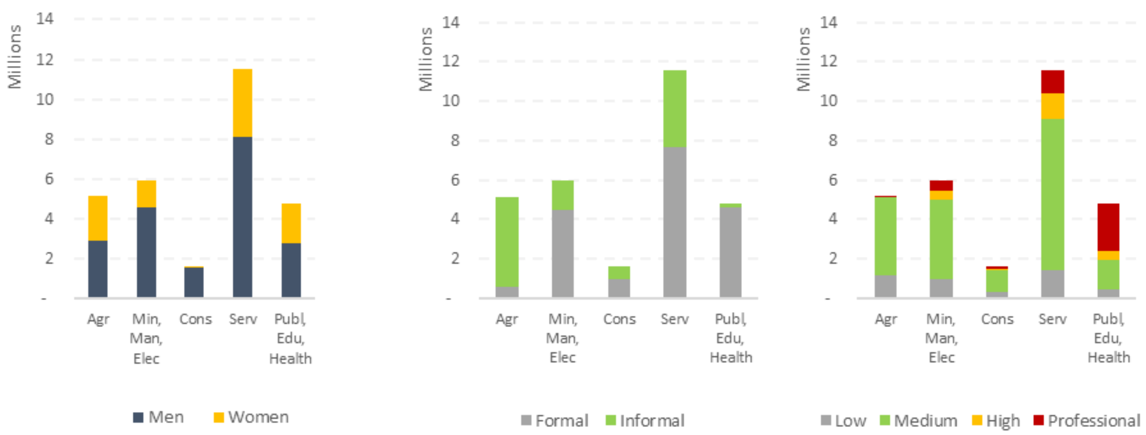


Figure 2 Labour market characteristics in aggregated industries, 2019. Employment distribution per gender (left panel); employment by formality status (central panel); and distribution of skilled work (right panel).

Aggregated industries: Agr = Agriculture, forestry, and fisheries. Min, Man, Elec = Mining and quarrying; manufacturing, electricity and water. Cons = Construction. Serv = Services. Publ, Edu, Health = Public administration and defence, education, health and social services.

In 2019, Turkish GHG emissions amounted to 506.1 Mt CO_2eq. GHG emissions in Türkiye are mostly concentrated in the energy sector (Figure 3), with almost three quarter of all emissions being associated with the burning of fossil fuels, making the decarbonisation of the energy system paramount for the transition to a low-carbon economy.

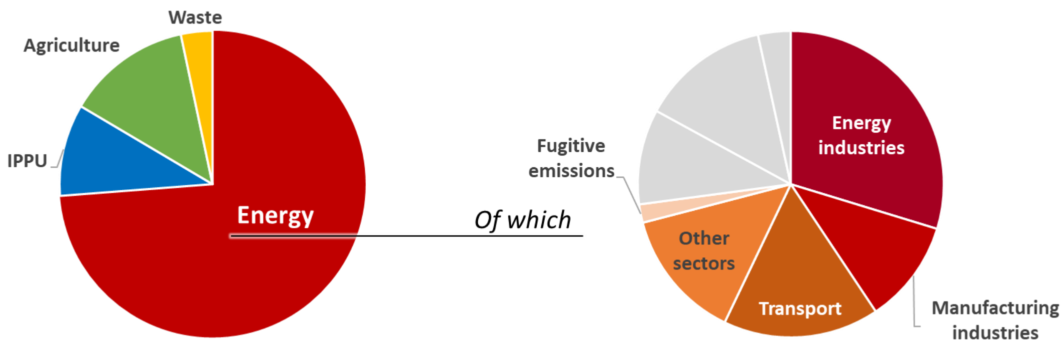


Figure 3 Greenhouse gas emissions by activity[5] and detail for energy-related emissions in 2019[12].

1.3. The electricity sector

Türkiye's energy supply is highly dependent on fossil fuels – 27% of total energy consumption stems from coal and lignite, 30% from oil products, 30% from natural gas, and only 12% is based on renewables and biofuels[13]. Although around half of electricity generation sources are renewable, natural gas and coal still dominate Turkish electricity production[12].

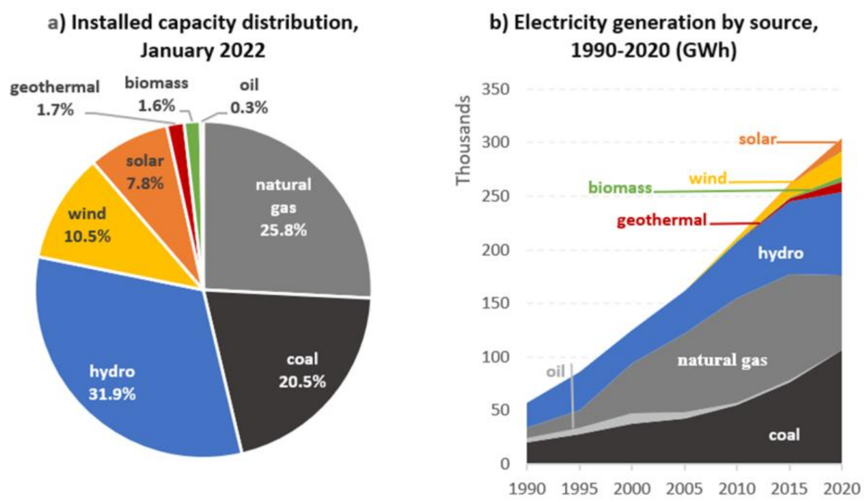


Figure 4 a) Distribution of installed capacity for electricity generation by source in January 2022[14] (left panel); b) Electricity generation by source, in GWh, in 5-year intervals, between 1990 and 2020[15] (right panel)

By January 2022, Türkiye had 99 GW installed capacity for electricity production[14], as shown in Figure 4. Over half of the current electricity production capacity comes from renewable energy, mostly hydropower, which accounts for nearly one third of all generation capacity in Türkiye and around 25% of all electricity generated in Türkiye[15]. The renewables share grew considerably in the past decade, especially for new renewable sources such as geothermal, solar, and wind. Geothermal generation grew more than 14-fold, from 0.3% of the total electricity generation in 2010 to 3.3% in 2020. Wind generation grew over 8-fold, jumping from 1.4% in 2010 to 8.1% in 2020. Solar energy amounted to only 0.1% in 2015 but increased to 3.7% in 2020. Although the renewable share of installed capacity and electricity generated is growing steadily, electricity generation and electricity imports remain mostly dominated by fossil fuels.

[5] Excluding emissions and sinks from land use, land use change, and forestry (LULUCF)

Besides reducing GHG emissions, the growth of renewable electricity sources has other benefits that contribute to a just transition. The diversification of sources makes the electricity system more reliable and resilient from external factors, such as droughts and international fossil fuel prices, which are likely to be affected by climate change and climate policies. Increasing domestic energy production not only strengthens the security of supply but also boosts the economy by creating more economic activity domestically, both in the energy producing industries and in upstream value chains. A larger share of renewables also reduces the import dependency on fossil fuels; 60% of coal, 93% of oil, and 99% of natural gas consumed in Türkiye are imported[16].

Türkiye has implemented a number of policies and targets for the growth of renewable electricity technologies in the last decade, especially for wind and solar photovoltaics, such as the INDC submitted by Türkiye to the UNFCCC[17], the Climate Change Strategy[18], and more recently, pledges made during the COP26 in Glasgow for phasing down coal-based electricity and deciding against no new investments in coal-fired power plants. Government support for this growth is essential. Here, two programs can be highlighted[16]. The Renewable Energy Support Mechanism (YEKDEM) provided a stable financing environment for renewables with feed-in tariffs, with extra support for components manufactured in Türkiye. Public tenders for bigger renewable projects in Renewable Energy Resource Areas (YEKA) are making large-scale renewable projects more competitive and incentivizing technology transfer and the use of domestic equipment and components[19].

However, renewables are only one part of the equation to produce electricity (and energy) from local sources. Current strategies by the Turkish government for reducing the import of energy include support for increasing oil and gas production (including new plans to explore new natural gas fields such as the Sakarya field in the Black Sea from 2023[16]) and increasing lignite mining for use in industry and power production. Currently, most of the coal used for electricity production is imported. Therefore, increasing electricity production with domestic source – renewable sources or non-renewable fuels – can give a boost to the Turkish economy by increasing the demand for goods and services produced by national industries. The decarbonisation of the electricity industry, however, is paramount for Türkiye to participate in a global economy which is increasingly putting value on decreasing their carbon footprints with tools such as carbon border taxes[20,21] as part of policies such as the European Green Deal[22].

Türkiye has a great potential for renewable electricity. Currently, most of the renewable electricity in Türkiye comes from hydropower. However, the current installed hydropower capacity is close to the Turkish technical potential, and expansion of new hydropower beyond 2023 is estimated to be limited[16]. Therefore, in this report we only consider the expansion of wind and solar photovoltaics electricity to meet the expected increase in Turkish electricity demand between 2022 and 2030.

2. Methods and data

2.1. Using supply-and-use tables for policy analysis

Policies have effects throughout the economy. A climate or energy policy that affects one industry directly – for example, coal power plants – causes ripple effects throughout the economy. The decrease in the demand of coal will impact the demand for products from the coal mining industry. The decrease in the demand for coal will also affect the demand for machinery and financial services related to coal mining. The reduced demand in machinery will, in turn, affect the demand for metals and components, which will affect the demand for iron ore. The substitution of the coal power plants for solar energy for production of electricity will lead to an increase the demand for photovoltaic panels and for electric inverters. Those will then increase the demand for electronic components, for products from copper mining and refining, and other industries that provide goods and services for these new products. The direct effects of the policies – decrease of coal electricity, increase of solar electricity – will therefore have indirect economic effects on different industries due to the changes in the demand of goods and services from the industries directly affected - which will also impact their suppliers, and the suppliers of their suppliers, and so on.

The increase or decrease of economic activity will impact jobs. With any policy, there will be industries which will increase their economic output and therefore increase the demand for workers, but there will also be industries that will have a decrease in their economic output, leading to job losses. Assessing the positive and negative impacts of policies is, therefore, necessary to maximise the potential benefits and minimise potential negative economic, social, and environmental implications.

GJAMs are built to quantify these ripple effects of climate policies and green structural change. GJAMs are macro-economic models based on IOTs or SUTs that integrate economic data with data on jobs and GHG emissions. The starting point are the economic SUTs, compiled by statistical offices. These tables give a picture of the total supply and the total use of goods and services in the economy, quantifying the transactions in products between industries, purchases by final consumers, and to and from international trade. Supply tables describe what industries produce and how much of each product is imported. It also includes the trade and transport margins and taxes less subsidies on products, which represent the difference between the production (basic) prices and the final consumer (purchase) prices. Use tables describe all products used by industries in the country, as well as products purchased by final consumers and exported, and gross value added (VA) generated by industries.

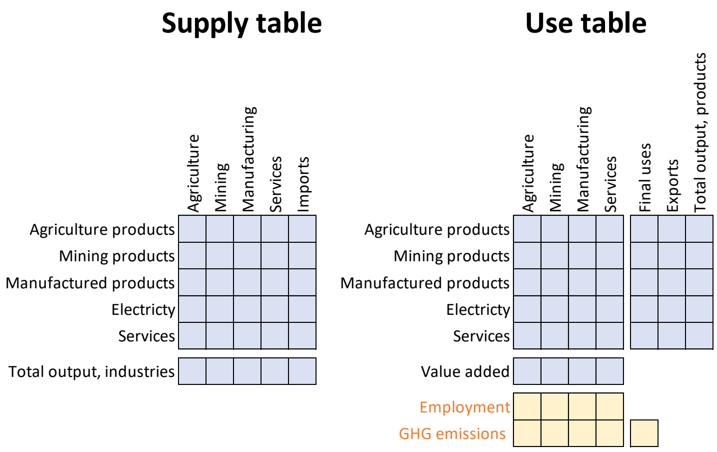


Figure 5 Simplified illustration of a supply table (left) and a use table (right), extended with employment and GHG emissions data per industry.

Models based on SUT can simulate the direct and indirect effects of different policies on the economic output of the different industries. Not only that, but supply-and-use and input-output tables can be linked with social and environmental indicators (called extensions) that describe direct impacts of each industry on workers and on the environment. A simplified supply-and-use table is illustrated in Figure 5. Note that we do not model inflation. The only price changes that can be modelled are those due to changing technology of production in the scenarios, which are reported in constant prices.

GJAM Türkiye quantifies impacts of policies on:

- **The economy**. Gross value added correspond to the GDP by industry, giving insights on the effects of climate policies to national GDP growth, and on the growth or decrease of each industry's economic activity
- **Greenhouse gas emissions**. Besides direct changes due to, for example, decrease of coal electricity, it also considers the net changes in emissions including increased emissions from infrastructure investments, and from increased or decreased economic activities in other industries.
- **Employment**. The model gives insights of the potential increase or decrease of the demand for workers in different industries. By including information on the structure of workers in each industry – per gender, skill level, and formality status – it can measure how the demand for skills will change in the economy, and how it can affect workers in disadvantaged groups.

It is important to note that GJAMs are not economic forecasting models. Rather, these models are a tool to inform about possible effects of "what-if" scenarios on emissions and labour demand by industries, given that the remaining structure of the economy remains as is. The results show how changes in individual economic activities influence the economic structure and reflect on direct, indirect, and induced effects. A technical description of the model is available in section A.1 in the appendix.

How do Green Jobs Assessment Models work?

Green Jobs Assessment Models are built to answer one main question: **How do climate and other green policies affect workers?**

Here is how it works:

First, policies questions are translated into scenarios, describing these policies in values such as:

- Which are the industries directly affected? For example, electricity generation industries when shifting from coal to solar and wind electricity
- How fast and by how much do green industries grow? For example, how does the electricity mix changes year by year, by increasing green electricity and decreasing in coal shares?
- What are the investments needed for this transition? Investments include, for example, goods, services, research, and training.

Next, these scenarios are implemented in the model:

- A baseline scenario for economic growth is built using macro-econometric parameters for economic and population growth
- New green industries are added to the supply-and-use table
- Annual changes in the market shares of green and traditional industries supplying products according to green industries' growth
- Annual investments in green industries distributed in products as additional investments to the economy or replacing investments in traditional (such as coal) industries.

Finally, the model quantifies direct impacts on the industries affected, and how these changes affect the demand for goods and services from other industries (and how increase or decrease of economic output from these other industries affect the demand from other industries, and so on).

The results of the GJAM model, then, comprise all (direct and indirect) impacts of the modelled policies on the economic output of every industry in the national economy, and how these affect workers and greenhouse gas emissions in each industry.

2.2. Data used for the Green Jobs Assessment Model

This section describes the data sources needed to develop the GJAM.

In this report, we used **the most recent SUT available** in TurkStat, which describes the economy in 2012 for 64 products and industries, and updated the SUT for 2019, based on macro-economic data also available from TurkStat (see Table A1 and

Table A2 in appendix for the full industry and product detail). The base year for the analysis in this report is hence 2019, and all economic growth is estimated based on 2019 constant prices. The method and data used for estimating the 2019 SUT are detailed in section A.2 in the appendix.

The **labour data** used comprise microdata from the labour force surveys from TurkStat, processed and harmonized by ILO. It is available in the same industry classification and year as the SUT (excluding the green electricity industries), and fully allocated to the original industries in the model. It is available in a high detail of indicators of labour force composition, describing employment per gender, skill level and formality. It also includes ILO estimations on the employment by gender, skill level, and formality of the Syrian population in Türkiye[6]. The total employment indicators available in the GJAM Türkiye model is available in Table A6 in the appendix.

The **GHG emissions data** used comprise the official Turkish Greenhouse Gas Inventory for 2019[12]. The GHG inventory provides information on emissions of CO_2, CH_4 and N_2O[7] according to broad and detailed activities described in the IPCC guidelines[23] for GHG inventories. However, the IPCC sector classification does not match the SUT ISIC classification so that a concordance table to allocate emissions to the SUT industries were necessary. For non-energy related emissions, over 99% of the emissions can be allocated to one specific industry in the SUT, and no assumptions needed to be used. For emissions from fossil fuel combustion, when allocation was necessary between one inventory activity (e.g. 1.A.2.C Emissions from fuel combustion in chemical industries) and two or more industries in the SUT (in this case, C20 Chemical and chemical products, and C21 Basic pharmaceutical products and pharmaceutical preparations), emissions were allocated based on the share of fossil energy products use by industry from the use table. The available GHG emission indicators and the correspondence between original activity in the GHG inventory and allocation to the 2019 SUT industries is available in Table A7 and Table A8 in the appendix.

Modelling the effect of the growth of green electricity requires the **split of the original electricity generation industry** into wind electricity, solar electricity, and the remaining electricity generation technologies. For this, data on the use of inputs to produce electricity[24,25] (i.e. the operation of the power plants, not counting construction and investments) from wind and solar is used to estimate the industry structure of the green electricity in the use table, and the split of the supply of electricity in the supply table obeys the share of wind and solar electricity in the total electricity generation in 2019[26].

To compile the annual tables between the base year 2019 and 2030 for the reference scenario, we use a historical time series of data from the Turkish System of National Accounts[9], complemented with forecast of macro-economic and population growth, as described in section 3.

2.3. Modelling of the green industries in the supply-and-use tables

The foundation for the GJAM model is a **recent SUT.** The base year of the GJAM model is constructed by adding two dimensions to the SUT. First, **labour and GHG data** (in orange in the use table, Figure 6) are allocated to the industries in the SUT as extensions. Next, the 2019 SUT is expanded by adding the **green electricity industries**, in this case, onshore wind and solar photovoltaic (in green in the SUTs, Figure 6), splitting them from the original electricity generation industry (in red in the SUTs, Figure 6).

[6] The term " Syrian population under temporary protection in Turkey" is meant to cover Syrians who acquaired Turkish nationality, Syrians with residence permits, and Syrians under temporary protection residing in Turkey.

[7] HFCs, PFCs and SF6 are available for emissions from industrial processes and product use in the Turkish GHG inventory, comprising mainly products used in refrigeration in substitution for ozone depletion substances. However, in this study, we do not use these emissions due to the lack of information to allocate to industries in the SUT. These emissions represent 1.2% of total Turkish GHG emissions in 2019.

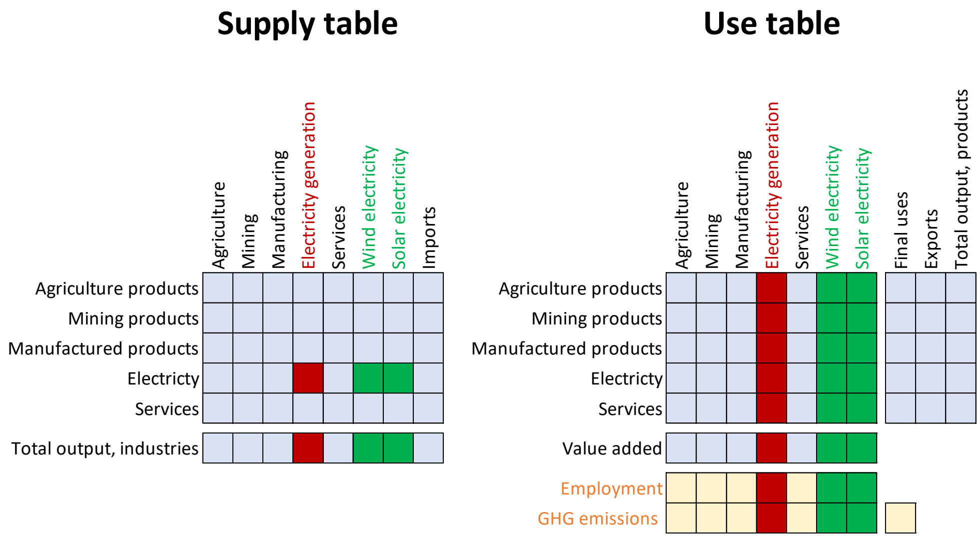


Figure 6 Simplified illustration of the base-year table for GJAM model, comprising a supply table (left) and a use table (right), extended with employment and GHG emissions data per industry, and split of supply and use of products and extensions between original electricity generation industry (red cells) and new wind and solar photovoltaic electricity industries (green cells). Blue cells contain the original values for the 2019 SUTs.

The split of the green electricity industries was done by combining the share of wind and solar electricity in electricity generation with the distribution of goods and services needed for the operation of onshore wind farms and solar photovoltaics power plants. The split of the electricity industry output is based on the share of wind and solar energy in total electricity generation. In 2019, 7% of output from the electricity industry was allocated to wind energy, and 3% to solar[26].

The inputs of goods and services required to produce non wind/solar electricity is taken from the SUT, while the requirements for wind and solar technologies are based on the report "*Costs of low-carbon generation technologies*"[24,25], and are shown in Table 1. The table only shows the products where the inputs are higher than 5% for at least one of the technologies; the remaining are grouped into "*Other products*".

Table 1 Inputs distribution to original electricity and gas industry, and new green electricity industries Wind and Solar. Darker shades of blue correspond to higher share of inputs.

Products	Electricity and gas	Wind electricity	Solar electricity
Mining of energy products	21%	0%	0%
Chemicals and chemical products	0%	2.9%	7.9%
Fabricated metal products, except machinery and equipment	0%	11%	8.2%
Computer, electronic and optical products	0.2%	3.1%	12%
Electrical equipment	0.2%	11%	14%
Machinery and equipment n.e.c.	0%	7.2%	0.2%
Other transport equipment	0%	8.4%	0%
Electricity, gas, steam and air conditioning	48%	0.5%	0.4%
Constructions and construction works	0.2%	1.4%	7.5%
Financial and insurance; Real estate; Professional, scientific and technical activities; Administrative and support service activities	2.8%	16.0%	7.3%
Other products	2.2%	8.4%	8.3%
Value added	25%	30%	34%
Total output	**100%**	**100%**	**100%**

3. Scenarios and Assumptions

This section describes the underlying assumptions for each scenario in more detail. The model's base year is 2019, for which we use the historic data described in Section 2.2. The model takes 2019 as the start year for the projections for 2020 to 2030. For the years 2020 to 2023 we additionally use data from OECD Economic Outlook[27] to calibrate the model for recent economic development after 2019. In addition, we use exogenous information for the years 2020 to 2030 on population growth (UNDESA World Population Prospects[28], medium fertility variant, see Figure 7) and on global economic development from the OECD Long View[29], which assumes 3.4% economic growth annually.

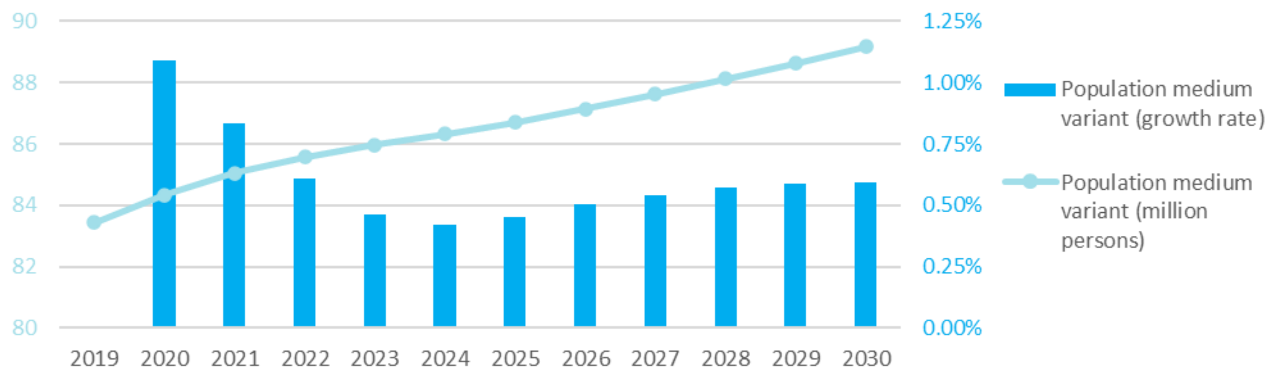


Figure 7 Population development, Türkiye, 2019-2030

3.1. Reference scenario: Economic growth and additional electricity supplied by new coal power plants

The purpose of having this reference scenario is to have an economic development which can serve as a baseline to which the development in the green scenario can be compared. Here, we assume that the economy grows (as specified in the following paragraphs), but that the structure of the economy does not change. That is, industries are continuing to produce with the same production technology and the import shares of products remains stable.

In the reference scenario, we calibrate the model to follow the macro-economic trends from the OECD Economic Outlook[27] for the years up to 2022 for the demand side variables *changes in inventories*, *exports*, *government consumption* and *gross fixed capital formation*, as displayed in Table 2.

Table 2 Values for exogenous variables 2020-2023 from the OECD Economic Outlook[27]

Selected variables: ready-made growth rates (in Percentage, 2009)		2020	2021	2022	2023
Change in inventories, contributions to changes in real GDP	CIESR	0.05 %	-0.04 %	-0.01 %	0.00 %
Exports of goods and services, volume (national accounts basis)[1)]	EXPR	-14.80 %	16.92 %	6.98 %	6.10 %
Government final consumption expenditure, volume	GOVR	2.09 %	2.78 %	2.50 %	1.69 %
Gross fixed capital formation, total, volume	GFCFR	7.25 %	8.95 %	5.11 %	6.75 %
Gross domestic product, volume, growth		1.79 %	9.04 %	3.29 %	3.92 %

[1)] Note that we had to reduce the export growth rate in 2020 to be 30% and in 2021 to be 50% of the values in this table to ensure model stability. Imports are endogenous and changed correspondingly less as well, so that net exports are about the same.

After 2022:

- Government consumption grows (exogenous to the model) with the population growth rate
- Gross fixed capital formation (exogenous to the model for the current year) grows with the previous year's GDP growth rate and investment into new coal power plants are given exogenously (see below for more information)
- Exports (exogenous to the model) grow with the global GDP growth rate
- Changes in inventories (exogenous to the model) decrease by 1% annually.

For both time periods (up to and after 2023), the product shares for these variables in the total are constant.

Household consumption is endogenous to the model, as is GDP (the sum over all industries' value added). The household consumption model utilises income elasticities from USDA international food comparison programme[30,31] for nine consumption categories, see Table 3. The change in household income for the consumption model is approximated by the change in GDP.

Table 3 Income elasticities for Türkiye from the USDA international food comparison programme[30,31]

Income elasticities for broad consumption categories, 144 countries, 2005								
Food, beverages & tobacco	Clothing & footwear	Housing	House furnishing	Medical & health	Transport & communication	Recreation	Education	Other
0.691	0.966	1.067	1.05	1.333	1.16	1.447	0.922	1.337

The economic structure (described by the market share matrix *D*, calculated from the 2019 supply table) and the technology coefficient matrix *B* (calculated from the 2019 use table) are kept constant for the years 2020-2030. This entails that the economy is assumed to have a static Leontief production function without technological change or any economies of scale or price effects. Import shares per product are constant. As there is no technological change or changes in the structure of primary inputs (value added components), prices are constant.

Production by industry *g* is calculated using the industry-by-commodity commodity-demand-driven SUT model[32] $g = D (I - BD)^{-1} y$. In this demand-driven model, this results in for example electricity production growing with electricity demand in monetary terms.

Since the technology coefficient matrix *B* is constant, the share of value added in total industry output is also constant. Value added per industry is then determined endogenously, by multiplying the value added in output shares with output per industry. Total GDP equals the sum over all industries' value added, and is then used to determine the development of household consumption expenditures. Since both total value added/GDP and household consumption expenditures are endogenous to the model, they are not completely equal to the forecast, with a slightly lower growth rate in 2021 (8.0% compared to 9.0%) and a higher growth rate in 2022 (5.6% instead 3.3%) than in the OECD Economic Outlook (see lower right panel in Figure 11 for the model projections and the last row in Table 2 for the OECD Economic Outlook projections). These differences are for a large part driven by the changes for the export growth rate assumption to ensure model stability, see note under Table 2.

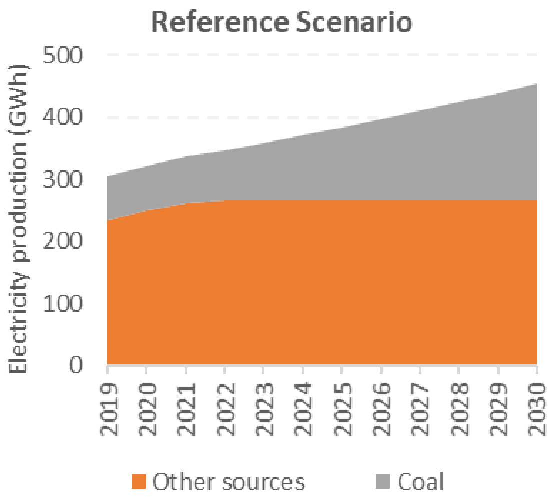
In this reference scenario we assume constant labour productivity (persons employed per unit industry output). To estimate the employment requirements, we thus multiply the (constant) number of per unit of industry output with the projected output by industry in monetary terms. The same procedure is used for GHG emissions. Note that the model (akin to other macro-economic models[33]) does not include land use, land use change and forestry (LULUCF) emissions.

Coal investments in the Reference Scenario

Türkiye's electricity demand grows rapidly, and forecasts suggest a 20% growth by 2025 compared to 2020[26]. To project the required installed capacity by 2030, we extrapolate the electricity demand linearly to 2030 assuming a similar growth. In the Reference scenario, we assume that this growth will be met solely by new coal power plants, while in the Green scenario, it will comprise of new wind and solar power plants. This means that the total electricity (in GWh) produced by all other electricity sources (see Figure 4) remains constant, but that the share of coal (in the Reference scenario) and of wind and solar (in the Green scenario) in total electricity production increases. Figure 8 (left) shows the estimated growth in electricity demand by 2030 and the participation of coal in total electricity generation, and the new installed capacity, in MW, required to meet this new energy demand (Figure 8, right). It is estimated that new coal power plants will operate with the same average capacity factor as current thermal electricity power plants in Türkiye, of 42%[26].

Electricity demand, however, is endogenous to the model. As investments in electricity generation technologies have a time requirement for planning, licensing, project development, construction until operation and electricity generation, the investments modelled in this report do not depend on the annual electricity demand from the model. Due to assumptions on economic growth versus linear estimated electricity demand in GWh, after 2026, the exogenous growth in electricity generation (in GWh) is higher than the monetary output growth (in TRY) from the electricity industry.

Investments into new power plants are distributed as follows. Investments in new coal power plants are fully allocated to the year before the power plants enter operation. Investments start in 2022, for added capacity from 2023. We assume average costs for new ultra-supercritical coal power plants without carbon capture and storage[34], with investments costs of 3 676 USD/kW installed, and an average exchange rate for 2019 of 5.7 TRY/USD[35]. Total additional investments to the model are the same in the Reference and in the Green scenarios. They represent the cost of new investments in coal power plants between 2022 and 2029. These investments correspond to 89.5 billion USD for the period (between 9.3 and 12.5 billion USD per year, Figure 10), which amount to 510 billion TRY (in 2019 constant prices).



New installed capacity (MW)	
Year	**Coal**
2020	1 126
2021	1 135
2022	2 515
2023	2 532
2024	2 951
2025	2 887
2026	2 985
2027	3 087
2028	3 192
2029	3 300
2030	3 413
Total	29 122

Figure 8 Estimated electricity generation and participation of coal electricity (left) and annual new installed capacity for new coal power plants (right) in the Reference scenario

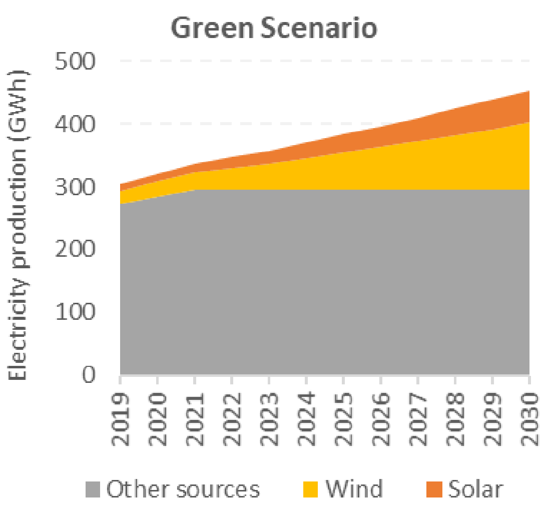
3.2. Green scenario: Increasing electricity generation from solar photovoltaics and wind, and investing in energy efficiency and electricity grids

The Green scenario uses the same inputs as the reference scenario, although with specific changes for the electricity industry, namely:

- Changes in the market share of industries producing electricity
- Investments in new wind and solar power plants. These investments replace the coal investments in the reference scenario, but they do not replace existing investments in other industries.

- Building coal power plants is more expensive per GWh produced than for wind and solar[34,36]. Therefore, compared to the coal investments in the reference scenario, money is available for other uses after investing in wind and solar. As part of a green scenario for the electricity system, we assume this extra available investment is used to improve energy efficiency for households and the modernisation of the electricity grid to absorb more intermittent and distributed renewable electricity.

In the Green scenario, we assume that the electricity growth will be solely met by new wind and solar power plants. This means that the total electricity (in GWh) produced by all other electricity sources remains constant, but that the share of wind and solar in the total electricity production increases, as shown in Figure 9. The total electricity production, in GWh, is the same as in the Reference scenario. The distribution of new electricity generation between wind and solar follows the proportion of these two technologies estimated in 2022, of 67% wind and 33% solar. Capacity factor for wind and solar electricity throughout 2019 to 2030 were assumed to be the same as in 2019, of 32.8% for wind and 18.2% for solar[26]. By 2030, the share of wind and solar in the total electricity mix rises from 10% to 35%, which would not constitute a technical barrier due to the intermittent electricity production. Figure 9 (right panel) shows the total new estimated installed capacity between 2020 and 2030 for wind and solar.



New installed capacity (MW)			
Year	**Wind**	**Solar**	**Total**
2020	1 313	726	2 039
2021	946	1 414	2 360
2022	2 417	2 552	4 969
2023	2 602	2 267	4 869
2024	3 033	2 642	5 675
2025	2 966	2 584	5 550
2026	3 067	2 672	5 739
2027	3 172	2 763	5 935
2028	3 280	2 857	6 137
2029	3 392	2 955	6 347
2030	3 507	3 055	6 562
Total	29 695	26 487	56 182

Figure 9 Estimated electricity generation and participation of wind and solar electricity (left) and annual new installed capacity for wind and solar power plants (right) in the Green scenario

As explained in Section 3.1, the growth in electricity generation is not endogenous to the model. This modelled energy output is distributed to the industries that produce electricity – wind, solar, and remaining electricity industries – according to their share in the total electricity generation in Figure 9 (left). The changes in market share are only applied from 2022 until 2030.

Investments into new power plants are distributed as follows. Investments in new wind power plants are distributed equally in the two years before the installed capacity enters operation, and investments in new solar power plants are fully allocated to the previous year. We assume average global costs for new wind and solar technologies[36], with investments costs of 1 355 USD/kW and 883 USD/kW for wind and solar, respectively, and the same average exchange rate for 2019 of 5.7 TRY/USD[35] as in the Reference scenario.

The distribution of the total investments in the Reference and in the Green scenarios are shown in Table 4 and Figure 10. Table 4 shows how investments are distributed in the scenarios between different technologies (total investments on coal electricity in the reference scenario, and approximately one third of investments in each green technology in the Green scenario) and how investments in each technologies are distributed in the products in the Turkish SUT[34]. The national content for the electricity generation equipment is assumed to be in line with the legislation for participation in the YEKA biddings[37], of 55% local content. The demand for local content is a key policy incentive to promote the Turkish industry, especially the industry for machinery and equipment. This extra benefits to the manufacturing industry is not explicitly modelled in this scenario. That is, we do not model the growth of wind turbine or solar panel manufacturing industries, but the effects are modelled indirectly due to increased demand from the industries that produce electricity generation equipment and electronic and optical equipment.

The investments needed for building new wind and solar power plants is lower than the capital investments needed for building coal power plants – both in terms of installed capacity, and in terms of electricity generated[34,36]. Therefore, producing the same electricity from the green technologies requires lower investment than if the energy was provided by new coal power plants. The difference in the investments required by coal in the Reference scenario and by the green electricity in the Green scenario was considered as available for investing in other green technologies. Therefore, we distribute this extra capital into a mix of investments for improving energy efficiency in households, and investments on the modernisation of the power grid. These investments are assumed to be distributed between machinery and equipment, electrical equipment, construction services, engineering and technical services, and research and development. Here, a conservative approach is taken and the outcomes of energy efficiency are not modelled, such as increased available household income spend on other goods and services. In this scenario, households will benefit from non-monetary better living conditions such as better heating and cooling and increased use of household appliances[38].

Table 4 Distribution of investments per technology in the Reference scenario (grey shade) and in the Green scenario (green shade)

Products	Coal	Wind	Solar Photovoltaic	Energy efficiency and power grid
Machinery & equipment, including electricity generation equipment (turbines, balance of plant)	45%	61%	18%	20%
Electrical equipment	7%	7%	30%	20%
Construction services	10%	13%	4%	30%
Insurance	11%	4%	5%	0%
Auxiliary financial services and insurance	6%	0%	2%	0%
Legal and accounting services; Services of head offices; management consulting services	8%	7%	3%	0%
Architectural and engineering services; technical testing and analysis services	14%	8%	1%	20%
Electronic and optical equipment (photovoltaic panels)	0%	0%	37%	0%
Research and Development	0%	0%	0%	10%
Total investments (billion TRY)	**510**	**171**	**163**	**176**

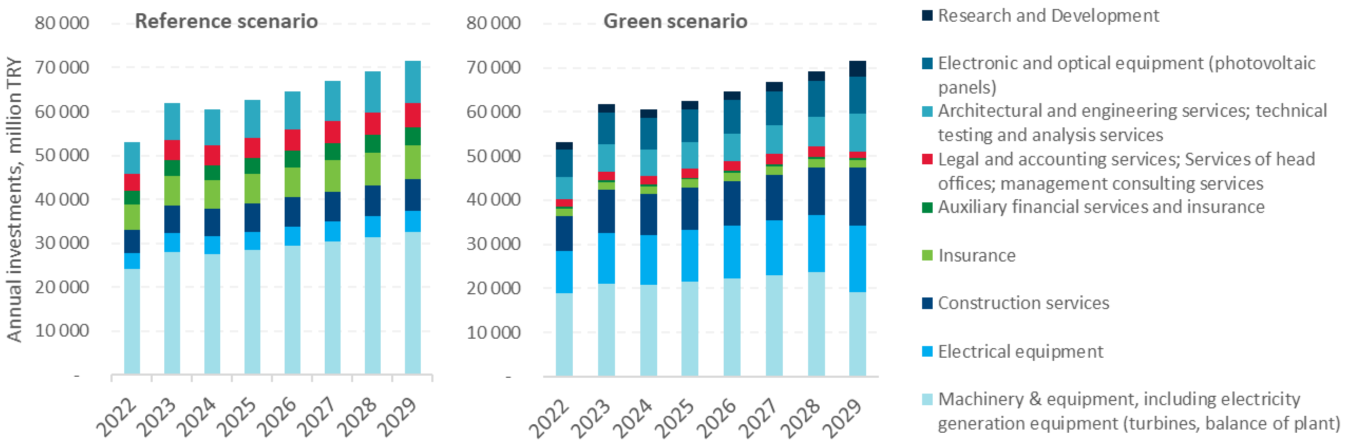


Figure 10 Distribution of investments per MW installed for wind and solar power plants (left) and total investments per year in the Green scenario (right)

In both scenarios, investments do not happen before 2022. Investments in 2030 are not modelled due to investments made in 2030 would enter operation in 2031-2032, which is after the scenario time frame. This means that, when interpreting the results, two things should be noted:

- The drop in value added in 2030 compared to 2029 is due to investments stopping in 2029. Of course, to further increase electricity capacity, it is necessary to continue investments. For analysis purposes, however, the results for 2030 as shown in this report, indicate the effect of the long-term structural change of the economy, while the results for the years up to and including 2029 show both the short-term investment effects and the effect of the structural change towards renewable electricity production.
- Effects in 2030 reflect the economic and labour changes in the economy due to the direct and indirect structural changes in the economy. Those are due to growth in the economy from green investments, growth of the wind and solar industries, and the indirect effects due to demand for goods and services (and reduced demand for imports of fossil fuels) by the green electricity industries. Those impacts are considered long-term impacts that do not depend on constant flow of investments.

It is important to note that both "Reference Scenario" and "Green Scenario" can be considered as conservative. This was done in order to compare the direct and indirect effects of investments in coal versus wind and solar energy. The reference scenario includes more investment in coal energy than current energy investments, which have been partly focused on renewable energy sources. On the other hand, the green scenario can also be seen as conservative, as it does not foresee any absolute coal energy reduction consistent with a transition towards a net-zero target.

4. Green Jobs Assessment

4.1. Reference Scenario

Here, we shortly present the development in the reference scenario. This is the scenario to which we compare the development in the green scenario in the next section. The macro-economic trends are shown in Figure 11. As described in Section 3.1, the model is calibrated follows the OECD's Economic Outlook[27] in 2020-2022. The Turkish economy grows significantly in 2021 and 2022, with the growth rate declining to about 3% after that. Note that the growth rate in 2030 is artificially lower than in the other years as we stop modelling investments into new coal power plants. This is to show in the effects of the long-term structural change, without the short-term effects from investing. Int this reference scenario, differences in the growth rate of different industries in the economy stem from changes in the household consumption structure caused by increasing income, and investments into new coal power plants. GHG emissions (blue line in the lower left panel) grow slightly faster than GDP (grey line), which in turn grows slightly faster than employment (red line). This can be explained by a higher demand for intermediate and final goods and services with high GHG emissions intensity and low labour intensity than the opposite (low carbon intensity but high labour intensity).

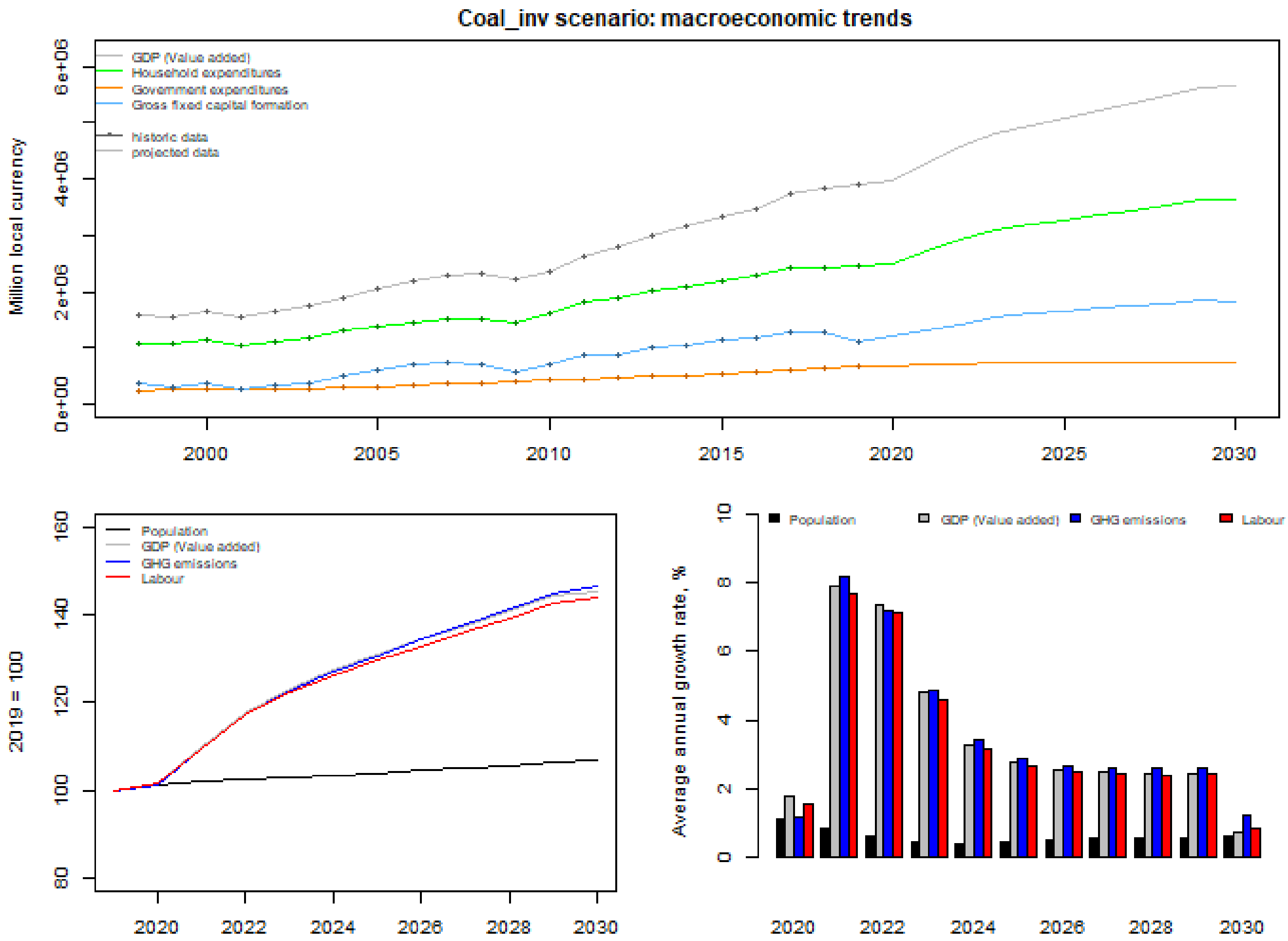


Figure 11 Macro-economic development in the Reference scenario, 2019-2030

Value added by industry in 2025 and 2030 relative to 2019 is shown in Figure 12. In the baseline economic growth scenario, on average, the (real, constant prices) total VA for the entire Turkish economy is 30% higher than 2019 in 2025, and 44%

higher in 2030. Overall, agriculture, low-value-added manufacturing industries such as food products and textiles, public administration, education, and health and social work are estimated to grow slower than the average economy.

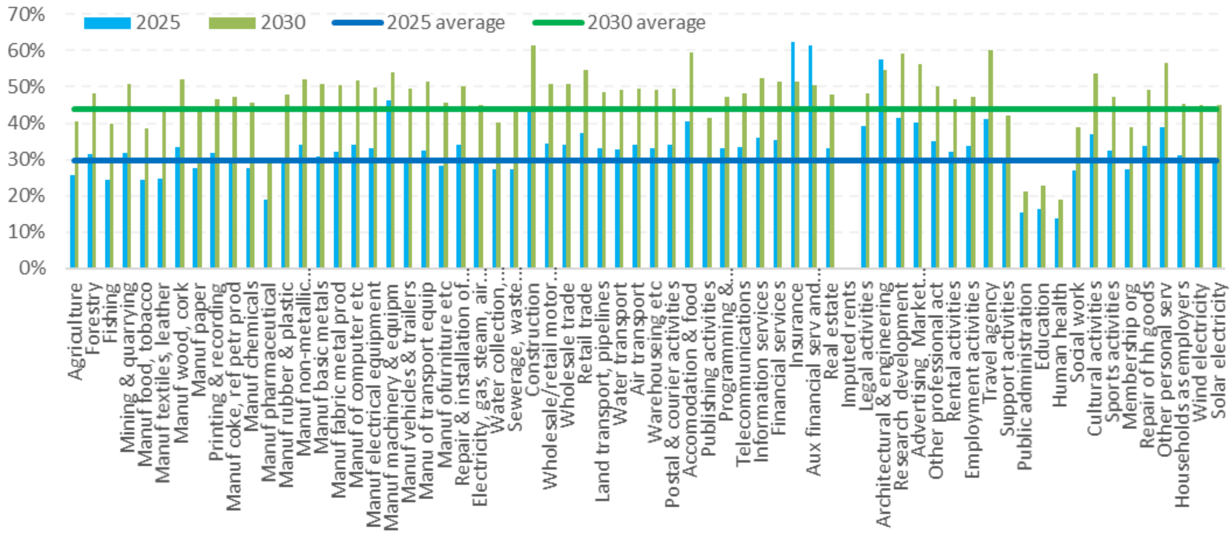


Figure 12 Value added by industry in 2025 and 2030 compared to 2019

4.2. Green Scenario

Recall, in the Green Scenario, instead of investing into new coal power plants, Türkiye is assumed to invest into wind and solar power. In addition, as these are lower than investments into coal power plants per (estimated) GWh of electricity produced, money is available to invest into energy efficiency of buildings. In the Green scenario, outcomes are positive in terms of economic gains, employment, and reduced GHG emissions (Table 5). Economic and employment gains from green investments and from the growth of green electricity industries outweigh gains from coal investments, with a significant decrease in annual GHG emissions.

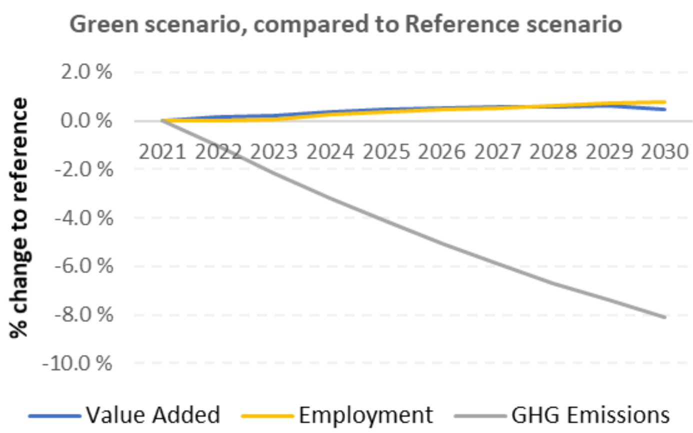


Figure 13 Changes in annual value added, labour, and GHG emissions in the Green scenario, compared to the Reference scenario

The figure summarises the changes on annual value added, employment, and GHG emissions between the reference scenario and the green scenario. That is, **what are the outcomes of the green scenario in difference to the outcomes of the reference scenario?** As mentioned in section 2, the outcomes of the green scenario should always be compared to the reference scenario, due to the fact that the GJAM does not attempt to predict what happens in the rest of the economy, only what happens in a "what if" situation of comparison what are the effects of investments in renewable electricity and energy efficiency, compared to the same investments in coal electricity. The outcomes illustrated in Table 5 and are due to a combination of impacts of **investments** in new infrastructure, and **long-term structural changes** in the electricity industry and in the demand for goods and services from other industries to operate and maintain these new power plants. Compared to the reference scenario, the green scenario results in additional 10-45 billion TRY (in 2019 constant prices) in Turkish annual GDP, over 300 thousand extra jobs by 2030, and lead to a decrease of 60,000 Mt CO2-eq, 8% lower annual emissions compared to the reference scenario.

Table 5 Outcomes of the Green scenario, compared to the Reference scenario

	Value added		Employment		GHG emissions	
	million TRY	% difference	jobs	% difference	Mt CO2-eq	% difference
2022	10 135	0.2 %	- 179	0.0 %	- 6 277	-1.1 %
2023	12 192	0.2 %	15 934	0.0 %	- 13 405	-2.2 %
2024	22 251	0.3 %	91 579	0.3 %	- 20 323	-3.2 %
2025	29 244	0.4 %	139 465	0.4 %	- 27 085	-4.1 %
2026	34 227	0.5 %	176 129	0.5 %	- 33 887	-5.0 %
2027	38 286	0.6 %	207 515	0.5 %	- 40 654	-5.9 %
2028	41 925	0.6 %	236 389	0.6 %	- 47 372	-6.7 %
2029	45 154	0.6 %	286 836	0.7 %	- 53 614	-7.4 %
2030	36 451	0.5 %	311 262	0.8 %	- 60 364	-8.1 %

Total investments – between 9 and 12 billion USD per year – in both reference scenario and in green energy scenario are the same, but they are distributed differently. The total investments in the green scenario are allocated to, approximately, one third to the construction of new wind power, one third to new solar, and one third to measures for improved energy efficiency and modernisation of electricity infrastructure. The distribution of these investments in the green scenario brings better outcomes on both employment and value added compared to the same investment in coal power plants, as shown in Figure 14, in the light part of the bars. The effects of these investments on economic activity in terms of value added (Figure 14, left) grow throughout the investment phase. In 2030, there is no investment on new plants. Nonetheless, the economy has been put on a higher growth path compared to the reference scenario. That is, the long-term effect on the Turkish economy of investments in the green scenario are higher than investments in a scenario where the same amount would be spent in coal power plants. The effects of investments on employment (Figure 14, right) is slightly negative in the first two years, where investments in coal power plants lead to higher impacts of investments as the Green Scenario. However, after the first two years, the net employment impact from investments are positive, and by 2030, the total amount of jobs in the Turkish economy are around 0.25% higher than in a scenario with investments in coal.

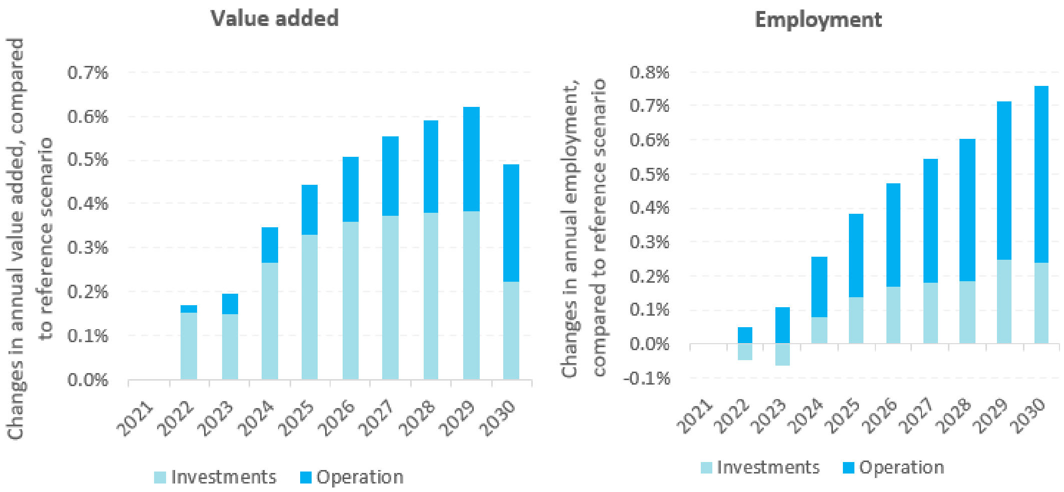


Figure 14 Value added (left) and employment (right) outcomes of Green scenario, compared to reference scenario, detailed between impacts from investments and from operation of wind and solar power plants.

Note that the different types of investment in the green scenario compared to the reference scenario result in lower employment in the first two years. However, this negative impact is more than offset by the positive employment effect of the structural change in the economy due to increasing use of wind and solar and decreasing use of coal power plants. This positive effect of the structural changes related to renewable electricity generation and its indirect impacts in the economy for the operation and maintenance of the new power plants increases in the long term for two reasons. First, the operation of renewable electricity generates more jobs than of fossil electricity, due in parts to the distributed nature of wind and solar compared to thermoelectric power plants. Second, the inputs to the current electricity and gas industry comprise of mainly energy products (coal and natural gas) and electricity (see Table 1 in section 2.3). The coal and natural gas which serve as inputs to thermal electricity are mostly imported. Thus, losses of economic output and jobs from the lower demand from coal affects mostly workers outside of Türkiye. In contrast, the operation and maintenance of solar and wind power plants increases the demand for goods and services produced by Turkish industry, leading to positive indirect impacts on the economy.

4.2.1. Employment gains and losses

Although the Green scenario has a positive net impact on jobs, it is important to identify where and which jobs will be gained, and which jobs will be lost. Anticipating where jobs will be created and where jobs will be lost will allow for the design of policies and strategies to maximise benefits of job creation and growth of decent jobs, and alleviate negative impacts from job losses by identifying opportunities for job transitioning for affected communities. Table 6 shows the total job gains and losses between 2022 and 2030 in the green scenario.

Table 6 Total job gains and losses in the green scenario, compared to the reference scenario

	2022	2023	2024	2025	2026	2027	2028	2029	2030
Job gains	50 853	77 585	153 454	206 712	249 261	286 764	321 870	380 027	370 035
Job losses	-51 033	-61 651	-61 876	-67 246	-73 132	-79 249	-85 481	-93 191	-58 774

Employment gains in the Green Scenario are widespread in the economy. Out of the 66 detailed industries from the SUT, only eight industries experience job losses in 2025 compared to the reference scenario, and only three industries remain with net-losses by 2030. In Figure 15 and Figure 16, jobs gains and losses by 14 broad industry group are shown. Most jobs lost, as expected, are in the traditional (fossil fuel) electricity industry. In addition, the green investment portfolio generates less jobs in financial services and in technical and administrative activities (mostly, engineering and consultancy services). Those potential losses in jobs affect, mostly, high-skilled and professional workers, while industries that currently employ lower-skilled people, informal workers, and Syrian workers experience higher employment opportunities.

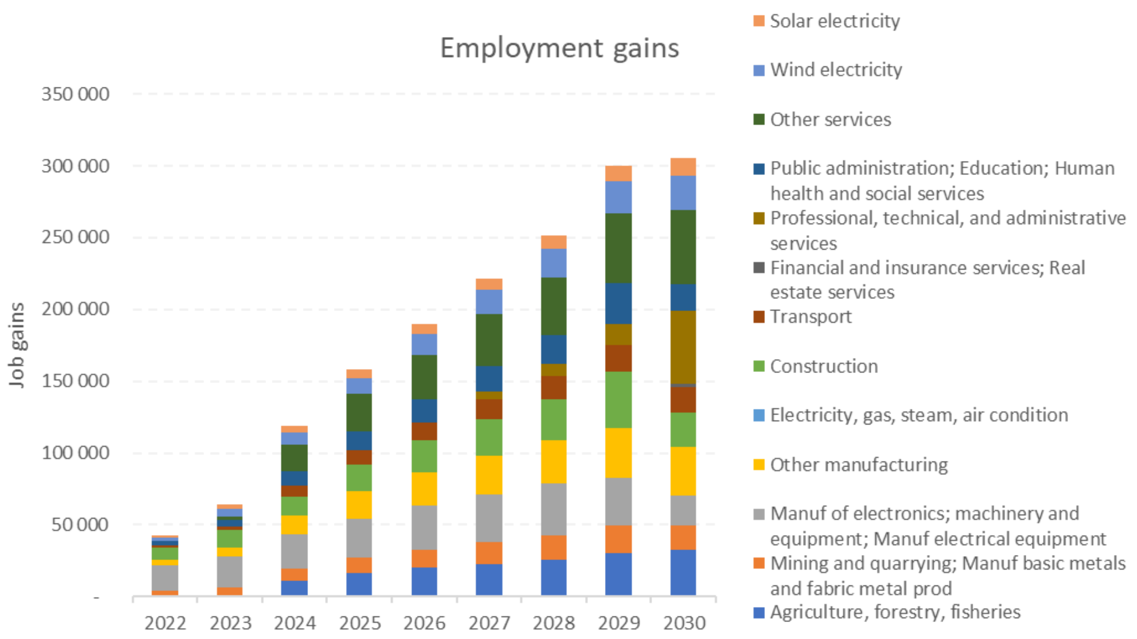


Figure 15 Employment gains in the green scenario per year and broad industry groups

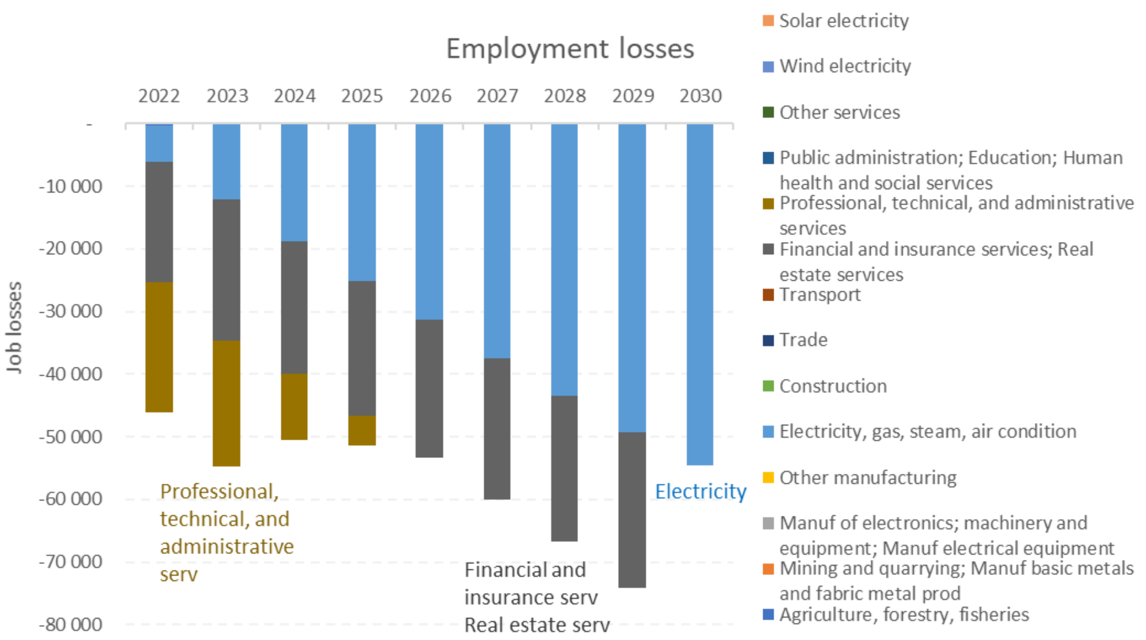


Figure 16 Employment losses in the Green Scenario per year and broad industry groups

Figure 17 summarises job gains and job losses for the years 2025 (including short-term investment effects) and 2030 (long-term structural change effects). It becomes immediately apparent that the effects are different between the investment and the long-term operational phase. Even though the average difference between the Green Scenario and the Reference Scenario is lower in the long run, the variation in the effects is larger across industries. Employment in electricity generation from fossil fuels (industry: Electricity, gas, steam) and its most important supplier (Mining & quarrying) are significantly more negatively impacted in the long run, while especially the service industries are more positively impacted. Lower long-term effects than short-term effects are in the manufacturing of electronic equipment (computers, etc). as well as electrical equipment, both industries supplying important inputs for renewable energy technologies. The short-term effect on auxiliary financial services, legal activities, and architectural activities are negative, while they are positive in the long run. This can be explained by a larger share of investments in the Reference scenario going into larger infrastructure projects (coal power plants) so there is more need for financial and legal services, while especially solar PV investments are more granular.

Figure 18 displays the same indicator as Figure 17, job gains and job losses, but in relative terms. That is, relative to the size of the industries in the Reference Scenario. Here, it becomes apparent that employment in the manufacturing industries supplying components for the renewable energy technologies grows significantly. This is a positive effect of the local content requirements. This in turn also results in a higher demand for services, additionally increasing the positive employment opportunities.

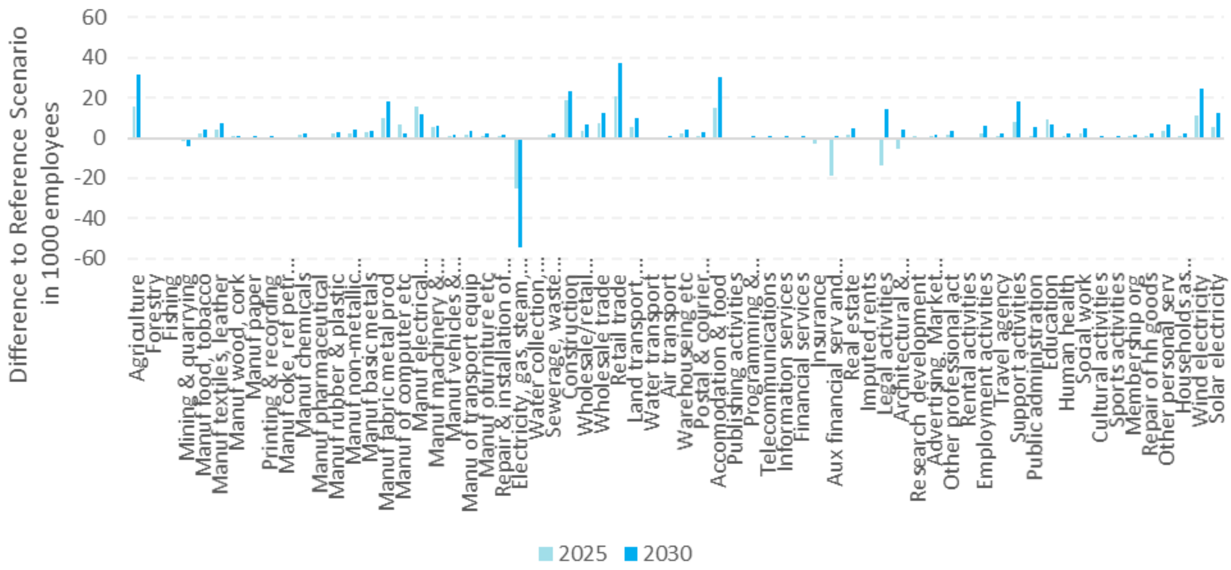


Figure 17 Difference in employment to the reference scenario, by industry. Short term investment effects in 2025 and long-term structural change effects in 2030.

Figure 19 shows the relative impacts by type of employment (male/female, low/medium/high skilled, formal/informal). High and professionally skilled employees are in higher demand in the long run. This effects both formal and informal employment, as well as jobs typically held by men and by women. In the short run, however, high-skilled jobs typically held by women (formal and informal employment), are those that experience losses. This is due to high-skilled women having a share of the jobs in the industries that are demanded less during the investment phase for renewable energy technologies, compared to the investment into coal power plants. In the long run, the number of jobs for this skill level increases significantly in the Green Scenario compared to the Reference Scenario. During the investment phase a lot of jobs are created that have a high share of professionally skilled Syrians under temporary protection (men). The next section describes expected job outcomes for the different groups in more detail.

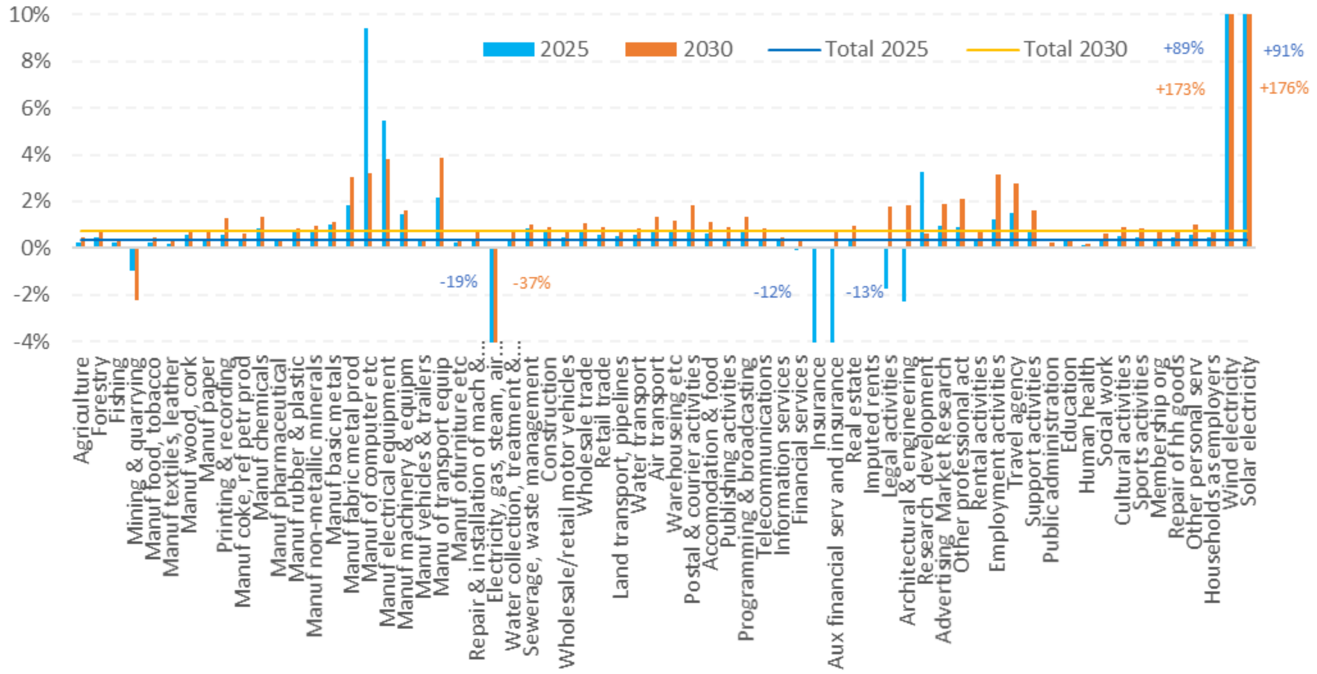


Figure 18 Relative difference in employment to the Reference Scenario, by industry

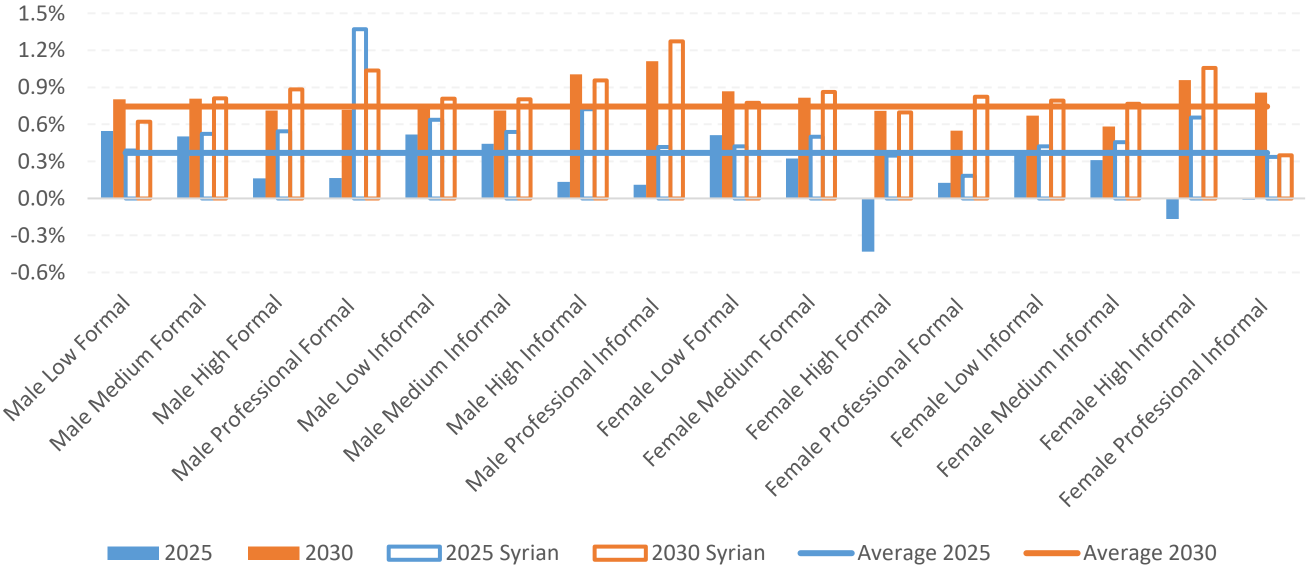


Figure 19 Relative difference in labour indicators, compared to Reference Scenario

4.2.2. Green transition effect on disadvantaged groups

The total net-effect on employment in the Green Scenario compared to the Reference Scenario is positive for all types of employment in the long run. However, some jobs will be lost, while other opportunities, possibly for different occupations and skill levels arise.

Figure 20, Figure 21 and Table 7 summarise the effects per group of workers for the total Turkish population. Here we can see that more jobs are created that are typically held by men (left panel in Figure 21), formally employed (middle panel in Figure 21), and medium skilled (right panel in Figure 21). These groups are also those with the largest number of lost job opportunities, with one exception: Job losses in the short term are almost evenly distributed across medium, high and professionally skilled. This is due to the lower demand for auxiliary financial, legal, and architectural services.

Table 7 Gains and losses of employment per group of workers

Note: male + female = 100%; formal + informal = 100%, sum over skill levels = 100%

	2025		2030	
	Gains	Losses	Gains	Losses
Male	156 596	-47 269	276 560	-52 800
Female	50 115	-19 977	93 476	-5 974
Formal	146 450	-61 097	258 945	-57 456
Informal	60 262	-6 149	111 090	-1 318
Low	30 909	-3 776	53 539	-5 945
Medium	129 674	-25 614	230 964	-30 784
High	21 635	-20 947	41 532	-16 612
Professional	24 493	-16 910	44 000	-5 433

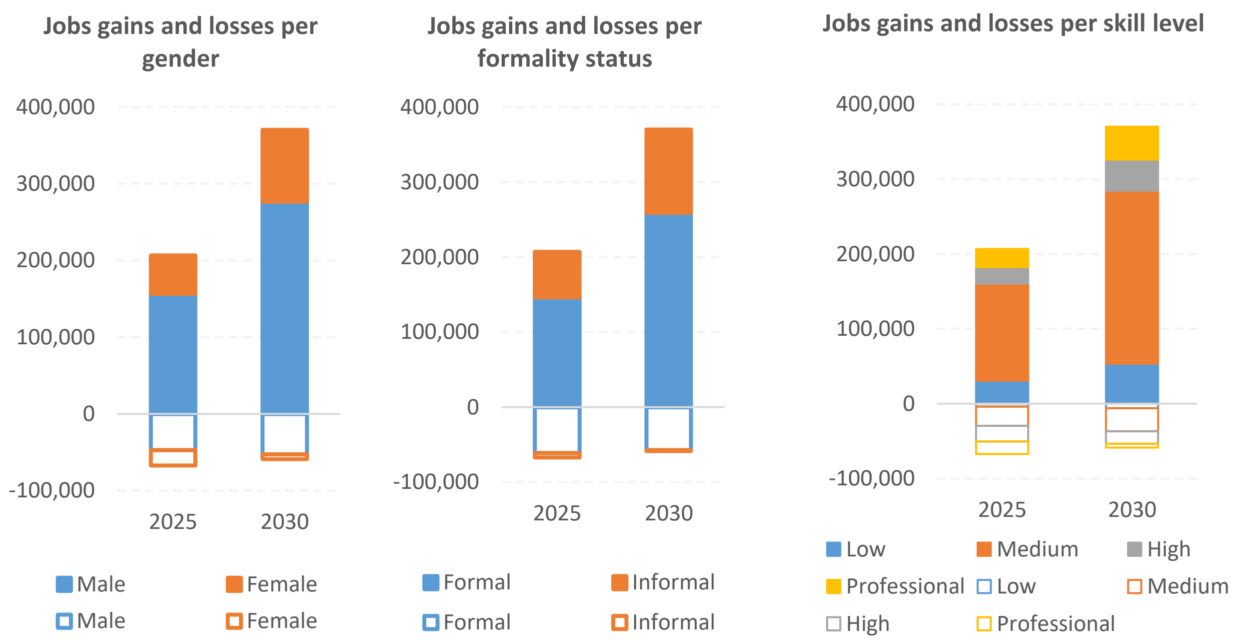


Figure 20 Absolute difference in labour indicators by gender, formality status, and skill level, compared to Reference Scenario, total Turkish population

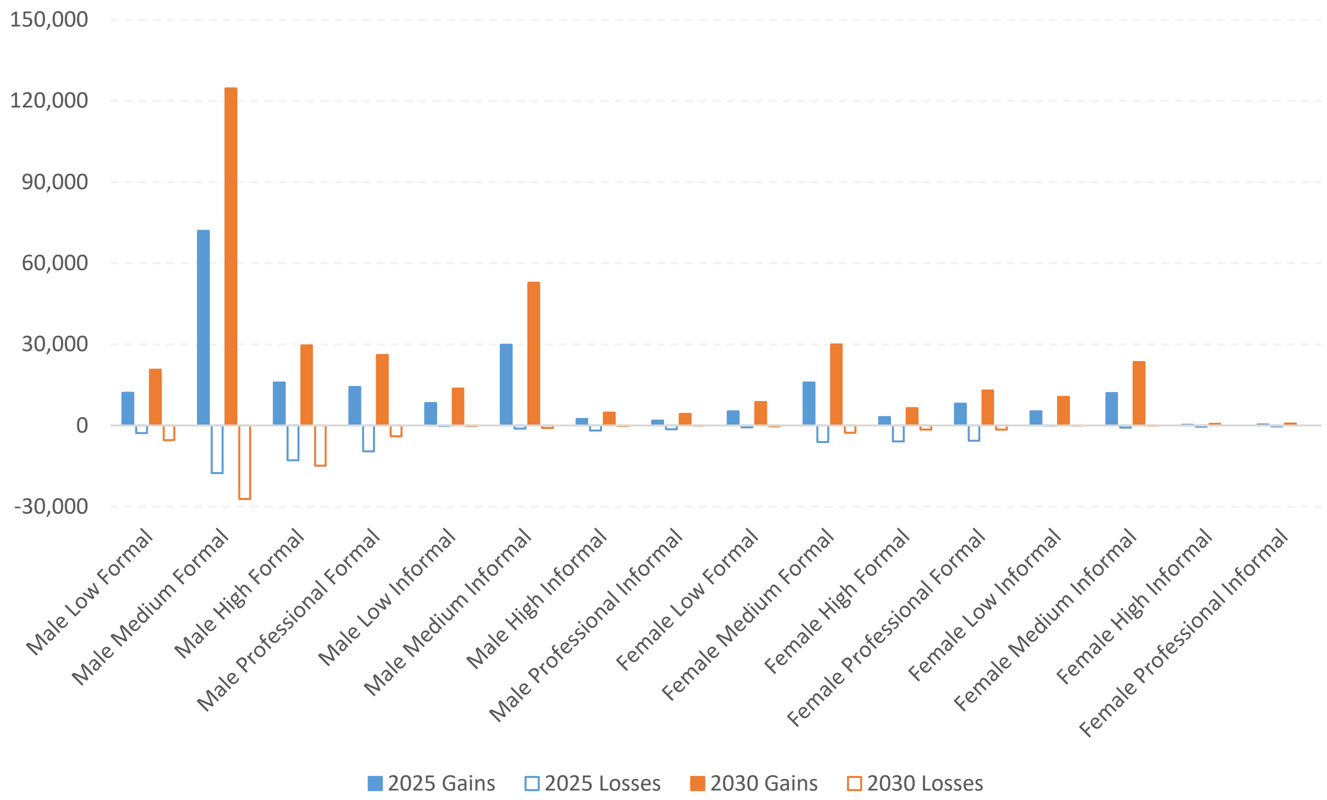


Figure 21 Absolute difference in labour indicators for total Turkish population, compared to Reference Scenario

Syrian population under temporary protection

Figure 22, Figure 23, and Table 8 summarise effects on jobs that are held by Syrians under temporary protection. In contrast to the effects on the total Turkish population, it is informal jobs that are increasingly demanded. In addition, there is a relatively higher increase in demand for low-skilled jobs. It is also striking, that only very few Syrians under temporary protection are employed in the industries that experience job losses in the short run or the long run.

Table 8 Gains and losses of employment of Syrian population under temporary protection per group of workers

Note: male + female = 100%; formal + informal = 100%, sum over skill levels = 100%

	2025		2030	
	Gains	Losses	Gains	Losses
Male	5 734	-78	8 967	-22
Female	1 398	-47	2 737	0
Formal	1 113	-70	1 735	0
Informal	6 020	-55	9 968	-22
Low	2 406	-8	3 722	-22
Medium	3 712	0	6 420	0
High	409	0	668	0
Professional	605	-116	893	0

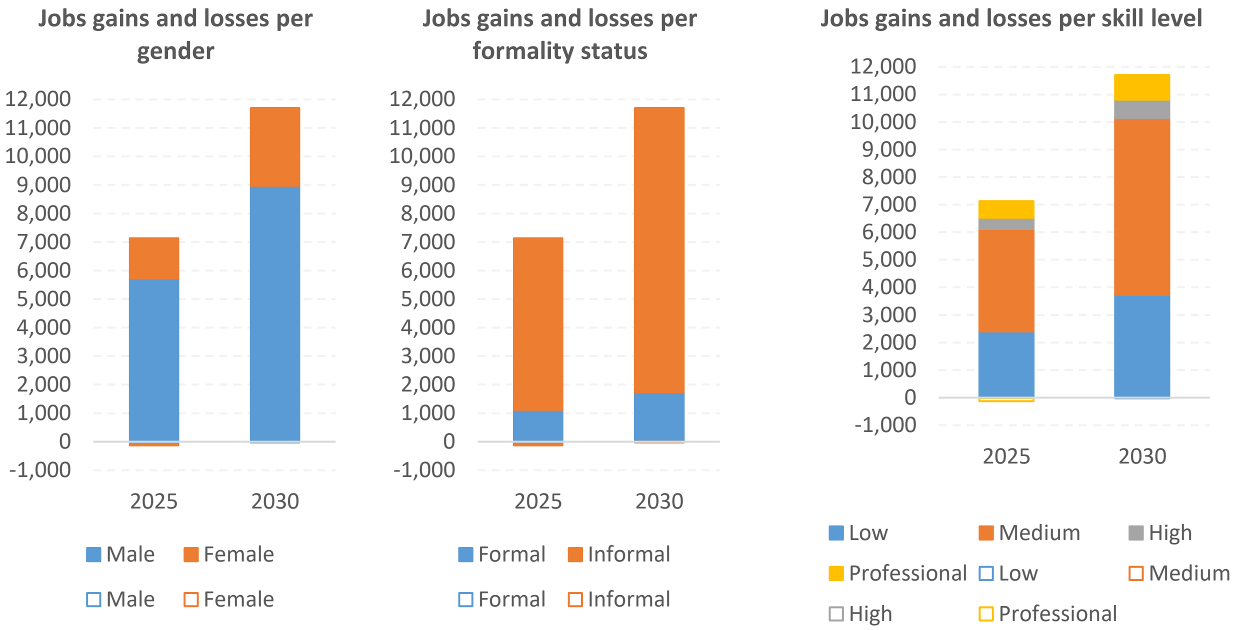


Figure 22 Absolute difference in labour indicators by gender, formality status, and skill level, compared to Reference Scenario, Syrians under temporary protection

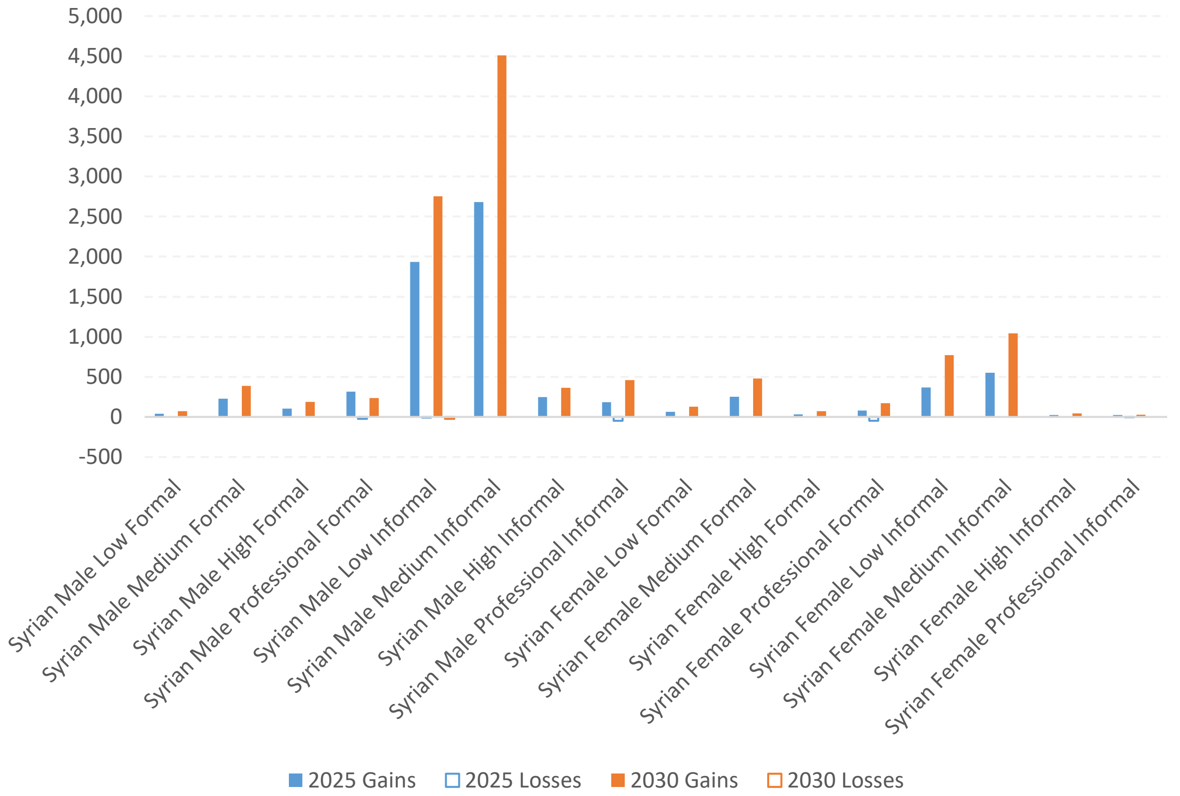


Figure 23 Absolute difference in labour indicators for Syrians under temporary protection, compared to Reference Scenario

5. Conclusion

This report presented an application of the Green Jobs Assessment Model for Türkiye. This model assessed direct, indirect, and induced effects of a green energy scenario on the national economy, compared to a reference scenario. Electricity consumption grows until 2030. The difference between the reference and green scenario was which technologies were prioritized to fulfil this growth. In the reference scenario, the growing electricity demand is met with additional coal power, most of it fired by imported coal following current trend, while in the green scenario, all additional electricity is met with wind and solar power. Total additional investments required to satisfy those energy needs are assumed to be the same in both scenarios.

By 2030, outcomes of the green scenario are positive in terms of economic growth, employment creation, and reduced GHG emissions. Compared to the reference scenario, the green scenario results in additional 10-45 billion TRY (in 2019 constant prices) in annual GDP, over 300,000 extra jobs by 2030, and lead to a decrease of 60,000 Mt CO2-eq, that is, 8% lower than in the reference scenario. In the long-term, the employment and economic effects are positive, even when investments cease. These are due to long-term structural changes in the energy and electricity industry which, in turn, increase the demand for goods and services from other industries within the Turkish economy to operate and maintain these new green industries. Second, the operation of renewable electricity generates more jobs than of fossil electricity, due to the distributed nature of wind and solar compared to thermoelectric power plants. And third, the inputs to the current electricity and gas industry comprise of mainly fossil fuel-based coal and natural gas. The coal and natural gas which serve as inputs to thermal electricity are mostly imported. Thus, losses of economic output and jobs from the lower demand from coal affects mostly workers outside of Türkiye. In contrast, the operation and maintenance of solar and wind power plants increases the demand for goods and services produced by Turkish industry, leading to positive indirect impacts on the economy.

As in any structural change, although there are net gains in jobs in the Turkish economy, there are industries which experience job losses. It is therefore important to identify where and which jobs will be gained, and which jobs will be lost. Anticipating where jobs will be created and where jobs will be lost will allow for the design of strategies to maximise benefits of job creation and growth of decent jobs and alleviate negative impacts from job losses by identifying opportunities for economic transitioning for affected communities. Most of the 66 industries detailed in the Green Jobs Assessment Model for Türkiye experience job gains, and only three industries experience net losses by 2030, mostly in the traditional (mostly fossil fuel) electricity industry due to the switch to wind and solar electricity, and the changes in different inputs to operate and maintain power plants. Investments in green energy, on the other hand, creates long-term employment growth in Turkish manufacturing industries such as electronic and electrical equipment, which supply important inputs for renewable energy technologies. In addition, there will be an increased demand for higher-skilled formal jobs, as well as jobs occupied by women.

In this report, we show that the transition to a renewable electricity future instead of a continuation of investment in fossil fuels will lead not only to reduced GHG emissions but will also lead to social and economic benefits in the Turkish economy and society. Designing policies to maximise the gains and minimise the losses of energy and climate policies will make this transition not only green, but also just.

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Annex

A.1. The Green Jobs Assessment Model

The GJAM we develop for Türkiye applies the same philosophy and modelling approach as taken for MEIO Norway[39,40], GJAM Nigeria[41] and GJAM Zimbabwe[42]. It is based on the model suggested in the International Labour Organizations GAIN Training Guidebook[43], adapted to the use of supply-and-use tables. We have further introduced endogeneity of some macro-economic key variables to capture dynamic development paths over time. To this end we follow ideas put forward by the Interindustry Forecasting Project at the University of Maryland[44]. We embed the supply-use-model into a set of linear macro-economic equations, see Figure A1. Population and exports are exogenous drivers of the model, while investments (gross capital formation), household demand and GDP (and value added) are endogenous. The model is dynamic-recursive and can be classified as a simple macro-econometric input-output (MEIO) model[45,46]. While similar to computable general equilibrium (CGE) models, the most important differences are that MEIO models are more empirically based (estimation of behavioural parameters), assume myopic foresight of all agents, and have a Leontief production function[47] in contrast to e.g. a constant elasticity of substitution (CES) production function. Although some price effects are considered in the GJAM model family, these models are to date simpler than other MEIO models such as E3MG[48] and related models or models from the INFORUM family, such as INFORGE[49,50] for Germany.

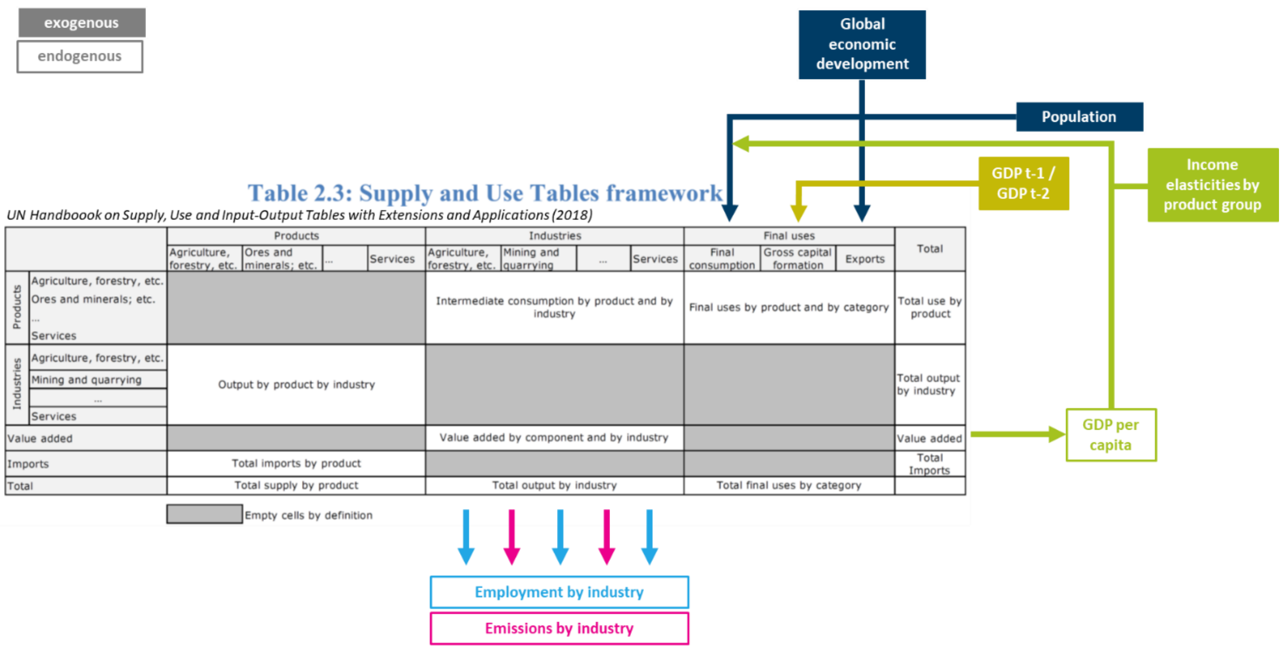

Figure A1 Schematic representation of the supply-and-use table based model

General limitations and strengths of the modelling approach –

Excerpt from general documentation of the software for the economic core model (SUT_core)

SUT based macro-econom(etr)ic IO models / GAIN type Green Jobs Assessment Models are not economic forecasting models. Rather, these models are a tool to inform about possible effects of "what-if" scenarios on emissions and labour demand by industries, given that the remaining structure of the economy remains as is.

The results should be assessed relative to the reference scenario. They indicate the direction and possible size of the effects but should be taken as indicative estimates.

The results show how changes in individual economic activities influence the economic structure. Direct, indirect, and induced effects of technological change and changes in household, government and investment structure are reflected.

A(n imperfect) list of limitations to the modelling approach

- The model is based on historic relation between economic activity, income and consumption and the production structure of the base year (currently last year available at TurkStat is 2012), which in turn might be estimated based on older supply-and-use tables. For some countries, the most recent available SUT might be from 2010 or 2012, while other countries might have tables as recent as 2019. Extrapolating data over the next decade based on such data will not necessarily give a complete picture, but it constitutes a valuable starting point for assessing effects of climate change mitigation and adaptation and other sustainability policies through "what-if" analyses.
- While the option for price changes is given, there is no adjustment of production structure or investments based on price changes. Household demand for different product groups, however, is modelled using own- and cross-price elasticities.
- Investments grow with the previous year's growth rate, and the structure of the investment remains the same, with one exception: the exogenously given investment for individual scenarios, which comes in addition to the general investments. This entails that the additional investments in the scenarios are not crowding out other investments but come as an additional economic stimulus.
- The results show which industries are likely to have an increased demand for labour, and which industries might contract. The actual labour market outcomes also depend on other factors as well as dynamic labour market adjustments such as wage adjustments, labour availability, labour productivity changes etc, that are not considered here.
- The current modelling of international trade is very simplified. Import shares by product are based on the supply table from the base year. Exports grow with global GDP projections from the IMF or OECD.

Once these limitations are well understood, they contribute to the **main strength of the model: simplicity and transparency**. These are reinforced by the other strengths:

- The model depends on very few types of data, which can be combined into one consistent framework with few equations.
- The model is data-driven and reflects country-specific characteristics very well.
- Scenarios are implemented using one Excel sheet and the model runs in only a few seconds, which allows to calculate a large number of scenarios and thereby assessing the validity of different scenario assumptions.
- For every single result, we can find an explanation that is in the data or one of the very few assumptions underlying the model.

Modelling Overview and Analysis

The Green Jobs Assessment Model for Türkiye GJAM Türkiye is a dynamic-recursive model combining macro-economic equations with a supply-and-use table system. The model is set up in constant 2019 prices. The macro-economic equations are:

- Exports, which grow with an exogenously assumed global GDP growth rate[8].
- Gross capital formation (investments), which grow with last year's growth rate. This stabilises the model by exogenising investments when finding the solution for the current year, while still allowing for different growth paths across scenarios.
- Government consumption, which depends on population growth and lagged GDP and is estimated econometrically based on time series data from the system of national accounts. (Note, for this first version of the model, government consumption is not based on econometrically estimated parameters, but is assumed to grow at the same rate as population)
- Population is assumed to follow the medium fertility scenario from UN DESA's world population prospects[28]

We assume that the share of each product in total exports, total investments and total government consumption remains constant in the reference scenario, while these can be exogenously changed in the green transition scenarios.

Household consumption expenditures are modelled using a **demand system** where household consumption by product *prod* depends on total income (GDP) and income (*eI*), own-price (*eop*) and cross-price (*ecp*) elasticities, with *gr*X denoting the growth (in %) in variable X:

$$HHEprod_t = HHEprod_{t-1} + (eI \times grGDP) + (eop \times grOwnPrice) + (ecp \times grOtherPrices)$$

Here, income, own-price and cross-price elasticities are taken from the USDA international food comparison programme[30,31], but can be estimated econometrically if time series with a sufficient number of observations are available. Product price changes are determined in the input-output core, using the Leontief price model. Note that we do not model inflation. The only price changes that can be modelled are those due to changing technology of production in the scenarios. Prices in the reference and the current green scenario are constant.

Figure A1 shows the circular flow between final demand by product, value added by industry, which considering taxes and other flows determines GDP per capita, which is used to model final demand. In mathematical terms, the use matrix is denoted *U* and the supply matrix is the transpose of the make matrix, V^T. The industry-by-commodity commodity-demand-driven SUT model[32] is

$$g = D(I - BD)^{-1} y$$

Where *y* is the final demand by product (obtained by summing the individual final demand vectors), and *B* is the use coefficient matrix:

$$B = U\, diag(g)^{-1}$$

where *g* is the vector of industry output. *D* is the market share matrix:

$$D = V\, diag(q)^{-1}$$

where *q* is the vector of product output.

The model iterates in every year until the change in final household demand from one iteration to the next is below a given threshold. The next year is then initialised with endogenous variables being set to the current year solution and exogenous variables as well as scenario inputs taking the next year's value.

For the scenarios it is possible to model

- additional investment by product
- changes in the structure of household and government demand
- changes in the use coefficient matrix, i.e. the technology with which an industry produces
- changes in the market share matrix, i.e. which industries produce which share of a product
- changes in the import shares by products
- changes in emission intensities of industries

[8] In future development of this model, exports growth will be estimated with an equation with econometrically estimated parameters.

Production and value added are always endogenous. From this we can estimate changes in employment by using a constant labour intensity (that is, a fixed number of workers by skill and gender per unit of value added by industry) multiplied with the new value added by industry.

A.2. The Turkish supply-and-use table

The SUT for Türkiye shows the flows of goods and services between industries and final consumers, in TRY, throughout the entire year of 2012. It describes the entire Turkish production economy in 64 products and industries (Table A1 and Table A2) and final users of goods and services (Table A3), besides the volume and distribution of value added in each industry (Table A4).

The supply table describes the total supply of the 64 products in the economy and how those products are distributed by the 64 supplying industries and imports. Figure A2 gives an overview of the supply table for 2012, with shading according to monetary values, where darker shades of red correspond to higher values, and white corresponds to 0. It can be seen that, even though many industries supply a wide range of products, there is a high correspondence between industries and products supplied in the economy, in the diagonal, for example, with the industry *Crop and animal production, hunting and related service activities* (first column) supplying, mainly, *Products of agriculture, hunting and related services* (first row). The last shaded column in the table shows imports of products.

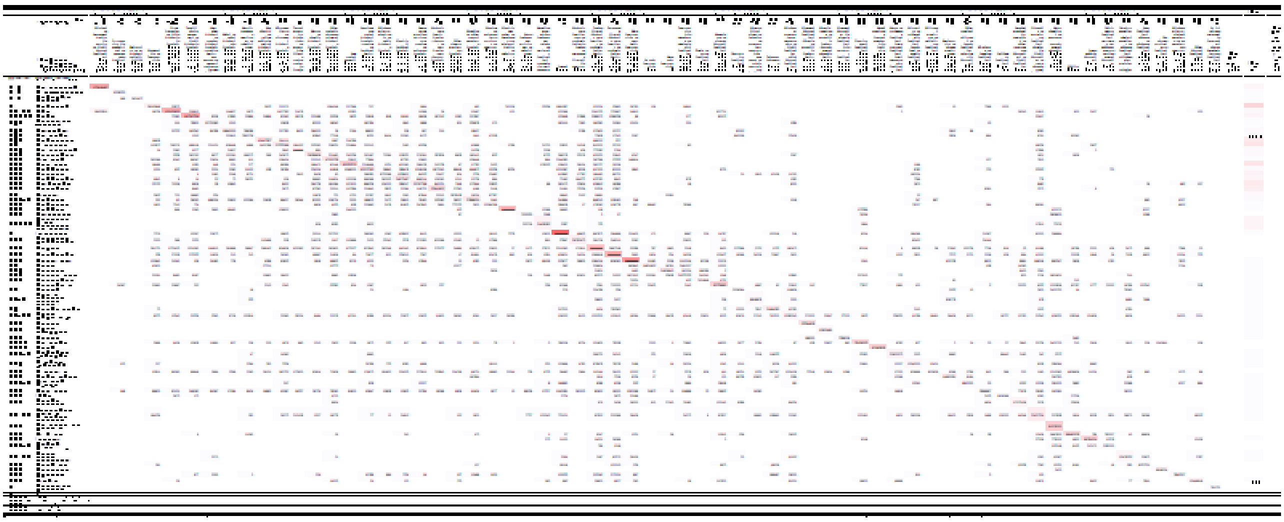

Figure A2 Overview of the Turkish Supply table for 2012, with shaded values corresponding to monetary volume in the inter-industry matrix and in the imports column.

The use table describes how each of these 64 products are used by the 64 industries and by final users in the economy, and how much value added[9] is created in each of the industries. Figure A3 gives an overview of the use table for 2012, with shading according to monetary values, where darker shades of red correspond to higher values, and white corresponds to 0. Shaded areas correspond to the inter-industry flows (that is, inputs of goods and services into each industry in Türkiye to produce their own goods and services), and columns on the right correspond to final purchases by households, government, gross fixed capital formation, change in inventories, and exports. Differently from the use table, every industry consumes a wide range of goods and services.

[9] Measure to calculate national Gross Domestic Product (GDP). GDP can be calculated by sum of value added in each industry, plus total exports, minus total imports.

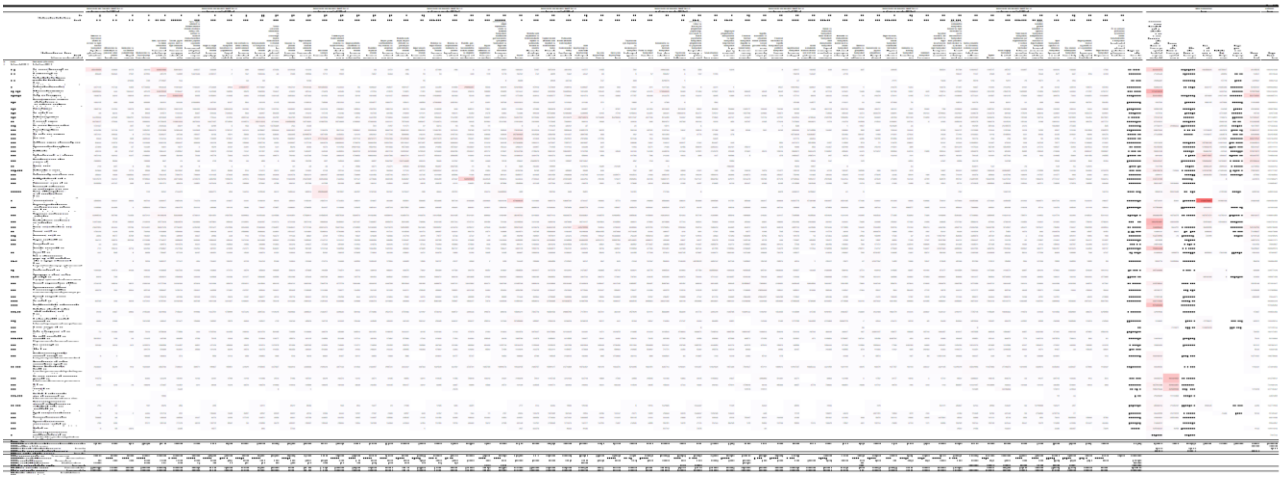

Figure A3 Overview of the Turkish Use table for 2012, with shaded values corresponding to monetary volume in the inter-industry matrix and in the final uses columns.

A.2.1. Updating the supply-and-use table from 2012 to 2019

The SUT was updated to reflect a more recent base-year for the GJAM model, to the latest year available for the GHG emissions inventory, 2019. For this, both the supply and the use table were scaled to match the 2019 macro-economic variables available from TurkStat using a SUT-RAS algorithm[51]. The data used to do this update are[10] (a) total VA by industry, (b) total output by industry, (c) imports and exports by product, and (d) final demand by product for each final demand category (Table A3) by product. The data sources and assumptions to estimate these data are detailed below.

Value added by industry: Data on GDP per industry from 2019 are available from the *Annual Gross Domestic Product* database from TurkStat[52] in 1-digit NACE code, covering 20 industries. For detailed mining, manufacturing, and service industries (excluding financial services) in up to 4-digit NACE code, data for VA is available from the *Annual Industry and Service Statistics*[53]. The estimates for VA per detailed industry was done according to the following assumptions:

- For agricultural industries (A01-A03), financial services and insurance (K64-K66), and real estate (L68A-L68B), it was assumed that the distribution of GDP in the detailed industries within each corresponding 1-digit NACE industry remained constant, due to no further data being available. For example, *Crop and animal production, hunting and related service activities* corresponded to 95% of the VA in the broad *Agriculture, forestry, and fishing* industry in 2012, and was assumed that this share would be the same in 2019. The total VA was then scaled up to correspond to 95% of the *Agriculture, forestry, and fishing* GDP data for 2019.
- For mining and quarrying (B); electricity, gas, steam and air conditioning supply (D35); construction (F), accommodation and food service activities (I), public administration and defence (O84), education (P), and households as employers (T), the industries in the SUT are a direct correspondence to the 1-digit industry detail in the GDP per industry data for 2019, and no allocation was needed.
- For the remaining of the industries, the distribution of each industry in the VA of the corresponding 1-digit NACE industry was taken from the detailed value added per industry available in the *Annual Industry and Service Statistics* and then scaled up to the GDP per industry data for 2019.

The split of total VA per industry for each value added category (Table A4) was assumed the same as in 2012, as no analysis on each element of value added is being done in this report.

[10] All data for 2019 in the same industry/product classification as in the 2012 SUT.

Total output by industry: Data on total output by industry is not available from national accounts database in TurkStat. For detailed mining, manufacturing, and service industries (excluding financial services) in up to 4-digit NACE code, data for total output (production value) is available from the *Annual Industry and Service Statistics*[53]. The estimates for total output per detailed industry was done according to the following assumptions:

- For agricultural industries (A01-A03), financial services and insurance (K64-K66), real estate (L68A-L68B), public administration and defence (O84), and households as employers (T), it was assumed that the share of value added of total output was the same in 2019 as in the 2012 SUT. Total output for 2019 was then scaled up based on the new VA data for 2019.
- For all other industries, the changes in the share of VA of total output between 2012 and 2018 from the *Annual Industry and Service Statistics* was applied to the 2012 share of VA of total output. Total output for 2019 was then scaled up based on the new VA data for 2019.

Imports and exports by product: Data for total imports and exports by products is available from the *Foreign Trade Statistics* database from TurkStat[54]. For both imports and exports, the distribution of goods imported/imported was scaled to the total imports and exports values for 2019 from the *Annual Gross Domestic Product* database.

Final demand by product: Total final demand by category (households, government expenditure, gross capital formation, changes in inventories) are available from the *Annual Gross Domestic Product* database. The changes in distribution of products consumed by households from the 2012 SUT was based on the differences between 2012 and 2019 for broad product groups in *Household final consumption by COICOP* dataset from the *Annual Gross Domestic Product* database. The 2019 distribution of expenditure in main gross fixed capital formation product types (construction, machinery and equipment, other assets) was estimated based on the difference in products distribution between 2012 and 2019. For government expenditures and changes in inventories, the products distribution was assumed to be the same as in 2012, due to no further available data. The new distribution of products consumed by final demand categories was then scaled to the total values for 2019 from the *Annual Gross Domestic Product* database.

A.2.2. Split of mining products

The major impacts on the economy of the decreasing share of fossil fuels in electricity production happen in the upstream demand for fossil fuels. However, the original products classification in the Turkish SUT does not differentiate the mining of energy products from other mining and quarrying. The characteristics of the GJAM model and the Green Scenario, nevertheless, demands that these products are portrayed separately. The main reason is that changes in the demand for coal and natural gas has different impacts on the economy (and therefore, on labour and emissions) than changes in the demand of other mining products. This is due to the high import rate of energy products compared to non-energy mining products. A higher import rate of fuels result in lower losses of GDP and employment in Türkiye due to the reduced demand for fossil fuels for electricity production.

For the split of the mining products, we used the distribution of outputs from energy and non-energy mining for 2018 from the Inter-Country Input-Output (ICIO) Database[55], which describes the world economy for 66 countries, detailed in 45 industries, in annual tables from 1995 to 2018.

For the split of the mining products, we used three sets of data points. First, the distribution of total (domestic and imported) energy and non-energy mining products used as inputs to Turkish industries and final consumers. For example, according to this database, inputs of mining products into the petrochemical industry correspond to 98% energy products and 2% non-energy products, while inputs to manufacturing of machinery correspond to 30% energy products and 70% non-energy products. Second, the participation of each product in total imports and exports of mining products: 98% of imports and 39% of exports of all products from mining corresponded to energy products.

For the supply table, we assumed that energy products are supplied by the industries *Mining and Quarrying* and *Electricity, gas, steam and air conditioning supply*. The supply of mining products by other industries were fully allocated to non-energy products.

The total import share of mining products, according to the estimated 2019 SUT, is of 56%. That corresponds to the total mining products used by Turkish industries and final consumers that is not produced in Türkiye. Taking into account the split of the products, the new import shares are of 85% and 3% for energy and non-energy products, respectively.

A.2.3. List of industries, products, value added categories and final consumers in the SUT

Table A1 Industries in the Turkish supply-and-use table, with new green electricity industries at the end in blue shade

NACE Code	Industry name	Short name
A01	Crop and animal production, hunting and related service activities	Agriculture
A02	Forestry and logging	Forestry
A03	Fishing and aquaculture	Fishing
B	Mining and quarrying	Mining & quarrying
C10-C12	Manufacture of food products; beverages and tobacco products	Manuf food, tobacco
C13-C15	Manufacture of textiles, wearing apparel, leather and related products	Manuf textiles, leather
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	Manuf wood, cork
C17	Manufacture of paper and paper products	Manuf paper
C18	Printing and reproduction of recorded media	Printing & recording
C19	Manufacture of coke and refined petroleum products	Manuf coke, ref petr prod
C20	Manufacture of chemicals and chemical products	Manuf chemicals
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	Manuf pharmaceutical
C22	Manufacture of rubber and plastic products	Manuf rubber & plastic
C23	Manufacture of other non-metallic mineral products	Manuf non-metallic minerals
C24	Manufacture of basic metals	Manuf basic metals
C25	Manufacture of fabricated metal products, except machinery and equipment	Manuf fabric metal prod
C26	Manufacture of computer, electronic and optical products	Manuf of computer etc
C27	Manufacture of electrical equipment	Manuf electrical equipment
C28	Manufacture of machinery and equipment n.e.c.	Manuf machinery & equipm
C29	Manufacture of motor vehicles, trailers and semi-trailers	Manuf vehicles & trailers
C30	Manufacture of other transport equipment	Manu of transport equip
C31_C32	Manufacture of furniture; other manufacturing	Manuf ofurniture etc
C33	Repair and installation of machinery and equipment	Repair & installation of mach & equip
D35	Electricity, gas, steam and air conditioning supply	Electricity, gas, steam, air condition
E36	Water collection, treatment and supply	Water collection, treatment & supply
E37-E39	Sewerage, waste management, remediation activities	Sewerage, waste management
F	Construction	Construction
G45	Wholesale and retail trade and repair of motor vehicles and motorcycles	Wholesale/retail motor vehicles
G46	Wholesale trade, except of motor vehicles and motorcycles	Wholesale trade
G47	Retail trade, except of motor vehicles and motorcycles	Retail trade
H49	Land transport and transport via pipelines	Land transport, pipelines
H50	Water transport	Water transport
H51	Air transport	Air transport
H52	Warehousing and support activities for transportation	Warehouseing etc
H53	Postal and courier activities	Postal & courier activities
I	Accommodation and food service activities	Accomodation & food
J58	Publishing activities	Publishing activities

J59_J60	Motion picture, video, television programme production; programming and broadcasting activities	Programming & broadcasting
J61	Telecommunications	Telecommunications
J62_J63	Computer programming, consultancy, and information service activities	Information services
K64	Financial service activities, except insurance and pension funding	Financial services
K65	Insurance, reinsurance and pension funding, except compulsory social security	Insurance
K66	Activities auxiliary to financial services and insurance activities	Aux financial serv and insurance
L68B	Real estate activities excluding imputed rents	Real estate
L68A	Imputed rents of owner-occupied dwellings	Imputed rents
M69_M70	Legal and accounting activities; activities of head offices; management consultancy activities	Legal activities
M71	Architectural and engineering activities; technical testing and analysis	Architectural & engineering
M72	Scientific research and development	Research development
M73	Advertising and market research	Advertising Market Research
M74_M75	Other professional, scientific and technical activities; veterinary activities	Other professional act
N77	Rental and leasing activities	Rental activities
N78	Employment activities	Employment activities
N79	Travel agency, tour operator reservation service and related activities	Travel agency
N80-N82	Security and investigation, service and landscape, office administrative and support activities	Support activities
O84	Public administration and defence; compulsory social security	Public administration
P85	Education	Education
Q86	Human health activities	Human health
Q87_Q88	Residential care activities and social work activities without accommodation	Social work
R90-R92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities	Cultural activities
R93	Sports activities and amusement and recreation activities	Sports activities
S94	Activities of membership organisations	Membership org
S95	Repair of computers and personal and household goods	Repair of hh goods
S96	Other personal service activities	Other personal serv
T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	Households as employers
D35wind	Wind electricity	Wind electricity
D35solar	Solar electricity	Solar electricity

Table A2 Products in the Turkish supply-and-use table, with new mining products in blue shade

CPA Code	Industry name	Short name
A01	Products of agriculture, hunting and related services	Agricultural products
A02	Products of forestry, logging and related services	Forestry products
A03	Fish and other fishing products; aquaculture products; support services to fishing	Fish
B05_06	Mining of energy products	Mining energy products
B07-B09	Other mining and quarrying	Mining & quarrying
C10-C12	Food, beverages and tobacco products	Food, tobacco
C13-C15	Textiles, wearing apparel, leather and related products	Textiles, leather
C16	Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials	Wood, cork

C17	Paper and paper products	Paper
C18	Printing and recording services	Printing & recording
C19	Coke and refined petroleum products	Coke, ref petr prod
C20	Chemicals and chemical products	Chemicals
C21	Basic pharmaceutical products and pharmaceutical preparations	Pharmaceutical
C22	Rubber and plastic products	Rubber & plastic
C23	Other non-metallic mineral products	Non-metallic minerals
C24	Basic metals	Basic metals
C25	Fabricated metal products, except machinery and equipment	Fabric metal prod
C26	Computer, electronic and optical products	Computer etc
C27	Electrical equipment	Electrical equipment
C28	Machinery and equipment n.e.c.	Machinery & equipm
C29	Motor vehicles, trailers and semi-trailers	Vehicles & trailers
C30	Other transport equipment	Transport equip
C31_C32	Furniture and other manufactured goods	Furniture etc
C33	Repair and installation services of machinery and equipment	Repair & installation of mach & equip
D35	Electricity, gas, steam and air conditioning	Electricity, gas, steam, air condition
E36	Natural water; water treatment and supply services	Water
E37-E39	Sewerage services; sewage sludge; waste collection, treatment and disposal services; materials recovery services; remediation services and other wa...	Sewerage, waste management
F	Constructions and construction works	Construction
G45	Wholesale and retail trade and repair services of motor vehicles and motorcycles	Wholesale/retail motor vehicles
G46	Wholesale trade services, except of motor vehicles and motorcycles	Wholesale trade
G47	Retail trade services, except of motor vehicles and motorcycles	Retail trade
H49	Land transport services and transport services via pipelines	Land transport, pipelines
H50	Water transport services	Water transport
H51	Air transport services	Air transport
H52	Warehousing and support services for transportation	Warehouseing etc
H53	Postal and courier services	Postal & courier activities
I	Accommodation and food services	Accomodation & food
J58	Publishing services	Publishing activities
J59_J60	Motion picture, video and television programme production services, sound recording and music publishing; programming and broadcasting services	Programming & broadcasting
J61	Telecommunications services	Telecommunications
J62_J63	Computer programming, consultancy and related services; Information services	Information services
K64	Financial services, except insurance and pension funding	Financial services
K65	Insurance, reinsurance and pension funding services, except compulsory social security	Insurance
K66	Services auxiliary to financial services and insurance services	Aux financial serv and insurance
L68B	Real estate services excluding imputed rents	Real estate
L68A	Imputed rents of owner-occupied dwellings	Imputed rents
M69_M70	Legal and accounting services;Services of head offices; management consulting services	Legal activities
M71	Architectural and engineering services; technical testing and analysis services	Architectural & engineering
M72	Scientific research and development services	Research development
M73	Advertising and market research services	Advertising Market Research
M74_M75	Other professional, scientific and technical services and veterinary services	Other professional act
N77	Rental and leasing services	Rental activities
N78	Employment services	Employment activities

N79	Travel agency, tour operator and other reservation services and related services	Travel agency
N80-N82	Security and investigation services; services to buildings and landscape; office administrative, office support and other business support services	Support activities
O84	Public administration and defence services; compulsory social security services	Public administration
P85	Education services	Education
Q86	Human health services	Human health
Q87_Q88	Residential care services; social work services without accommodation	Social work
R90-R92	Creative, arts, entertainment, library, archive, museum, other cultural services; gambling and betting services	Cultural activities
R93	Sporting services and amusement and recreation services	Sports activities
S94	Services furnished by membership organisations	Membership org
S95	Repair services of computers and personal and household goods	Repair of hh goods
S96	Other personal services	Other personal serv
T	Services of households as employers; undifferentiated goods and services produced by households for own use	Households as employers

Table A3 Final demand categories in the Turkish supply-and-usetable

Final demand categories
Final consumption expenditure by households and non-profit institutions serving households
Final consumption expenditure by government
Gross fixed capital formation
Changes in inventories
Exports (fob)

Table A4 Value added categories in the Turkish supply-and-use table

Value added category
Compensation of employees
Other taxes on production
Other subsidies on production
Consumption of fixed capital on operating surplus
Operating surplus, net / Mixed Income, net

A.3. Split of green electricity industries

The Green electricity industries in the GJAM Türkiye model are onshore wind and solar photovoltaics power plants. Both the structure of the old and the new industries correspond to inputs for the operation of the power plants, i.e. production of electricity and operation and maintenance of power plants. Investments into building or renovating these power plants are not included in this structure. For this split, we combine the following information.

First, the split of the electricity industry output is based on the share of wind and solar energy in total electricity generation in 2019, based on installed capacity and capacity factors for 2019[26]: 7.2% of output from the electricity industry was allocated to wind energy, and 3.1% to solar.

The inputs of goods and services to the production of wind and solar electricity, as well as share of total output that corresponds to value added as compensation of employees and other operation surplus are based on the report "*Costs of* *low-carbon generation technologies*"[24,25]. Table A5 below shows the distribution of inputs into the original *Electricity and gas* industry, and the new green technologies industries. Values shown in the table correspond to at least 1% of inputs to one of the industries; values under 1% for all industries are grouped into "*Other products*".

Table A5 Inputs distribution to original electricity and gas industry, and new green electricity industries Wind and Solar, detailed. Darker shades of blue correspond to higher share of inputs.

Products	Electricity and gas	Wind electricity	Solar electricity
Mining of energy products	21%	0%	0%
Chemicals and chemical products	0%	2.9%	7.9%
Other non-metallic mineral products	0%	0%	2.6%
Basic metals	0.1%	1.2%	0%
Fabricated metal products, except machinery and equipment	0.0%	11%	8%
Computer, electronic and optical products	0%	3.1%	11.9%
Electrical equipment	0%	11.4%	14%
Machinery and equipment n.e.c.	0%	7.2%	0.2%
Other transport equipment	0.0%	8.4%	0.0%
Electricity, gas, steam and air conditioning	48.0%	0.5%	0.4%
Constructions and construction works	0.2%	1.4%	7.5%
Wholesale trade services, except of motor vehicles and motorcycles	0%	3%	2%
Financial services, except insurance and pension funding	2%	2%	0%
Legal and accounting services; Services of head offices; management consulting services	0%	2.4%	1.1%
Architectural and engineering services; technical testing and analysis services	0%	1%	0.5%
Employment services	0.0%	2.0%	1%
Travel agency, tour operator and other reservation services and related services	0.0%	3%	2%
Security and investigation services; services to buildings and landscape; office administrative, office support and other business support services	0%	2.7%	1.2%
Other products (less than 1% of inputs)	2%	7.1%	5%
Value added	25%	30.2%	34.4%
Total output	**100%**	**100%**	**100%**

A.4. Labour and emissions extensions

A.4.1. Labour extensions

Labour extensions refer to the employment statistics from Labour Force Surveys (LFS), allocated to each industry in the SUT. For each industry, we have the amount of people employed per gender, skill level, and formality status. We also have data on distribution of the Syrian population under temporary protection in employment by industry, in the same indicators classification as the total employment in Türkiye. The labour extensions in GJAM Türkiye comprise of 32 indicators, detailed in Table A6.

For the split of labour indicators in the new green electricity industries, it was assumed to follow same number of persons employed per total VA (which includes compensation of employees and mixed income) in the *Electricity, gas, steam and air* *conditioning supply* original industry. The estimated employment in wind and solar photovoltaics electricity was then subtracted from the original Electricity industry. The structure of employment (gender, skill level, formality, share of employment from Syrian population under temporary protection) was assumed to be the same between all electricity industries, green and traditional.

Table A6 All indicators available in labour extensions of GJAM Türkiye, and the distribution of employment in 2019

Population	Gender	Skill level	Formality	Share
All Türkiye	Male	Low	Formal	5%
All Türkiye	Male	Medium	Formal	28%
All Türkiye	Male	High	Formal	5%
All Türkiye	Male	Professional	Formal	8%
All Türkiye	Male	Low	Informal	4%
All Türkiye	Male	Medium	Informal	17%
All Türkiye	Male	High	Informal	1%
All Türkiye	Male	Professional	Informal	1%
All Türkiye	Female	Low	Formal	2%
All Türkiye	Female	Medium	Formal	8%
All Türkiye	Female	High	Formal	2%
All Türkiye	Female	Professional	Formal	6%
All Türkiye	Female	Low	Informal	4%
All Türkiye	Female	Medium	Informal	10%
All Türkiye	Female	High	Informal	0.2%
All Türkiye	Female	Professional	Informal	0.2%

A.4.2. Greenhouse gas emissions extensions

The extensions for GHG emissions are based on the emission reporting following the IPCC guidelines[23]. The emission reporting follows four main activities: *1. Energy*; *2. Industrial processes and product use* (IPPU); *3. Agriculture, forestry, and other land use* (AFOLU); and *5. Waste management*.

The emissions in GJAM Türkiye are separated for the three main GHG emissions (CO_2, CH_4 and N_2O; other gases were not included), and they were categorised in energy- and non-energy emissions, that will be affected differently in the green electricity scenario. The emissions categories are shown in Table A7 and explained in detail below.

Table A7 Indicators for GHG emissions in GJAM Türkiye, in Gg CO_2-eq, and correspondence to emission inventory categories

	CO2				CH4				N2O			
	Energy	IPPU	AFOLU	Waste	Energy	IPPU	AFOLU	Waste	Energy	IPPU	AFOLU	Waste
Energy CO_2 emissions	X											
Energy CH_4 emissions					X							
Energy N_2O emissions									X			
Non-energy CO_2 emissions		X	X	X								
Non-energy CH_4 emissions						X	X	X				
Non-energy N_2O emissions										X	X	X

Energy emissions

Following the 2006 IPCC guidelines[23], emissions from energy are reported for the three gases, and divided by main energy activities and use of fuels. The categories in the Turkish GHG inventory data are:

Emissions from fuel combustion activities: includes all emissions from fuel combustion, and is split in:

- Energy industries: emissions that are directly allocated to the **energy transformation sector**, for production of electricity and fuels, and does not include the burning of these energy products. They are detailed in the following activities: public electricity and heat production, petroleum refining, and manufacture of solid fuels and other energy industries.
- Manufacturing industries and construction: emissions that happen due to the **use of energy products** in industries and construction activities. In the inventory they are detailed for the following industries: iron and steel; non-ferrous metals; chemicals; pulp, paper and print; food processing, beverages and tobacco; non-metallic minerals; and other non-specified industries.
- Transport: emissions from the use of fuels by civil aviation, road transportation, railways, water-borne navigation, and transport by pipelines.
- Other sectors: direct emissions by fuel combustion in agriculture (fuels used in agriculture machinery and off-road vehicles), commercial and institutional sectors, and residential emissions. Residential emissions include emissions from burning of fuel for heating and cooking, but not for passenger cars.

Fugitive emissions from fuels: emissions allocated to **mining of fossil fuels**. It includes fugitive emissions from solid fuels (coal mining, handling, storage, and transport), and extraction of oil and natural gas (including venting and flaring of oil and natural gas). Fugitive CO2 from pipeline transportation is not significant.

Table A8 details how emissions were allocated to the SUT industries. In the table, main categories for emissions are in grey, and detail under each category are in white. The sum of the detailed categories in white corresponds to the main categories. It is shown that 88.4% of the energy emissions had a direct corresponding industry, while 11.6% of the emissions were allocated between different industries based on the consumption of energy products in the economic SUT.

Table A8 Allocation of energy emissions from original activity reported in the national inventory to the industry classification in GJAM Türkiye

Activity in the inventory	Share in energy emissions	Allocation to SUT industries
Energy Industries	39.0%	
Electricity and Heat	36.5%	Electricity, gas, steam and air conditioning
Petroleum refining	1.8%	Coke and refined petroleum products
Manufacture of solid fuels and other energy industries	0.6%	Mining and quarrying
Manufacturing	14.3%	
Iron and steel	1.2%	Basic metals
Non-ferrous metals	0.2%	Basic metals
Chemicals	1.7%	Allocated between Chemicals and chemical products, Basic pharmaceutical products and pharmaceutical preparations, based on the use of energy products in the SUT
Pulp, paper and print	0.3%	Allocated between Paper and paper products, Printing and recording services, based on the use of energy products in the SUT
Food processing, beverages and tobacco	1.4%	Food, beverages and tobacco products
Non-metallic minerals	6.7%	Other non-metallic mineral products

Other industries	2.9%	Allocated to all other manufacturing and mining industries, based on the use of energy products in the SUT
Transport	26.1%	
Civil Aviation	4.6%	Air transport services
Road transport	20.1%	Land transport services and transport services via pipelines
Railways	0.1%	Land transport services and transport services via pipelines
Water-borne navigation	1.1%	Water transport services
Pipeline transport	0.2%	Land transport services and transport services via pipelines
Other Sectors	18,1%	
Commercial and public services	3.8%	Allocated to all service industries, except transport, based on the use of energy products in the SUT
Residential	11.4%	Allocated directly to households
Agriculture/Forestry/Fishing	2.8%	Allocated between Agric, Animal, Hunting, and related Services, Forestry and Logging, and Fishing and Aquaculture, based on the use of energy products in the SUT
Fugitive emissions	2.5%	
Solid fuels	1.8%	Mining and quarrying
Oil and natural gas	0.8%	Mining and quarrying

Non-energy emissions

Non-energy emissions correspond to the IPPU, AFOLU, and Waste management categories. They correspond, in total, to 26.2% of Turkish GHG emissions.

For estimating emissions extensions for new green electricity industries, we assume that they are proportional to the use of products responsible for direct emissions. For energy-related emissions, they correspond to the inputs of fossil energy products to the industry, here identified as Coke and refined petroleum products, and products from mining and quarrying (which includes coal and natural gas). That means that the direct emissions attributed to wind electricity and solar photovoltaics electricity are relative to the consumption of fossil fuels in the total electricity production. That consumption is, for example, in fuels for transport and operating machinery. There are no non-energy related GHG emissions allocated to new green electricity industries.