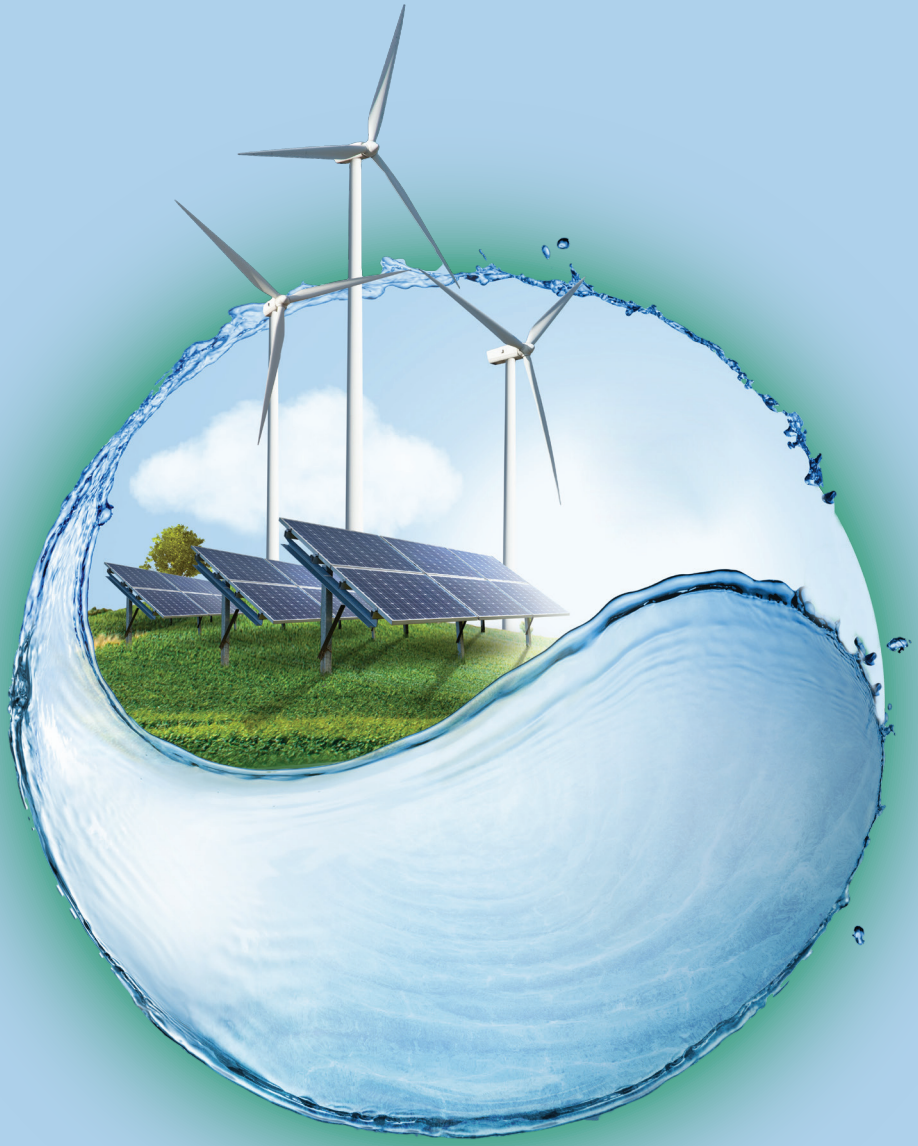
TÜRKİYE YENİLENEBİLİR ENERJİ GÖRÜNÜMÜ | 2022



Executive Summary & **Launch Slides**

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About IICEC

Sabancı University Istanbul International Center for Energy and Climate (IICEC) was established as a future-oriented, independent research and policy center to conduct objective and quality research on energy and climate issues.

IICEC contributes to a cleaner and more secure energy future with its national, regional, and global studies on the energy and climate agenda and within the success triangle model that supports government-industry-academia collaborations.

Being a part of one of the most distinguished universities in the region, IICEC carries out analytical studies with a strategic and holistic perspective on the Turkish energy sector while also encouraging the exchange and development of ideas by providing a unique platform that brings together key stakeholders in the fields of energy and climate. "Turkey Energy Outlook", published by IICEC as a first-of-its-kind study in Türkiye in 2020, supports an efficient, secure, competitive, technology-oriented, and sustainable future of the energy sector with solid recommendations.

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Executive Summary

Türkiye Renewable Energy Outlook Executive Summary

General Overview and IICEC Scenarios

Renewable energy, together with energy efficiency, is one of the most critical success factors if Türkiye is to meet its increasing energy demand and to create a secure and clean energy future for its energy system. Although the breakdown of resources has varied considerably over the past thirty years, the overall contribution of renewable energy to electricity generation has generally been between 35% and 45%. The direct contribution of renewable energy to the final energy demand was approximately 20% in 1990, most of which came from traditional biomass sources. This figure declined to 5% in 2021, as the growth in the use of direct modern renewable energy was outpaced by that of other fuels, primarily natural gas, in final energy demand. Renewable energy currently meets 12% of the final energy demand in Türkiye. The high potential of renewable energy resources, which has yet to be fully evaluated, can be rapidly harnessed through energy, climate and industrial policies, markets, investment, and environment and technological opportunities, and create multidimensional benefits.

The Türkiye Renewable Energy Outlook (TREO) is based on a detailed inventory of Türkiye's energy economy, the "Turkey Energy Outlook" that was published by IICEC as a first-of-its-kind study in Türkiye, and the IICEC Energy Model. This holistic modeling framework employs a database covering the entire energy supply and demand chain, reflects global and regional energy and climate dynamics; current trends in national energy, industry, and climate policies; developments in energy markets; and investments together with advancements in technologies. This report analyzes in details the growth and development perspective of all energy sectors regarding renewable-electricity generation and direct renewable energy use alongside the multidimensional avenues for Türkiye to reach its significant renewable energy potential.

This first-of-its-kind study in the sector was carried out with a scenario-based approach to assess growth perspectives in renewable energy through 2050. Two different TREO scenarios are showcased to assess the contribution of renewable energy to improving energy resource diversification and energy security, alleviating the country's energy import bill, achieving a clean energy transition and net-zero emission targets, improving air quality, enhancing overall system efficiency, and fostering sustainability with solid indicators and metrics.

The High (high adoption) Scenario benefits from supportive energy and climate policies and the development of energy markets and an investment environment to fuel growth in renewable energy. The potential of energy efficiency is effectively utilized in the electricity sector and the benefits from global technological developments in renewable energy and other clean energy technologies are highly captured in end user energy sectors. It is supported by concrete energy and climate targets and roadmaps encompassing a broad ecosystem including innovation and human resources in support of a renewable energy-driven future. This enables a higher utilization of Türkiye's unexploited renewable energy resource base compared to the current trends and provides critical contributions to energy security, energy-related macro-economic balances, clean energy transformation aspirations, and other sustainability benefits.

The Slow (slow adoption) Scenario, on the other hand, exhibits underwhelming progress in all respective areas, especially within the policy framework, and markets do not provide sufficient support for predictable growth in investments.

The renewable energy potential is partly utilized with a limited contribution to energy and environmental performance as compared to the high potential of Türkiye.

TREO Scenarios Summary

In the High Scenario, electricity demand develops on a more efficient growth pathway, with the contribution of factors such as insulation in buildings, efficiency in electrical appliances, efficient transformation in electric motors, development of self-consumption-oriented distributed generation in the industry, and the widespread use of distributed and efficient renewable energy solutions in agricultural irrigation. As a result of higher improvements in grid losses and efficiency gains in the entire electricity generation system, Türkiye realizes 15% lower gross electricity demand in 2050 compared to the Slow Scenario but provides electrical energy services with the same comfort and quality.

The share of renewable energy in installed capacity and power generation is 76% and 61%, respectively, in 2050 in the Slow Scenario, where there is no significant acceleration in the current growth momentum in renewable energy-based power investments. The installed capacity in the High Scenario, on the other hand, increases to 294 GW in 2050 while the share of renewable energy in installed power reaches 80% in 2040 and 90% in 2050, predominantly from solar and wind energy. The contribution of renewables in electricity generation increases to over 75% by 2040 and doubles from 43% at present to 87% in 2050. The combined share of solar and wind in gross electricity generation increases by more than four times to reach two-thirds of gross electricity generation by 2050. In the High Scenario, nearly the entire power generation portfolio becomes low-carbon in 2050, supporting the net-zero emission goal and creating significant advantages for the sustainable competitiveness of industries and the overall economy.

The High Scenario supports a more efficient and faster growth in renewable energy in the period until 2050 with an investment requirement of only 6% over the Low Scenario ($14.9 billion/year vs $14.1 billion/year in 2022 currency values). However, a significant shift takes place in the sectoral breakdown of investments: the share of power grids, energy storage, and demand-side efficiency investments, which stood below 30% in recent years and is around 30% in the Slow Scenario, increases to roughly 40% in the High Scenario. In the High Scenario, the average annual investment amount for renewable electricity generation in the period until 2050 is estimated as $5.5 billion.

The High Scenario delivers a significant pay-off in energy security, clean energy transformation, and associated costs. For example, compared to the Slow Scenario, Türkiye can realize an annual savings of $2 billion[1] in its energy-import bill despite an annual increase of $800 million in total investment, a fuel import-savings multiplier of 2.5. In the High Scenario, emissions from electricity generation peak before 2030 and fall 85% below their present level by 2050. At a carbon price level of $100/ton, emissions-related average cost savings of up to $6.7 billion/year can be achieved compared to the Slow Scenario, an emission cost-savings multiplier of 8.4. Towards 2050, annual emissions of important air pollutants such as sulfur dioxide and nitrogen-oxides decrease by one-third compared to 2022 in the Slow Scenario, while the High Scenario nearly eliminates these after 2040 to limited natural gas consumption.

[1] With the IEA Announced Pledges Scenario price series. 8.4 milyar $ with current commodity prices

The share of electricity in final energy demand increases from 20% to 40% by 2050 replacing fossil fuels in energy demand. Meanwhile, the direct contribution of renewable energy in final energy consumption increases from 5% to 15% in 2050, especially with the wider adoption of geothermal energy in buildings and agriculture, solar energy in industry and buildings, and sustainable biofuels in air transport. Thus, the total share of renewable energy in final energy demand rises from 12% at present to 22% in 2030, 35% in 2040, and 50% in 2050, representing a more than fourfold increase.

Renewable Energy Future in the Power Sector

GW	Absolute Value				
Electricity	**2021**	**2030 Slow**	**2030 High**	**2050 Slow**	**2050 High**
Peak Demand	**56.3**	**77.0**	**73.7**	**160.5**	**134.3**
Installed Capacity	**99.8**	**146.2**	**155.1**	**296.3**	**294.1**
Renewables	53.6	91.6	101.9	224.9	264.5
Hydro	31.5	35.6	36.1	41.5	42.0
Wind	10.6	22.0	25.9	65.9	80.2
Solar	7.8	28.4	32.2	105.7	128.9
Biomass	2.0	3.5	3.6	6.2	6.8
Geothermal	1.7	2.1	4.1	5.6	6.6
Nuclear	-	4.8	4.8	18.3	12.4
Coal	20.4	21.8	21.8	16.8	-
Natural Gas	25.6	28.0	26.5	36.4	17.2
Oil	0.3	-	0.1	-	-
Domestic	63.7	101.7	112.0	230.0	264.5
Imported fuel	36.1	44.4	43.0	66.3	29.6
Low carbon	53.6	96.4	106.7	243.2	276.9
Fossil fuels	46.2	49.8	48.4	53.2	17.2
Solar and Wind	18.4	50.4	58.1	171.6	209.1

TWh	Absolute Value				
Electricity	**2021**	**2030 Slow**	**2030 High**	**2050 Slow**	**2050 High**
Consumption	**331.7**	**451.7**	**432.5**	**878.1**	**747.6**
Generation	**334.7**	**451.7**	**432.5**	**878.1**	**747.6**
Renewables	119.9	219.5	257.0	539.5	647.8
Hydro	55.9	76.1	77.2	68.3	70.7
Wind	31.4	63.6	74.9	190.5	235.4
Solar	13.9	52.2	62.1	217.3	268.4
Biomass	7.8	13.8	14.2	24.4	26.8
Geothermal	10.8	13.8	28.7	38.9	46.5
Nuclear	-	33.6	33.6	128.2	86.9
Coal	103.4	114.4	76.2	88.1	-
Natural Gas	111.2	84.1	65.4	122.2	12.9
Oil	0.3	-	0.2	-	-
Domestic	168.3	272.8	292.5	566.5	647.8
Imported fuel	166.4	178.8	139.9	311.5	99.8
Low carbon	119.9	253.2	290.7	667.7	734.7
Fossil fuels	214.8	198.5	141.8	210.3	12.9
Solar and Wind	45.4	115.8	136.9	407.8	503.8

%	Pay				
Electricity Installed Capacity	**2021**	**2030 Slow**	**2030 High**	**2050 Slow**	**2050 High**
Renewables	54%	63%	66%	76%	90%
Hydro	32%	24%	23%	14%	14%
Wind	11%	15%	17%	22%	27%
Solar	8%	19%	21%	36%	44%
Biomass	2%	2%	2%	2%	2%
Geothermal	2%	1%	3%	2%	2%
Nuclear	0%	3%	3%	6%	4%
Coal	20%	15%	14%	6%	0%
Natural Gas	26%	19%	17%	12%	6%
Oil	0%	0%	0%	0%	0%
Domestic	64%	70%	72%	78%	90%
Imported fuel	36%	30%	28%	22%	10%
Low carbon	54%	66%	69%	82%	94%
Fossil fuels	46%	34%	31%	18%	6%
Solar and Wind	18%	34%	37%	58%	71%

%	Pay				
Electricity Generation	**2021**	**2030 Slow**	**2030 High**	**2050 Slow**	**2050 High**
Renewables	36%	49%	59%	61%	87%
Hydro	17%	17%	18%	8%	9%
Wind	9%	14%	17%	22%	31%
Solar	4%	12%	14%	25%	36%
Biomass	2%	3%	3%	3%	4%
Geothermal	3%	3%	7%	4%	6%
Nuclear	0%	7%	8%	15%	12%
Coal	31%	25%	18%	10%	0%
Natural Gas	33%	19%	15%	14%	2%
Oil	0%	0%	0%	0%	0%
Domestic	50%	60%	68%	65%	87%
Imported fuel	50%	40%	32%	35%	13%
Low carbon	36%	56%	67%	76%	98%
Fossil fuels	64%	44%	33%	24%	2%
Solar and Wind	14%	26%	32%	46%	67%

Renewable Energy Future in the Total Final Energy Consumption

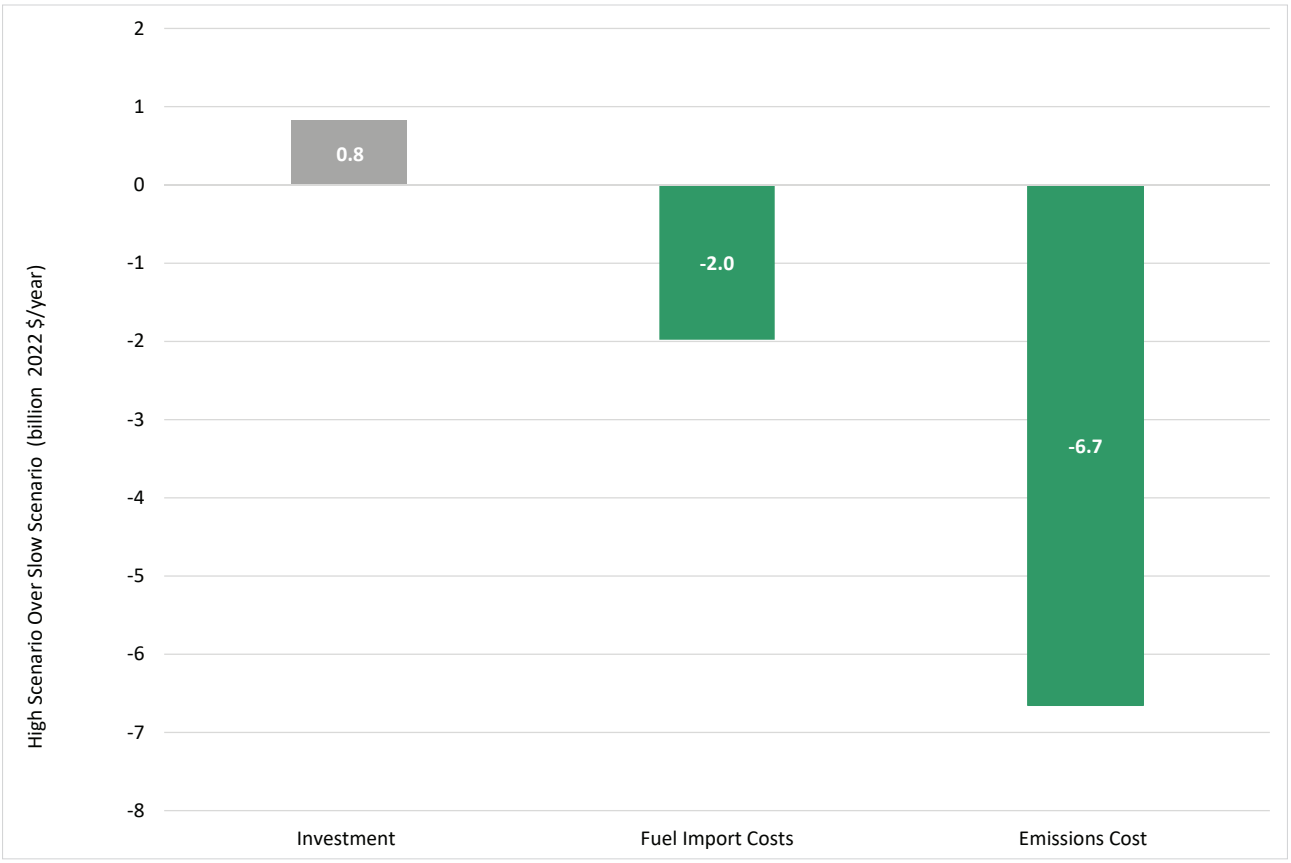
TWh	2021	2030 High	2050 High
Electricity Generation	**334.7**	**432.5**	**747.6**
Renewable	**119.9**	**257.0**	**647.8**
Hydro	55.9	77.2	70.7
Wind	31.4	74.9	235.4
Solar	13.9	62.1	268.4
Biomass	7.8	14.2	26.8
Geothermal	10.8	28.7	46.5

Electricity Generation (%)	2021	2030 High	2050 High
Renewables	**36%**	**59%**	**87%**
Hydro	17%	18%	9%
Wind	9%	17%	31%
Solar	4%	14%	36%
Biomass	2%	3%	4%
Geothermal	3%	7%	6%

Mtoe	2021	2030 High	2050 High
Final Energy Consumption	115.4	123.5	146.5
Electricity	24.4	31.7	58.1
Renewable Electricity	8.8	18.8	50.3
Direct Renewables	5.6	8.8	23.0
Total Renewables	**14.4**	**27.6**	**73. 3**

Final Energy Consumption (%)	2021	2030 High	2050 High
Electricity	21%	26%	40%
Renewable Electricity	8%	15%	34%
Direct Renewables	5%	7%	16%
Total Renewables	**12%**	**22%**	**50%**

Average Annual Change in the High Scenario Compared to the Slow Scenario



The Türkiye Renewable Energy Outlook is not a net-zero emissions study. However, a strong contribution from energy efficiency, clean electrification, and direct use of renewable energy can greatly reduce the high intensity of fossil fuels in the primary energy supply. These three areas can provide almost 60% of total final energy consumption by 2050, a development that lays the groundwork for the net-zero emission perspective with other clean energy actions that can be realized in many emerging technology areas such as clean hydrogen and carbon-capture-storage technologies. In addition to several tangible contributions to a secure and clean energy future, the High Scenario provides an important gateway to economic growth, social development, innovative industry, exports, and entrepreneurship models around clean energy technologies in harmony with global and regional trends and advancements. All these benefits can be realized with developments on several fronts such as policy targets and roadmaps, market development and investment environment, grids and a holistic power system, R&D and manufacturing competencies in critical technologies, and more efficient growth in energy-demand services supported by the public sector, private sector, and academia success triangle model.

IICEC Recommendations

IICEC recommends the following to harness the strong potential of Türkiye in renewable energy and related technologies and thus provide multiple benefits for energy security, a clean energy transition, and a more competitive and technology-driven development of the industry:

1. Developing roadmaps for resources, technologies, and sectors to achieve over 250 GW of total renewable energy installed capacity, with a more than 85% renewable energy contribution in power generation and a 50% renewable energy contribution in final energy demand by 2050,

2. Ensuring an efficient, cost-reflective, and more predictable electricity market and developing sustainable investment and financing models to enable strong growth in the project portfolio,

3. Strengthening the capacity and flexibility of the networks that form the backbone of the electricity system with technology-oriented investments supported by long-term dynamic planning,

4. Continuing efforts to develop wind and solar technologies in a way that supports the sustainability of supply chains and supports Türkiye becoming a regional clean energy technologies production base while also advancing developments in energy storage and green hydrogen-production technologies,

5. In addition to clean electrification, increasing the direct contribution of renewable energy at least threefold in buildings, industry, transport, and other energy-consuming sectors to support energy security and a clean energy transition,

6. Turning the growth in the renewable energy ecosystem into high value-added opportunities by utilizing energy efficiency potential and digitalization solutions across the value chain,

7. Developing qualified human resources and a talent pool together with an entrepreneurship ecosystem that supports strong, sustainable, and competitive growth in renewable energy.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RENEWABLE ENERGY
OUTLOOK | 2022
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RENEWABLE ENERGY OUTLOOK
IICEC energy outlook series support a more secure and cleaner energy future.
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TÜRKİYE
RENEWABLE ENERGY OUTLOOK

Türkiye Renewable Energy Outlook (TREO) supports realization of high potential with multiple benefits by presenting solid recommendations.

WHY TREO?

- Strong global growth in renewable energy.
- High renewable energy resource potential of Türkiye.
- Multi-fold opportunities to support a more secure and clean energy future.
- An independent, participatory and exemplary study.

HOW TREO?

- Turkey Energy Outlook & a holistic energy model by IICEC.
- A detailed inventory of Türkiye's electricity generation and final energy consuming sectors & scenario analyses.
- Global & regional orientations, relevant policy choices in Türkiye, impacts of market development and technological advancements.
- Independent research, quant analyses and perspectives.
- Stakeholder engagement built upon "Government-Industry-Academia" success triangle.

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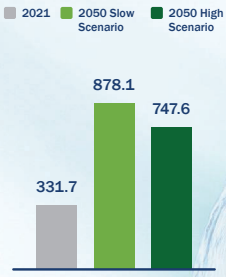
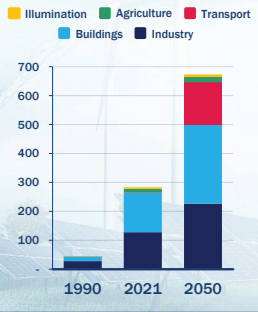
TÜRKİYE
RENEWABLE ENERGY OUTLOOK

Impacts of different growth and development pathways on energy balances and emissions inventory were assessed under two IICEC scenarios.

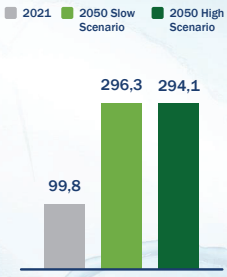
Gross Demand (TWh)



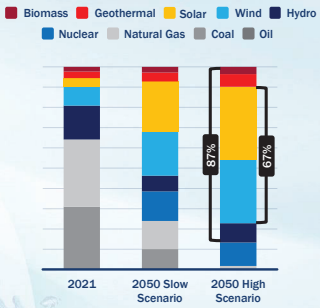
Net Demand in High Scenario (TWh)



Total Installed Capacity (GW)



Power Generation Mix (%)



The High Scenario meets the consumption at the same comfort and quality with 15% less demand and can cover around 90% of power generation by 2050 from renewables.

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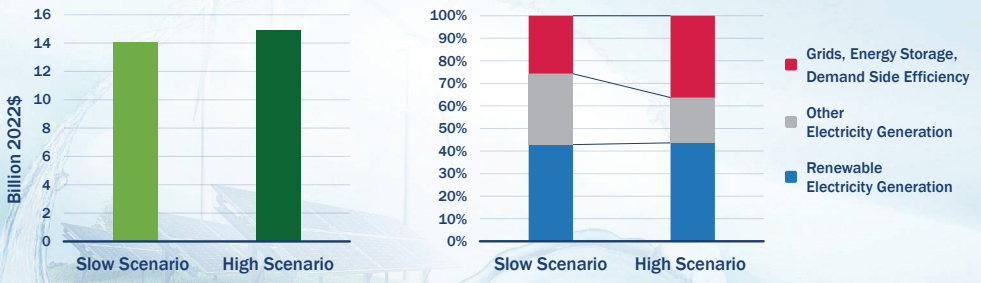
The High Scenario can realize higher renewable energy contribution with a limited increase in investments.

Annual Average Electricity Sector Investment & Breakdown (2022 - 2050, 2022 billion $, %)



Investment allocation to grids, energy storage and demand side efficiency is critical to support an efficient and renewable energy-driven growth.

Electricity sector emissions peak before 2030 in parallel to the reduction in fossil fuel use in the High Scenario.

Fossil Fuel Import Input to Electricity Sector (TWh)

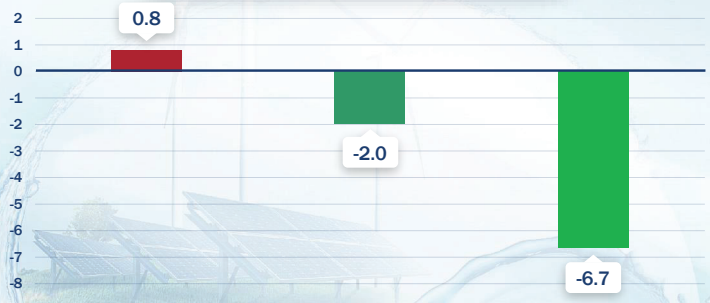
GHG Emissions from Electricity Sector ($MtCO_2e$)

GHG Emissions intensity in the Power Grid (gCO_2e/kWh)

This development supports a net-zero emissions perspective and a more secure and cleaner energy future while lowering the fossil fuel imports.

The High Scenario enables greater economic gains over limited additional investment compared to the Slow Scenario.

Differences Between Scenarios (Billion 2022 $/Year)

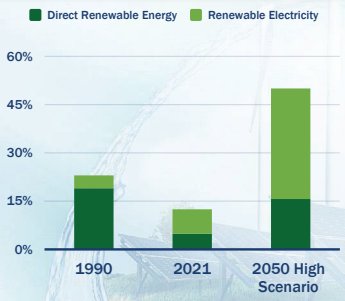


Savings / Investment multiplier is >10 in fossil fuel imports and emissions -elated spending.

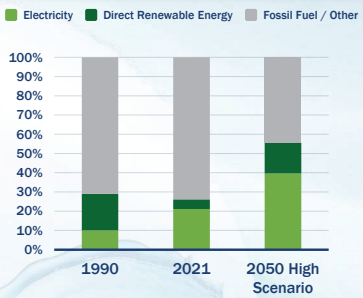
*With IEA APS fuel prices and at 100$/t carbon price.

Contribution of renewable energy to total final enegy consumption increases by more than 4 times in the High Scenario.

Renewable Energy Contribution in Total Final Energy



Breakdown of Total Final Energy Demand by Sources



Around 60% of final energy demand can become fossil-fuel free
by realizing opportunities in clean electrification, renewable energy and energy efficiency.

TREO presents critical development areas and opportunities to realize the high potential and multiple benefits.

- Policy Targets & Road Maps
- Energy Markets & Investments
- Electricity Networks
- Holistic Efficiency & Digitalization
- Clean Energy Technologies
- Final Energy Consumption
- Human Resources & Entrepreneurship

TÜRKİYE
RENEWABLE ENERGY OUTLOOK

Developing roadmaps for resources, technologies, and sectors to achieve over 250 GW of total renewable energy installed capacity, with a more than 85% renewable energy contribution in power generation and a 50% renewable energy contribution in final energy demand by 2050.

TÜRKİYE
RENEWABLE ENERGY OUTLOOK

7 IICEC
RECOMMENDATIONS

1 2 3 4 5 6 7

Ensuring an efficient, cost-reflective, and more predictable electricity market and developing sustainable investment and financing models to enable strong growth in the project portfolio.

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TÜRKİYE
RENEWABLE ENERGY OUTLOOK

7 IICEC
RECOMMENDATIONS

1 2 3 4 5 6 7

Strengthening the capacity and flexibility of the networks that form the backbone of the electricity system with technology-oriented investments supported by long-term dynamic planning.

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TÜRKİYE
RENEWABLE ENERGY OUTLOOK

7 IICEC RECOMMENDATIONS

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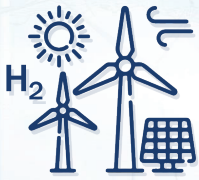

Continuing efforts to develop wind and solar technologies in a way that supports the sustainability of supply chains and supports Türkiye becoming a regional clean energy technologies production base while also advancing developments in energy storage and green hydrogen-production technologies.

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7 IICEC RECOMMENDATIONS

1 2 3 4 **5** 6 7

In addition to clean electrification, increasing the direct contribution of renewable energy at least threefold in buildings, industry, transport, and other energy-consuming sectors to support energy security and a clean energy transition.

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7 IICEC
RECOMMENDATIONS

1 2 3 4 5 **6** 7

Turning the growth in the renewable energy ecosystem
into high value-added opportunities by utilizing energy efficiency potential
and digitalization solutions across the value chain.

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TÜRKİYE
RENEWABLE ENERGY OUTLOOK

7 IICEC
RECOMMENDATIONS

1 2 3 4 5 6 **7**

Developing qualified human resources and a talent pool together
with an entrepreneurship ecosystem that supports strong, sustainable,
and competitive growth in renewable energy.

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RENEWABLE ENERGY OUTLOOK

7 IICEC RECOMMENDATIONS

1. Developing roadmaps for resources, technologies, and sectors to achieve over 250 GW of total renewable energy installed capacity, with a more than 85% renewable energy contribution in power generation and a 50% renewable energy contribution in final energy demand by 2050.
2. Ensuring an efficient, cost-reflective, and more predictable electricity market and developing sustainable investment and financing models to enable strong growth in the project portfolio.
3. Strengthening the capacity and flexibility of the networks that form the backbone of the electricity system with technology-oriented investments supported by long-term dynamic planning.
4. Continuing efforts to develop wind and solar technologies in a way that supports the sustainability of supply chains and supports Türkiye becoming a regional clean energy technologies production base while also advancing developments in energy storage and green hydrogen-production technologies.
5. In addition to clean electrification, increasing the direct contribution of renewable energy at least threefold in buildings, industry, transport, and other energy-consuming sectors to support energy security and a clean energy transition.
6. Turning the growth in the renewable energy ecosystem into high value-added opportunities by utilizing energy efficiency potential and digitalization solutions across the value chain.
7. Developing qualified human resources and a talent pool together with an entrepreneurship ecosystem that supports strong, sustainable, and competitive growth in renewable energy.

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THANK YOU

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TÜRKİYE YENİLENEBİLİR ENERJİ GÖRÜNÜMÜ | 2022

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