SHURA
ENERGY TRANSITION CENTER

RENEWABLE HYDROGEN IN TÜRKİYE'S DECARBONIZATION PATH: PRIORITY APPLICATION AREAS AND POLICY RECOMMENDATIONS

About SHURA Energy Transition Center

SHURA Energy Transition Center, founded by the European Climate Foundation (ECF), Agora Energiewende, and Istanbul Policy Center (IPC) at Sabancı University, contributes to the decarbonisation of the energy sector via an innovative energy transition platform. It caters to the need for a sustainable and broadly recognized platform for discussions on technological, economic, and policy aspects of Türkiye's energy sector. SHURA supports the debate on the transition to a low-carbon energy system through energy efficiency and renewable energy by using fact-based analysis and the best available data. Taking into account all relevant perspectives by a multitude of stakeholders, it contributes to an enhanced understanding of the economic potential, technical feasibility, and the relevant policy tools for this transition.

Authors: Hasan Aksoy, Rafet Yağız Çalışkan, Sena Serhadlıoğlu (SHURA), Emir Çolak (Agora Energiewende), Ahmet Can Kırlıoğlu (PhD candidate) and Büşra Çetiner (PhD candidate) contributed to the technology-related parts of the report under the leadership of Sabancı University Faculty of Engineering and Natural Sciences (FENS) Vice Dean Selmiye Alkan Gürsel.

Acknowledgments

We would like to thank SHURA Energy Transition Center Director Alkım Bağ Güllü for her valuable feedback during the preparation of the report. Barış Sanlı, Dr. Değer Saygın (OECD) and Prof. Dr. İskender Gökalp (ODTÜ) reviewed draft texts at various stages of the study and provided feedback. We are grateful for all the reviews, opinions and feedback provided.

SHURA Energy Transition Center is grateful to the generous funding provided by the BMWK.
This report can be downloaded from www.shura.org.tr

For further information or to provide feedback, please contact the SHURA team at info@shura.org.tr

Design

Tasarımhane Tanıtım Ltd. Şti.

ISBN 978-625-6956-61-2

Disclaimer

This report and the assumptions made within the scope of the study have been drafted based on different scenarios and market conditions as of end June 2024. Since these assumptions, scenarios, and the market conditions are subject to change, it is not warranted that the forecasts in this report will be the same as the actual figures. The institutions and the persons who have contributed to the preparation of this report cannot be held responsible for any commercial gains or losses that may arise from the divergence between the forecasts in the report and the actual values.

Sabancı Üniversitesi

RENEWABLE HYDROGEN IN TÜRKIYE'S DECARBONIZATION PATH: PRIORITY APPLICATION AREAS AND POLICY RECOMMENDATIONS

Executive Summary

A. Introduction

Türkiye became a party to the Paris Climate Agreement in November 2021 and subsequently committed to transition to a net-zero emissions economy by 2053. With this development, Türkiye has taken its place in the fight against global climate change and has begun developing new actions and policies in the axis of increasing renewable energy, energy efficiency, and electrification applications, which are considered to be the main components of the energy transition. In the context of the energy transition and in parallel with the decarbonization of the electricity sector, a radical transformation is also required in energy-intense end-use sectors (e.g. buildings, industry, and transportation). Direct electrification and energy efficiency applications come to the fore in the decarbonization of sectors that are heavily dependent on fossil fuels, especially industry, buildings, and transportation. However, with existing technologies, direct electrification offers limited application areas in long-distance transportation and for the industrial sector, where high process heat is needed. Therefore, new technologies such as renewable (green) hydrogen are needed to ensure the decarbonization of these sectors.

Considering current renewable hydrogen costs and sectoral usage areas, it is important to first deploy renewable hydrogen in the sectors expected to create the most added value in the short term. Therefore, prioritizing the sectors where hydrogen will provide maximum benefits and encouraging its use in these sectors can be adopted as a main strategy. Creating a renewable hydrogen ecosystem can be achieved by establishing a predictable market environment for investors. In this context, holistic energy transition policies that include renewable hydrogen will be needed. In line with this aim, various targets and strategies, including renewable hydrogen, have already been established by the public sector in Türkiye. Among these studies, the Turkish National Energy Plan (NEP) and the Turkish Hydrogen Technologies Strategy and Roadmap published by the Ministry of Energy and Natural Resources (ETKB) in January 2023 can be cited. The medium-term projections of the NEP target a total electrolyser capacity of 5 GW by 2035.[1] In the hydrogen road map, in addition to the quantitative targets regarding renewable hydrogen, Türkiye's long-term vision and the main policy recommendations to be implemented are also discussed.[2]

In addition to providing a substitute for fossil fuels in the transportation sector and industrial sectors which require high heat, hydrogen can also be used as a raw material in some sectors. Therefore, the use of renewable hydrogen in hard-to-abate sectors is considered to be an important strategy. Various policies and support mechanisms for the creation of a value chain for renewable hydrogen and its derivatives have been established in international markets. The Inflation Reduction Act (IRA), which came into force in the United States in 2022, and the "Hydrogen Bank" established in the European Union (EU) can be given as examples for such mechanisms. Along with the IRA, various tax breaks for investments in low-carbon hydrogen projects in the United States have been on the agenda. Significant cost reductions will be achieved with the designated tax breaks. These regulations may pave the way for the United States to provide renewable hydrogen production at a reasonable cost and become an important hydrogen exporter in the near future.

[1] ETKB, 2023. Türkiye National Energy Plan. https://enerji.gov.tr/duyuru-detay?id=20317
[2] ETKB, 2023. Türkiye Hydrogen Technologies Strategy and Roadmap.https://enerji.gov.tr/duyuru-detay?id=20316

The Hydrogen Bank established in the EU is a very important support mechanism for achieving the established hydrogen targets. The Hydrogen Bank aims to facilitate the establishment of a hydrogen market and trading system by bridging the gap between production costs and demand-side prices for hydrogen projects that have already reached investment decision stages. It aims to ensure the income stability of investments through tenders, in which renewable hydrogen producers will be rewarded with a fixed income per kilogram (kg) of hydrogen produced.[3]

It is assumed that the supports and incentives mentioned above will be an important point of leverage in the early stages of the renewable hydrogen market. Nevertheless, since the current production costs have not reached the desired levels, the realization of investments has slowed down. Additionally, financing costs, transportation and storage costs, and facility conversion costs are other obstacles that remain in place for renewable hydrogen development.

In light of all these developments, the most important issues to be addressed are related to the prioritisation of sectors and purposes for the use of renewable hydrogen initially in the course of energy transition. This study, prepared by the SHURA Energy Transition Center, examines the end-use areas of renewable hydrogen and its derivatives, which are expected to play an important role in the decarbonization of the Turkish economy, while focusing on identifying priority sectors for the use of renewable hydrogen and its derivatives in Türkiye. The sectoral benefits that renewable hydrogen and its derivatives could create in the Turkish economy until 2053 have been computed through cost-benefit analyses. Additionally, policy recommendations for leveraging the formation of a renewable hydrogen ecosystem and market were provided in the study.

B. Results and Discussion

Strategic Areas of Renewable Hydrogen Use in Türkiye

Although renewable (green) hydrogen is expected to play a significant role in the hard-to-abate sectors, applications for the production and use of renewable hydrogen are still in the development stage in many countries. Implementing policies that directly support hydrogen production and its use will accelerate the transition from fossil fuels to renewable hydrogen in some sectors and applications. Establishing a hydrogen market is also an important step for developing low-emissions hydrogen projects and for investments to become operational. In this context, the recommended steps are as follows:

- Preparation and implementation of an action plan that includes medium- and long-term hydrogen strategies on a sectoral basis for the establishment of the hydrogen market
- Preparation of the necessary legal regulations for the formation, scaling up, and acceleration of international trade and investments in the hydrogen market
- Creating a pipeline of hydrogen projects by ensuring demand-side security for low-emissions hydrogen, via the establishment of standards, quotas, and public procurement rules

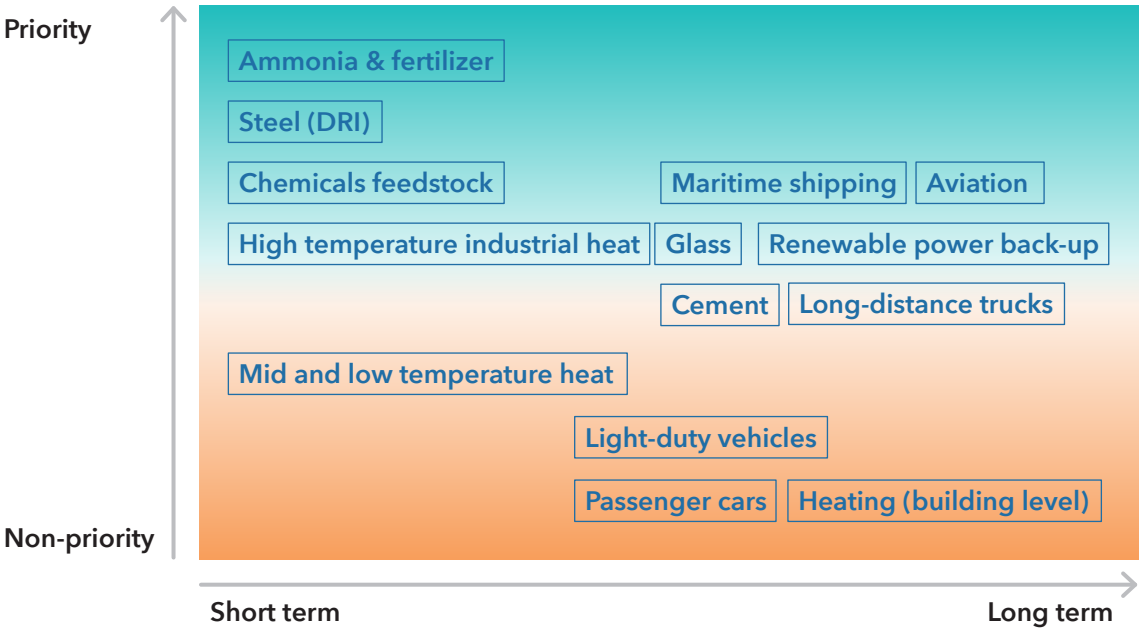
[3] European Commission, 2023. European Hydrogen Bank. https://energy.ec.europa.eu/topics/energy-systems-integration/hydrogen/european-hydrogen-bank_en

- Determining the practices and incentives to improve the cost competitiveness of renewable hydrogen in particular
- Establishing effective support mechanisms and subsidies considering the entire value chain (R&D, production, transportation, storage, etc.) including demand creation for scaling up low-emissions hydrogen
- Development of transportation and storage infrastructure for the efficient use of hydrogen

Considering the ongoing research and development processes related to renewable hydrogen technology and efficiency, it is anticipated that renewable hydrogen will be used in limited amounts in the short to medium term. Therefore, it is essential to prioritize the most efficient use of hydrogen for high value-added sectors and applications. However, renewable hydrogen should not compete directly with other decarbonisation technologies (e.g., heat pumps, electric vehicles, etc.). Renewable hydrogen should be complementary to direct electrification by supporting the efficient use of electricity generated from wind and solar.

As a result of the analyses and evaluations carried out within the scope of the report, the application areas where renewable hydrogen can be prioritized in Türkiye are summarized in Figure ES1. Initially, the use of renewable hydrogen in the production of green ammonia (fertilizer), iron and steel, chemical and petrochemical industrial products (including refineries) can be adopted due to their added value and their priority in the Turkish industry. In the medium to long term, hydrogen can be prioritized in the glass and ceramic sectors and long-distance transportation.

Figure ES1. Recommended priority areas for renewable hydrogen applications in Türkiye



In this context, the strategies that can be implemented in Türkiye can be evaluated within the following areas:

- Facilitating/prioritizing the transition to renewable hydrogen for sectors with experience in hydrogen production/consumption (e.g., refineries and fertilizers),
- Partnering on establishing globally implemented best practices and projects or initiating such projects in Türkiye,
- Using renewable hydrogen in scalable sectors (e.g., iron and steel), and
- Supporting renewable hydrogen as an alternative fuel by conducting sectoral cost analyses without affecting competitiveness.

Sectoral Assessment of Renewable Hydrogen Utilization in Türkiye

In this study, priority sectors for renewable hydrogen and its derivatives were identified through structural analyses of these sectors in Türkiye, supplemented by sectoral cost-benefit evaluations. Long-term fossil fuel costs[4] and carbon price projections [5], which were taken into account within the scope of cost-benefit analyses conducted on a sectoral basis, have been estimated via the use of International Energy Agency (IEA) forecasts. The carbon emissions coefficients[6] taken into account in the analysis were taken from Carbon Independent analyses. The levelized cost of hydrogen (LCOH) is based on the projections in the Turkish National Hydrogen Strategy published by the Ministry of Energy and Natural Resources (ETKB).[7]

The sectoral evaluations as well as the sectoral results of cost-benefit analyses, and emissions reductions via the use of renewable hydrogen in Türkiye are summarized below:

Iron and steel sector:
Türkiye has become the world's 8th largest steel producer and 9th biggest exporter in 2023, with a production of 33.7 million tons (Mt).[8] Unlike other countries, more than 70% of steel production is currently conducted via electric arc furnaces, which shows that Türkiye is in a better position compared to the world average (~35%) in terms of electrification in this sector. Iron and steel products are also covered under Phase 1 of the Carbon Border Adjustment Mechanism (CBAM). The iron and steel sector is one of the most important focus sectors in the context of both the need for structural transformation to increase added value in the manufacturing industry and the green transformation.

Currently, the technologies used in the production process use significant amounts of coal and natural gas. In this regard, renewable hydrogen can be used as a heat source, especially in integrated plants, and to reduce energy in converting iron ore into iron. However, in DRI-EAF

[4] Price projections based on fuels are given in parentheses for the years 2030, 2040, and 2050, respectively: Coal (USD 57/t, USD 45/t, USD 43/t), oil (USD 42/bbl, USD 30/bbl, USD 25/bbl), and natural gas (USD 4.3/MBtu, USD 4.2/MBtu, USD 4.1/MBtu) (IEA, 2024).
[5] The carbon price is assumed to be USD 90/tCO2 by 2030, USD 160/tCO2 by 2040, and USD 200/tCO2 by 2050 (IEA, 2024).
[6] It is assumed that there are 390 tCO2 carbon emissions per 1 GWh of energy produced using coal, 185 tCO2 per 1 GWh of energy produced using natural gas, and 1,080 tCO2 per 1 GWh of energy produced using oil.
[7] LCOE for renewable hydrogen is considered as USD 2.4/kg H_2 for 2030–2040 and 2040-2045 periods; USD 1.2/kg H_2 for the 2045–2055 period (ETKB, 2023).
[8] Steel Exporters Association, 2025. STATISTICS. https://www.cib.org.tr/tr/istatistikler

technology, which combines the use of direct reduced iron (DRI) technology with existing electric arc furnaces (EAF), renewable hydrogen can be used as an oxidizing agent in the natural gas shaft furnace, contributing to the decarbonization of the sector. In the analyses made for the iron and steel industry, it has been accepted that EAF technology will evolve into the H_2-DRI-EAF production process, and integrated facilities will be modernized to include DRI-EAF technology.[9]

According to the results of the cost-benefit analysis, the cumulative benefits of renewable hydrogen use in the sector is calculated as USD 9.5 billion between 2025 and 2053, and the projected emissions reduction is computed to be 85.8 Mt CO_2.

Cement, Glass and Ceramics sectors

The cement sector continues to be a competitive market in Türkiye in which many investors, both domestic and foreign, take part. With cement production reaching 81.5 Mt in 2023, an increase of 10.5% compared to the previous year, Türkiye is the fifth largest producer globally and the leading producer in Europe.[10]

In the cement sector, which is one of the sectors listed within the scope of CBAM, the carbon intensity of cement and cement clinker to be exported to EU countries must be reduced. In this direction, renewable hydrogen can be used as an alternative fuel in combustion reactions other than chemical reactions in the cement sector. Thus, it is possible to prevent emissions arising from the cement sector by 35%–40%. The main need in the sector is to produce low emission cement products. The use of biomass in the decarbonization of the cement sector is another important issue. The development of carbon capture, utilization, and storage (CCUS) technology may be an alternative way for the cement sector to achieve its decarbonization goal.

Türkiye is also among the top five countries in the world in glass production. Also, in 2023 Türkiye exported glass worth USD 1.6 billion. Approximately 78% of the total energy consumption of the Turkish glass industry consists of natural gas, which is used as high heat fuel source required in the production process.[11] In the glass sector, it is possible to use hydrogen as an alternative fuel in production processes that require high temperatures. However, in order to benefit from hydrogen in the glass production process, furnace technology and all combustion processes must be designed to be compatible with the properties of hydrogen flame.[12]

TSimilarly, the ceramic sector is another leading sector in Türkiye. The export volume of the Turkish ceramics industry has increased by 65% over the last five years, and the export amount in 2022 reached USD 1.9 billion.[13] Natural gas accounts for 62% of the final energy consumption of the

[9] The conversion costs of plants/factories are not taken into account. The substitution of fossil fuels with renewable hydrogen is analysed in the context of fuel cost, carbon cost, and LCOH.

[10] AA, 2024, Cement production increased by 10.5 percent in 2023, reaching 81.5 million tons. https://www.aa.com.tr/tr/ekonomi/cimento-uretimi-2023te-yuzde-10-5-artisla-81-5-milyon-tona-ulasti/3157113

[11] ETKB, 2023. EİGM Reports. https://enerji.gov.tr/eigm-raporlari

[12] Eurotherm, 2019. Hydrogen or Electrical Power for a Greener Glass Industry. https://www.eurotherm.com/glass-manufacture/hydrogen-or-electrical-power-for-a-greener-glass-industry/

[13] Cement, Glass, Ceramics and Soil Products Exporters' Association, 2022. Activity Report. https://ccst.org.tr/Uploads/arastirmaRaporlari_view/ccisb---2022-faaliyet-raporu---web.pdf

Turkish ceramic sector, and coal (hard coal and lignite) accounts for 18%.[14] Therefore, since a large portion of the emissions generated in the ceramics sector are fuel-related, it is technically possible to reduce emissions to a large extent thanks to the use of renewable hydrogen instead of fossil fuels. In addition, detailed technical feasibility studies[15] should be carried out in order for renewable hydrogen to be used as fuel in the ceramic production process.

It is estimated that a cumulative benefit of USD 50.3 billion and a carbon emissions reduction of 272.7 Mt can be achieved in the period from 2025 to 2053 by using renewable hydrogen as fuel to reach high heat in furnaces in the glass, ceramic and cement sectors.

Chemical, Petrochemical and Fertilizer sectors

The chemical sector mainly consists of facilities that produce various products such as petrochemicals, fertilizers, pharmaceuticals, etc. Approximately 70% of the raw materials used in the chemical sector are imported. On the other hand, exports amounted to USD 45.5 million in 2022.[16] Approximately 64% of the sector's total energy consumption consists of fossil fuels used as both raw materials and fuel.[17] In Türkiye, grey (fossil fuel-based) hydrogen is already used in some application areas in the petrochemical industry (mostly in refineries), in the chemical sector, and in ammonia production.

Renewable hydrogen can be used as both a raw material and a fuel alternative in many subsectors of the chemical sector. Therefore, the gradual transition of these sectors from grey hydrogen to renewable hydrogen will be easier. In the fertilizer sector, it is possible to reduce emissions by using renewable hydrogen instead of natural gas, especially in the production of ammonia (NH_3) by producing renewable ammonia.

In the cost-benefit analysis conducted for the chemical sector, it was computed that the use of renewable hydrogen would provide a cumulative benefit of approximately USD 3 billion and a CO_2 emissions reduction of 14.6 Mt in the 2025–2053 period. The petrochemical (including refineries) and fertilizer sectors were evaluated together in the analyses. The total benefit of the use of renewable hydrogen in the fertilizer and petrochemical sectors during the analysis period (2025–2053) is approximately USD 3 billion, with emission reductions of 17.4 Mt CO_2.

Transportation Sector

Within the scope of the transportation sector, long-distance transportation is of critical importance in Türkiye's international trade. According to the statistics published by the Turkish Ministry of Commerce and the Turkish Statistical Institute (TUİK), in 2023, 65.9% of exports (56% by sea, 9.9% by air) and 68.7% of imports (53.9% by sea, 14.8% by air) were transported via long-distance

[14] ETKB, 2023. EİGM Reports. https://enerji.gov.tr/eigm-raporlari

[15] A mixture of 20% hydrogen and 80% natural gas can be used in currently used tunnel furnaces. Since natural gas and hydrogen have different calorific values and densities, burners installed in existing facilities may not be sufficient for the use of renewable hydrogen. (Kamps ve diğerleri, 2021). If a mixture of natural gas and hydrogen is to be used in existing facilities, the hydrogen ratio must be analysed in advance. In addition, the pipeline and its fittings may need to be replaced during the transition from pure natural gas consumption to a mixture of natural gas and hydrogen. (Kamps et al., 2021).

[16] ETKB, 2023. EİGM Reports. https://enerji.gov.tr/eigm-raporlari

[17] ETKB, 2023. EİGM Reports. https://enerji.gov.tr/eigm-raporlari

transportation.[18] Therefore, the ports and airports located in Türkiye are of great importance in terms of the effectiveness of Türkiye's foreign trade

In the short term, direct electrification will be a priority strategy in transportation; in the medium term, it is expected that hydrogen and its derivatives will be used more widely in long-distance transportation. In particular, falling battery technology costs have become a very attractive solution for the electrification of passenger cars. In the medium to long term, renewable hydrogen and its derivatives may be an important strategy for decarbonization in maritime and air transportation.

As a result of the cost-benefit analysis conducted within the transportation sector, it has been computed that a cumulative benefit of USD 17.6 billion and a reduction of 207.6 Mt carbon emissions can be achieved through the use of renewable hydrogen and its derivatives in the period of 2025–2053.

Electricity sector

The electricity sector in Türkiye stands out due to its robust infrastructure and diversified energy supply. Expanding renewable energy capacity is crucial for decarbonizing the sector and ensuring supply security. However, integrating renewable sources with variable production patterns, such as solar and wind energy, necessitates increased grid flexibility.

As a storage technology, renewable hydrogen is not currently considered a priority for the electricity sector. In the short term, grid flexibility in Türkiye can be enhanced through solutions such as battery energy storage systems, strengthening interconnections, demand-side participation, and efficient use of hydropower. Nonetheless, in the long term, if the capacity of solar power plants reaches high levels, renewable hydrogen could be utilized for seasonal storage to enhance supply security and grid flexibility. Hydrogen can help address seasonal production imbalances—one of the sector's primary challenges—by ensuring consistent energy supply.

Analysis indicates that using renewable hydrogen in the electricity sector between 2025 and 2053 could yield economic benefits of USD 47 billion and reduce carbon emissions by 429 million tons.

Buildings

It is expected that heat pumps will replace natural gas boilers in building heating. The inefficiency of using hydrogen in building heating compared to heat pumps and the direct use of electricity supplied from renewable energy capacity in more strategic areas bring the use of heat pumps to the fore.

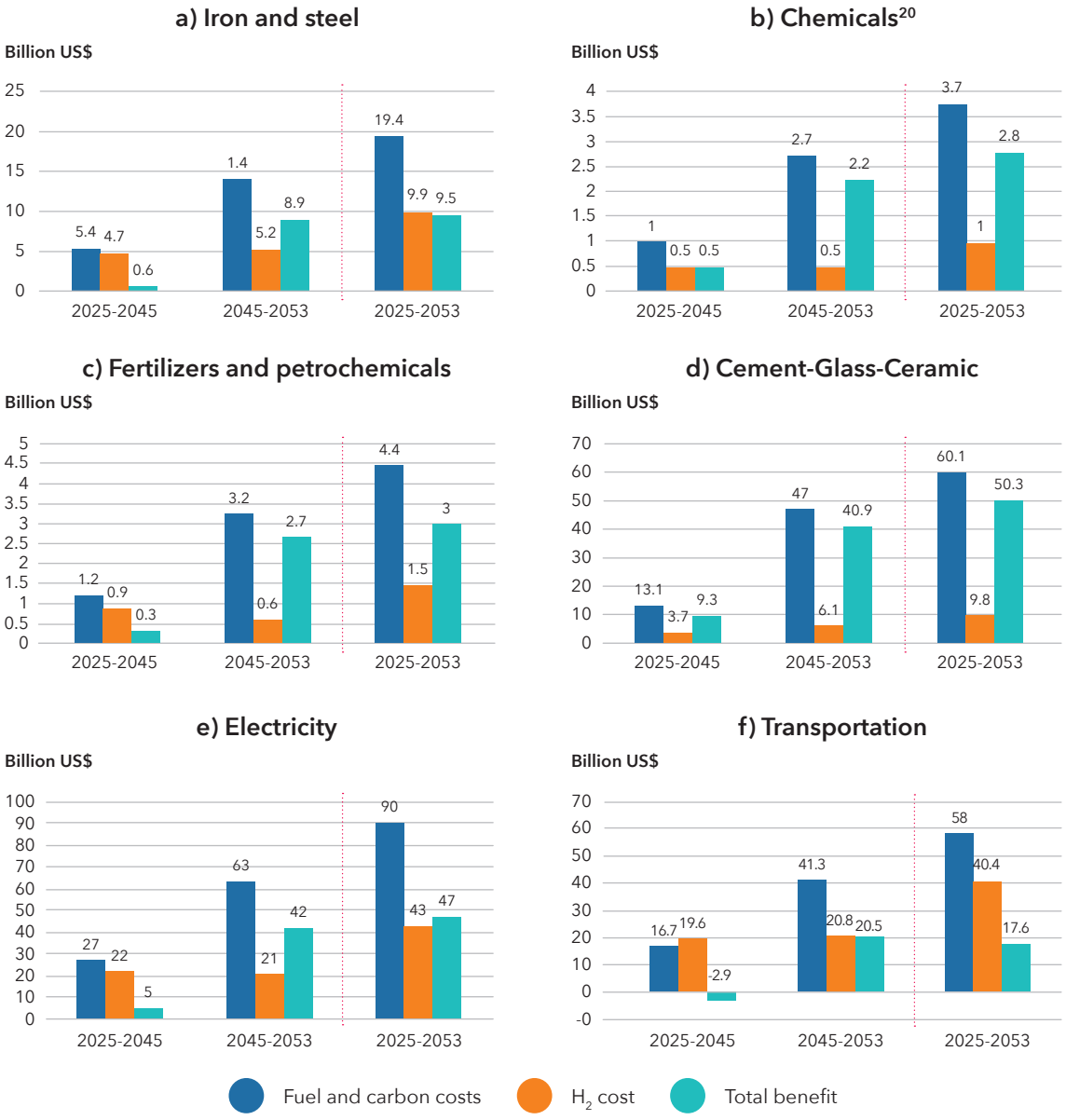
Cost-Benefit Projections of Renewable Hydrogen

Renewable hydrogen holds significant potential as an energy carrier and raw material for Türkiye, offering opportunities to advance decarbonization and reduce energy dependency. To fully understand its contribution, it is essential to conduct sectoral cost-benefit analyses using a holistic approach that considers economic growth and inter-sectoral dynamics.

[18] TÜİK, 2024. Foreign Trade Statistics, December 2023. https://data.tuik.gov.tr/Bulten/Index?p=Foreign-Trade-Statistics-December-2023

This report evaluates the cost-benefit projections[19] of renewable hydrogen based on the fundamental assumption that fossil fuels will be subject to carbon pricing in the near future, driven by mechanisms such as the Carbon Border Adjustment Mechanism (CBAM). In this context, the economic and environmental benefits of renewable hydrogen are closely tied to the effectiveness of existing and future energy policies.

Figure ES2. Cumulative costs and benefits of the use of renewable hydrogen and its derivatives on a sectoral basis in certain periods.



[19] In the conducted cost-benefit analysis, the sectoral growth of each relevant sector until 2053 was modelled by taking into account the SHURA net-zero 2053 (NZ2053) scenario assumptions. In the cost-benefit analyses, the sectoral need for imported fossil fuels are computed in line with the total energy content of renewable hydrogen and its derivatives would provide in those sectors. Additionally, carbon emission costs and imported fuel costs were considered according to the anticipated fuel type and amount. For example, calculations were made assuming that imported coal and natural gas would be used mostly in the iron and steel sector, whereas imported coal would be used mostly in the electricity sector.

[20] Calculated excluding the Fertilizer and Petrochemical sectors.

Holistic Strategies and Policy Recommendations for the Development of Renewable Hydrogen in Türkiye

Sector-based analyses have identified priority sectors for renewable hydrogen deployment in Türkiye, highlighting opportunities across various industries. **In the short term, sectors such as fertilizers, iron and steel, and chemicals—including petrochemicals and refineries—emerge as key areas for renewable hydrogen application. In the medium and long term, industries such as long-distance transportation, glass, and ceramics are also being evaluated as promising candidates for renewable hydrogen integration.** From the market point of view, inducing the industrial demand would in turn increase the hydrogen production levels, which would also reduce the hydrogen production costs due to economies of scale. Technological developments (e.g., the reduction in the levelized cost of electricity of renewable energy sources and electrolyser costs) as well as financial incentives will be useful in reducing costs. For example, since the aviation sector needs high-density molecules such as synthetic kerosene, the direct electrification in this sector is quite limited considering the existing available technologies. Currently, renewable hydrogen and its derivatives are costlier compared to fossil fuels such as jet fuel. Due to the price gap between renewable hydrogen and fossil fuels, it is required to reduce the costs associated to hydrogen and its derivatives.

Another important consideration is preventing competition between renewable hydrogen production and the transformation of the electricity sector. The steadily increasing share of renewable energy sources in electricity production plays an important role in reducing external dependence on energy and fossil fuel consumption. To this end, installing new renewable energy power plants, rather than relying on existing ones, could make the transition more effective. Therefore, it is important to plan the use of renewable energy power plants allocated for renewable hydrogen production and to establish the necessary legislation by taking into account the principle of additionality.

Significant infrastructure development is needed for the renewable hydrogen ecosystem. It is necessary to implement policies and support mechanisms to prepare the necessary infrastructure in sectors where hydrogen use will be prioritized. Hydrogen-related policies should not only focus on production but should be holistically evaluated to address the transportation, storage, and use of hydrogen at end-use points.

It is recommended that the cost differences between renewable hydrogen production and applications in priority sectors (such as industry) should be taken into account, and the development of the renewable hydrogen market should be supported accordingly in this direction. In order to support the development of the hydrogen economy and have an internationally competitive industry, it will be important to maximize the use of renewable energy in the first place.

Maximizing the use of renewable energy is critical to fostering a sustainable hydrogen ecosystem and strengthening Türkiye's industrial competitiveness. Prioritizing renewable energy potential will not only support the hydrogen economy but also enhance its contribution to the national economy and Türkiye's international standing.

The main findings of the report are summarized below:

The use of renewable hydrogen and its derivatives (green ammonia, synthetic kerosene, etc.) should be prioritized in sectors where they offer the highest benefits and where direct electrification alone is insufficient for decarbonization: The priority areas for renewable hydrogen use in Türkiye are ammonia (fertilizer), iron and steel, chemicals (including refineries and petrochemicals), glass-ceramics, and long-distance transportation (airline, maritime, etc.).

It is proposed to stimulate demand for renewable hydrogen and its derivatives by establishing specific targets in sectors where direct electrification is not sufficient to transition to a net-zero carbon economy: By determining sector-specific quotas, demand for renewable hydrogen can be created. The integration of renewable hydrogen use in the industry can be accelerated with the help of facilitating investments. In this context, the fertilizer sector and refineries that currently use grey hydrogen, as well as the iron and steel sectors, may be required to purchase a mandatory amount of renewable hydrogen.

Providing financial incentives for renewable hydrogen production to stimulate domestic supply is proposed: Tax exemptions and other financial incentives can be used to increase renewable hydrogen production, especially in the early years when costs are higher compared to fossil fuel alternatives. For example, Feed-in Tariff (FIT) for a limited volume of hydrogen can be implemented to help determine the initial price of hydrogen. In addition, hydrogen auctions (similar to renewable energy resource area -YEKA) can be utilized in the refinery and iron and steel sectors. An example of this is the competitive tender process conducted by the European Commission's European Hydrogen Bank.

In planning the renewable energy sources to be used in renewable hydrogen production, it is recommended that regulations and policies are created within a holistic framework, taking into account the additionality principle: In the renewable hydrogen production process, instead of utilizing renewable energy plants that are already producing electricity, it is important to establish new renewable energy plants. Thus, hydrogen production will not compete with the decarbonization of the electrical system and the increase of direct electrification. Additionally, in order to prevent renewable energy curtailments, the excess amount of renewable generation can be utilised to produce hydrogen via electrolysers.

By encouraging energy transition in the transportation sector, the creation of a renewable hydrogen ecosystem can be achieved: Initiatives can be taken to promote the production and use of renewable hydrogen derivatives (such as synthetic kerosene, e-ammonia, and e-methanol) to reduce emissions, especially in the maritime transport and aviation sectors. A road map can also be determined for domestic shipyards that have experience in innovative ship design and construction. In this context, the development of new hybrid ships using LNG and hydrogen derivatives (e-ammonia, e-methanol) can be targeted.

In terms of the production, transportation, distribution, and use of hydrogen, it is important to improve airport and port infrastructures: In addition to tax incentives for the creation of a hydrogen ecosystem, airport and port infrastructure will need to be developed, which will have a major role in the use and transportation of renewable hydrogen. In addition to providing direct

financial support to support all relevant construction, regulations defining tax breaks or the identification of subsidies for infrastructure investments will help ensure that these investments are completed on time.

To establish a public unit in which administrative decertification processes and support mechanisms related to renewable hydrogen are determined, coordinating inter-sectoral production and development plans is proposed: Primary and secondary legislation related to the creation of a public unit specifically focusing on hydrogen production can be prepared. A roadmap for investors, hydrogen production facility areas and related technical principles, and solutions for financing can be created.

Mixed financing within the scope of public-private partnerships for the commercial dissemination of renewable hydrogen technologies can be considered: Currently, various international institutions and organizations are involved in different levels of hydrogen project financing. In this context, hydrogen funds, which will be provided with mixed financing opportunities to be created within the scope of public-private sector business associations, can be used to support projects that achieve financial closure. In addition, it will be important to accelerate development through establishing partnerships with foreign companies.

Regulating the industrial technical and safety standards related to renewable hydrogen within a legal framework is required: For the safe use of renewable hydrogen, it is necessary to determine the responsibilities in the production, storage, transportation, and consumption processes of hydrogen. Thus, in the case of exporting hydrogen, the application of the same standards in all relevant countries can also be ensured. This will also help Türkiye export renewable hydrogen in the future.

Establishing technical standards for the production and storage of renewable hydrogen in the electricity sector is recommended: It is necessary to establish standards and legal regulations that will ensure the safe use of renewable hydrogen in the electricity sector. It is proposed to ensure the continuity of R&D projects for infrastructure improvements aimed at using a gas mixture consisting of natural gas, renewable hydrogen, and other renewable hydrogen derivatives, specifically for the natural gas network.

Creating an export strategy for renewable hydrogen production surplus is proposed: In order for Türkiye to play an important role in the international renewable hydrogen market, it is of importance to create a market environment in which the amount and price of hydrogen available for export are identified. There is a need to employ holistic strategies to ensure that pricing takes into account hydrogen production costs.

It is proposed to support R&D activities for the domestic development of electrolyser technologies: Defining the financial incentives and supports for the local development and production of electrolyser technology will be an important step in developing green hydrogen production considering its high initial investment costs. Sectoral knowledge and human resources trainings are among the other important factors that should be prioritized. Finally, it is recommended that Türkiye's strengths in hydrogen ecosystem technologies, particularly in transportation, storage, and end-use, be identified and that strategies and support mechanisms be developed accordingly.

About Istanbul Policy Center at Sabancı University

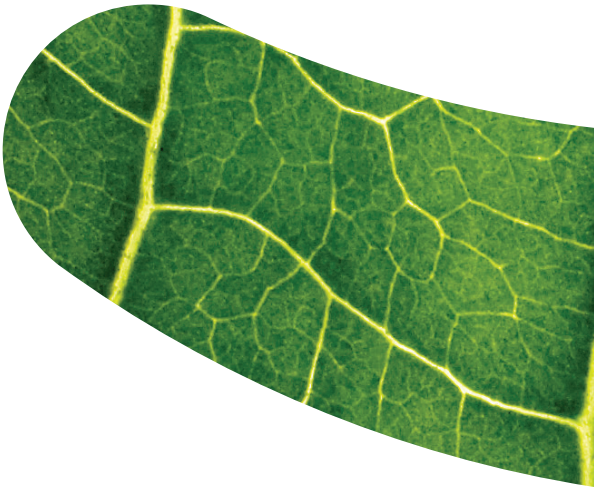
Istanbul Policy Center (IPC) is a global policy research institution that specializes in key social and political issues ranging from democratization to climate change, transatlantic relations to conflict resolution and mediation. IPC organizes and conducts its research under three main clusters: The Istanbul Policy Center–Sabancı University–Stiftung Mercator Initiative, Democratization and Institutional Reform, and Conflict Resolution and Mediation. Since 2001, IPC has provided decision makers, opinion leaders, and other major stakeholders with objective analyses and innovative policy recommendations.

About European Climate Foundation

The European Climate Foundation (ECF) was established as a major philanthropic initiative to help Europe foster the development of a low-carbon society and play an even stronger international leadership role to mitigate climate change. The ECF seeks to address the "how" of the low-carbon transition in a non-ideological manner. In collaboration with its partners, the ECF contributes to the debate by highlighting key path dependencies and the implications of different options in this transition.

About Agora Energiewende

Agora Energiewende develops evidence-based and politically viable strategies for ensuring the success of the clean energy transition in Germany, Europe and the rest of the world. As a think tank and policy laboratory, Agora aims to share knowledge with stakeholders in the worlds of politics, business and academia while enabling a productive exchange of ideas. As a non-profit foundation primarily financed through philanthropic donations, Agora is not beholden to narrow corporate or political interests, but rather to its commitment to confronting climate change.



SHURA
ENERGY TRANSITION CENTER

Bankalar Caddesi, No:2, Minerva Han,
Kat:3, 34420 Karaköy, İstanbul/Türkiye
T: +90 (212) 292 49 39
E-mail: info@shura.org.tr
www.shura.org.tr

SHURA is founded by

İPM | IPC İSTANBUL POLİTİKALAR MERKEZİ
SABANCI ÜNİVERSİTESİ KAMPÜSÜ
İSTANBUL POLICY CENTER
AT SABANCI UNIVERSITY

European Climate Foundation

Agora Energiewende