SHURA
ENERGY TRANSITION CENTER

ENABLING RENEWABLE HYDROGEN IN TÜRKİYE

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 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 (SHURA).

Acknowledgements

We would like to thank Burak Baykal (TTGV), Can Erkey (Koç University), Cansu Atılgan (GMKA), Çağatay Ölken (TÜPRAŞ), Dursun Baş (Sabancı University, İstanbul Politikalar Merkezi), Eren Yiğit (AKFEN), Fatih Kuşçu (H2DER), Hilal Gümüşlü (TENMAK), Hüseyin Devrim (TEK-SİS), İskender Gökalp (ODTÜ), Pauline Seyfert (Adlera Group), Selmiye Alkan Gürsel (Sabancı University), Tuğba Onur Dalgöğüsoğlu (TEK-SİS) for their valuable contributions by attending the stakeholder participation meetings during the course of the study.

We are grateful to Alkım Bağ Güllü (SHURA Energy Transition, Director), Dr. Sena Serhadlıoğlu (SHURA Energy Transition Center, Senior Energy Analyst), and Emir Çolak (Agora Energiewende, Project Officer Hydrogen) for their valuable contributions and feedback during the development of this report.

SHURA Energy Transition Center is grateful for the generous funding provided by the ECF.

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 978-625-6956-95-7

Disclaimer

This report and the assumptions made within the scope of the study have been drafted based on different scenarios and market conditions as the end of 2025. 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.

ENABLING RENEWABLE HYDROGEN IN TÜRKİYE

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

°C	Degree Celsius
BF	Blast furnace
BOF	Basic oxygen furnace
CBAM	Carbon Border Adjustment Mechanism
COP27	27th Conference of Parties
COP28	28th Conference of Parties
DRI	Direct reduced iron
EAF	Electric arc furnace
ECE	Economic Commission for Europe
EPDK	Republic of Türkiye Energy Market Regulatory Authority (EPDK T.C. Enerji Piyasası Düzenleme Kurumu)
ENTSO-E	European Network of Transmission System Operators
EPİAŞ	Energy Exchange Istanbul (Enerji Piyasaları İşletme A.Ş.)
EU	European Union
FiT	Feed-in Tariff
GAZBİR	The Association of Natural Gas Distributors of Türkiye (Türkiye Doğal Gaz Dağıtıcıları Birliği)
GAZMER	Natural Gas Professions Examination and Certification Centre (Doğal Gaz Enerji Eğitim Belgelendirme ve Denetim Merkezi)
GW	Gigawatt
H_2	Hydrogen
H-GO	Hydrogen Guarantees of Origin
IEA	International Energy Agency
ISO	International Organization for Standardization
Kg	Kilogram
LNG	Liquefied Natural Gas
ETKB	Republic of Türkiye Ministry of Energy and Natural Resources (ETKB T.C. Enerji ve Tabii Kaynaklar Bakanlığı)
Mt	Million Tons
OSB	Organized Industrial Zone (Organize Sanayi Bölgesi)
PEM	Proton Exchange Membrane
R&D	Research and Development
SBB	Republic of Türkiye Presidency of Strategy and Budget (T.C. Strateji ve Bütçe Başkanlığı)
TENMAK	Turkish Energy, Nuclear and Mineral Research Agency (Türkiye Enerji, Nükleer ve Maden Araştırma Kurumu)
TOGG	Türkiye's Automobile Joint Venture Group (Türkiye'nin Otomobil Girişim Grubu)
TS	Turkish Standards
TÜBİTAK	Scientific and Technological Research Council of Türkiye
TÜİK	Turkish Statistical Institute (Türkiye İstatistik Kurumu)
TWh	Terawatt-hour
UHS	Underground Hydrogen Storage
UN	United Nations
US$	United States Dollar

Key Messages

- **A comprehensive regulatory framework should be built on the additionality principle.**
  It is important to establish a holistic regulatory framework based on the principle of additionality in renewable hydrogen production. This approach plays a critical role in preventing hydrogen production from competing with the transformation of the power sector. In this context, rather than utilizing existing renewable power plants, it is essential to prioritize the realization of new renewable energy investments dedicated specifically to renewable hydrogen production. With this way, it will be possible to prevent potential competition with the decarbonization of the power system and direct electrification targets.

- **The use of hydrogen should be prioritized for sectors where direct electrification falls short and high added value is created.**
  In line with SHURA's (2025) analyses, the use of renewable hydrogen in green ammonia (fertilizers), iron-steel, chemicals, and petrochemicals (including refineries) sectors should be prioritized in the short and medium term. Glass and ceramics sectors, as well as long-distance transportation applications, will become increasingly significant over the medium and long term. Such strategic prioritization will support the scaling up of renewable hydrogen, leading to reduced costs, accelerated technological learning, and paving the way for its expansion into broader sectors.

- **Demand for renewable hydrogen should be created through policy mechanisms.**
  For the renewable hydrogen market to develop, sectoral regulations that will create demand for priority sectors using hydrogen as fuel or feedstock must be implemented. In this context, the policy mechanisms to be developed will accelerate the adoption of renewable hydrogen in the roadmaps of sectors particularly affected by the Carbon Border Adjustment Mechanism (CBAM).

- **A clear, binding, and predictable legal framework for renewable hydrogen must be established.**
  For the renewable hydrogen market to develop in a healthy and transparent manner under market conditions, it must be granted a clear and binding definition within the legal framework. By clarifying the scope of renewable hydrogen, emission standards, and certification principles, this definition will reduce legal uncertainties for investors and support long-term investment decisions. Furthermore, it will establish a strong and consistent legal foundation for the incentive mechanisms and market regulations to be developed in later stages. In this regard, it is recommended to establish a public entity that will define administrative permitting processes and related support mechanisms for renewable hydrogen, while coordinating cross-sectoral production and development plans.

Introduction

The global energy transition is vital for reaching the Paris Agreement's goal of limiting the average global temperature increase to two degrees Celsius (°C) above pre-industrial levels. Carbon dioxide (CO_2) emissions originating from the energy sector account for approximately two-thirds of global greenhouse gas emissions. Therefore, the energy sector plays a critical role in achieving global climate targets. Countries that signed the Paris Agreement are developing comprehensive transformation strategies centred on renewable energy, energy efficiency, electrification, and new technologies in order to transition toward net-zero emissions economies.

Türkiye has also taken significant steps to align with this global transformation process. In July 2021, Türkiye published the European Green Deal Action Plan, and in October 2021, it ratified the Paris Agreement, committing to achieve net-zero emissions by 2053. Following these developments, Türkiye entered a process of restructuring its climate and energy policies within the framework of its energy transition.

In the transition toward a net-zero emissions economy, the three core pillars of the energy transition—renewable energy sources, electrification, and energy efficiency—are placed at the centre of short- and medium-term targets set out in policy documents. However, in areas in which high process heat is required for industrial processes and long-distance transportation, direct electrification does not provide a sufficient solution due to existing technological constraints. The decarbonization of these sectors requires alternative, complementary technologies such as renewable (green) hydrogen.

Renewable hydrogen can serve as a substitute for fossil fuels in industrial applications requiring high process heat and in specific sub-segments of the transport sector. In addition, it can be used as a raw material in certain industrial sub-sectors. In this context, prioritizing renewable hydrogen in sectors and applications defined as hard-to-abate sectors is of critical importance both for cost-effectiveness and for maximizing emissions reductions. This approach positions renewable hydrogen as a strategic instrument in the energy transition.

Türkiye holds significant advantages in the production and utilization of renewable hydrogen thanks to the country's substantial renewable energy potential and strategic geographical location. To realize this potential, it is essential to develop implementable action plans aligned with the targets set out in policy documents and roadmaps. In this regard, establishing an institutional structure responsible for renewable hydrogen, creating a comprehensive regulatory framework, developing appropriate support mechanisms, gradually building a market structure, identifying priority sectors that will generate hydrogen demand, and planning and implementing the necessary infrastructure are all required.

During the early stages of renewable hydrogen market development, incentives and support mechanisms are expected to play a critical role. Currently, production costs remain above competitive levels, resulting in delayed investment decisions and slower market development. Moreover, high financing costs, expenditures related to transportation and storage infrastructure, and the costs associated with converting existing facilities constitute significant structural barriers to the widespread deployment of renewable hydrogen.

At the same time, renewable hydrogen production must be planned in a way that does not conflict with the transformation objectives of the power sector. In Türkiye, increasing the share of renewable energy sources in power generation plays a decisive role in reducing fossil fuel consumption and dependency on energy imports. Therefore, renewable hydrogen production should not be based on diverting or substituting existing renewable electricity capacity but on additional renewable energy investments commissioned exclusively for hydrogen production. This approach is defined in the literature as the 'principle of additionality', ensuring that hydrogen supports the decarbonization of the power sector rather than hindering it. Prioritizing the principle of additionality in regulatory design and planning processes is a prerequisite for positioning hydrogen as a genuine and measurable emissions reduction tool. At the same time, this framework prevents renewable hydrogen from being directed toward widespread and fragmented end uses at an early stage, thereby enabling limited renewable resources to be utilized in a strategic and cost-effective manner.

Following the use of renewable hydrogen in priority sectors where it can deliver maximum benefits, planning for the export of potential production surpluses to neighbouring countries should be carried out in alignment with international standards. Such planning must adopt a holistic perspective, encompassing production technologies, the hydrogen value chain, transportation methods, and the necessary port, pipeline, and broader logistics infrastructure requirements. This approach would contribute to positioning Türkiye as a competitive and strategic actor in the emerging renewable hydrogen market in Europe.

Today, however, a significant share of renewable hydrogen projects worldwide is falling behind planned timelines or being postponed. The expected capacity of hydrogen production, which is based on projects planned to be operational by 2030, has declined from 49 million tons (Mt) to 37 Mt over the past year due to cancellations and delays. More than 80% of this decline is attributed to projects involving renewable hydrogen production and electrolyser technologies across Africa, the Americas, Europe, and Australia (IEA, 2025). Insufficient infrastructure, the absence of comprehensive regulatory frameworks, technological immaturity, and high production costs are among the primary causes of these delays. Furthermore, the limited scope of market mechanisms such as carbon pricing and support mechanisms makes it difficult for renewable hydrogen demand to materialize in the short term.

In this context, it will be critical for Türkiye to closely monitor global developments in hydrogen-related policies, market structures, and technologies, and to regularly update its hydrogen roadmap in order to build a sound, sustainable, and competitive hydrogen ecosystem.

SHURA has published three studies on hydrogen to date. The first study, *Priority Areas for a National Hydrogen Strategy for Turkey,* published in February 2021, identified the strategic priorities required to unlock Türkiye's renewable hydrogen potential. The second study, *Techno-Economic Study of Turkey's Production and Export Potential for Green Hydrogen,* published in December 2021, examined the domestic use and export potential of renewable hydrogen with a view toward 2050 The third study, *Renewable Hydrogen in Türkiye's Decarbonization Path: Priority Application Areas and Policy Recommendations,* published in February 2025, evaluates the areas of renewable hydrogen use in end-use sectors in Türkiye and assesses their economic feasibility, presenting sector-based cost-benefit analyses grounded in prioritization.

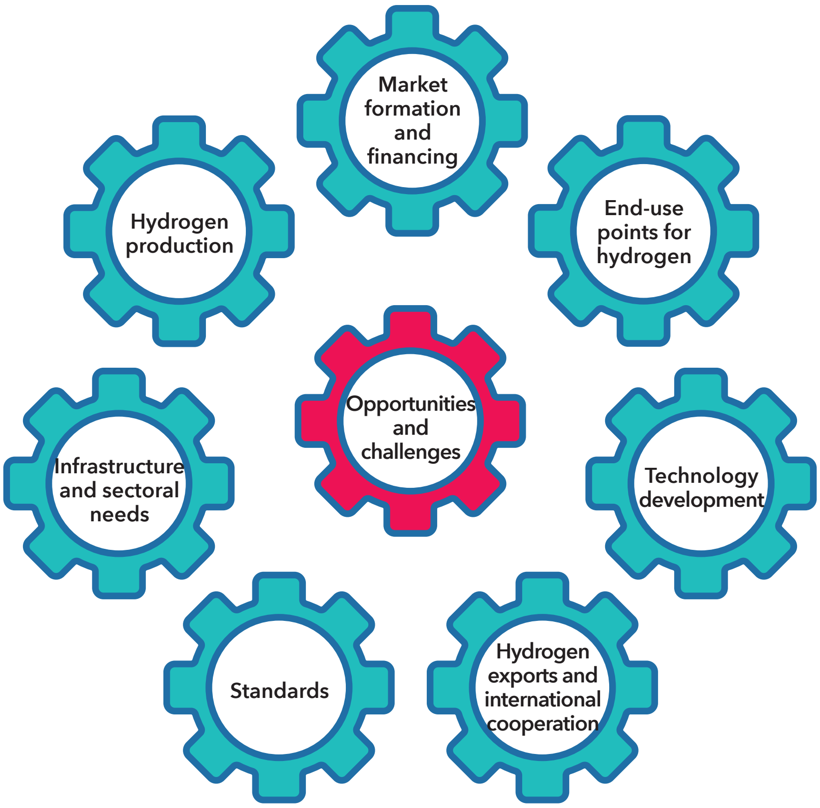
This report complements SHURA's first three renewable hydrogen-focused publications. It aims to contribute to policy and academic discussions by examining, under specific thematic headings, the opportunities and challenges Türkiye faces at both the national and international levels in the process of building its renewable hydrogen ecosystem.

Challenges and Opportunities for the Development of Renewable Hydrogen in Türkiye

Renewable hydrogen offers significant potential as an alternative feedstock and energy carrier in Türkiye's pathway toward achieving its 2053 net-zero emissions target. In addition to its substantial solar and wind energy potential—stemming from its geographical location—the widespread use of grey hydrogen in refineries and in the chemical and fertilizer sectors provides an important advantage for the near-term adoption of renewable hydrogen (SHURA, 2025). However, several factors limit the realization of this potential, including insufficient technical infrastructure, high hydrogen production costs, uncertainty surrounding the regulatory framework, and the absence of an established market structure.

In this context, the establishment of a renewable hydrogen ecosystem requires a comprehensive approach addressing multiple policy and implementation areas. Türkiye faces both significant opportunities and various structural and institutional challenges in these areas. Within the scope of this report, these opportunities and challenges are examined under specific thematic headings.

Figure 1. Thematic headings on the pathway toward a renewable hydrogen ecosystem



SECTION 1
Hydrogen Production

Türkiye holds a significant advantage in hydrogen production due to its renewable energy potential and strategic geographical location. Expanding renewable hydrogen production would not only enhance energy supply security but also facilitate progress toward a low-carbon economy. Moreover, growing global demand for renewable hydrogen—particularly from the European Union (EU)—reveals Türkiye's potential to become a major exporter in this field.

However, renewable hydrogen production should not compete with direct electrification (SHURA, 2025). In other words, using hydrogen in areas where direct electrification is feasible may hinder the transformation of the power sector.

The fact that hydrogen technologies are still in a developmental phase, combined with high costs, difficulties in accessing long-term financing, infrastructure gaps, and uncertainty surrounding the regulatory framework, creates significant risks for investors. Therefore, in advancing renewable hydrogen production and market formation, Türkiye must carefully assess not only existing opportunities but also the multidimensional risks involved.

Challenges and Opportunities for Türkiye in Hydrogen Production

1.1 Market Uncertainty and Lack of Demand

One of the most significant uncertainties facing Türkiye in hydrogen production is the absence of an established market for renewable hydrogen. Currently, there is no clearly defined market structure, fixed-price purchase guarantee mechanism, or long-term offtake agreements for renewable hydrogen. This situation makes it difficult for investors to economically plan and implement renewable hydrogen production projects.

Carbon taxes or carbon pricing mechanisms expected to be applied to fossil fuels have not yet been implemented in Türkiye. Carbon pricing will be critical for enhancing the competitiveness of renewable hydrogen.

Additionally, the absence of a strategic determination of priority sectors in which renewable hydrogen will be used, as well as the lack of medium- and long-term demand projections, creates additional uncertainty from an investor's perspective.

1.2 Human Resources

A qualified human resources pool capable of operating across the renewable hydrogen value chain is of critical importance. Hydrogen technologies require interdisciplinary expertise, including energy systems engineering, materials science, and chemistry. Moreover, beyond certain sectors that already use grey hydrogen—such as the chemical and petrochemical industries—the lack of technically experienced professionals with sector-specific expertise slows down investment processes and limits the practical deployment of hydrogen technologies.

1.3 Competition with Renewable Energy Supplies and the Transition of the Power Sector

Renewable hydrogen production through electrolyser technology requires water and renewable energy sources. In Türkiye, recently published policy documents and action plans set ambitious targets for increasing installed renewable energy capacity. Accordingly, installed capacity—particularly in solar and wind energy—has grown rapidly in recent years. However, the majority of existing renewable energy capacity should primarily be utilized for the transformation of the power sector. In other words, the renewable energy required for renewable hydrogen production should be supplied from new investments rather than from already operational power plants. For this reason, the increase in installed renewable energy capacity needed specifically for renewable hydrogen production must be planned separately. This approach would prevent renewable hydrogen production from competing with the transformation of the power sector.

1.4 Lack of a Regulatory Framework for Renewable Hydrogen

With the publication of the *Türkiye Hydrogen Technologies Strategy and Roadmap* in 2023, Türkiye established long-term targets based on renewable hydrogen. However, the absence of a comprehensive legislative and regulatory framework to support these targets has led investors to adopt a cautious approach, which directly affects the development of domestic production. Therefore, establishing specific hydrogen legislation emerges as a critical requirement for enabling renewable hydrogen production in Türkiye. This process will require the creation of a comprehensive regulatory framework, starting from the definition of renewable hydrogen and extending to support mechanisms, certification systems, and safety standards. In this context, public institutions are continuing their efforts—e.g., through working groups formed in cooperation with the private sector—to establish the legal infrastructure that will strengthen hydrogen's role in the energy transition.

Additionally, the absence of an authority responsible for holistically coordinating hydrogen production, transportation, storage, and end-use applications creates a significant governance gap that may slow down the development of the hydrogen ecosystem.

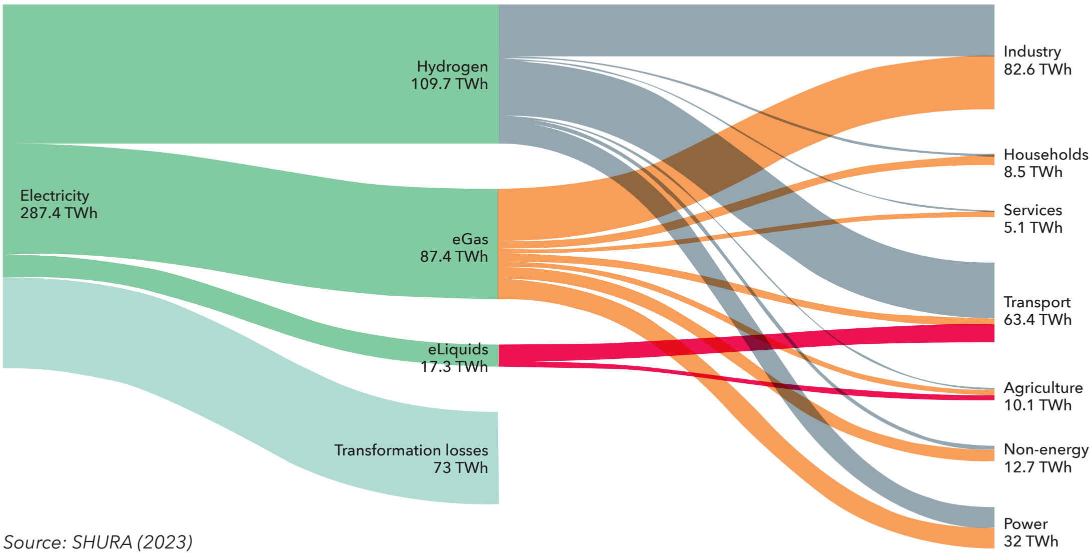
1.5 Türkiye's 2053 Net-Zero Emissions Target and Renewable Energy Potential

In 2021, Türkiye announced its Green Deal Action Plan, committing to transition to a net-zero emissions economy by 2053, and subsequently became a party to the Paris Agreement. In line with these developments, climate and energy policies have begun to be shaped in alignment with energy transition objectives. Within this framework, the critical role that renewable hydrogen is expected to assume in sectoral transformation has been explicitly emphasized in targets set by public authorities.

In sectors where direct electrification remains insufficient for decarbonization, the use of renewable hydrogen as both a raw material and a fuel is expected to make a substantial contribution to achieving net-zero emissions targets across various industrial sub-sectors and long-distance transport. In this context, policy documents set specific targets for domestic renewable hydrogen production. The Türkiye Hydrogen Technologies Strategy and Roadmap foresees the initial use of renewable hydrogen primarily for on-site consumption and to meet industrial demand, setting a phased electrolyser installed capacity target of 5 gigawatts (GW) by 2035 and 70 GW by 2053 (ETKB, 2023).

According to the main findings of SHURA's Net Zero 2053: A Roadmap for the Turkish Electricity Sector study, the use of renewable hydrogen and its derivatives is critical in end-use sectors that are hard to decarbonize through direct electrification (SHURA, 2023). The results of SHURA's model indicate that renewable hydrogen and its derivatives are projected to meet 15% of total final energy demand by 2053. To meet this projected demand, approximately 70 GW of electrolyser capacity would be required by 2053 (see Figure 2).

Figure 2. E-fuel production by type and sectoral consumption in 2053



Source: SHURA (2023)

Türkiye's substantial renewable energy potential provides a significant cost advantage for renewable hydrogen production. High-capacity factors in solar and wind energy can enable more efficient utilization of electrolysers in hydrogen production. Moreover, directing surplus generation from solar and wind sources to electrolysers can help limit renewable energy curtailment. However, achieving low-cost hydrogen production requires electrolysers to operate at high-capacity utilization rates. This, in turn, underscores the need for additional renewable energy investments dedicated to hydrogen production.

1.6 A Market Offering New Investment Opportunities

Türkiye stands out as a new and strategic market for investors interested in the ongoing development of the renewable hydrogen sector, which is supported by defined targets and ongoing research and development (R&D) efforts. The electrolyser capacity targets and renewable hydrogen cost targets per kilogram set for 2035 and 2053 demonstrate that Türkiye has taken an important step toward creating a competitive and attractive investment environment (ETKB, 2023).

In line with these targets, the hydrogen market in Türkiye is expected to generate significant financial returns and strategic added value, thereby attracting both domestic and international investors. The establishment of a clear regulatory framework and the implementation of public support mechanisms would reduce investment risks and position Türkiye as a promising destination for renewable hydrogen production projects—offering both early-stage investment opportunities and long-term growth potential.

However, persistent uncertainties on both the demand and supply sides hinder the formation of a functioning market in which hydrogen can be effectively traded.

1.7 Renewable Hydrogen Valleys

The first steps toward establishing Türkiye's first renewable hydrogen valley were taken in 2023 under the HYSouthMarmara Hydrogen Valley project. Led by the Scientific and Technological Research Council of Türkiye (TÜBİTAK) and the Republic of Türkiye Ministry of Industry and Technology, the project aims to produce 500 tons of renewable hydrogen annually. With a total budget of EUR 36 million, it represents the largest single funding allocation Türkiye has received from the European Union to date (TÜBİTAK, 2023). This project has the potential to serve as a model for future renewable hydrogen valleys and production facilities to be established in Türkiye. Companies operating within the hydrogen valley are expected to accelerate investments and transition processes related to renewable hydrogen consumption. The renewable hydrogen produced under the HYSouthMarmara project is anticipated to be used in end-use sectors such as the glass and ceramics industries. Accordingly, the project is expected to act as a driving force for sectoral transformation, gradually increasing demand for renewable hydrogen and thereby accelerating the reduction of fossil fuel use. The planned integration of regional solar and wind power plants for hydrogen production under the project provides a concrete example of infrastructure development and a strategic vision for the expansion of hydrogen production facilities in energy-intensive industrial regions across Türkiye (HYSouthMarmara, n.d.). In this way, increasing demand for renewable hydrogen and its derivatives in Organized Industrial Zones (OSB) and energy-intensive facilities could lower energy costs and facilitate sustainable production. The likelihood of energy-intensive industrial regions establishing integrated hydrogen production facilities to meet their own renewable hydrogen demand is expected to grow over time.

The establishment of hydrogen valleys in different regions of Türkiye could serve as a driving force for the development of hydrogen. However, mismatches between the price expectations of producers and consumers, infrastructure gaps, and the insufficiency of hydrogen support mechanisms are among the key challenges limiting the development of such hydrogen valleys.

1.8 The Export Potential of Hydrogen

Leveraging the country's strategic geographical position and strong renewable energy resource base, Türkiye is well-positioned to become a key player in renewable hydrogen exports. However, realizing this potential hinges on aligning all strategic frameworks with the 2053 net-zero emissions target.

In this context, Türkiye should determine its domestic hydrogen demand and key industrial sectors. Once internal market balance is established, international partnerships and export strategies can be developed on a more solid and sustainable foundation.

In particular, partnerships with Europe, the Middle East, and Eastern Mediterranean countries present considerable opportunities in terms of both technology transfer and economic development. Such collaborations would provide substantial momentum to the development of Türkiye's renewable hydrogen ecosystem. Europe's high hydrogen demand, combined with Türkiye's geographical proximity to this market, constitutes a major advantage. In the future, relatively low transportation costs for renewable hydrogen exports to Europe could position Türkiye as a highly competitive actor in the international renewable hydrogen trade.

In addition, Türkiye could assume the role of a strategic energy bridge or transit corridor within potential hydrogen trade corridors from the Middle East to Europe. In light of these developments, the adoption of well-structured and integrated strategies could enable Türkiye to emerge as a regional hub in the emerging hydrogen economy. Such a position would also support the expansion of domestic hydrogen production. Moreover, the fact that many countries are seeking to secure a position in the emerging global hydrogen trade is likely to lead to an increase in bilateral agreements and intensified international competition.

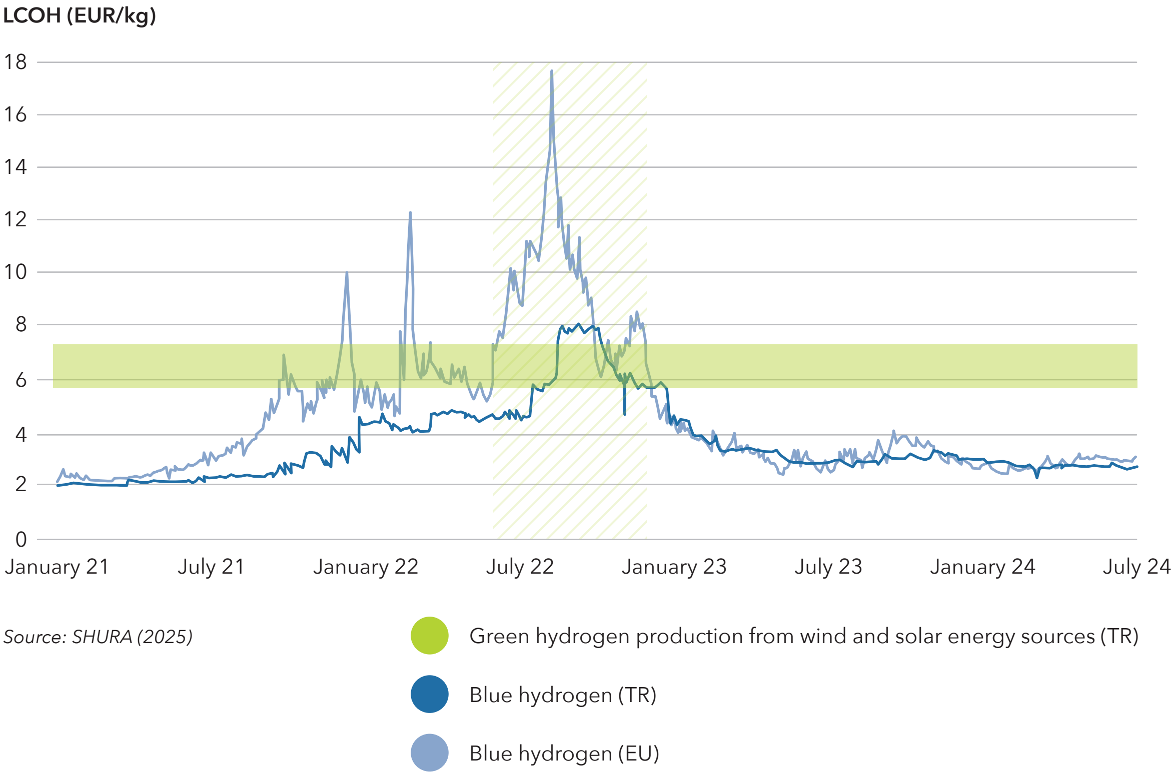
1.9 The Cost of Renewable Hydrogen Production

Although Türkiye's electricity generation costs based on solar and wind energy are relatively low compared to many countries, the production cost of renewable hydrogen has not yet declined to a level that can compete with fossil fuel-based production methods. One of the most significant factors behind this gap is the high investment costs of electrolysers. Although a significant reduction in electrolyser costs is anticipated in the coming years, the supply chain volatility associated with imported technologies continues to exert upward pressure on overall production costs. The absence of domestically developed and competitive electrolyser technology increases dependency on imports and introduces cost uncertainty. At the same time, achieving competitiveness between domestic technologies and established international technologies will be a highly challenging process. Furthermore, the technical infrastructure required for the hydrogen value chain—including storage and transportation—remains at an early stage of development, which constitutes another factor contributing to elevated overall costs.

As illustrated in Figure 3, during the periods represented by the green-shaded area, renewable hydrogen produced in Türkiye's western regions could become cost-competitive compared to blue hydrogen produced either in Türkiye and/or in Europe. However, as long as fossil fuel prices remain low, blue hydrogen may be more cost-effective than renewable hydrogen. The primary reason for this is that, under current conditions, renewable hydrogen production remains globally more expensive than fossil fuel-based hydrogen production. Additionally, due to uncertainties surrounding carbon capture and utilization (CCUS) technologies and natural gas prices, blue hydrogen is likely to remain exposed to price volatility. The production cost of renewable hydrogen depends on renewable electricity generation costs, electrolyser investment and operating costs, and capacity utilization rates. Therefore, it is assessed that there will be no risk in terms of energy cost fluctuations in renewable hydrogen production compared to blue hydrogen.

A major reason why renewable hydrogen production is currently more expensive is the relatively high cost of investment (CAPEX) for electrolysers. This is mainly due to increased investment and financial costs, particularly due to global inflation.

Figure 3. Green and blue H_2 costs for Türkiye (Western regions) and the EU[1]



Source: SHURA (2025)

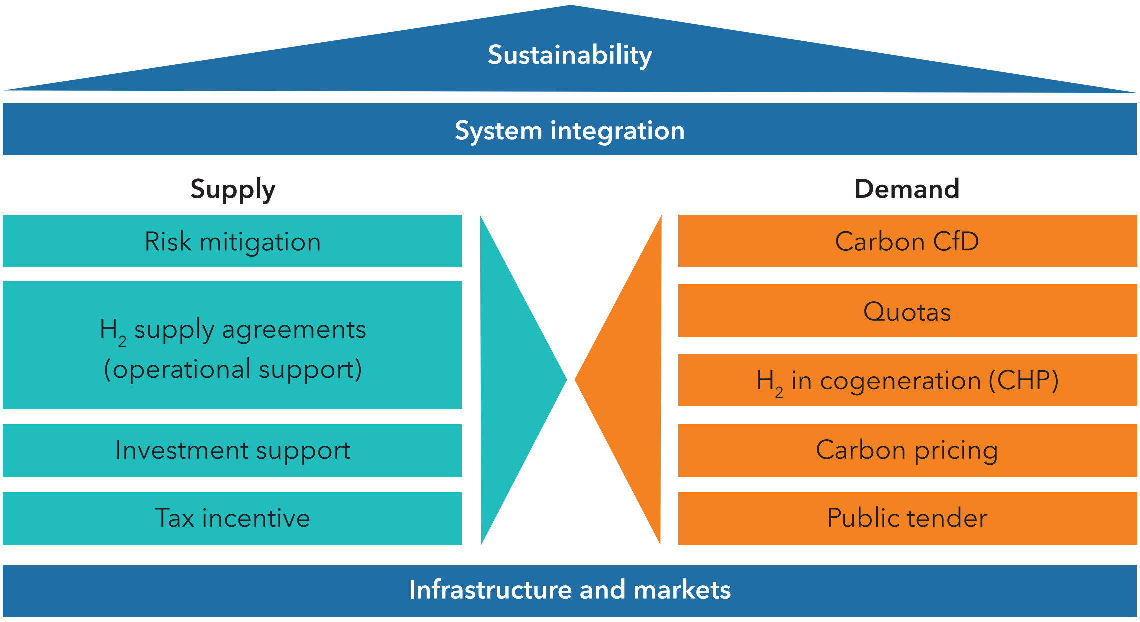
[1] Full-load hour data for renewable energy resources were analysed specifically for İzmir. Blue hydrogen is assumed to be based on steam methane reforming (SMR) with a 95% carbon capture rate. Renewable hydrogen production is directly linked to renewable energy resources. The relevant data were calculated using Agora Energiewende's LCOH (Levelized Cost of Hydrogen) calculation tool (2024). Full-load operating hours for renewable energy resources were taken specifically for the city of İzmir. Natural gas price data were sourced from the EPİAŞ Transparency Platform (Türkiye) and the TTF (EU).

SECTION 2
Market Formation and Financing

Market formation and financing are the primary factors in the sustainable development of renewable hydrogen in Türkiye. During the transition toward a renewable hydrogen economy, the establishment of an operational market framework, alongside the activation of public support and incentive mechanisms, is critical for effective process management.

Financing mechanisms designed for renewable hydrogen should encompass all segments of the hydrogen value chain. In this context, careful consideration must be given to hydrogen production, storage, transportation, the manufacturing or import of equipment used in production, and the development of infrastructure required for end-use delivery. In addition, the financing structure of projects and their bankability assessments vary depending on factors such as the country's access to renewable energy resources and existing infrastructure, as well as the location of the facility—whether operational or planned.

Figure 4. Example of a regulatory framework for hydrogen market development



Source: Agora Energiewende (2021)

Challenges and Opportunities for Hydrogen Market Formation and Financing in Türkiye

2.1 Incentives and Support Mechanisms

Currently, there is no dedicated incentive or support mechanism in Türkiye specifically designed for renewable hydrogen investments. This constrains the potential for early-stage market formation and increases entry barriers for investors. However, the development of renewable hydrogen could be encouraged through direct support instruments such as purchase guarantees, Contracts for Difference (CfD), or capacity-based support schemes, as well as through indirect policy mechanisms such as carbon pricing.

However, in designing such support mechanisms, it is crucial that renewable hydrogen promotion is not conducted indiscriminately across all sectors. Instead, support should be strategically targeted toward hard-to-abate end-use sectors and structured in line with the principle of additionality. Failure to do so risks misallocating limited public resources toward sectors with marginal emissions reduction potential, while potentially undermining the decarbonization of the power sector. Therefore, support mechanisms should be designed within a framework that is both sector-specific and conditional upon additional renewable energy capacity investments.

2.2 High Investment Costs

Beyond ongoing R&D initiatives focused on electrolyser technologies, Türkiye currently lacks domestic manufacturing capabilities for equipment and technologies across the renewable hydrogen value chain. Consequently, it is anticipated that the requisite technologies for renewable hydrogen production will remain largely import-dependent. In this regard, substantial capital expenditures are likely to be incurred in the procurement of electrolysers and advanced hydrogen storage systems. Within this framework, ensuring that the scaling process progresses in a controlled and cost-effective manner depends on directing renewable hydrogen investments toward priority application areas and sectors where direct electrification is insufficient. The widespread deployment of hydrogen across a broad range of applications at an early stage could prevent the full realization of technological learning effects, thereby leading to higher system-wide costs.

2.3 Carbon Pricing and Certification

The fact that carbon pricing and certification infrastructure has not yet been fully developed in Türkiye is among the key factors limiting the ability of renewable hydrogen to compete with fossil fuels. However, with the establishment of Türkiye's Emissions Trading System (ETS), carbon costs are expected to be reflected in fossil fuel-based production and consumption processes. This development could enhance the competitiveness of renewable hydrogen, particularly in hard-to-abate end-use sectors such as industry and transport.

In addition, the European Union's (EU) Carbon Border Adjustment Mechanism (CBAM) and similar regulations are increasing transparency and traceability requirements regarding the carbon footprint of export-oriented sectors in Türkiye. In this context, the development of certification systems that clearly demonstrate renewable hydrogen as a genuinely low-emissions option is of critical importance for both domestic market development and export-oriented applications.

2.4 Existing Market Experience and Infrastructure

Türkiye's institutional and technical experience in electricity and natural gas markets provides a significant advantage for the establishment of an organized market structure for renewable hydrogen. In this context, the organized energy markets operated by EPİAŞ serve as an important institutional reference point for the gradual integration of renewable hydrogen into an organized market framework.

Similarly, the experience of the Energy Market Regulatory Authority (EPDK as Türkiye's market regulator could contribute to shaping the hydrogen market at an early stage through providing a model for a transparent, predictable regulatory framework grounded in the principle of additionality.

2.5 Opportunity to Deepen Integration with the EU

The European Union (EU) clearly identifies hydrogen as a critical component of the energy transition. In this context, regulatory frameworks are being established for EU member states, and EU-wide efforts are underway to anticipate and build the infrastructure necessary to meet short- and medium-term renewable hydrogen demand.

Under the European Green Deal and the 'Fit for 55' package, the EU adopted the Hydrogen and Decarbonised Gas Market Package. After this package was adopted in August 2024, EU member countries have been given until August 2026 to transpose and implement its provisions (European Hydrogen Observatory, 2025).

The primary objective of the package is to increase the use of clean fuels, with the expectation that renewable hydrogen will play a key role in achieving decarbonization in the short and medium term. In this context, the package aligns existing legislation with specific new provisions. These provisions build on elements of the EU's Clean Energy Package, including incentives for clean energy solutions, the role of prosumers, and measures to facilitate supplier switching. Accordingly, the European Commission has been granted the authority to define the limits of 'low-carbon' hydrogen within this framework. The regulation also aims to establish an independent structure for hydrogen networks. In this regard, further cooperation between the European Commission and the European Network of Transmission System Operators for Electricity (ENTSO-E) is foreseen, with the objective of operationalizing the framework by the end of 2025. Common rules have also been set for hydrogen transportation, supply, and storage (European Hydrogen Observatory, 2025).

Accordingly, the package explicitly identifies hydrogen as a key element in the decarbonization of the natural gas sector. In addition, it states that the further development of the hydrogen market will be implemented under a regulatory framework to be established in the EU's next regulatory period.

Under the 'Fit for 55' package, renewable hydrogen production of 5.6 Mt by 2030 has been projected. Through the European Commission's REPowerEU Plan, an additional 15 Mt of hydrogen production has been added to this target. A total projected production volume of 20.6 Mt by 2030 is expected to be supplied through multiple sources, including demand-side co-located electrolyser facilities, centralized hydrogen production based on renewable energy, pipeline imports, and maritime imports of hydrogen derivatives such as ammonia or methanol. Within this framework, the European Union plans to import 10 Mt of hydrogen and produce 5 Mt domestically in Europe (EHB, 2022).

In this context, new developments are taking place in renewable hydrogen trade at the global level. Many countries are seeking to engage in green hydrogen trade through bilateral agreements. As an example of such cooperation, an agreement was signed between Canada and Germany in 2022. The agreement includes the trade of up to 500,000 tons per year of ammonia produced from renewable hydrogen by 2025 (Uniper, 2022). Germany has also established various partnerships with other countries, including the United Arab Emirates. Countries such as the United States, Spain, Australia, Canada, India, Japan, and Egypt are actively pursuing initiatives related to renewable hydrogen production, consumption, and trade.

In light of these developments, it is important that Türkiye establish a structure that operates in alignment with the EU in areas such as hydrogen market formation, the definition and certification of low-carbon fuels, and the development of technical and market standards. Such an integrated framework would enable Türkiye to achieve a competitive position in renewable hydrogen both in its domestic market and in trade with the EU. Moreover, it would present a significant opportunity to deepen energy integration with the EU.

SECTION 3
Infrastructure and Sectoral Needs

The integration of renewable hydrogen into sectoral transformation processes is possible not only through the production of new technologies but also through the establishment of comprehensive and coherent infrastructure. In this context, the requirements of all components of the hydrogen value chain—including production facilities, transportation, storage, distribution, and end-use points—must be thoroughly analysed.

Challenges and Opportunities for Türkiye's Infrastructure and Needs

3.1 The Development of Hydrogen Infrastructure in the Transport Sector

The synergistic development of hydrogen infrastructure at maritime ports and airports is paramount to unlocking the potential of renewable hydrogen. This includes the integrated design of liquefaction facilities and pipelines at airports. Furthermore, ports will need infrastructure to facilitate the storage and transportation of ammonia.

3.2 Hydrogen Refuelling Stations

emissions. In this context, SHURA (2025) prioritizes increasing electrification and predicts more widespread use of hydrogen in long-distance transportation in the medium term. Within this framework, the deployment of road-based hydrogen refuelling infrastructure is considered a prerequisite for the large-scale adoption of renewable hydrogen within the transportation sector.

Türkiye is still at the early stages regarding hydrogen refuelling stations. The absence of hydrogen fuel cell and internal combustion vehicles in the market is also delaying investments in refuelling infrastructure. High installation costs, demand uncertainty, and the current rise of electric vehicles prevent hydrogen refuelling stations from becoming economically attractive in the short term.

3.3 Competition and the Transformation of the Electricity Sector

Positioning renewable hydrogen as a complementary element in sectors where direct electrification is technically or economically unfeasible is critical for achieving Türkiye's net-zero targets. In this context, designing renewable hydrogen as a tool that accelerates the decarbonization of the electricity sector should be a fundamental policy priority.

In this context, the electricity used for renewable hydrogen production should be based on additional renewable energy investments deployed specifically for hydrogen production rather than redirecting or substituting the output of existing renewable energy plants. Applying the principle of additionality in this way will prevent hydrogen production from eroding the decarbonization gains in the electricity sector, ensuring that both transformation processes progress in a mutually reinforcing manner.

The absence of targeted incentives and support mechanisms for renewable hydrogen production leads investors to place their limited capital in renewable energy investments in the electricity market, where revenue visibility is higher. This situation risks delaying the additional capacity investments needed for renewable hydrogen and slowing the development of the hydrogen ecosystem. Therefore, developing policy instruments that are based on the principle of additionality and that incentivize new renewable energy investments dedicated to hydrogen production is critically important for establishing a hydrogen market that is compatible with the transformation of the electricity sector.

3.4 Renewable Energy Potential and Electricity System Infrastructure

Türkiye is a country with abundant renewable energy resources, particularly in clean technologies such as solar and wind, whose full potential has not yet been fully utilized. This high potential provides Türkiye with significant strategic advantages in renewable (green) hydrogen production. Furthermore, due to its favourable geographical conditions, it is expected that the production costs of renewable hydrogen in Türkiye will be lower than in many other countries globally.

In recent years, Türkiye has made significant progress in renewable energy investments, focusing on meeting its growing energy demand and reducing dependence on energy imports. Notable increases have been observed in energy production from renewable energy sources, particularly solar and wind, and the share of renewable energy within total installed capacity has risen rapidly over the years. As of December 2021, renewable energy sources accounted for 53.3% of total installed capacity. By September 2025, this share had increased by 8%, reaching 61.4% of total installed capacity. In electricity generation, the share of renewable energy sources also increased by 10% over this period (EPDK, 2021; EPDK, 2025).

While sustainability is an important target outlined in Türkiye's energy policies, technological advancements in renewable energy and government-provided incentives have also supported the growth of Türkiye's renewable energy sector. In this context, Türkiye is positioning renewable energy investments as a key element of its long-term climate policies and action plans.

Türkiye's extensive, geographically distributed interconnected electricity infrastructure will facilitate the efficient transmission of electricity to regions where electrolyzers will be located. Türkiye's high renewable energy potential, together with the targeted total installed wind and solar capacity of 120 GW by 2035, will support the low-cost, carbon-neutral electricity production needed for hydrogen generation. Additionally, relevant infrastructure investments include plans for high-voltage direct current (HVDC) systems, which reduce losses over long distances. By 2035, Türkiye plans to install a total of 14,700 km of HVDC lines and 40 HVDC converter stations. Under Türkiye's Green Transmission Infrastructure goal, investments totalling USD 28 billion are planned for the grid by 2035 (ETKB, 2024). The simultaneous development of concrete storage projects will also ensure the reliable operation of the system. Taken together, Türkiye's electricity infrastructure is expected to provide significant advantages in supporting the renewable hydrogen ecosystem in the coming period.

Türkiye's renewable energy potential gives it a significant advantage in renewable hydrogen production. While this enables the provision of the low-cost electricity necessary for hydrogen production, the effective utilization of this potential requires comprehensive infrastructure specifically for renewable hydrogen. With the development of such infrastructure, electrolyzers will be able to operate at high-capacity factors using low-cost renewable electricity. This will allow hydrogen to be transported cost-effectively from regions rich in renewable energy to regions with demand. The main challenge in developing this infrastructure is the current lack of demand for renewable hydrogen and its derivatives, which poses a risk that investments in this area may remain underutilized.

3.5 Existing Natural Gas Pipeline Infrastructure and Experience

Thanks to the country's strategic geographic location, Türkiye serves as a critical energy corridor between Europe, the Middle East, Central Asia, and Russia. In this context, natural gas supplies and transit activities to neighbouring and surrounding countries are effectively maintained through the existing natural gas transmission pipelines. By blending hydrogen into the natural gas network at certain ratios (up to 20%), the carbon intensity of the network can be reduced. However, in hydrogen–natural gas blending, it is particularly important to use technically appropriate ratios, establish safety standards, and study the effects on end-use devices.

Türkiye's experience in the construction and operation of natural gas pipelines is expected to provide significant benefits for the construction and operation of hydrogen pipelines. However, although Türkiye's natural gas network is more developed than in many other countries, its compatibility with hydrogen needs to be examined in detail. Hydrogen has a tendency to embrittle components and steel pipelines containing elements such as aluminium, and titanium, which are used in the natural gas network (Hafsi et al., 2018). Therefore, the proportion of hydrogen blended into the natural gas network is determined according to the tolerance of each system component. Consequently, for infrastructure safety, tests assessing the hydrogen sensitivity of each component across the entire network are necessary.

3.6 Geographical Location and Access to Water Resources

One of the key inputs for renewable hydrogen production is water. Türkiye's water resources primarily meet domestic needs, especially in agriculture. However, recent droughts have caused a significant decrease in water levels in reservoirs. Therefore, access to clean water for hydrogen production is a critical challenge that must be considered. The current status of water resources in certain regions of Türkiye, particularly areas with high agricultural water consumption, may limit hydrogen production. Consequently, the water stress in the region and the water needs of related sectors should be evaluated when selecting a site for hydrogen production facilities. Water scarcity is expected to become a significant constraint in the 2030–2050 period, making it important to develop water-friendly hydrogen projects in estuaries and stream mouths (SHURA, 2021).

Alternatively, due to Türkiye's geographical location, being surrounded by seas on three sides, situating hydrogen production facilities near coastal areas can provide advantages. Alternative water sources obtained through the desalination of seawater or the recovery of wastewater in coastal regions will support the sustainability of renewable hydrogen production facilities.

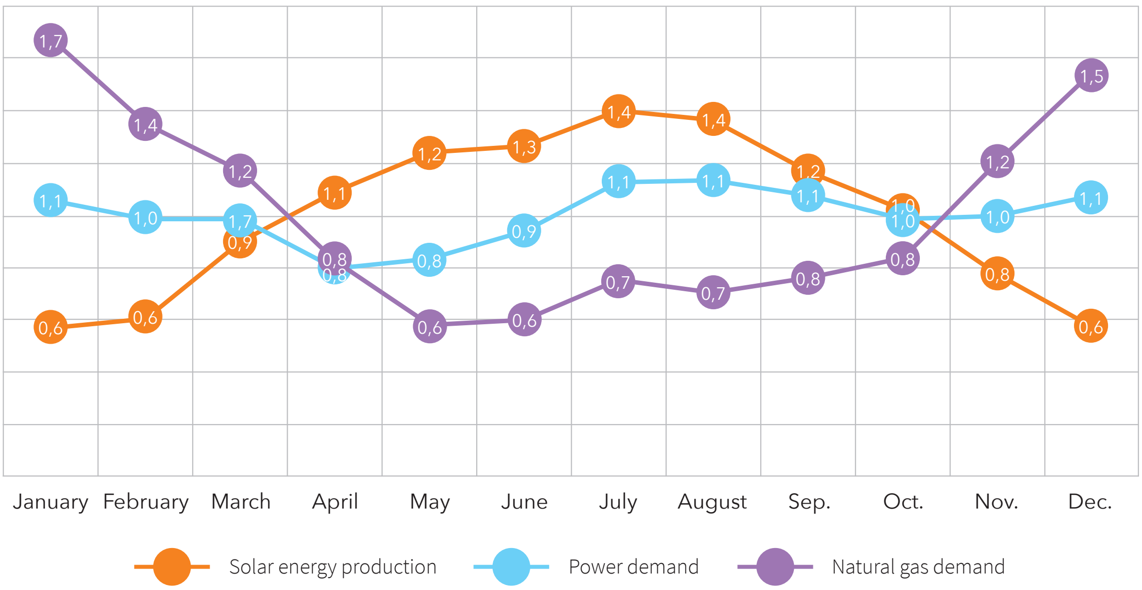
In SHURA's (2021) report *Techno-Economic Study of Turkey's Production and Export Potential for Green Hydrogen,* the analysis indicates that by 2050, the desalination of seawater in coastal areas could serve as an alternative to address the potential water scarcity that Türkiye may face.

3.7 Storage Infrastructure

Although there are clear targets for renewable energy sources and hydrogen use across various sectors, the role of large-scale hydrogen storage has not been fully defined. To fill this gap and provide a solid foundation for the widespread integration of hydrogen into the global energy market, comprehensive planning and investments in Underground Hydrogen Storage (UHS) projects are emerging as key priorities. However, the challenges of underground hydrogen storage are not limited to infrastructure and project development. Rock–fluid interactions during storage play a critical role in the safety and efficiency of the process (Miocic et al., 2023; Perera, 2023). Furthermore, converting renewable hydrogen back into electricity after storage may not be cost-efficient. The main reasons are the high investment costs of building hydrogen storage facilities and the energy losses associated with changing the energy's form. However, hydrogen storage and power generation from hydrogen can still serve as an important complementary component in the integration of renewable energy in Türkiye.

SHURA (2023) analysed Türkiye's energy sector and estimated that by 2053, 32 terawatt-hours (TWh) of electricity could be generated from hydrogen and renewable hydrogen derivatives, accounting for approximately 4% of the electricity generation mix. In particular, production shortfalls in solar energy during the transition from summer to winter can be mitigated through seasonal hydrogen storage. Türkiye's national hydrogen strategy emphasizes the importance of using excess electricity for hydrogen production as an alternative energy storage tool to prevent renewable energy interruptions. The strategy also highlights the need to explore the possibility of storing hydrogen in underground salt caverns (ETKB, 2023).

Figure 5. Seasonal assessment of solar electricity generation, electricity demand, and natural gas demand in Türkiye



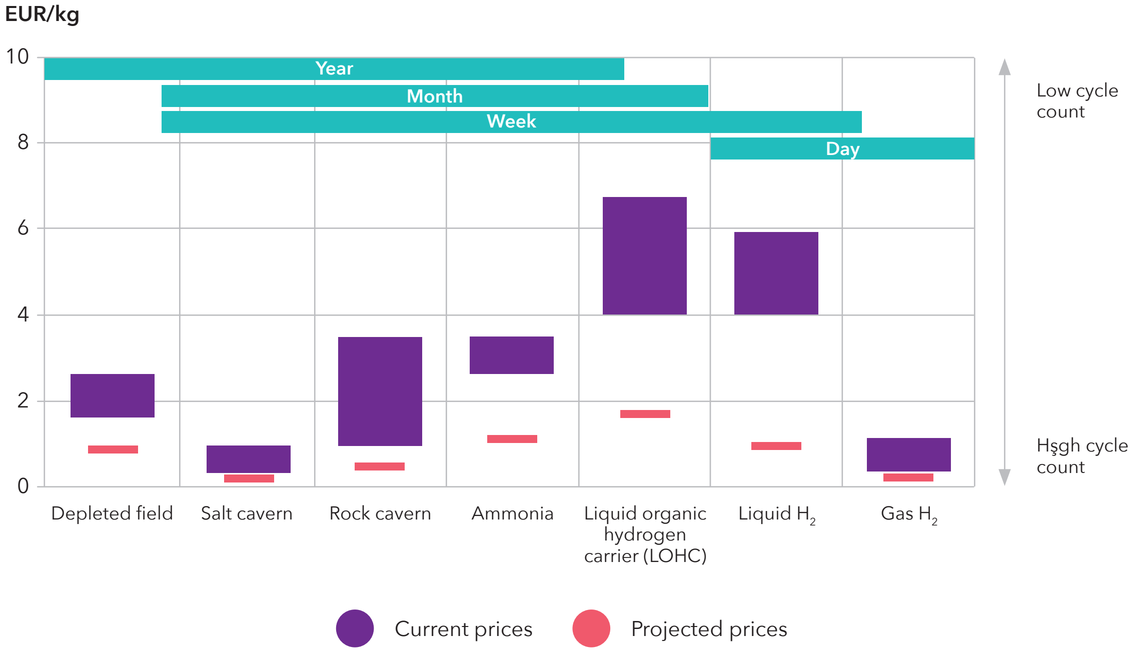
Source: SHURA (2021)

Türkiye has an advantage in developing geological storage sites due to its existing reservoirs and experience with natural gas storage. The largest natural gas storage site is located in Silivri, west of Istanbul, Türkiye's main demand centre. Hydrogen can also be stored in areas suitable for natural gas storage. The second largest underground natural gas storage site is Tuz Gölü (Salt Lake). Existing studies indicate that approximately 2.5 TWh[2] of hydrogen could be stored in the current caverns of Tuz Gölü (Şan et al., 2021). Türkiye's salt caverns have significant large-scale hydrogen storage potential. In addition, the experience gained from natural gas storage sites will provide important contributions to the development of next-generation hydrogen storage systems due to their similarities (Dinçer et al., 2020).

Salt caverns are considered more cost-effective than other storage methods when longer storage durations are considered (Figure 6). Compared to other geological formations, salt caverns also have higher cycling rates, which translates into greater system flexibility.

[2] Due to its molecular weight, this value is 12 TWh for natural gas.

Figure 6. Levelized hydrogen storage costs for different technologies



Source: Agora Energiewende (2021)

SECTION 4
End-Use Points for Hydrogen

Renewable hydrogen is important due to its potential as an energy carrier and as an alternative raw material and fuel in sectoral energy transition planning. Various end-use sectors, such as industry, transportation, and the electricity sector, are priority areas that can benefit from this potential. Renewable hydrogen is expected to serve as an alternative to fossil fuels, particularly in sectors where direct electrification falls short of achieving decarbonization. In this way, renewable hydrogen will act as a complementary tool for the decarbonization of the entire economy.

Challenges and Opportunities for Türkiye at End-Use Points

4.1 Required Modifications in Production Processes

Iron and Steel Sector

To create a value chain in the iron and steel sector that does not rely on fossil fuels, blast furnace (BF) and basic oxygen furnace (BOF) technologies must be converted into facilities capable of using hydrogen. Another important consideration is for electric arc furnace (EAF) plants to eliminate fossil fuel use by employing direct reduced iron (DRI) technology.

In 2023, Türkiye became the world's eighth-largest steel producer and ninth-largest exporter, with a production capacity of 33.7 million tons (Mt) (Steel Exporters' Association, 2025). Unlike other countries, more than 70% of Türkiye's production is already based on EAF technology, placing Türkiye in a stronger position for electrification compared to the global average (~35%). Consequently, the iron and steel sector in Türkiye exhibits a lower carbon intensity than the global average.

The H_2-DRI conversion of BF and BOF technologies, which account for the majority of emissions in the iron and steel sector, will be critical for further decarbonization of the steel sector. Currently, Türkiye does not have any EAF plants with direct reduced iron technology (DRI-EAF). Integrating hydrogen into the sector (H_2-DRI-EAF) would accelerate the decarbonization process. The main challenge in this context is the high investment costs associated with these transformations.

Chemical and petrochemical sectors

The chemical sector mainly consists of facilities where various products such as petrochemicals, fertilizers, and pharmaceuticals are produced. In Türkiye, 70% of the raw materials used in the chemical sector are imported. The sector exported USD 45.5 billion worth of goods in 2022 (Ministry of Trade of the Republic of Türkiye, 2024). Fossil fuels, which are used both as feedstock and fuel, account for 64% of the sector's total energy consumption (ETKB, 2023). In Türkiye, grey hydrogen (fossil fuel-based) is currently used mainly in refineries, as well as in certain applications within the petrochemical industry, the chemical sector, and ammonia production. Renewable hydrogen can be used as both a feedstock and a fuel alternative in many sub-sectors of the chemical industry. In particular, the transition from grey hydrogen to renewable hydrogen is expected to be relatively easier due to existing infrastructure and usage practices. This transformation could significantly contribute to reducing sectoral emissions. However, this transition will also entail certain modifications in production processes and additional investments in the relevant sectors. Additionally, considering that the sector's entire methanol demand is met through imports, green methanol, together with renewable hydrogen, can be considered as an opportunity for the transformation of Türkiye's chemical sector.

Glass and ceramics sectors

The glass and ceramics sectors are among Türkiye's leading industrial sub-sectors, both in terms of production and their increasing export performance in recent years. In the production processes of both sectors, high heat is required in furnaces, and this demand is generally met using natural gas as fuel.[3] Since a significant portion of the emissions generated by both sectors is fuel-related, replacing natural gas with renewable hydrogen as a fuel would substantially reduce emissions. However, in this process, technical feasibility studies are required to adapt the production processes of both sectors to hydrogen. Specifically, in the glass sector, furnace technologies and combustion processes need to be adjusted to be compatible with hydrogen flames. In the ceramics sector, due to hydrogen's different calorific value and density, the installation of burner technologies suitable for hydrogen is required. In addition, during the transition from full natural gas consumption to a natural gas–hydrogen blend, changes in pipelines and connection components may be necessary (Kamps et al., 2021). These modifications will also entail certain investment costs.

4.2 The Distance Between Production and Consumption Points

The geographical disparity between production and consumption points—the primary and terminal stages of the renewable hydrogen value chain—presents significant logistical challenges, particularly during the initial deployment phases. Given that these sites are often situated in disparate regions, efficient transportation to end users is critical. While Türkiye possesses a robust natural gas infrastructure, pipeline transport remains unfeasible in the short to medium term without specialized modifications. Even with blending strategies, current research limits hydrogen concentration to a maximum of 20%. Consequently, while compressed or liquefied transport emerge as primary alternatives, they entail substantial costs and energy losses. Furthermore, domestic distribution via road networks necessitates rigorous regulatory compliance, including specific licensing and certification frameworks. In this context, locating renewable hydrogen production and consumption points within the same region at the initial stage may help reduce infrastructure needs. Establishing a centralized electrolyzer facility integrated with renewable energy projects in areas with high energy demand may provide a relatively reliable and uninterrupted supply for direct use in the industrial sector at the initial stage. On-site production eliminates energy losses and safety risks arising from transportation while enabling producers to reduce their carbon footprint.

[3] In 2023, natural gas accounted for 72% of the total energy consumption in the glass sector and 58% in the ceramics sector (Ministry of Energy and Natural Resources, 2024).

4.3 Storage Needs

A primary long-term barrier to the integration of renewable hydrogen across Türkiye's end-use sectors is the absence of reliable storage infrastructure. Currently, hydrogen storage investment costs are high, and storage standards and regulatory frameworks have not yet been fully defined.

Türkiye also has the advantage of developing geological storage sites due to its existing reservoirs and experience in natural gas storage. However, for such storage methods, specific legislation and standards tailored to renewable hydrogen must also be established. All these elements make storage both a strategic issue in Türkiye's transition to the hydrogen economy and one of the fundamental infrastructure needs of the planned hydrogen ecosystem.

4.4 New Investments and Costs

The transition to the use of renewable hydrogen in end-use sectors entails significant additional investments and costs, as it requires existing technologies and processes to be made compatible with hydrogen. In this context, end-use sectors in Türkiye need to plan certain modifications in their technical infrastructure and production processes to enable the use of renewable hydrogen. This process includes not only equipment replacement but also the reconfiguration of existing production lines to comply with hydrogen's different combustion characteristics, as well as pressure and safety requirements. These changes will also entail certain new investments and additional costs. In sectors such as petrochemicals, where grey hydrogen is already used in Türkiye, the additional costs arising during this transition process are expected to be relatively lower compared to other sectors.

In addition to all these transformations, companies may need to develop training programs for their employees on hydrogen technologies, implement new safety procedures, and update maintenance and repair infrastructure, which could increase operational costs. Therefore, while renewable hydrogen offers significant long-term opportunities, it is expected to entail certain economic and technical adjustment costs for end-use sectors in the short and medium term.

4.5 Consumption of Renewable Hydrogen Derivatives in Maritime and Air Transport

Long-distance freight and logistics constitute a pivotal component of Türkiye's international trade infrastructure. According to data from the Turkish Statistical Institute (TÜİK), in 2024, 65.7% of exports (55.8% by sea, 9.9% by air) and 68.3% of imports (54.5% by sea, 13.7% by air) were carried out via long-distance transport (TÜİK, 2025). These figures underscore the strategic importance of Türkiye's maritime ports and airports for foreign trade efficiency. In the short term, direct electrification is expected to be the primary strategy in the transportation sector. Falling battery costs in particular provide an attractive solution for the electrification of passenger vehicles. In the medium term, the use of hydrogen and its derivatives in long-distance transport is expected to become more widespread. Renewable hydrogen and its derivatives are considered an important strategy for decarbonizing maritime and air transport in the medium and long term.

In this context, the use of renewable hydrogen derivatives, particularly in air and maritime transport, should be encouraged in the medium to long term. For example, under the EU ReFuelEU Aviation initiative, a model compliance package has been prepared for the aviation sector. The regulation adopted within this framework mandates that each aircraft landing in Europe consumes a certain proportion of Sustainable Aviation Fuel (SAF). The SAF usage rate will start at 2% in 2025, rise to 6% in 2030, and reach 70% by 2050. Additionally, from 2030 onward, 1.2% of aircraft fuels, and by 2050, 35% of aircraft fuels must consist of synthetic fuel (Presidency of the Republic of Türkiye, Directorate for EU Affairs, 2023). The main goal of the package is to increase both the demand and supply of SAF, which has lower carbon dioxide (CO_2) emissions compared to kerosene derived from fossil fuels, and to ensure fair competition in the EU aviation market. Promoting the widespread use of SAF is aimed at reducing carbon emissions from air transport.

In the context of maritime transport, similar steps in this direction were taken during the 2^{7th} United Nations Climate Change Conference of the Parties (COP27). Currently, shipping accounts for approximately 3% of global greenhouse gas emissions, and without intervention, this share is projected to rise to 50% by 2050. In line with the agreement reached at COP27, renewable hydrogen production for maritime transport is targeted to reach 5.5 Mt per year by 2030, with a commitment to achieve full decarbonization of maritime transport by 2050 at the latest.

In Türkiye, incorporating the use of renewable hydrogen in maritime and air transport—sectors critical for international trade—into medium-term targets through established quotas and planning could serve as a driving force for the transformation of these sectors.

4.6 Status of EAF Technology in the Iron and Steel Sector

Türkiye maintains competitive leadership in the decarbonization of the iron and steel industry relative to global peers. This position is underpinned by the sector's structural composition; of the 44 existing iron and steel facilities nationwide, 30 utilize Electric Arc Furnace (EAF) technology (Turkish Steel Producers Association, 2025).

In contrast to global steel production trends, Türkiye's output is predominantly driven by Electric Arc Furnace (EAF) facilities. Approximately 65% of the nation's total annual production capacity is derived from scrap-based EAF operations, representing a significant structural differentiation from international averages (SHURA, 2023). Therefore, Türkiye already has a high degree of electrification in steel production, resulting in lower carbon intensity in the sector compared to the global average.

The fact that the majority of total production and plant types are based on EAF technology will facilitate the integration of hydrogen into Türkiye's iron and steel sector. This process will primarily involve the implementation DRI technology, followed by the deployment of hydrogen-based DRI technology. Considering that renewable hydrogen is expected to be a strategic option under the EU's CBAM, which plays a leading role in carbon regulation, Türkiye is well-positioned compared to other countries in the transformation of its iron and steel sector.

4.7 Current Demand for Grey Hydrogen

In Türkiye's petrochemical sector, particularly in refineries, grey hydrogen is currently used in certain applications and in ammonia production. Thanks to the existing infrastructure and operational experience with hydrogen consumption in these sectors, current users are more likely to integrate renewable hydrogen into their production processes. However, analyses and modifications to process equipment may be required to meet different pressure and purity requirements compared to grey hydrogen. Nevertheless, the existing demand for grey hydrogen provides a reliable market for renewable hydrogen producers and will also help lead the transformation process for other sectors.

4.8 Organized Industrial Zones (OSB)

In the initial phase of renewable hydrogen adaptation, the proximity of electrolyzer facilities to factories in end-use sectors will be important both in terms of cost and infrastructure development. In this regard, organized industrial zones (OSB) stand out due to the large number of end-use sectors they host and the advantages they offer in terms of energy infrastructure. The presence of OSB in various provinces in Türkiye provides multiple alternatives for selecting the location of pilot facilities.

Izmir OSB could be an alternative location for establishing an electrolyzer facility due to the presence of producers in the iron and steel and chemical sectors, which can directly utilize hydrogen, as well as the province's high renewable energy potential. This would also help avoid costly processes such as hydrogen storage and transport. The high-voltage power lines in Izmir OSB will be advantageous given the high electricity consumption of electrolyzer technology. Additionally, the zone has existing wastewater management infrastructure. Since the chemical sector is the second-largest consumer of natural gas after OSBs, the existing natural gas infrastructure in Izmir OSB will facilitate the sector's gradual transition. Considering these advantages, factories within Izmir OSB that can consume renewable hydrogen once the necessary technical infrastructure is developed are expected to lead the hydrogen transformation in the relevant sectors.

SECTION 5
Standards

The hydrogen value chain, encompassing all stages of hydrogen use from renewable hydrogen production to its consumption in end-use sectors, must be assessed according to established standards. In this context, standards such as ISO 14687:2025, CertifHy, and ISO/TS 19870 aim to create a common international framework addressing technical and environmental aspects, including hydrogen quality requirements, certification processes, and traceability.[4] Therefore, a country's level of compliance with these standards serves as an important indicator for achieving its nationally determined targets, the effectiveness of its energy policies, and its capacity to participate in international markets. Accordingly, developing Türkiye's renewable hydrogen value chain in alignment with international standards and trade-focused regulations such as the European Green Deal will facilitate its competitive positioning in the global hydrogen market.

Challenges and Opportunities for Türkiye's Compliance with International Standards

5.1 Compliance with the Global Standardization Process

Many countries and regions are developing comprehensive standards across the entire hydrogen value chain, from production to end use, to promote the widespread adoption of renewable hydrogen. These standards are critically important both for investment security and for establishing mutual recognition agreements in international trade. Within this framework, the standards also include establishing criteria for hydrogen production methods and safety requirements as well as measuring carbon emissions and purity levels across all stages of the value chain.

In this context, countries are developing their own domestic regulations while taking steps to align with international standards and participate in global agreements. For example, at COP28, the Subcommittee on Hydrogen Technologies of the International Organization for Standardization (ISO/TC197 SC1) presented the draft technical specification for determining greenhouse gas emissions in hydrogen production and transport (ISO/TS 19870:2023) (ISO, 2023). This specification is intended to cover the entire supply chain. Türkiye's potential to comply with this standard is quite high, both in terms of technical capacity and its strategic targets. However, realizing this potential requires establishing a certification infrastructure specific to renewable hydrogen. For instance, the Netherlands operates through the CertifHy system, which provides renewable hydrogen guarantee certificates compatible with ISO/TS 19870 for hydrogen produced in Europe (CertifHy, n.d.). The certification is the world's first non-governmental guarantee scheme for hydrogen (Clean Hydrogen Partnership, 2020). This system allows transparent and verifiable tracking of renewable hydrogen, including its source and greenhouse gas intensity.

The EU's Renewable Energy Directive (RED) establishes environmental criteria and carbon emissions targets for hydrogen to be recognized as a renewable energy source. In this context, hydrogen produced by water electrolysis using renewable electricity is classified as 'Renewable Liquid and Gaseous Fuels of Non-Biological Origin' (RFNBO) (European Parliament, n.d.). This term broadly covers renewable hydrogen produced from renewable energy sources other than biomass, as well as other renewable fuels produced without biomass. Under this regulation, hydrogen is considered green if its lifecycle-based emissions are below 3.38 kg CO_2e/kg H_2.

[4] ISO 14687:2025 supports the implementation of quality standards to ensure the safe and efficient use of hydrogen fuel in technologies such as PEM fuel cells and internal combustion engines (ISO, 2025). ISO/TS 19870:2023 is critically important for standardizing the assessment of greenhouse gas emissions across various hydrogen production pathways (ISO, 2023).

In addition, a 70% reduction in greenhouse gas emissions is expected throughout the process (European Parliament, 2023).

Under the EU's Guarantees of Origin (H-GOs), systems are being established to certify that the electricity used in the production of renewable hydrogen is renewable and to document the source of the produced hydrogen (Emissions-EUETS, 2025).

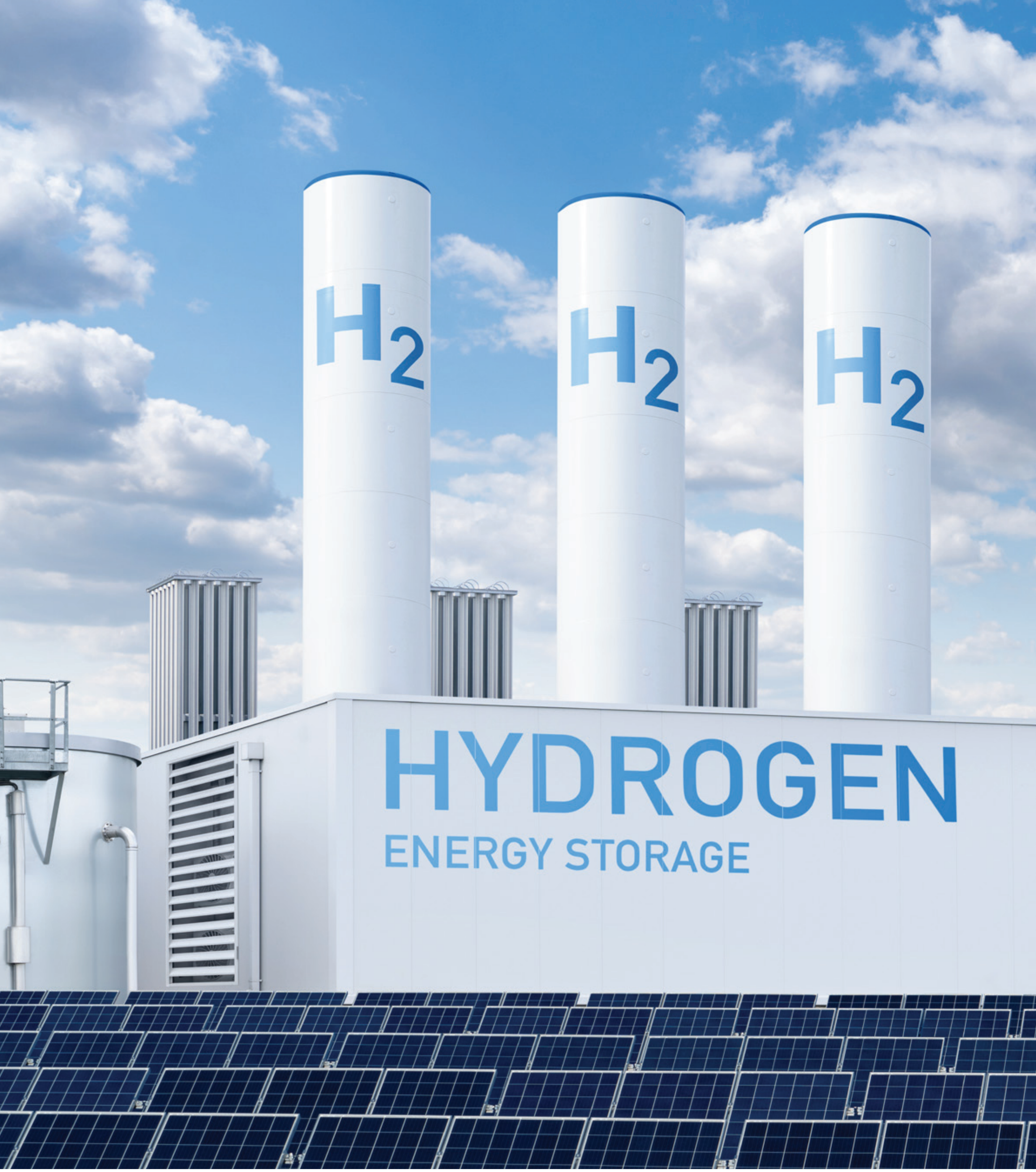
Germany has defined technical regulations for hydrogen technologies, including renewable hydrogen, through its Standardization Roadmap for Hydrogen Technologies. These regulations provide a nationally coordinated roadmap covering infrastructure, production, transport, quality, and safety standards. The final standardization roadmap for hydrogen technologies is planned to be published by the end of 2025 (DIN, 2025).

New Zealand has adopted 13 ISO Standards[5] related to hydrogen production, consumption, and safety standards and has developed a roadmap for scaled-up domestic production and exports. With this step, it has been stated that paving the way for renewable hydrogen trade represents the most effective and efficient pathway for the energy transition. In the next phase, approximately 20% hydrogen integration into the natural gas grid distribution line is planned, and efforts are focused on the adoption of 10 additional standards covering electrolysis and on-site hydrogen production to support the refuelling of heavy-duty vehicles (Standards New Zealand, 2024).

At COP28, held in Dubai at the end of 2023, the Hydrogen Declaration (COP28 Declaration of Intent) was introduced and subsequently endorsed by 37 countries (COP28, 2023). At its core, the declaration reflects the intention of participating countries to cooperate in developing mutually recognizable certification systems for renewable and low-carbon hydrogen (and its derivatives), as well as in facilitating global trade. It was further stated that internationally recognized standards, such as ISO's greenhouse gas emissions methodology for hydrogen production and transportation, would be taken into consideration in this process and that progress would be monitored on an annual basis.

It is observed that global renewable hydrogen standards focus on carbon intensity, traceability, safety, and certification compliance. In order for Türkiye—which holds a significant position in terms of both domestic consumption and export potential—to realize this potential, standardization and international harmonization must be planned and implemented simultaneously with regulatory and infrastructure development. Given that target markets for renewable hydrogen exports demand hydrogen that meets high-quality and specific certification standards, it is anticipated that Türkiye will face high compliance costs in the initial phase. Although Türkiye possesses significant potential to establish a renewable hydrogen ecosystem aligned with these standards, it is necessary to develop national renewable hydrogen standards and a certification system. In developing these standards, ensuring alignment with ISO Standards and the RFNBO criteria will be crucial in order to assess Türkiye's export potential to the European market.

[5] ISO has established specific standards for the stages within the hydrogen value chain. The main references covering hydrogen production, storage, and transportation are provided in Annex A of the report.



SECTION 6
Technology Development

There are numerous factors affecting the cost of renewable hydrogen. Among these factors is whether the technologies used within the hydrogen value chain are produced domestically or imported. These technologies are not limited to electrolysers alone but encompass a wide range of systems, including transportation and logistics systems used during hydrogen transport (e.g., pipeline systems and tankers) as well as storage systems (e.g., compressed gas tanks and liquid hydrogen storage).

In this context, the domestic production of technologies within the renewable hydrogen value chain will constitute an important strategy for reducing external dependency in this field.

Challenges and Opportunities for Türkiye in Technology Development

6.1 Regulatory Framework, Standards, and Patent Constraints

The absence of established regulations and technical standards concerning the technologies used in the renewable hydrogen production process negatively affects Türkiye's technology development trajectory and constrains future investments.

A significant portion of the technologies that play a critical role in renewable hydrogen production—such as electrolysers, fuel cells, and hydrogen storage tanks—have been patented by companies operating in Europe, the United States, and Asian countries. This situation complicates Türkiye's ability to develop original products and systems and increases costs due to licensing fees and intellectual property constraints.

6.2 Education and Workforce Gaps

Although R&D activities targeting the development of specific technologies within the renewable hydrogen value chain have only recently begun in Türkiye, establishing a qualified human capital base is equally important for the commercialization and widespread deployment of these technologies. In this regard, adopting a strategic approach to human capital development is essential, particularly through the support of critical engineering disciplines such as chemical engineering and process engineering. The process should also be managed by analysing which areas require specialized human capital for the development of technologies used in renewable hydrogen production. Furthermore, it is necessary to incorporate programs and elective courses focused on hydrogen and fuel cells into the curricula of universities and vocational higher education institutions.

6.3 Support for R&D Activities

Through the localization of technology, external dependency in this field can be reduced, enabling the country to shift from a technology-importing position to technology-exporting one. In recent years, greater emphasis has been placed on R&D activities targeting certain technologies used in the renewable hydrogen production process, and investment in related projects has increased accordingly. In particular, TÜBİTAK and the Republic of Türkiye Ministry of Energy and Natural Resources (ETKB) have developed important initiatives encouraging universities to take on an active role in R&D activities and strengthening academic and technical infrastructure. In addition, various policy documents and action plans published by the public sector have established targets addressing the technological needs of renewable hydrogen. Currently, the most comprehensive strategic document in this context is the Türkiye Hydrogen Technologies Strategy and Roadmap. The document outlines public-sector targets, identifies needs related to renewable hydrogen technologies, and includes the implementation of R&D incentives among the policy measures to be adopted (ETKB, 2023).

Under the European Green Deal Action Plan, the Technological Transformation/Development Specialized Working Group was established in 2022 by the Republic of Türkiye Ministry of Trade. Drawing on the outputs of this working group, their objective was to identify the technological needs of industrial enterprises in line with Türkiye's green development goals. The working group's study covered six major industrial sub-sectors, including renewable hydrogen in the chemical and cement sectors. In the chemical industry, the study recommended planning efforts focused on the development of renewable hydrogen production and storage technologies. In the cement sector, it recommended R&D activities that prioritize technology development for the use of hydrogen as a fuel in conventional kilns (TÜBİTAK, 2023; TÜBİTAK, 2023).

In 2024, the Republic of Türkiye Ministry of Industry and Technology published the report Türkiye's Sectoral Low-Carbon Roadmap. The study examines the steps required for the steel, aluminium, cement, and fertilizer sectors to achieve the 2053 net-zero emissions target. In the steel sector, it is envisaged that high-temperature blast furnaces will be replaced by hydrogen-based (DRI) technology. In the cement sector, the roadmap identifies the need to conduct feasibility and technology assessment studies regarding the use of renewable hydrogen. For the fertilizer sector, the roadmap also emphasizes the implementation of R&D activities aimed at reducing the production costs of renewable hydrogen and green ammonia, both of which can serve as key input materials (Republic of Türkiye Ministry of Industry and Technology, 2024).

In the 2025 Presidential Annual Program, published in November 2024, it is stated that support will be provided for the domestic development and commercialization of components, equipment, and systems related to renewable hydrogen value chain processes. Within this scope, it was announced that an R&D project based on a chemical hydrogen storage method supported by the Turkish Energy, Nuclear and Mineral Research Agency (TENMAK) will be implemented (Presidency of the Republic of Türkiye Strategy and Budget Office, 2024).

At the international level, various EU funds constitute an important source of financing for R&D activities in Türkiye. Among these, Horizon Europe is preferred by researchers from universities, public institutions, and the private sector, as it provides opportunities for collaboration with researchers in other European countries (Oyan et al., 2024).

The inclusion of clearly defined policies and action plans in public strategy documents demonstrates Türkiye's commitment to the development and domestic production of the technologies needed to support the hydrogen value chain. Investments aligned with the identified targets are expected to contribute to the advancement of the hydrogen economy by facilitating access to international funding, ensuring alignment with global standards, fostering the development of a skilled workforce, and strengthening collaboration between universities and industry.

6.4 Industrial Infrastructure

The renewable hydrogen ecosystem offers investment opportunities across numerous sub-sectors. With the publication of the Türkiye Hydrogen Technologies Strategy and Roadmap, concrete steps have begun to be taken in this field, providing significant advantages for potential producers and investors in Türkiye. In this context, it is essential to ensure the domestic production of technologies within the renewable hydrogen value chain is developed at an adequate scale and capacity.

R&D activities aimed at the domestic production of electrolyzer technology were initiated in 2022 under the leadership of TÜBİTAK Marmara Research Center (TÜBİTAK MAM) through collaboration with public institutions, the private sector, and academia. On December 20, 2024, it was announced that the first domestically developed Proton Exchange Membrane (PEM) electrolyzer, capable of producing hydrogen with 99.9% purity, had been completed (Temiz Enerji, 2024). Following these developments, Aselsan and several universities also began investing in R&D activities focused on the domestic production of this technology. However, domestic electrolyzer manufacturing has not yet been scaled up to commercial levels.

There is already a well-developed international market for electrolyzer manufacturing, with approximately 60% of global electrolyzer production capacity concentrated in China (IEA, 2025). In order to enable the domestic production of certain high-technology components of electrolyzers, Türkiye should foster sectoral expertise and develop a qualified domestic workforce. Such efforts would lay the groundwork for expanding high-value, technology-intensive manufacturing processes within the country. If R&D activities and incentive mechanisms are sustained over the long term, Türkiye could assume the role of a full-system manufacturer in the 2030–2035 period, alongside the production of advanced components such as membrane types. This strategy offers a pathway through which Türkiye could enhance both its energy transition autonomy and its economic competitiveness.

Additionally, hydrogen storage tanks are required for the storage of hydrogen produced on-site. The production of compressors, valves, and cooling systems used in hydrogen storage and transportation remains limited in Türkiye and is largely dependent on imports. These components are of strategic importance in the hydrogen production and supply process. Although the aforementioned equipment is not yet manufactured domestically at scale, the infrastructure of the Turkish machinery and chemical industries has the capacity to support production in this area. Türkiye's Hydrogen Technologies Strategy and Roadmap also sets a target to prioritize compressor applications for hydrogen distribution as of 2030 (ETKB, 2023).

6.5 Coordination Among Universities, Public Institutions, and the Private Sector

In Türkiye, priority is given to fostering cooperation between universities and public and private sector actors to enable the domestic production of electrolyzer technology. The Presidency of the Republic of Türkiye Strategy and Budget Office's (SBB) Medium-Term Program (2026–2028), published on September 8, 2025, states that R&D laboratories will be supported within the framework of the university–industry collaboration model (SBB, 2025).

Strengthening coordination among universities, public institutions, and the private sector is essential to enable the domestic production of equipment related to the production, transportation, storage, and end use of renewable hydrogen. In this context, a collaborative model similar to Türkiye's Automobile Joint Venture Group (TOGG)—where public and private sector actors act in concert—could be considered for application in the field of hydrogen technologies. At the same time, it is critically important that pilot research centres established within universities are designed to directly address sectoral needs. Where necessary, the establishment of international technology partnerships to accelerate technological development would further enhance progress in this field.

SECTION 7
Hydrogen Exports and International Cooperation

Renewable hydrogen is regarded not only as a complementary component of the energy transition but also as a strategic export commodity for countries with high renewable energy potential. The anticipated growth in global hydrogen demand in the near future has made international cooperation in this field a critical factor. Partnerships established between countries across various domains play a decisive role in shaping the development of the renewable hydrogen market.

Challenges and Opportunities for Türkiye in Exporting Hydrogen and International Cooperation

7.1 International Competition

In line with net-zero emissions targets, many countries have prepared action plans that assign a prominent role to renewable hydrogen. With intensifying global competition in the renewable hydrogen field, countries have begun positioning themselves as potential exporters. In this context, European and Gulf countries have put forward ambitious plans aimed at exporting hydrogen. However, according to data from the IEA, as of 2024, projects that have reached a final investment decision or have begun construction for renewable hydrogen production facilities represent only 4% of the globally projected capacity (IEA, 2025).

Türkiye can develop a comprehensive roadmap for domestic renewable hydrogen production by conducting sectoral consumption analyses to assess projected domestic demand and allocate surplus production for export. To assume a significant role in the global supply chain, multiple parameters must be evaluated simultaneously, including the ability to produce renewable hydrogen at relatively competitive costs compared to other countries, support production with robust infrastructure, and ensure compliance with international standards.

7.2 Establishing Standards

According to analyses by SHURA (2022), under policy frameworks that promote renewable energy deployment and cost-effective investments, Türkiye could produce approximately 3.4 Mt of renewable hydrogen annually by 2050 (3.4 Mt H_2 /year). The analysis further indicates that, beyond meeting domestic demand, an annual export potential of approximately 1.5–1.9 Mt H_2 could be achieved.[6] To fully operationalize Türkiye's significant potential within the renewable hydrogen sector, the development of a robust regulatory and technical framework across the entire value chain remains imperative. In defining these standards, it is recommended that internationally recognized frameworks—such as those applicable to the EU market—be carefully examined and incorporated where relevant. Ensuring alignment with such frameworks would facilitate consistency and compatibility with the standards of importing countries if Türkiye begins exporting hydrogen.

[6] The relevant analysis was conducted prior to Türkiye's announcement of its 2053 net-zero emissions target.

7.3 Strategic Position

Türkiye's location in proximity to oil- and natural gas-rich countries has positioned it as a transit corridor between Asia and Europe through pipeline infrastructure. Despite recent regional and global challenges, Türkiye retains the potential to support Europe's search for alternative energy supplies. According to the Global Hydrogen Review 2025, published by the IEA in September 2025, global hydrogen demand reached 100 Mt in 2024, reflecting a 2% increase compared to the previous year (IEA, 2025). In line with their net-zero emissions targets, many countries—including EU member states—are planning to increase renewable hydrogen imports.

7.4 Transport and Logistics Infrastructure

Maritime ports that are located in Türkiye could enable the maritime transportation of renewable hydrogen. In this context, the ports of Aliağa (İzmir) and Tekirdağ, which are currently used for the transport of chemical products such as oil, natural gas, and LNG, serve as illustrative examples. With targeted investments, these ports could be adapted to handle hydrogen and its derivatives. This would require the installation of specialized storage tanks, cooling systems, and dedicated loading and unloading infrastructure.

7.5 Existing Partnerships

There are currently several renewable hydrogen cooperation initiatives in which Türkiye is involved. In this context, the declaration signed by Türkiye and Japan to develop the Japan–Türkiye Energy Forum aims to establish a strategic cooperation platform covering various clean energy technologies, including renewable hydrogen (Anadolu Agency, 2023). Another example is the HYSouthMarmara Project, implemented with grant support from the EU and carried out in cooperation with Norway (HYSouthMarmara, 2024). The project facilitates knowledge and technology exchange with Norway. In addition, a multinational hydrogen initiative is being planned through a partnership between Türkiye-based ERIH Holdings and United Kingdom-based PASH Global, targeting 10 GW of renewable energy capacity and 5 GW of electrolyzer capacity (TAIYANGNEWS, 2023). These collaborations strengthen Türkiye's ambition to become a regional hub for hydrogen production and, if sustained, could create opportunities for additional international partnerships.

Conclusion and Policy Recommendations

The analysis presented in this report—which examines market formation, financing, infrastructure, technology, and standards for the renewable hydrogen sector—indicates that significant structural challenges remain in the development of the renewable hydrogen ecosystem. High investment costs, the lack of a sufficiently clear regulatory framework, gaps in carbon pricing and certification infrastructure, and limited demand visibility are contributing to delays in investment decisions.

At present, renewable hydrogen is regarded as a costly energy carrier and feedstock due to high production costs and the fact that technological maturity has not yet reached the desired level. As a result, many projects worldwide are being postponed or cancelled. According to the IEA, as of 2024, projects for renewable hydrogen production facilities that have reached a final investment decision or begun construction represent only 4% of the globally projected capacity (IEA, 2025). In contrast, global demand for renewable hydrogen increased by 10% in 2024 compared to the previous year. At the end of 2025, total renewable hydrogen production was expected to reach 1 Mt (IEA, 2025). This trend suggests that despite short-term supply-side challenges, demand for renewable hydrogen may strengthen over the medium to long term.

The economic benefits arising from the use of renewable hydrogen will be directly linked to the effectiveness of current and future energy policies. In this context, two fundamental principles should guide the design of renewable hydrogen policies. First, hydrogen production should be planned in a manner consistent with the decarbonization targets of the power sector. Second, hydrogen deployment should focus on end-use applications where it can have the greatest impact on emissions reduction. These principles ensure that renewable hydrogen makes an additional and complementary contribution to the energy transition while remaining aligned with existing policy instruments. Accordingly, designing policies and incentive mechanisms with a primary focus on applications in hard-to-abate sectors will be decisive in accelerating the transition from fossil fuels to renewable hydrogen.

For Türkiye to meet domestic demand along its decarbonization pathway while also assuming a meaningful and sustainable role in the global market, the initial priority should be the establishment of a comprehensive renewable hydrogen ecosystem. In this context, priority should be given to developing a regulatory framework and market structure that encompasses all stages of the renewable hydrogen value chain, establishing clear standards, scaling up ongoing R&D investments to support technological advancements, and facilitating the transformation of priority sectors that can most efficiently utilize renewable hydrogen as a fuel or feedstock. Support and incentive mechanisms that enable these sectors to integrate hydrogen use into their planning processes will contribute to demand formation and the scaling up of production. Strengthening the demand side would enable production to scale up, thereby contributing to lower hydrogen production costs through economies of scale.

Türkiye's institutional and technical experience in electricity and natural gas markets—particularly the capacity of institutions such as EPİAŞ and EPDK—provides a strong foundation for establishing a phased and controlled market structure for renewable hydrogen. In this context, the Organized Wholesale Natural Gas Market operated by EPİAŞ could, under appropriately designed regulatory conditions, serve as a reference model for renewable hydrogen market development. As the market regulator, EPDK could leverage its experience in designing and overseeing regulatory frameworks to provide the institutional structure necessary for hydrogen trading, pricing mechanisms, supply–demand balancing, and transparent market operations. This accumulated institutional expertise offers the Turkish market a significant advantage by enabling hydrogen to be integrated into the energy system in a predictable, measurable, and market-based manner rather than entering the market abruptly and in a fragmented manner.

For the development of the renewable hydrogen ecosystem, the establishment of a national-scale Hydrogen Bank model—similar to examples implemented in Europe—would constitute a strategic step. Such a structure would provide a financial and institutional framework that brings together renewable hydrogen producers and the demand side while stimulating the market through mechanisms such as price supports and offtake guarantees. A national Hydrogen Bank would both enhance investor confidence—thereby facilitating the realization of large-scale production projects—and strengthen the country's international competitiveness in line with its green transformation objectives.

To ensure the sustainability of renewable hydrogen production and to prevent competition with the transformation of the power sector, it is essential to expand installed renewable energy capacity through the development of new projects. In this context, additional renewable energy capacity should be deployed in parallel with the pilot electrolyzer facilities planned for installation so as to directly support hydrogen production. By systematically developing hydrogen production zones and related infrastructure in proximity to renewable energy power plants, the necessary foundation for sustainable and scalable production can be established in a planned manner. Locating the first electrolyzer facilities near renewable energy plants would help reduce production costs and improve overall energy efficiency.

To secure a competitive advantage in the global hydrogen market, leveraging Türkiye's substantial renewable energy potential must be established as a core strategic priority. Achieving this objective would enhance the sustainability of the hydrogen ecosystem and increase its medium-term contribution to the national economy. In addition, directing renewable hydrogen production that exceeds domestic demand toward exports would enable Türkiye to establish a strategic position in the global hydrogen market. In this context, it is essential to adopt a framework aligned with internationally recognized standards—particularly those of the EU—for renewable hydrogen production, transportation, and related technological infrastructure development. Such alignment would allow renewable hydrogen to become a new, high value-added component of trade relations between Türkiye and the EU. This process would also create opportunities to deepen energy integration with the EU and to develop joint project and financing models.
When assessed from a holistic perspective, renewable hydrogen represents not only an alternative that can enhance energy supply security for Türkiye but also a critical opportunity to advance sustainable development objectives. With its abundant renewable energy resources—particularly solar and wind—Türkiye has the potential to combine this capacity with renewable hydrogen production, thereby both reducing carbon emissions in its transition toward a net-zero economy and gaining a competitive advantage in international markets.

However, to realize this transformation, complementary action plans building upon the Türkiye Hydrogen Technologies Strategy and Roadmap published in 2023 must be developed. It is also necessary to strengthen public–private partnerships, ensure the continuity of R&D investments, and establish a comprehensive regulatory framework. In addition, clarifying safety standards and certification processes across the renewable hydrogen value chain, and aligning them with international initiatives—particularly the European Green Deal—would facilitate Türkiye's positioning as a potential renewable hydrogen exporter.

Taking into account the main findings of this report, several policy recommendations that may be considered in the process of establishing a renewable hydrogen ecosystem in Türkiye are summarized below.

Recommendations for the Development of Renewable Hydrogen in Türkiye

Türkiye should establish a dedicated public authority responsible for defining administrative permitting procedures and related support mechanisms for renewable hydrogen, as well as coordinating cross-sectoral production and development plans: Through the establishment of such a hydrogen-focused public body, it would be possible to develop both primary and secondary legislation, thereby providing investors with a clear and predictable roadmap. Within this framework, site selection criteria and technical standards for hydrogen production facilities could be defined, while support and incentive mechanisms facilitating access to financing could also be developed.

The proposed structure could be positioned within the SBB or ETKB. This would ensure that legislation, standards, and certification systems related to renewable hydrogen are developed by a single authority with dedicated expertise in this field. At the same time, the relevant public body would assume a central role in the sector from both a regulatory and strategic perspective.

A clear legal definition of renewable hydrogen should be established: For the renewable hydrogen market to develop in a sound, transparent, and predictable manner, renewable hydrogen must be provided with a clear and binding legal definition within the regulatory framework. In this regard, it is recommended that the necessary amendments be made to Law No. 5346 on the Use of Renewable Energy Resources for the Purpose of Generating Electrical Energy so that renewable hydrogen is formally defined as both an energy carrier and a feedstock produced using renewable energy sources.

Such a legal definition would help clarify the scope of renewable hydrogen, including applicable emissions standards and certification principles, thereby reducing legal uncertainty for investors and supporting long-term investment decisions. Furthermore, this regulatory clarification would enable renewable hydrogen to be addressed within a holistic policy framework encompassing energy, industrial, and climate policies. It would also provide a strong and coherent legal foundation for the development of future incentive mechanisms and market regulations.

Renewable hydrogen should not compete with the transformation of the power sector: A comprehensive regulatory framework for renewable hydrogen production should be established based on the principle of additionality. In this context, prioritizing new renewable energy investments dedicated specifically to hydrogen production—rather than relying on existing renewable energy plants—would help prevent competition with power sector decarbonization and direct electrification objectives. In addition, directing surplus electricity generation to electrolyzers as a complementary policy instrument should be considered as a means of reducing renewable energy curtailment.

In the deployment of renewable hydrogen and its derivatives (such as green ammonia and synthetic kerosene), priority should initially be given to sectors where the highest value-added can be achieved and where direct electrification alone is insufficient for deep decarbonization: This approach would enable the efficient use of limited resources, ensuring that renewable hydrogen delivers the highest benefit in terms of climate and industrial policy objectives. In this context, as indicated by SHURA (2025), priority use areas for renewable hydrogen in Türkiye include ammonia (fertilizer) production, the iron and steel sector, the chemical industry (including refineries and petrochemicals), the glass and ceramics industries, and long-distance transportation, particularly aviation and maritime transport. Deploying renewable hydrogen in these sectors would enable rapid and effective emissions reductions in areas with high abatement potential. Such prioritization would also support the scaling up of renewable hydrogen, contribute to cost reductions, accelerate technological learning processes, and facilitate hydrogen's gradual expansion into a broader range of sectors over the medium term.

A comprehensive regulatory framework for renewable hydrogen should be established in Türkiye: This framework should be designed to encompass all stages of the hydrogen value chain—including production, storage, distribution, and consumption—thereby eliminating existing legal and technical uncertainties and creating a predictable and stableenvironment for renewable hydrogen investments. In addition, the clear and coherent definition of safety, emissions, and quality standards would support the safe and efficient development of renewable hydrogen in the domestic market while facilitating potential cross-border trade through alignment with international standards. Such a regulatory framework would strengthen the integration of renewable hydrogen into Türkiye's energy system and contribute to the country's ability to assume an active role in the global hydrogen market.

Financial incentives should be introduced to promote domestic renewable hydrogen production: To support the development of local supply and accelerate renewable hydrogen production, targeted financial incentive mechanisms should be implemented. Tax exemptions and limited-volume FiT schemes could help offset high initial costs during the early stages of market development. In addition, competitive hydrogen auctions—similar in design to the Renewable Energy Resource Area (YEKA) model—could be introduced for priority consumers, particularly for refineries and the iron and steel sector. These incentive instruments would reduce investment risks, increase private sector participation, and support Türkiye's position in the renewable hydrogen market.

Ensure the simultaneous implementation of investments across the renewable hydrogen value chain to facilitate project progress and increase the likelihood of successful project realization: Investments across the renewable hydrogen value chain should be implemented simultaneously and in a coordinated manner. Planning simultaneous investments in production, transportation, storage, and consumption together would help prevent bottlenecks and ensure that projects progress in an integrated and balanced manner. This approach would enhance investor confidence, allow for early validation of technical integration, and support the scaling up of renewable hydrogen projects.

Establish hydrogen hubs (HUB) in areas close to renewable energy resources to drive the development of the hydrogen ecosystem: These hubs would enable integrated planning of the hydrogen value chain—from production to end use—while also fostering technological advancements through clustered R&D projects that strengthen collaboration between academia and industry.

Hydrogen Special Production Zones should be designated to address critical infrastructure needs: Hydrogen Special Production Zones—modelled after the YEKA framework—should be designated to address critical infrastructure needs. Through these zones, the infrastructure required for the reliable, sustainable, and scalable production of renewable hydrogen could be developed in a coordinated and planned manner. Positioning such zones in proximity to renewable energy resources would help reduce production costs and enhance overall energy efficiency.

Improving and upgrading airport and port infrastructure is important for supporting the production, transportation, storage, and utilization of hydrogen: To support the production, transportation, storage, and use of hydrogen, it is important that airport and port infrastructure be upgraded in a manner compatible with the renewable hydrogen ecosystem. In this context, in order to accelerate the implementation of the necessary construction and infrastructure investments, it is recommended that, in addition to direct financial support, tax incentives and subsidy mechanisms be introduced for infrastructure development.

Technical and safety standards for renewable hydrogen used in industry should be regulated within a clear legal framework: To ensure the safe and reliable use of renewable hydrogen, legal responsibilities across the production, storage, transportation, and consumption stages must be clearly defined. Establishing such legal clarity would also facilitate the application of consistent standards across all relevant countries once Türkiye is ready to export renewable hydrogen. This, in turn, would support Türkiye's potential future role as a renewable hydrogen exporter.

Strengthen domestic R&D capacity and collaboration between universities and industry: Joint R&D projects—of which there are already several examples in Türkiye—should be expanded with greater involvement from universities, and existing public incentive mechanisms should be further strengthened. Increasing the role of universities in facilitating the transition from pilot-scale to commercial-scale applications would also contribute to the development of a qualified workforce required for future high-technology production. In this context, specific legal and financial arrangements to support university-based R&D activities could be introduced. Such measures would enhance Türkiye's capacity to develop high-technology products and reduce external dependency in critical technologies.

Develop a qualified workforce in the field of hydrogen production and ensure continuity in employment: The implementation of renewable hydrogen projects in Türkiye will generate employment opportunities both during the construction phase and across all stages of the hydrogen value chain thereafter. In this context, course offerings related to renewable hydrogen technologies within existing engineering programs at universities should be expanded, and greater emphasis should be placed on graduate-level programs. Beyond universities, the establishment of a hydrogen academy—supported by dedicated funding and designed to provide expertise across each stage of the hydrogen value chain—could also be considered. In addition, strong partnerships that facilitate technology and knowledge transfer between the private sector and academia should be further strengthened.

Establish national and international standards to support the domestic production of technologies used in hydrogen production processes: Establishing clear technical standards for these technologies would accelerate domestic R&D activities and facilitate the commercialization of related products. Defining safety, quality, and environmental compliance standards for the domestic manufacturing process would also provide greater certainty for investors and enable secure investment decisions. To unlock the country's potential for domestic technology production and to compete effectively in global markets, Türkiye will need to develop a technology-focused regulatory infrastructure aligned with international rules and standards.

In Türkiye's renewable hydrogen production strategy, the energy dimension and the sustainability of water resources should be addressed in an integrated manner: Hydrogen production facilities should be located in regions with high renewable energy potential and access to sustainable water resources. Pressure on natural water resources should be reduced through the treatment and reuse of wastewater. In addition, to ensure the planned and efficient management of water consumption in hydrogen production, a coordination mechanism could be established between the ETKB and the Ministry of Environment, Urbanization and Climate Change. Within this framework, it is important that national water management efforts be expanded to incorporate renewable hydrogen planning.

Develop an export strategy for surplus renewable hydrogen production: For Türkiye to assume a meaningful role in the international renewable hydrogen market, it will be important to establish a market environment in which the quantity and pricing of hydrogen intended for export can be clearly determined. At the same time, comprehensive strategies are needed to ensure that pricing mechanisms adequately reflect hydrogen production costs, thereby supporting economically sustainable export decisions.

Develop sector-specific regulatory measures to accelerate the creation of demand for renewable hydrogen: Identifying priority sectors that will use renewable hydrogen as a feedstock or fuel and accelerating policy mechanisms aimed at stimulating demand in these sectors could facilitate the provision of offtake guarantees and support secure investment on the supply side. In a scenario where the CBAM becomes operational, sectors affected by the mechanism are also likely to accelerate their adoption of renewable hydrogen.

References

Agora Energiewende, 2021. Making renewable hydrogen cost-competitive. https://www.agora-energiewende.org/fileadmin/Projekte/2020/2020_11_EU_H2-Instruments/A-EW_223_H2-Instruments_WEB.pdf

Anadolu Ajansı, 2023. Türkiye-Japonya iş birliğinde "yenilenebilir enerji ve hidrojen" öne çıkıyor. https://www.aa.com.tr/tr/ekonomi/turkiye-japonya-isbirliginde-yenilenebilir-enerji-ve-hidrojen-one-cikiyor/2999651

Avrupa Parlamentosu, 2023. EU rules for renewable hydrogen. https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/747085/EPRS_BRI(2023)747085_EN.pdf

Avrupa Parlamentosu, t.y. Renewable hydrogen https://energy.ec.europa.eu/topics/eus-energy-system/hydrogen/renewable-hydrogen_en

CertifHy, t.y. About. https://www.certifhy.eu/

Clean Hydrogen Partnership, 2020. CertifHy. https://www.clean-hydrogen.europa.eu/get-involved/hydrogen-certification_en

COP28, 2023. COP28 DECLARATION OF INTENT. https://www.cop28.com/en/cop28-uae-declaration-on-hydrogen-and-derivatives

Çelik İhracatçıları Birliği, 2025. İSTATİSTİKLER. https://www.cib.org.tr/tr/istatistikler

DIN, 2025. Standardization roadmap for hydrogen technologies. https://www.din.de/en/innovation-and-research/hydrogen/standardization-roadmap-for-hydrogen-technologies/publication

Dinçer, İ., Ezan, M., 2020. TÜBA-ENERJİ DEPOLAMA TEKNOLOJİLERİ RAPORU. https://www.tuba.gov.tr/files/yayinlar/raporlar/T%C3%9CBA-Enerji%20Depolama%20Teknolojileri%20Raporu.pdf

Ehb, 2022. European Hydrogen Backbone. https://ehb.eu/files/downloads/ehb-report-220428-17h00-interactive-1.pdf

Emissions-EUETS, 2025. Hydrogen guarantees of origin (H-GOs). https://www.emissions-euets.com/rfnbo-temporal-correlation?view=article&id=2377:hydrogen-guarantee-of-origin&catid=1935#:~:text=As%20underlined%20in%20the%20ENTSO,electricity%20to%20include%20renewable%20hydrogen.

EPDK, 2021. 2021 Yılı Elektrik Piyasası Aralık Ayı Sektör Raporu. https://www.epdk.gov.tr/Detay/Icerik/3-0-23-3/elektrikaylik-sektor-raporlar

EPDK, 2025. 2025 Yılı Elektrik Piyasası Eylül Ayı Sektör Raporu. https://www.epdk.gov.tr/Detay/Icerik/3-0-23-3/elektrikaylik-sektor-raporlar

ETKB, 2023. EİGM Raporları. https://enerji.gov.tr/eigm-raporlari

ETKB, 2023. Türkiye Hidrojen Teknolojileri Stratejisi ve Yol Haritası. https://enerji.gov.tr/Media/Dizin/SGB/tr/Kurumsal_Politikalar/HSP/ETKB_Hidrojen_Stratejik_Plan2023.pdf

ETKB, 2024. Yenilenebilir Enerjide 2035 Yol Haritası Lansman Sunumu. https://enerji.gov.tr/Media/Dizin/BHIM/tr/Duyurular/Yenilenebilir%20Enerjide%202035%20Yol%20Haritas%C4%B1%20Lansman%20Sunumu_202410221014.pdf

European Hydrogen Observatory, 2025. Hydrogen and Decarbonised Gas Market Package. https://observatory.clean-hydrogen.europa.eu/eu-policy/hydrogen-and-decarbonised-gas-market-package

EVS, t.y. ISO/TS 19870:2023 https://www.evs.ee/en/iso-ts-19870-2023

Filament Technology, t.y. Our Story. https://www.filamentechnology.com/about

Filament Technology, t.y. Type-4 Hydrogen Storage Tanks. https://www.filamentechnology.com/products/hydrogen-storage-tanks

H_2eart for Europe, 2024. The role of underground hydrogen storage in Europe. https://h2eart.eu/wp-content/uploads/2024/01/H2eart-for-Europe_Report_Role-of-UHS-inEurope.pdf

H_2Türk, t.y. Hidrojen Tankı. https://www.h2turk.com.tr/tr/kategori/hidrojen-tanki/890

Hafsi, Z., Mishra, M., Elaoud, S., 2018. Hydrogen embrittlement of steel pipelines during transients. https://www.researchgate.net/publication/330028247_Hydrogen_embrittlement_of_steel_pipelines_during_transients

Hydrogen Newsletter, 2025. Powering the Future: Latest Breakthroughs in PEM Electrolyzers for Green Hydrogen in 2025. https://www.hydrogennewsletter.com/powering-the-future-latest-breakthroughs-in-pem-electrolyzers-for-green-hydrogen-in-2025/amp/

HYSouthMarmara, t.y. Hakkımızda. https://hysouthmarmara.org/hakkimizda

HYSouthMarmara, 2024. NORVEÇ-TÜRKİYE ORTAKLIĞI. https://hysouthmarmara.org/yazi/3

IEA, 2024. Hydrogen production. https://www.iea.org/reports/global-hydrogen-review-2024/hydrogen-production

IEA, 2025. Global Hydrogen Review 2025. https://www.iea.org/reports/global-hydrogen-review-2025

Iglauer, S., Ali, M., Keshavarz, A., 2020. Geophysical Research letters. https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020GL090814

IPEC, t.y. Hidrojen Depolama ve Dağıtım Sistemleri. https://ipec.com.tr/tr/hydrogen-storage-and-distribution-systems/

ISO, 2023. ISO at COP28: Accelerating climate action. https://www.iso.org/events/cop28.html

ISO, 2023. ISO/TS 19870:2023. https://www.iso.org/standard/65628.html

ISO, 2025. ISO 14687:2025. https://www.iso.org/standard/82660.html

ISO, t.y. ISO 19880-8:2024. https://www.iso.org/standard/83949.html

ISO, t.y. ISO/DIS 13984. https://www.iso.org/standard/86295.html

Kamps, A., Citters, C., Schut, C., 2021. Hydrogen for the ceramic industry. https://www.gasunie.nl/nieuws/publicatie-rapport-h2-voor-de-keramische-industrie

Miocic, J., Heinemann, N., Edlmann, K., Scafidi, J., Molaei, F., Alcalde, J. 2023. Underground

hydrogen storage: a review. https://chooser.crossref.org/?doi=10.1144%2FSP528-2022-88

Oyan, E., Boie, I., Dütschke, E., Kantel, A., Müller, V., Scherrer, A., Aboushady, N., Altenburg, T., Stamm, A., Strohmaier, R., 2024. Towards a Green H2 Economy: Türkiye Country Report. https://hypat.de/hypat-wAssets/docs/new/publications/hypat_country-report_turkey.pdf

Perera, 2023. A review of underground hydrogen storage in depleted gas reservoirs: Insights into various rock-fluid interaction mechanisms and their impact on the process integrity. https://www.sciencedirect.com/science/article/abs/pii/S0016236122035013?via%3Dihub

Petrotürk, n.d. Doğal gaz sektöründe hidrojene geçiş için 4 aşamalı yol haritası. https://www.petroturk.com/dogalgaz-haberleri/dogal-gaz-sektorunde-hidrojene-gecis-icin-4-asamali-yol-haritasi

RaillyNews, 2023. Financial Support for Hydrogen Initiatives Is Increasing. https://en.rayhaber.com/2023/10/hidrojen-girisimlerine-finansman-destegi-artiyor/

SHURA, 2021. Türkiye'nin yeşil hidrojen üretim ve ihracat potansiyelinin teknik ve ekonomik açıdan değerlendirilmesi. https://shura.org.tr/turkiyenin-yesil-hidrojen-uretim-ve-ihracat-potansiyelinin-teknik-ve-ekonomik-acidan-degerlendirilmesi/

SHURA, 2022. Türkiye'nin Yeşil Hidrojen Üretim ve İhracat Potansiyelinin Teknik ve Ekonomik Açıdan Değerlendirilmesi. https://shura.org.tr/turkiyenin-yesil-hidrojen-uretim-ve-ihracat-potansiyelinin-teknik-ve-ekonomik-acidan-degerlendirilmesi/

SHURA, 2023. Türkiye'de Konut ve Sanayi Sektörünün Elektrifikasyonu. https://shura.org.tr/turkiyede-konut-ve-sanayi-sektorunun-elektrifikasyonu-raporu/

SHURA, 2023. Net Sıfır 2053: Türkiye Elektrik Sektörü için Yol Haritası. https://www.shura.org.tr/wp-content/uploads/2023/05/Net-Zero-EN.pdf

SİS, t.y. Hydrogen technologies — Methodology for determining the greenhouse gas emissions associated with the production, conditioning and transport of hydrogen to consumption gate (ISO/TS 19870:2023). https://www.sis.se/en/produkter/energy-and-heat-transfer-engineering/hydrogen-technologies/sis-isots-198702024/

Standards New Zealand, 2024. Hydrogen as our fuel of the future takes a step closer with 13 newly published standards. https://www.standards.govt.nz/news-and-updates/hydrogen-as-our-fuel-of-the-future-takes-a-step-closer-with-13-newly-published-standards

ŞAN, S., KARAKILÇIK, M., 2021. TUZ DOMLARINDA HİDROJEN DEPOLAMA YÖNTEMLERİNİN İNCELENMESİ.
https://fbe.cu.edu.tr/storage/makaleler/2021/TUZ%20DOMLARINDA%20H%C4%B0DROJEN.pdf

TAIYANGNEWS, 2023. Cross Continent Green Hydrogen Joint Venture.
https://taiyangnews.info/business/cross-continent-green-hydrogen-joint-venture

T.C. Cumhurbaşkanlığı Strateji ve Bütçe Başkanlığı, 2024. 2025 YILI CUMHURBAŞKANLIĞI YILLIK PROGRAMI.
https://www.sbb.gov.tr/wp-content/uploads/2024/11/2025-Yili-Cumhurbaskanligi-Yillik-Programi-05112024.pdf

T.C. Çevre ve Şehircilik Bakanlığı, 2012. Türkiye'de Karbon Piyasası.
https://evcedruzgar.enerji.gov.tr/iklim_deg/document/karbon_piyasasi.pdf

T.C. Çevre, Şehircilik ve İklim Değişikliği Bakanlığı, 2024. Türkiye Karbon Piyasası Geliştirme Projesi Açılışı T.C. Çevre, Şehircilik ve İklim Değişikliği Bakanı Mehmet Özhaseki tarafından gerçekleştirildi.
https://iklim.gov.tr/turkiye-karbon-piyasasi-gelistirme-projesi-acilisi-t.c.-cevre-sehircilik-ve-iklim-degisikligi-bakani-mehmet-ozhaseki-tarafindan-gerceklestirildi-haber-4258

T.C. Dışişleri Bakanlığı Avrupa Birliği Başkanlığı, 2023. ReFuelEU Havacılık Girişimi: AB Konseyi, Havacılık Sektörünün Karbonsuzlaştırılmasına Yönelik Yeni Tüzüğü Kabul Etti.
https://www.ab.gov.tr/53623.html

T.C. Enerji ve Tabii Kaynaklar Bakanlığı, 2023. Türkiye Hidrojen Teknolojileri Stratejisi ve Yol Haritası.
https://enerji.gov.tr/Media/Dizin/SGB/tr/Kurumsal_Politikalar/HSP/ETKB_Hidrojen_Stratejik_Plan2023.pdf

T.C. Enerji ve Tabii Kaynaklar Bakanlığı, 2024. 2023 Yılı Ulusal Enerji Denge Tabloları.
https://enerji.gov.tr/duyuru-detay?id=30488

T.C. Enerji ve Tabii Kaynaklar Bakanlığı, 2024. Yenilenebilir Enerjide 2035 Yol Haritası.
https://enerji.gov.tr/Media/Dizin/BHIM/tr/Duyurular/Yenilenebilir%20Enerjide%202035%20Yol%20Haritas%C4%B1%20Lansman%20Sunumu_202410221014.pdf

T.C. Sanayi ve Teknoloji Bakanlığı, 2024. Türkiye Sektörel Düşük Karbonlu Yol Haritaları.
https://www.sanayi.gov.tr/assets/pdf/birimler/sektorel-dusuk-karbonlu-yol-haritalari-sunum.pdf

T.C. Strateji ve Bütçe Başkanlığı, 2025. Orta Vadeli Program (2026-2028).
https://www.sbb.gov.tr/wp-content/uploads/2025/09/Orta-Vadeli-Program-2026-2028.pdf

T.C. Ticaret Bakanlığı, 2024. Sanayi ve Hizmetler.
https://ticaret.gov.tr/ihracat/sektorler/Sanayi%20ve%20Hizmetler

Temiz Enerji, 2024. Türkiye, yeşil hidrojen üretimi için ilk yerli elektrolizörünü geliştirdi.
https://temizenerji.org/2024/12/20/turkiye-yesil-hidrojen-uretimi-icin-ilk-yerli-elektrolizorunu-gelistirdi/

TEKSİS, t.y. Hidrojen Depolama Çözümleri.
https://www.tek-sis.com/tr/sayfa/164/hidrojen-depolama-cozumleri

TÜBİTAK, 2023. Clean Hydrogen Partnership (Temiz Hidrojen Ortaklığı) 2022 Yılı Çağrısı Kapsamında HYSouthMarmara Projesi Avrupa Komisyonu Tarafından Desteklenmeye Hak Kazandı!.
https://ufukavrupa.org.tr/tr/haberler/clean-hydrogen-partnership-temiz-hidrojen-ortakligi-2022-yili-cagrisi-kapsaminda

TÜBİTAK, 2023. Türkiye'nin İlk Hidrojen Vadisi ve Türkiye'nin En Büyük Kapasiteli İlk Yerli Yeşil Hidrojen Tesisi Kuruluyor.
https://tubitak.gov.tr/tr/haber/turkiyenin-ilk-hidrojen-vadisi-ve-turkiyenin-en-buyuk-kapasiteli-ilk-yerli-yesil-hidrojen-tesisi-kuruluyor

TÜBİTAK, 2023. YEŞİL BÜYÜME TEKNOLOJİ YOL HARİTASI ÇİMENTO SEKTÖRÜ.
https://tubitak.gov.tr/sites/default/files/2024-04/Yesil_TYH_Cimento_29042024.pdf

TÜBİTAK, 2023. YEŞİL BÜYÜME TEKNOLOJİ YOL HARİTASI KİMYASALLAR SEKTÖRÜ.
https://tubitak.gov.tr/sites/default/files/2023-12/yesil_tyh_kimyasallar_raporu_16082023.pdf

TÜİK, 2025. Dış Ticaret İstatistikleri, Aralık 2024.
https://data.tuik.gov.tr/Bulten/Index?p=D%C4%B1%C5%9F-Ticaret-%C4%B0statistikleri-Aral%C4%B1k-2024-53538&dil=1

Türkiye Çelik Üreticileri Derneği, 2025. Çelik Haritası. https://celik.org.tr/harita/

Uniper, 2022. EverWind Secures Offtake from Key German Partner Uniper for Canada's First Green Hydrogen Hub in Nova Scotia.
https://www.uniper.energy/news/everwind-secures-offtake-from-key-german-partner-uniper-for-canadas-first-green-hydrogen-hub-in-nova-scotia

Yeşilhaber, 2025. H2DER Başkanı Günay: Yeşil hidrojen üretim sanayi bölgeleri ilan edilmeli.
https://yesilhaber.net/yesil-hidrojen-uretim-sanayi-bolgeleri/

Yeşilhat, 2023. Türkiye'nin ilk hidrojen köyü "HyVillage" yolda.
https://www.aa.com.tr/tr/yesilhat/teknoloji/turkiyenin-ilk-hidrojen-koyu-hyvillage-yolda/1819613

Appendix

Appendix A

The standards specified by ISO for the steps within the hydrogen value chain are presented in Table 1

Table1. ISO standards identified within the scope of the hydrogen value chain

Standard	Scope	Definition
ISO 22734	Production	It defines the construction, safety, and performance requirements of modular or factory-matched hydrogen gas generation appliances (hydrogen generators) that electrolyze water through electrochemical reactions to produce hydrogen from water.
ISO 22734-1:2025	Production	It specifies the safety requirements for hydrogen gas generation appliances or systems that use electrochemical reactions to produce hydrogen by water electrolysis.
ISO/TR 15916:2015	Production and storage	It provides guidelines for the use and storage of hydrogen in its gaseous and liquid states. It identifies fundamental safety concerns, hazards, and risks, and explains the safety-related properties of hydrogen. Detailed safety requirements associated with specific hydrogen applications are addressed in separate international standards.
ISO 13985:2006	Storage	It specifies the construction requirements for refillable fuel tanks for liquid hydrogen used in land vehicles, and the test methods necessary to ensure a reasonable level of protection against loss of life and property resulting from fire and explosion.
ISO 19880-1:2020	Distribution	It defines the minimum design, installation, commissioning, operation, inspection, and maintenance requirements for the safety and, where required, the performance of public and private fueling stations that dispense gaseous hydrogen to light-duty vehicles (e.g., fuel cell electric vehicles).
ISO 19880-2:2025	Distribution	It specifies the safety requirements and test methods for the components and systems that enable the transfer of compressed hydrogen to a hydrogen-fueled vehicle.
ISO 17268-1:2025	Distribution	It specifies the design, safety, and operational characteristics of refuelling connectors for gaseous hydrogen land vehicles.
ISO 14687:2025	End-use consumption	It specifies the minimum quality characteristics of hydrogen fuel intended for various applications, such as residential, commercial, industrial, vehicular, and stationary use. It establishes the requirements to ensure that hydrogen fuel meets the necessary safety and performance standards. It is particularly significant in the context of hydrogen's increasing role in energy systems to reduce greenhouse gas emissions.
ISO 21087:2019	End-use consumption	It specifies the validation protocol for analytical methods used to ensure the quality of gaseous hydrogen at hydrogen distribution centers and refueling stations for land vehicles utilizing proton exchange membrane (PEM) fuel cells. Additionally, it provides recommendations for calculating the uncertainty budget for the amount fraction.
ISO 23273:2013	End-use consumption	It specifies the essential requirements for the protection of persons and the environment, both inside and outside fuel cell vehicles, against hydrogen-related hazards.

Source: ISO

About Istanbul Policy Center at Sabancı University

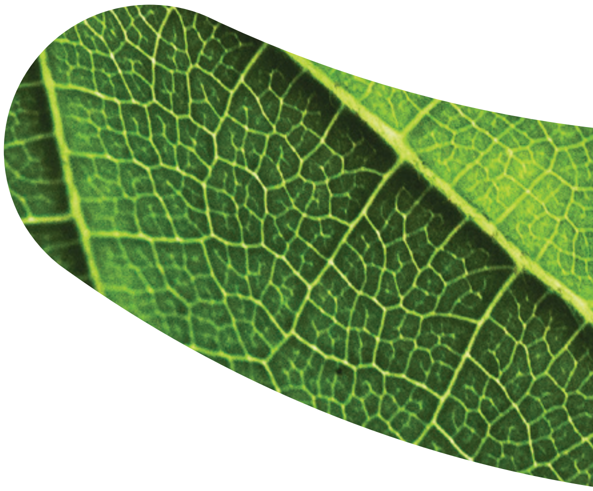
Istanbul Policy Center (IPC) is a global policy research institution that specializes in key social and political issues ranging from democratization to climate change, transatlantic relations to conflict resolution and mediation. IPC organizes and conducts its research under three main clusters: The 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 KAMPUSU İSTANBUL POLICY CENTER AT SABANCI UNIVERSITY

European Climate Foundation

Agora Energiewende

SHURAEDM SHURAEDM SHURA Enerji Dönüşümü Merkezi /company/shura @shuraedm