

# strategy&

“Türkiye’s promising steps at the verge of crossroads for establishing the green hydrogen economy”



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# “Türkiye’s promising steps at the verge of crossroads for establishing the green hydrogen economy”

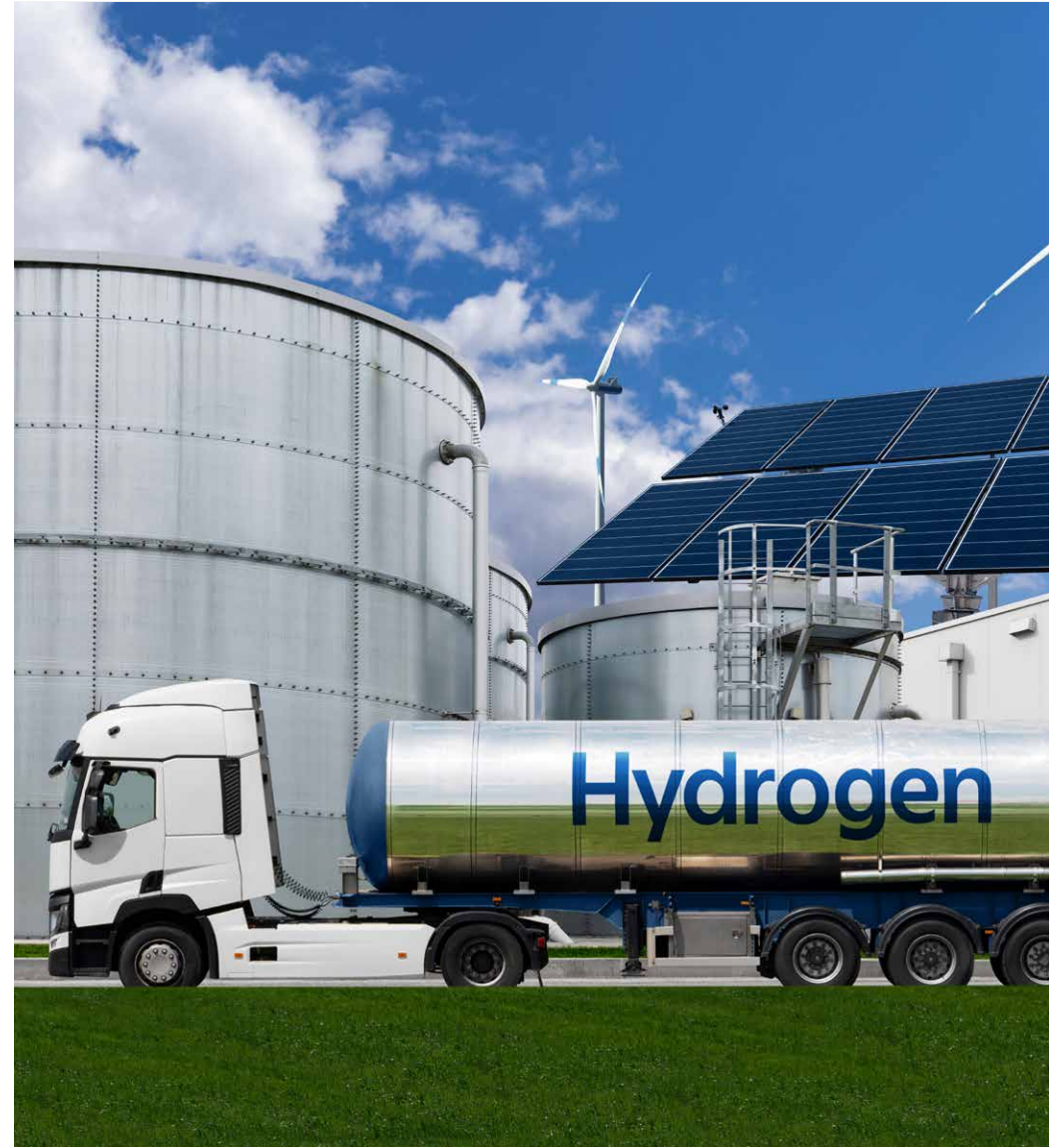
March 3<sup>rd</sup>, 2022

Global hydrogen demand is expected to increase toward 2030 and further, under the recent energy crisis triggered by geo-political shifts, price increases, decreasing cost of production and COP27 net-zero targets. After several pilot projects, the National Hydrogen Strategy and Roadmap, published in January 2023, has put Türkiye into the global landscape as one of the leading green hydrogen economies. As Strategy& Türkiye, we forecast the green hydrogen demand in Türkiye can exceed 1-1.5 Mt in 2030 and 2-2.5 Mt in 2050. We suggest the energy industry stakeholders to conduct a thorough

assessment of the market potential and a diligent competitive assessment for designing a game-changing market entry strategy for the new business models for the emerging green hydrogen economy in the country.

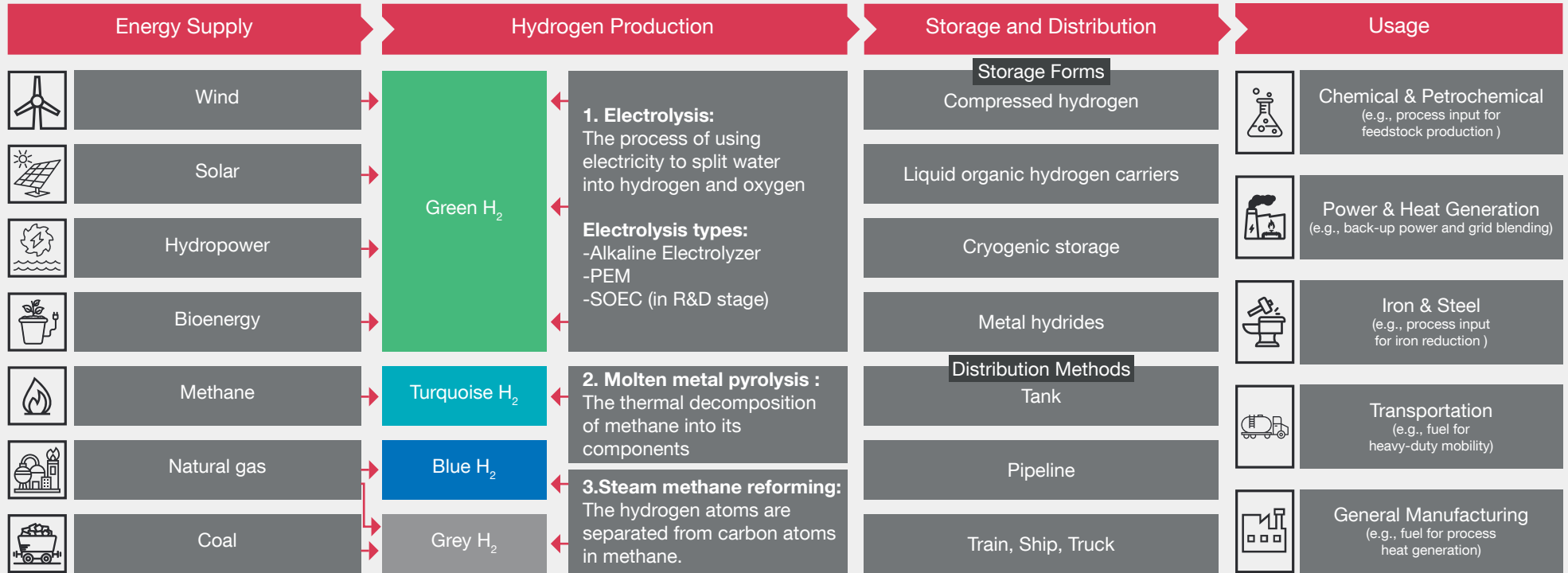
## What is green hydrogen?

**Hydrogen is the most common element in the nature** and consumed in several manufacturing processes across a wide-spread spectrum of major industries including oil refinery, steel manufacturing and glassmaking. **Green hydrogen, produced with the renewable energies** including wind, solar, hydropower, and bioenergy, is considered as **a major energy source.**



# Hydrogen value chain starts from energy supply and covers production, storage, distribution and usage

## Hydrogen value chain



Source: IEA, Technavio, Allied Market Research, Strategy& analysis

With the **technology advancements**, the cost of production is expected to decrease competitive levels for many countries from 2030 onwards. **Alkaline electrolyzer, the most popular and the cheapest technology** for green hydrogen investments, contains **potassium hydroxide and water or sodium hydroxide and water** are used as catalyst, which releases hydrogen towards cathode. **Polymer electrolyte membrane (PEM) electrolysis** separates the hydrogen and oxygen through a **solid polymer electrolyte (SPE)** and can operate at high current densities. Solid oxide electrolyzer (SOE) is the newest technology using **solid ceramics** as electrolytes which enables it to be applied in **fuel production, carbon dioxide recycling, chemical synthesis** and having advantages include long-term stability, fuel flexibility, low emissions and low operating costs.

# Global hydrogen market

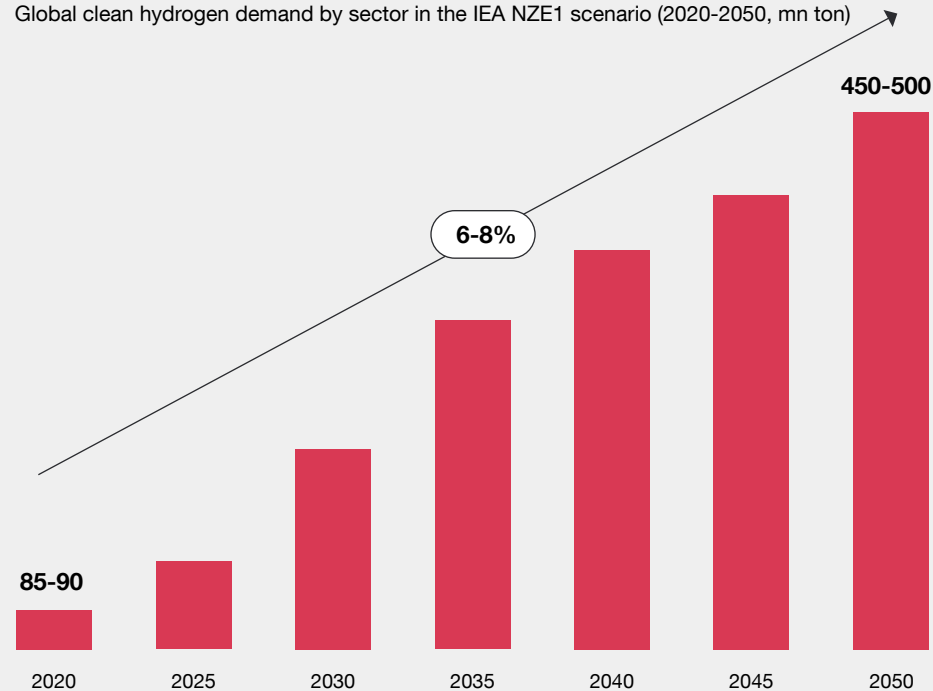
The global demand for green hydrogen is expected to **increase** at a rapid pace **especially after 2030**. According to **IEA's predictions**, the world's hydrogen demand is expected to increase from **94 million tons (Mt) in 2021 (95% of global production is currently grey)** to **nearly 200 Mt in 2030 and 450-500 Mt in 2050 (99% of global production needs to be clean)**, as per **net-zero emission (NZE) scenario**. If the **announced pledges of the countries' energy policies (APS scenario)** are considered, the forecasts for the green hydrogen volume can remain at half of this figure.

According to APS scenario, **Europe** is expected to become the **largest importer** of the green hydrogen with **~50 bcme** (billion cubic meter equivalent of natural gas) net import volume, followed by Japan and Korea. The USA and China are expected to rely on their domestic supply of 150 bcme for each. **Australia, Middle East, North Africa and Latin America** are expected to become the largest net exporters with the abundance of their renewable energy sources. Leading countries including **USA, Germany, Netherlands, United Kingdom and Japan** already announced **large-scale green hydrogen projects, official capacity targets and their support programs**.

## Global demand for clean hydrogen may increase to 450-500 mn tons in 2040 to meet the Paris agreement goals

### Global hydrogen demand until 2050

Global clean hydrogen demand by sector in the IEA NZE1 scenario (2020-2050, mn ton)



### Key remarks

- **~85-90 mn ton hydrogen** (including grey) was consumed globally in 2020
- In the Net Zero Emissions (NZE) Scenario, hydrogen demand is expected to **reach ~450-500 mn ton H2 by 2050 while announced pledges scenario (APS) forecasts reach only half of NZE scenario**
- **60% of the green hydrogen volume** will be consumed by energy-intensive end-use industries including **steel, cement and chemicals**

<sup>1</sup>IEA NZE: International Energy Association Net Zero Emission

Source: IEA Global Hydrogen Review, IEA World Energy Outlook 2022, Strategy& analysis

- **Two largest electrolyzers** started operating in 2022: A capacity of **150 MW** in China as a captive electrolyzer supplying to a methanol and chemicals plant and a solar-powered **20 MW** capacity in **Spain**. Two 200+ MW projects are expected in China and Netherlands until 2025.

- The EU aims to **install 17.5 GW capacity of electrolyzers by 2025** under **REPowerEU plan**. For instance, **Germany** already has commissioned **120 pilot projects** for green hydrogen production, while **several import projects** are being discussed with several countries South America, Africa and Australia, according to the German Energy Agency, Dena.

- On the incentives side, **Japan's Green Transformation (GX) Program**, while USA's Inflation Reduction Act in 2022 offered **10-year production tax credit** for clean hydrogen production facilities.

## Green hydrogen is going to be crucial for steel, chemicals, transportation, refining and power generation sectors

Sector prioritization to pursue low carbon hydrogen future



**In the steel industry...**

- **Direct reduction of iron – hydrogen to remove oxygen from iron ore** in its solid state, without melting it in the blast furnace– offers a promising path to decarbonization
- The technology is being tested by steel manufacturers in demonstration projects already



**In the chemicals industry...**

- **Hydrogen is used to make ammonia and methanol**, Ammonia is the primary resource of the fertilizer industry
- **Currently refining and chemicals industries account for more than 80% of global hydrogen demand** and grey hydrogen is widely used for ammonia production in Turkey
- Along with the decarbonization targets, **chemicals market is one of the prioritized industries for Turkey**



**In the transport sector...**

- **Heavy-duty mobility**, such as freight trucking is likely to **offer consumption volumes of hydrogen as a fuel** that could **be large enough to trigger economies of scale**
- Hydrogen is likely to become cost-competitive in transport before other sectors because the cost of diesel and gasoline is typically higher than the cost of the natural gas used in other industries



**The refining industry...**

- Is likely to start using **low carbon hydrogen** as a **substitute for the conventional hydrogen produced from coal and gas**
- The industry is planning to use low carbon hydrogen to manufacture synthetic fuels in combination with captured carbon, among other applications
- Compliance with existing **renewable energy regulations** and **economic incentives may accelerate this change**



**In power generation...**

- **Hydrogen blended with natural gas or pure hydrogen can power gas turbines** and engines to decarbonize the sector
- **Gas turbine and gas engine manufacturers are currently addressing the technical challenges** caused by hydrogen combustion, such as higher flame propagation speeds and nitrogen dioxide emissions, to design fully hydrogen - compatible turbines and engines by 2030, in line with the objectives of industry body EU Turbines

Source: IEA, Strategy& analysis

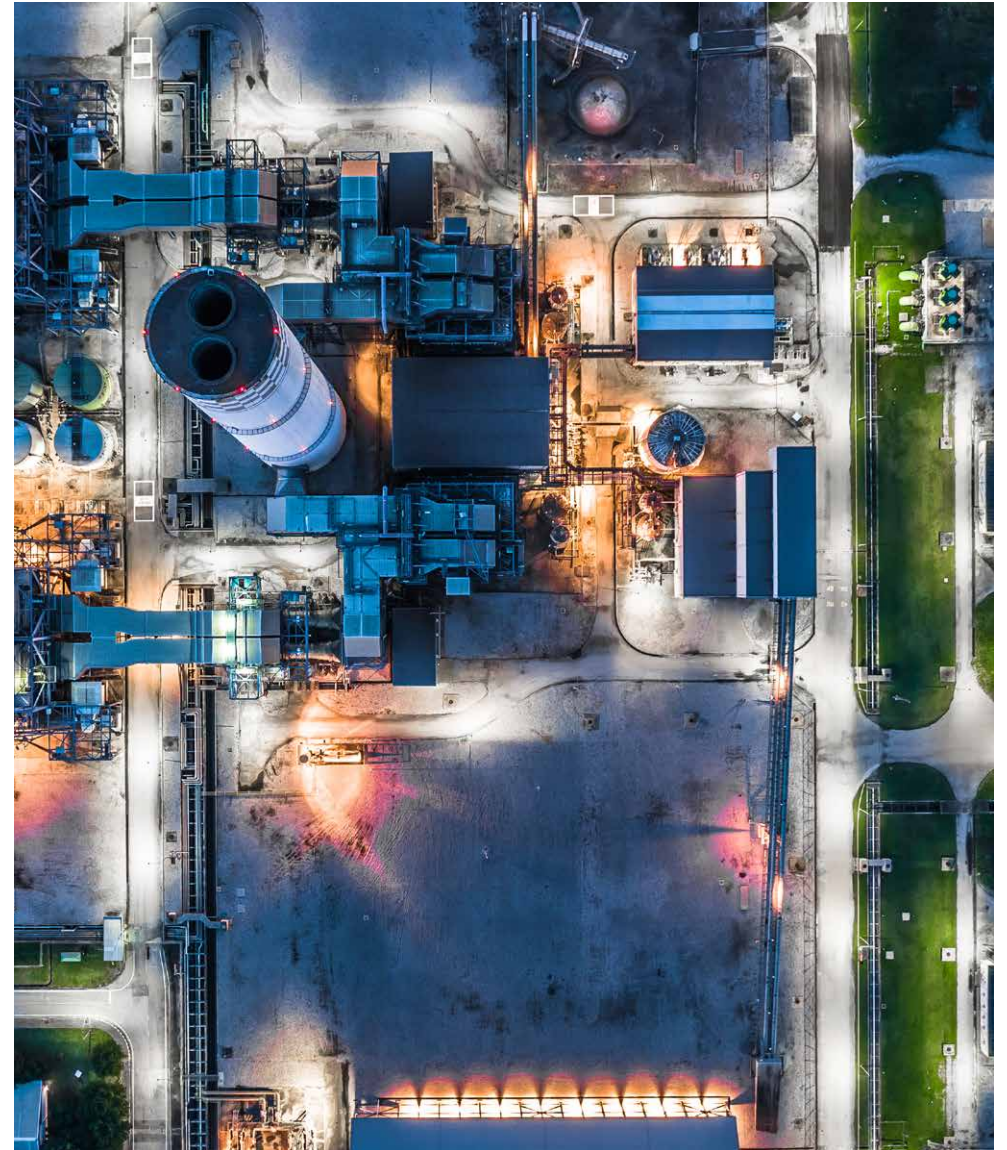
Since 41% of global emissions is directly effected via thermal energy needs, **green hydrogen** will be crucial for energy-intensive industries including steel, chemicals, transportation, refining and power generation. Each industry utilizes green hydrogen for a different application area, and the green transition is expected to change the share of end-user industries until 2050.

- **Steel:** With the expectation of direct reduction of iron (DRI) becoming a primary technology in the long term, 3% of energy consumption used for steel-making can be generated from hydrogen by 2030 and 25% in 2050. This will increase the share of **steel and iron industry** in the global hydrogen capacity to **8% in 2050**.
- **Chemicals:** Hydrogen is used to make ammonia (primary resource of the fertilizers) and methanol. Consuming **53%** of the global hydrogen volume, the demand of clean hydrogen in the **chemicals sector** is expected to reach **almost 60 Mt by 2050**.
- **Refining:** While **refineries** were the **biggest source of demand** for global clean hydrogen in **2020**, the demand is expected to **decrease** from **41%** share to **2%** share over the other sectors at the **end of 2050**.

- **Transportation:** Hydrogen is expected to transform heavy-duty mobility with a high scale of economies. The **growth rate** of clean hydrogen demand in **transportation sector** is anticipated to **surpass all the other sectors** with a **CAGR of 12% between 2020 and 2050** reaching **almost 100 Mt demand in 2050**, including applications in **sustainable aviation fuel and methanol for ships**.

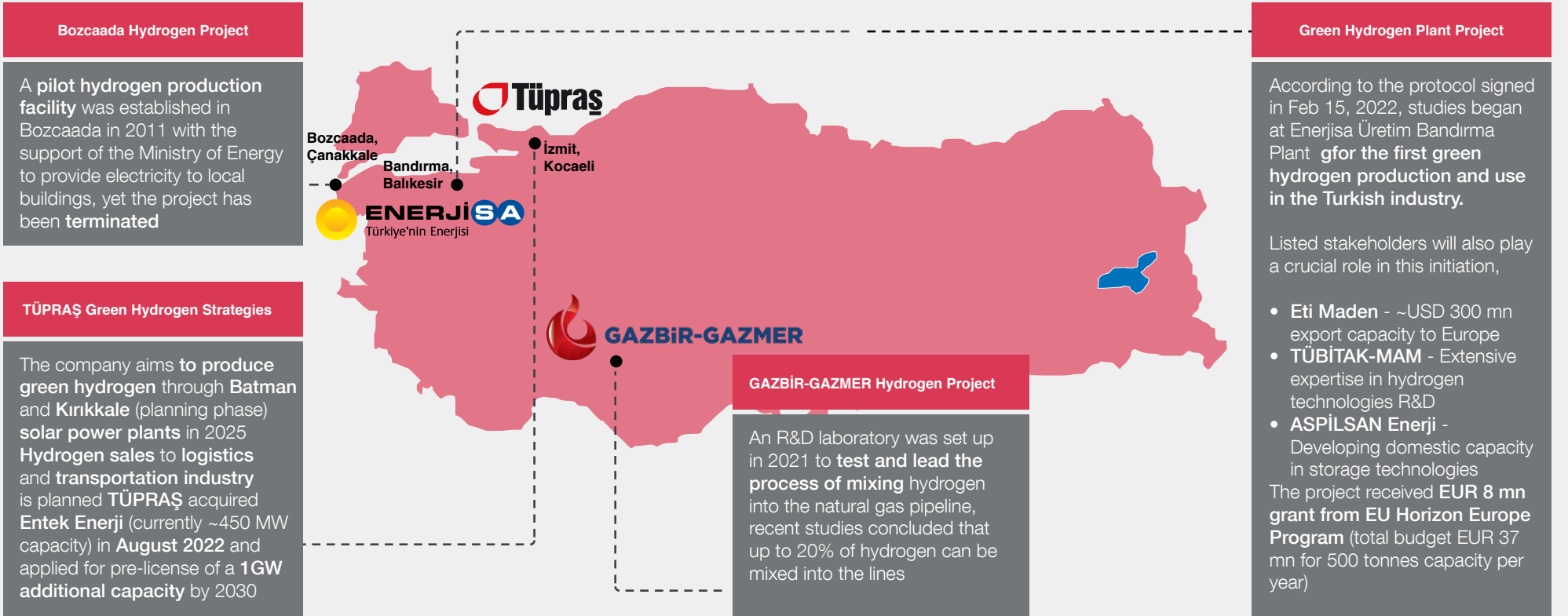
## Recent green hydrogen developments in Türkiye

With the expectations of **emerging regulations**, selected energy players in Türkiye have **accelerated their efforts and investments**. While several Turkish energy players are discussing the potential and challenges of the green hydrogen, **initial pilot projects**, including **Enerjisa's green hydrogen capacity in Bandırma**, **Bozcaada Hydrogen Project (cancelled)**, **TÜPRAŞ Green Hydrogen Investment** and **GAZBİR-GAZMER Hydrogen Project**, already emerged.



## Focus on green hydrogen in Türkiye has accelerated in 2022 with the first pilot project in Bandırma

### Recent milestones for green hydrogen in Türkiye



Turkish Ministry of Energy and Natural Resources published “Türkiye’s National Hydrogen Strategy and Roadmap” in January 2023 and placed the country among the leading green hydrogen economies on a global scale. The published strategy lays out important strategic priorities among electrolyzer capacity targets by 2053, reduction in the cost of green hydrogen production, R&D support for domestic sources, public-private collaboration, export of green hydrogen and ammonia, priority green hydrogen industries and hydrogen transportation / distribution. According to the national hydrogen strategy, Türkiye aims to establish 2 GW hydrogen production capacity by 2030, 5 GW by 2035 and 70 GW by 2053.



## The Hydrogen Technologies Strategy and Roadmap lays out priority areas for Türkiye's transition towards green hydrogen

Priority areas from the National Hydrogen Technologies Strategy and Roadmap



### Electrolyzer capacity targets

Installed capacity of hydrogen electrolyzers in Türkiye is expected to reach **2 GW** by 2030, **5 GW** by 2035, and **70 GW** by 2053



### Cost of production

The production cost of hydrogen production is aimed to be **decreased** to the competitive levels of **2.4 USD/kgH** until 2035 and **1.2 USD/kgH** until 2053



### R&D support for domestic sources

Supportive mechanism for the **R&D activities** on the utilization of **domestic sources** (e.g., coal) in **hydrogen production** and **storage** is anticipated to be built by the government



### Public private collaboration

Türkiye intends to **collaborate with public and private sector** to promote the **commercial demands and investments** on the industry, technology, standards, certification improvement, and supply chain



### Green hydrogen and ammonia

Export of the **surplus green hydrogen and ammonia** to the global market with focus on European markets (note that Türkiye signed a memorandum of understanding with Germany)



### Prioritized client industries

Türkiye will design an **incentive mechanism** for the usage of green hydrogen in **carbon-intensive industries** (e.g., chemicals, steel, transportation, glass, ceramics)



### Leveraging natural gas pipelines

**Incorporating hydrogen** into the **natural gas pipelines**, **contribution to the gradual decarbonization** of heat sector is anticipated

**TENMAK<sup>1</sup> issued an R&D call for hydrogen technologies under the Technology-Focused Industry attempt program**

<sup>1</sup>TENMAK: Turkish Energy, Nuclear and Mining Research Council

Sources: MENR, Strategy& analysis

As Strategy& Türkiye, we **forecast** the green hydrogen demand in Türkiye can **exceed 1-1.5 Mt** in 2030 and **2-2.5 Mt** in 2050, based on the growth trajectory of the green hydrogen demand from the energy-intensive industries. **Steel, cement, transportation, chemicals, ceramics, oil & gas and power generation industries** are expected to capture the **highest share** in the overall demand. Research and development activities are ongoing for the **conventional usage** of new **green hydrogen production technologies**.



**New business models and leading players** in Türkiye are expected to emerge from **raw material supply, electrolyzer and equipment manufacturing, production** (local consumption and export), **distribution and retail sales**. Among these,

- Majority of the local investments in the country can be concentrated around **electrolyzer and equipment manufacturing** (e.g., special pipeline materials), **production and distribution**. Türkiye Energy, Nuclear and Mining Research Institute (TENMAK) issued an **R&D call for clean hydrogen technologies under the Technology-Focused Industry attempt program** with a focus on clean hydrogen production, storage and liquification and fuel cells.
- Secondly, with the **increasing demand from key consumption industries and the emergence of the local ecosystem players**, Türkiye can be positioned as a **net green hydrogen supplier for the major European countries** and other nearby countries with its **growing installed renewables capacity, geographical proximity to major countries, extensive natural gas pipeline, logistics infrastructure, rich natural resources and relatively lower costs of green hydrogen production**. Therefore, the leading energy producers, energy distributors, pipeline operators, logistics solution providers and technology companies can play a historical role in this new business opportunities.

## As a company, how can you benefit from the growing hydrogen market in Turkey and globally?

We can suggest the companies that consider entering the Turkish hydrogen market by thoroughly **assess the potential of the market** in terms of the **size, growth, and application areas**. **A diligent competitive assessment** can help you identify a **unique market positioning** across the **value chain** and reveal the **differentiating capabilities** that needs to be invested.

After that, **six key strategic questions** need to be answered to develop and implement a game-changing market entry strategy for a right-to-win in the Turkish hydrogen market.



## Key strategic questions for new hydrogen market entrants



What are the strategic options that we can evaluate for a successful market entry into the Turkish hydrogen market?



Which part(s) of the hydrogen value chain can we create most value?



What is the size of the addressable market and expected profitability levels for these strategic options? How much do we need to invest?



How much do we need to invest?



What are the key market, competitive and regulatory risks that we need mitigate?



How does the hydrogen production fit our existing or future capabilities?



Can we tap on synergy opportunities?



What kind of business models can we create with partnerships?



How should we design our go-to-market strategy around key target clients, products, pricing levels, supplier network and the required capacity?

Sources: Strategy& analysis

As PwC Strategy&, we leverage our **strategy-through-execution** capabilities to help our clients in the energy industry from day zero of their investment evaluation to various support areas including **market** and **competition assessment**, financial due-diligences, **M&A research**, and program management with an integrated approach.

## Contact

### Kağan Karamanođlu

Strategy& Türkiye, Partner  
kagan.karamanoglu@strategyand.tr.pwc.com

### Dirk Niemeier

Strategy& Germany, Director  
dirk.niemeier@pwc.com

### Cem Çamlı

Strategy& Türkiye, Director  
cem.camli@pwc.com

### Mehmet Özenbaş

Strategy& Türkiye, Direktör  
mehmet.ozenbas@pwc.com