Low Carbon Hydrogen Economy in Türkiye

European Bank for Reconstruction and Development

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THE COLOURS OF HYDROGEN

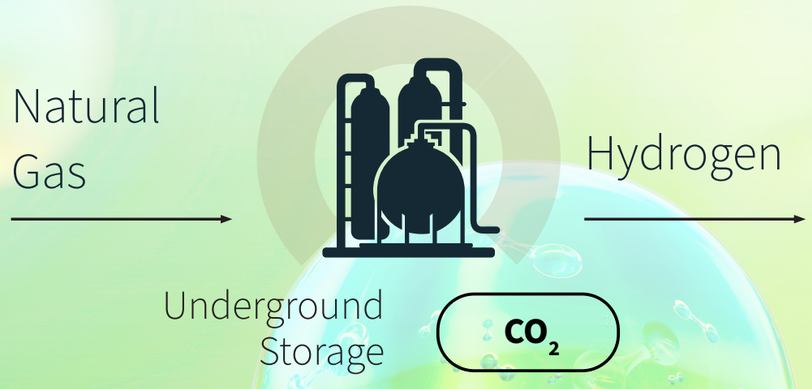
Grey Hydrogen

Steam methane reforming (SMR) of natural gas

- Fossil fuels are used as a feedstock and chemically converted to yield hydrogen
- High emissions and uses non - renewable resource

Blue Hydrogen

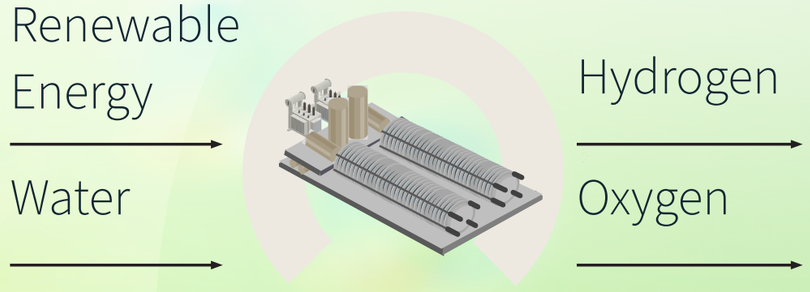
SMR with carbon capture and storage (CCS)



- Similar to grey hydrogen but with capture and storage of CO_2 emissions
- Low Scope 1 and 2 emissions but still uses non-renewable resource

Green Hydrogen

Water Electrolysis



- Uses electrolysis (separation of water into H_2 and O_2) to form hydrogen
- Minimal Scope 1 and 2 emissions

Türkiye’s strengths in developing a low carbon hydrogen economy

Industrial sectors for production of low-carbon fuels and fertilisers provide focal point for low carbon hydrogen production

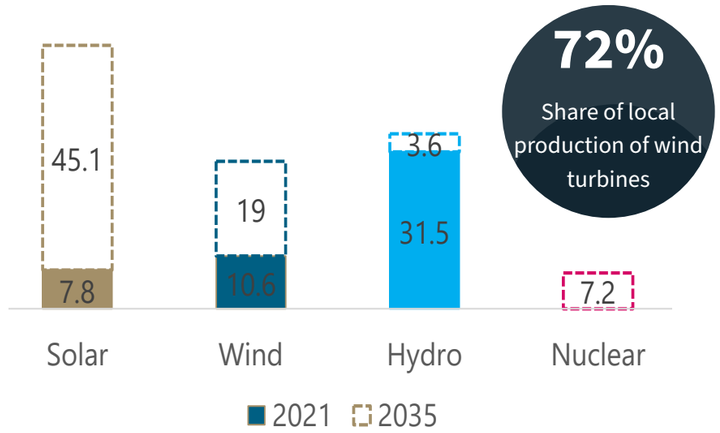
Tüpraş, Türkiye’s largest producer of transportation fuels, is pursuing initiatives to transition towards carbon neutrality by 2050. They aim to produce green hydrogen, sustainable aviation fuel (SAF), and expand their electrolyser capacity to 400 MW by 2030 and 1 GW by 2035. By 2030, they plan to supply green hydrogen to heavy transport and convert all grey hydrogen production to green by 2040. Tüpraş will start by converting an existing process unit at their Izmir refinery.

Türkiye’s fertiliser industry heavily relies on imported grey ammonia, with ~1 million tonnes imported each year. To address this, Türkiye seeks to replace these imports with domestically produced green ammonia. This strategic shift not only improves the country's fertiliser supply security but also opens up opportunities in the growing market for ammonia as a shipping fuel.

Türkiye is very well placed geographically with connections to Europe and Asia through shipping routes and natural gas pipelines

Türkiye enjoys a strategic location, positioned near key shipping routes in the Black Sea, Mediterranean Sea, and Suez Canal. It also holds a significant role as a major transit country for natural gas. The TurkStream pipeline and the Southern Gas Corridor (via SCP(X), TANAP, and TAP) transport gas exports from Azerbaijan to European markets. These pipelines offer potential future pathways for low carbon hydrogen, blended with natural gas up to 20% by volume. Preliminary studies have already examined the feasibility of utilising the TANAP and TAP pipelines for transporting blended hydrogen. Moreover, with the EU's REPowerEU policy, the expansion of these pipelines in the future becomes even more likely.

High-quality, low-cost renewable resources with high expansion potential



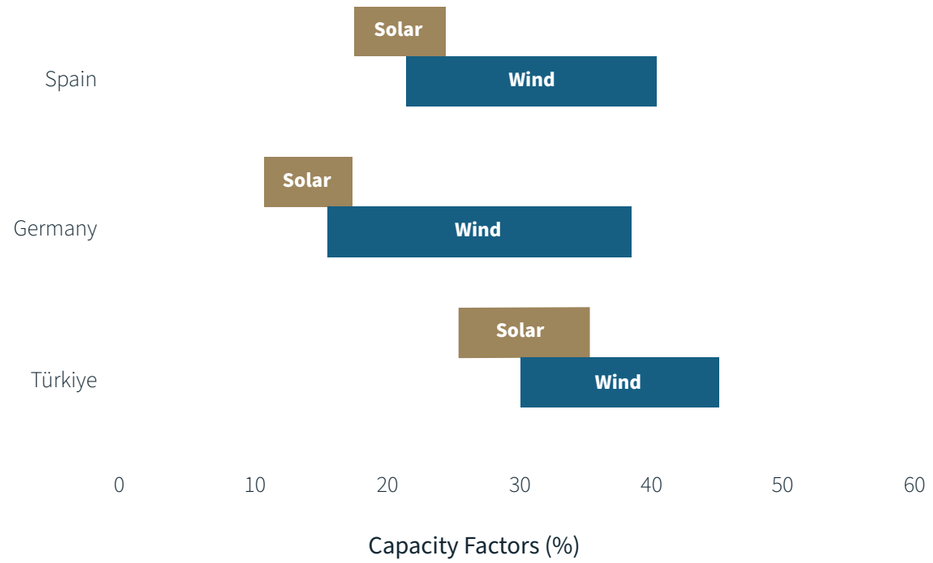
Growth in Electricity Generation Capacity (GW)

Türkiye boasts significant renewable energy potential, benefiting from a history of hydropower utilisation, excellent wind resources in western Türkiye, and favourable solar resources in Anatolian provinces and the Mediterranean region. As part of Türkiye's National Energy Plan, the total installed power generation capacity is projected to rise from 99.9 GW in 2021 to 189.7 GW by 2035. Renewables are expected to contribute 74.3% of the new power capacity, constituting 64.7% of Türkiye's total installed capacity by 2035 (compared to 54% in 2021). Türkiye has also prioritised increasing local content for its renewable developments, moving away from imports.

TÜRKIYE'S LOW CARBON HYDROGEN PRODUCTION COMPETITIVENESS

Green hydrogen production costs

Türkiye possesses significant renewables potential, benefiting from abundant and cost-effective renewable resources. This favourable environment is expected to facilitate the production of cost-competitive green hydrogen. By utilising a blend of solar and wind, Türkiye can maximise the load factor, enabling the production of hydrogen at a cost as low as 2.91 €/kg by 2030. As technology continues to mature, these costs are anticipated to fall.



Renewable resource capacity factors compared

Blue hydrogen potential

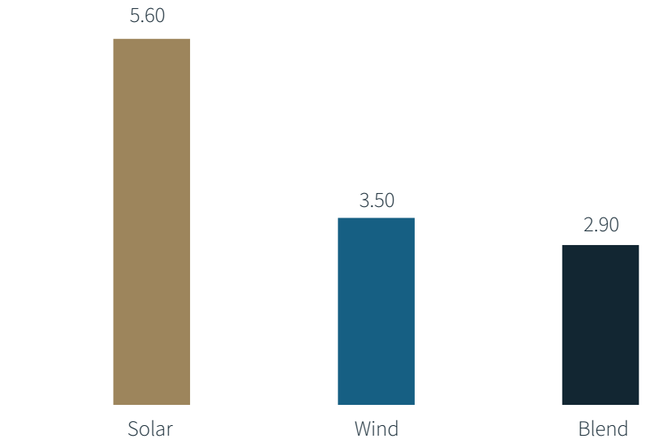
While Türkiye aims to develop the expansive Sakarya gas field, it is projected to continue being a net gas importer in the future. As a result, the cost of producing blue hydrogen is expected to align with the international gas price rather than reflecting the lower cost of domestic gas production. Consequently, the feasibility of Türkiye producing blue hydrogen competitively appears unlikely.

4.20

LCOH in €/kg of Türkiye blue hydrogen at international gas price of 60 €/MWh (HHV)

Regional considerations

Analysis has shown that the Western Marmara and Aegean regions have the lowest hydrogen costs in Türkiye. This is due to their high-quality renewable resources, especially wind. Additionally, the proximity of these regions to hydrogen demand centers in the refining, steel, and ammonia industries, as well as nearby ports, creates an excellent opportunity to develop a hydrogen economy in the region.



Green Hydrogen LCOH in EUR/kg (2030)

How low carbon hydrogen can be used in Türkiye and potential for exporting

Meeting domestic industrial demands for hydrogen

In the mid to long term, Türkiye will shift its focus towards the production and consumption of low carbon hydrogen for the domestic market. The increased demand for low carbon hydrogen will primarily come from sectors such as ammonia production, refining, and steel. Initially, the steel sector will focus on blending hydrogen into existing blast furnaces eventually transitioning to using 100% hydrogen through the direct reduced iron (DRI) process. The utilisation of low carbon hydrogen in refining, aligned with Tüpraş's ambitions, will further facilitate the development of a low-carbon hydrogen economy in Türkiye.

Shifting to green hydrogen to decarbonise industrial sectors

Manufacture of electrolysers

Türkiye has a long and successful track record of on-shoring equipment manufacturing, most recently for renewable projects, therefore it is in a strong position for establishing a domestic electrolyser market. Turkiye's natural boron reserves could be exploited as sodium boron hydride in hydrogen storage technologies, and in fuel cells. Additionally, Türkiye is well-positioned to serve as an equipment export hub for the MENA markets, where significant growth in green hydrogen production is expected. This offers Türkiye the opportunity to capitalise on the increasing demand for equipment in the region while contributing to the research and development of domestic hydrogen technologies.

Domestic electrolyser manufacture in Türkiye

Opportunities for shipping and export

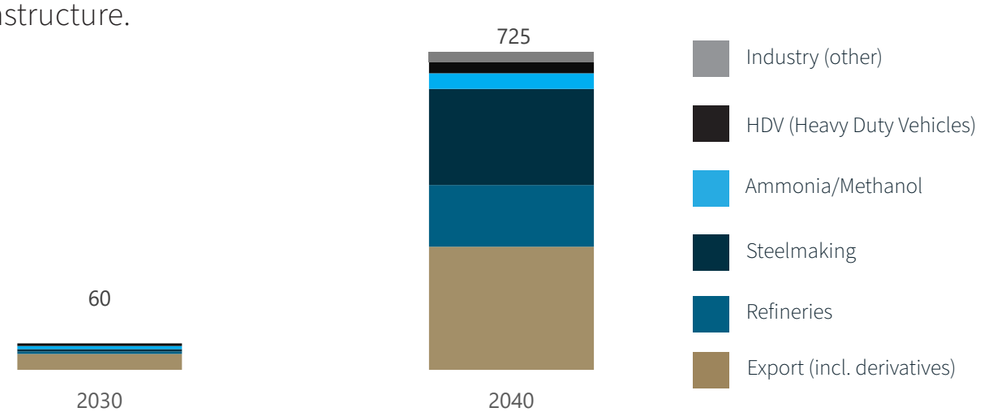
Türkiye's shipping industry, with its extensive experience in handling ammonia, possesses significant potential to emerge as a major exporter of ammonia to Europe. Looking ahead, Türkiye also holds promising prospects in the long term for hydrogen derivatives like methanol and e-fuels. These derivatives offer opportunities for bunkering and export to Europe. With access to key shipping routes in the Black Sea, Mediterranean, and Suez Canal, Türkiye is well-positioned to capitalise on the growth of these sectors and establish itself as a significant player in the shipping industry.

Hydrogen carriers and ammonia export potential

Export of hydrogen through re-purposed natural gas pipelines

Given its strategic location, Türkiye is expected to prioritise the short-term export of blended hydrogen and natural gas to the European Union (EU) through the TANAP and TAP pipelines. The implementation of the REPowerEU policy is likely to expedite the expansion of the Southern Gas Corridor capacity, offering an opportunity to future-proof compression investments for hydrogen blending within Türkiye. Potential injection points for hydrogen could be established at off-take locations in Eskişehir or Thrace. To support ambitions for hydrogen blending, Türkiye should concentrate on developing its gas transmission and distribution infrastructure.

Potential to re-purpose natural gas pipelines



Potential hydrogen demand in Türkiye (kilotonnes per annum)

**Hydrogen de-blended at downstream industrial sites*

Relevant Policy & Regulations

Türkiye has set ambitious goals and plans to become a major producer of green hydrogen. The country is actively investing in the development of a low carbon hydrogen economy, supported by comprehensive policies and task force. These initiatives aim to shape the future of hydrogen and its derivatives while also prioritising the decarbonisation of the electricity grid and reducing Türkiye's dependence on natural gas imports.

2010 — National Strategy on Climate Change and Climate Action Plan adopted

2020 — Ministry of Energy and Natural Resources (MENR) Organises stakeholder consultations on hydrogen economy

2021 — Year 2053 is set as net-zero target and Türkiye ratifies Paris Agreement

2021 — National Determined Contribution (NDC) pledges 41% GHG reduction by 2030

2023 — Türkiye announces National Energy Plan pledging to increase renewable energy generation and investment in low-carbon technologies

2023 — MENR announces the Türkiye's hydrogen strategy with a roadmap on scaling up green hydrogen

There are various enablers and drivers in developing a low-carbon hydrogen economy in Türkiye:

ENABLERS

- Carbon Border Adjustment Mechanism (CBAM) implementation could justify low carbon hydrogen projects
- Historically attractive market for international funding (donors and development banks) though Türkiye will still have to ensure competitive hydrogen pricing
- Unique opportunity to establish domestic electrolyser manufacture industry due to abundant natural resources and history of on-shoring equipment manufacturing
- Great geographical position for export to Europe and beyond through both shipping and re-purposed natural gas pipelines
- Established refining and fertiliser industry with existing hydrogen demand
- Expanding renewables market with domestic manufacturing of components

BARRIERS

- Freshwater scarcity in some parts of Türkiye.
- Lack of legislation to support the development of a low carbon hydrogen economy including financial, such as an ETS scheme or carbon tax.

What Türkiye needs to build a low carbon hydrogen economy

Turkish Government Actions

Under its National Hydrogen Technologies Strategy and Roadmap, Türkiye should establish sustainable development laws and frameworks that incentivises the production of low carbon hydrogen. This includes the development and application of a national strategy encompassing short-term subsidies and long-term taxation policies across the entire hydrogen supply chain. These measures should aim to increase tax revenues, address the fiscal deficit, and introduce a carbon tax system.

Additionally, Türkiye should focus on expanding its electricity grid infrastructure while emphasising the concept of "additionality" of renewable resources. This approach ensures that renewable energy sources are integrated into the grid to support the growing demand for green hydrogen production. By ensuring sufficient capacity to support hydrogen projects and providing low-cost access to the electricity grid.

Maximizing Low Carbon Economy Benefits

To maximise benefits to Türkiye, a coordinated ramp-up of the local supply chain and workforce upskilling is essential. This will enable the costs and risks associated with gigawatt scale hydrogen projects to be reduced, but also to better realise the true global demand for hydrogen and its derivatives.

Clear hydrogen roadmap and commitment to infrastructure

Financial Incentives and legislation

Expansion of electricity grid

Ramp up supply chain

Upskill work force

Decarbonising Existing Hydrogen Demand in Türkiye

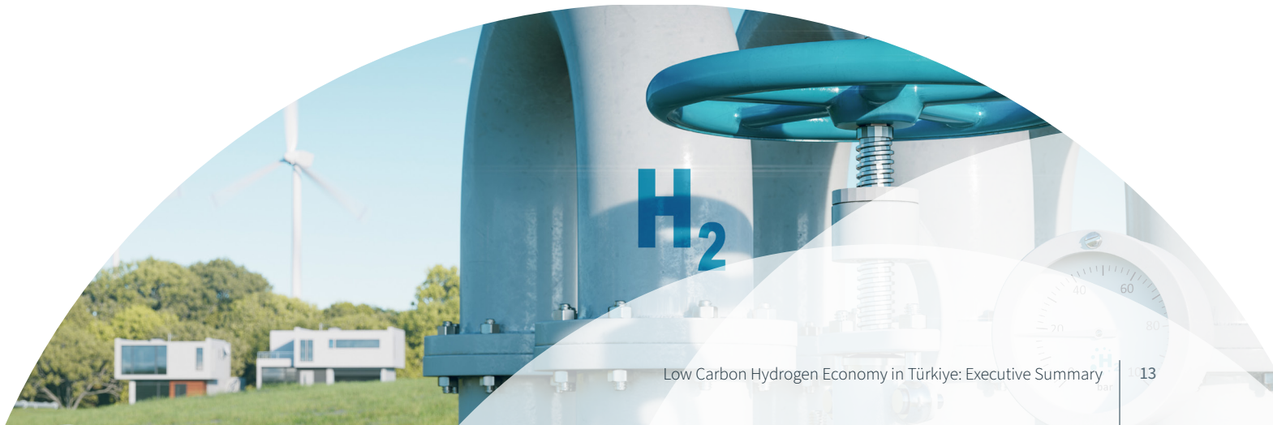
Developing the hydrogen economy in Türkiye is closely tied to existing demand in sectors like refining and fertilisers. In addition, utilising hydrogen in local transport, ports, terminals, and low-carbon ammonia production enables further opportunities for decarbonisation. Providing low-carbon hydrogen to these sectors not only promotes decarbonisation but also drives domestic investment, enables exports, and enhances energy security by reducing natural gas imports.

Whilst electrification is the main transportation decarbonisation solution, hydrogen serves as a viable alternative for remote areas or long-distance transport (e.g., along the Middle Corridor) and for heavy machinery in grid-limited mining operations.

Decarbonising Refining and Ammonia

Hydrogen export market

Hydrogen as fuel for remote locations



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