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REPORT

# Powering the hydrogen economy in Europe: what role for Turkey?

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REPORT

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Hydrogen has emerged as the centrepiece of energy transition debates around the world. Particularly the green variety of hydrogen, which emits no CO<sub>2</sub> when burned, is often touted as a panacea to mitigate the impact of climate change and facilitate the transition to a net zero world. Post-Ukraine, hydrogen is also increasingly relevant to energy supply security concerns in Europe. The rapid securitization of energy import dependence has led policymakers to fast-track diversification efforts, including substantial investments in hydrogen infrastructure. The European Union (EU) and energy-intensive economies like Germany are betting big on the hydrogen economy.<sup>1</sup>

The arrival of low-carbon technologies has the potential to not only disrupt and transform national economies but also shape the emergent patterns of geo-economic competition. For instance, the Inflation Reduction Act passed by the Biden Administration in August 2022 includes critical provisions that subsidize clean energy production, with various tax credits and subsidies totalling 369 billion dollars. The EU argues that this law is discriminatory and detrimental to Europe's industrial base. Investing in hydrogen and other clean energy technologies is thus of strategic importance for the EU and its competitiveness as a global economic power.

There are various technical hurdles regarding the production, storage, transport, and use of hydrogen. Hydrogen prices, while projected to decline significantly over the next decade, are still too high to be competitive. Even first-movers like Germany and Japan are still in the initial stages of establishing a regulatory framework for hydrogen markets. Amidst all this uncertainty, one thing is nearly certain: most European countries will not be able to produce enough hydrogen to fuel their energy transitions. If Europe wants to build a hydrogen economy over the next few decades, it will need to rely on imports, primarily from neighbouring countries.

This article assesses what role, if any, Turkey can play as a potential hydrogen supplier to Europe. The analysis is based on data from public documents, industry reports as well as select interviews with experts. The article is divided into four sections. The first section provides the state-of-the-art on hydrogen and its likely role in energy transition. The second section explores the hydrogen strategy of the EU, with an emphasis on the need for imports. The third section reviews the current state and potential of the hydrogen sector in Turkey. The last section evaluates the main policy challenges and next steps in hydrogen cooperation between the EU and Turkey.

1 'Germany bets on global green hydrogen economy,' *dw.com*, accessed 13 December 2022, <https://www.dw.com/en/germany-bets-on-global-green-hydrogen-economy/a-63757016>.

# Hydrogen: beyond the hype

The policy debate on hydrogen is essentially divided between supporters and skeptics. Those who sing the praises of hydrogen emphasize its availability, versatility, and most importantly, its low carbon impact. Sceptics raise concerns over the high cost of production, (in)efficiency, safety risks of certain hydrogen applications, and the lack of a proper market structure and regulatory framework.

There is much to love about hydrogen. It is the most abundant element in the universe, often found combined with other elements. Hydrogen is an efficient energy carrier; per kilogram,<sup>2</sup> it contains 2.2 times more energy than natural gas and 3 times more than oil.<sup>3</sup> Hydrogen is versatile; it can be used to store energy, burned as fuel, or used as feedstock. When burned in an engine or used in a fuel cell to chemically react with oxygen to produce electricity, hydrogen emits no pollutants or greenhouse gases. The only by-product is water vapour.

Hydrogen is not an energy source itself but rather an energy carrier. It needs to be produced using other sources of energy. Hydrogen can be classified based on the primary source of energy used in production. Today, fossil fuel-dependent production dominates hydrogen value chains. 'Black hydrogen' is produced from coal and 'grey hydrogen' is produced from natural gas. It is also possible (but not currently practiced) to use nuclear power to produce 'yellow hydrogen.' In terms of net zero goals, the most important types of hydrogen fuel are blue and green. 'Blue hydrogen' uses natural gas but couples it with carbon capture technologies to reduce emissions. Despite low carbon emissions, blue hydrogen production involves potential leakages of methane, a potent greenhouse gas. Limiting methane leakage is key to sustainable blue hydrogen production. Nonetheless, blue hydrogen is often considered a bridge to net zero policies, including those of the EU which notes "blue hydrogen can play a transitional role in ramping up the hydrogen economy."<sup>4</sup>

2 Efficiency per liter, however, which is key to the feasibility of transport, is much lower.

3 Badr Eddine Lebrouhi et al., 'Global hydrogen development - A technological and geopolitical overview,' *International Journal of Hydrogen Energy* 47, no. 11 (5 February 2022): 7019, <https://doi.org/10.1016/j.ijhydene.2021.12.076>.

4 European Parliament, 'EU hydrogen policy,' 2021, 4, [https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/689332/EPRS\\_BRI\(2021\)689332\\_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/689332/EPRS_BRI(2021)689332_EN.pdf).

Green hydrogen is the most promising variant in terms of its contribution to a net zero scenario. It is produced by splitting oxygen and hydrogen molecules in water using renewable electricity. The underlying technology based on electrolysis has been known for decades. The new and disruptive feature is the use of electricity from renewable sources, which qualifies the resulting hydrogen as green or clean. Today only a fraction of the global hydrogen output is generated through electrolysis. The share of green hydrogen will likely grow depending on the cost structure. According to the International Renewable Energy Agency (IRENA), green hydrogen can be expected to compete on cost with blue by 2030.<sup>5</sup> Some industry experts however point out that models predicting a radical decline in prices are based on strong assumptions of massive investment and breakthroughs in solar and wind generation, storage capacity, and electrolyser production over the next decade. Feasibility will partly depend on whether economies of scale can be achieved.

Hydrogen has been primarily used in industry as feedstock, for oil refining and ammonia production. Sceptics note that overhyping hydrogen and rushing its widespread use could *undermine* net zero goals. A recent *Nature* editorial notes that hydrogen production could be an inefficient use of renewable resources.<sup>6</sup> Using solar or wind-generated electricity to produce hydrogen at peak times, instead of using that clean energy to supplant fossil-generated power, could result in higher net emissions.

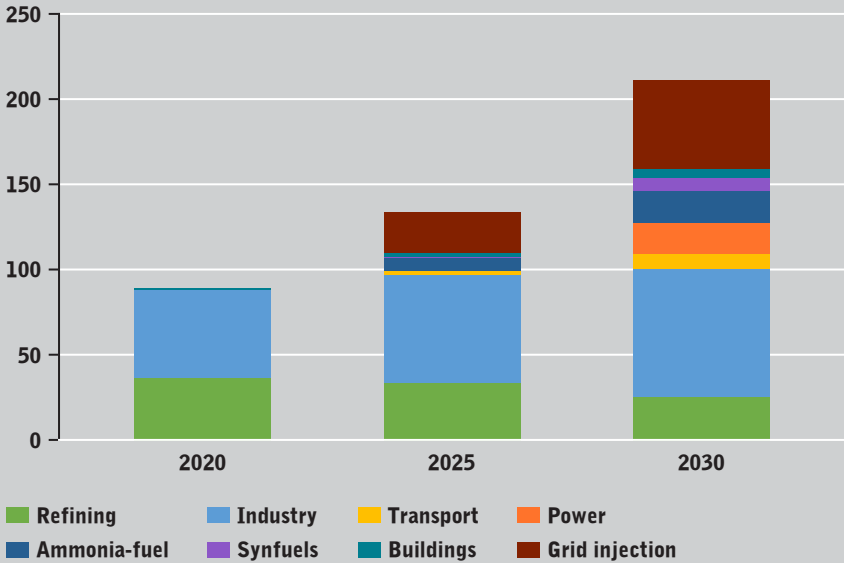
Similarly, experts raise doubts over certain applications of hydrogen that often come up in the media and public debates, such as heating homes and powering passenger vehicles. Burning hydrogen to heat homes may be not only less efficient than electricity, but possibly also unsafe.

There is also a growing interest in hydrogen-based e-fuels. However, industry experts remind us that e-fuels could be an option for heavy-duty transport vehicles, but they may not be readily available for passenger cars and other light vehicles. Hydrogen is currently used in hard-to-abate industries such as steel smelting and cement production, as well as refining.<sup>7</sup> Over the next decade, hydrogen demand is projected to diversify to include grid injection, power, ammonia, as well as limited use in buildings and transports (Figure 1).

- 5 IRENA, 'Geopolitics of the energy transformation: the hydrogen factor' (International Renewable Energy Agency, 2022), <https://www.irena.org/publications/2022/Jan/Geopolitics-of-the-Energy-Transformation-Hydrogen>.
- 6 'Overhyping hydrogen as a fuel risks endangering net-zero goals,' *Nature* 611, no. 7936 (16 November 2022): 426-426, <https://doi.org/10.1038/d41586-022-03693-6>.
- 7 Laima Eicke and Nicola De Blasio, 'The future of green hydrogen value chains' (Cambridge, MA: Belfer Center for Science and International Affairs, 2022), <https://www.belfercenter.org/publication/future-green-hydrogen-value-chains-geopolitical-and-market-implications-industrial>; Mathieu Blondeel et al., 'The geopolitics of energy system transformation: a review,' *Geography Compass* 15, no. 7 (2021), <https://doi.org/10.1111/gec3.12580>.

**Figure 1: Global hydrogen demand by sector in the net zero scenario, 2020-2030**

(Million tonnes)



Source: IEA, <https://www.iea.org/data-and-statistics/charts/global-hydrogen-demand-by-sector-in-the-net-zero-scenario-2020-2030>

Persistent uncertainties over the cost, efficiency, and safety of widespread hydrogen use point to an urgent need for a proper regulatory environment. More than 20 countries have released national hydrogen strategies, with many others (including Turkey) working on similar long-term vision documents.<sup>8</sup> Nonetheless, even early adopters like Japan or Germany do not currently operate under a comprehensive legal and technical framework to regulate the production, distribution, and consumption of hydrogen.

<sup>8</sup> Anthony Kosturjak et al., 'Advancing hydrogen: learning from 19 plans to advance hydrogen from across the globe,' accessed 11 November 2022, <https://www.futurefuelsrc.com/wp-content/uploads/RP1.1-03-Hydrogen-Strategies-Final-Report-EXTERNAL-1.pdf>; Michel Noussan et al., 'The role of green and blue hydrogen in the energy transition - a technological and geopolitical perspective,' *Sustainability* 13, no. 1 (31 December 2020): 298, <https://doi.org/10.3390/su13010298>.



Neither is there a well-developed hydrogen market yet. Today, the vast majority of hydrogen is still produced and consumed on-site within a facility rather than being traded on the market.<sup>9</sup> Long-distance transportation remains a logistical challenge. Transportation costs will likely come down due to economies of scale and improvements in technology, which will make international hydrogen trade more feasible. Transporting hydrogen through pipelines or shipping<sup>10</sup> would allow access to remote renewable resources.<sup>11</sup> Depending on the relative costs of various transportation modes, a dual market for hydrogen might emerge: a regional market consisting primarily of pipeline transport and a global market for ammonia.<sup>12</sup>

## The EU's hydrogen strategy

The EU issued its hydrogen strategy in July 2020, proposing 20 key actions.<sup>13</sup> The first action brought up the European Clean Hydrogen Alliance, tasked with developing an investment agenda to stimulate the production and use of hydrogen. At the Third Hydrogen Forum, the Alliance published a 'pipeline of projects,' including more than 750 projects on clean hydrogen production, transportation, and application.<sup>14</sup> Through the Alliance, the EU plans to raise an investment of 100 billion euros by 2030. An additional 300 billion are planned for investment in solar and wind capacity, crucial to generating green hydrogen.<sup>15</sup> A related platform is the European Hydrogen Backbone initiative, which consists of 31 energy operators working toward developing hydrogen infrastructure in 28 countries.<sup>16</sup>

How much hydrogen does Europe need? The EU seems to have a moving target. While the 2020 hydrogen strategy set a target of 10 million tonnes (Mt) of renewable hydro-

9 Thijs Van de Graaf et al., 'The new oil? The geopolitics and international governance of hydrogen,' *Energy Research & Social Science* 70 (December 2020): 3, <https://doi.org/10.1016/j.erss.2020.101667>.

10 Liquefaction of hydrogen for transport is a costly and challenging process. In the near future, the most likely option for maritime transport of hydrogen is ammonia.

11 The process of integrating renewable endowments in developing countries into regional and global energy markets would possibly raise issues of unequal exchange and neo-dependency. Aiming for more equitable forms of partnerships between industrialized countries and renewable energy exporters would be a critical issue as energy markets evolved towards net zero.

12 IRENA, 'Geopolitics of the energy transformation: the hydrogen factor,' 71.

13 European Commission, 'A hydrogen strategy for a climate-neutral Europe,' Pub. L. No. COM(2020) 301 final (2020), <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0301>.

14 "Project pipeline of the European Clean Hydrogen Alliance," [https://single-market-economy.ec.europa.eu/industry/strategy/industrial-alliances/european-clean-hydrogen-alliance/project-pipeline\\_en](https://single-market-economy.ec.europa.eu/industry/strategy/industrial-alliances/european-clean-hydrogen-alliance/project-pipeline_en).

15 Lebrouhi et al., 'Global hydrogen development,' 198.

16 European hydrogen backbone, 'European hydrogen backbone: a European hydrogen infrastructure vision covering 28 countries,' 2022, <https://ehb.eu/files/downloads/ehb-report-220428-17h00-interactive-1.pdf>.

gen,<sup>17</sup> the *RePowerEU* strategy developed in response to post-Ukraine energy challenges pushed the target to a total of 20 Mt by 2030 (10 Mt domestic production and 10 Mt imports).<sup>18</sup> The EU's hydrogen production goals are considered rather ambitious by many, including the Commission's own internal analysis.<sup>19</sup> Even with massive investments in production capacity, it is highly unlikely that the EU will be able to meet a significant portion of the demand for green hydrogen using its own resources. Indeed, Frans Timmermans, the Executive Vice President for the European Green Deal, said 'Europe is never going to be capable to produce its own hydrogen in sufficient quantities.'<sup>20</sup>

This is indeed why the 2020 hydrogen strategy identifies 'international cooperation' as a key action point, highlighting Southern and Eastern Neighbourhood partners, Energy Community countries (notably Ukraine), and the African Union as potential cooperation partners.<sup>21</sup> Having incurred significant costs from overdependence on Russian gas, the EU now places a great deal of emphasis on the diversification of its hydrogen supply. Timmermans said during a press conference on a visit to Turkey: 'We want to create partnerships, especially with countries around the Mediterranean, to create a future hydrogen-based economy where we are not dependent on one or two single suppliers, but we have a diversification of supplies and demand.'<sup>22</sup> The urgency to import hydrogen has paved the way for intense 'hydrogen diplomacy' in Europe and beyond.<sup>23</sup> These efforts often range from preliminary feasibility studies to memoranda of understanding and even some trial shipments. Over the next decade, cross-border hydrogen trade will likely create new interdependencies between importers and exporters and potentially reshape geopolitical and geo-economic relations between them.<sup>24</sup>

17 European Commission, 'Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: a hydrogen strategy for a climate-neutral Europe' (2020), <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0301>.

18 European Commission, 'Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions: REPowerEU plan' (2022), <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN&qid=1653033742483>.

19 European Commission, 'Commission staff working document implementing the REPower EU action plan: investment needs, hydrogen accelerator and achieving the bio-methane targets – accompanying the document REPowerEU plan' (2022), <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=SWD%3A2022%3A230%3AFIN&qid=1653033922121>.

20 Leigh Collins, "Europe is never going to be capable of producing its own hydrogen in sufficient quantities": EU climate chief, *Recharge News*, 4 May 2022, sec. energy\_transition, <https://www.rechargenews.com/energy-transition/europe-is-never-going-to-be-capable-of-producing-its-own-hydrogen-in-sufficient-quantities-eu-climate-chief/2-1-1212963>.

21 European Commission, 'A hydrogen strategy.'

22 Collins, "Europe is never going to be."

23 Van de Graaf et al., 'The new oil?'

24 Pier Paolo Raimondi, 'The scramble for Mediterranean hydrogen: energy or geopolitics?', ISPI, 13 May 2021, <https://www.ispionline.it/it/publicazione/scramble-mediterranean-hydrogen-energy-or-geopolitics-30429>.

Germany is leading the effort in forging bilateral hydrogen trade and infrastructure deals. While Germany has several ongoing infrastructure projects at home, it is nonetheless estimated that domestic production could meet, at best, one-third of Germany's green hydrogen demand by 2045.<sup>25</sup> Therefore, Germany has moved to negotiate deals with a wide range of potential suppliers, including Australia, Chile, Congo, Morocco, Namibia, Tunisia, and Ukraine. Germany also launched the H2Global Foundation, which initially received 900 million euros from the government to establish an auction scheme. The H2Global mechanism will purchase hydrogen from the world market and auction it to the highest bidder within the EU. This will include long-term purchase agreements of hydrogen and its derivatives, such as ammonia and methanol. The German government plans on investing more than 4 billion euros into H2Global.<sup>26</sup>

As hydrogen importers scramble for supplies, prospective exporters are also engaged in hydrogen diplomacy in the hopes of attracting investment to develop their hydrogen sectors. A country's renewable hydrogen potential is shaped by three main factors: i) renewable energy endowments, ii) availability of freshwater and land, iii) capacity to build and operate infrastructure to produce and transport hydrogen.<sup>27</sup> Germany's partner Namibia, for instance, is well-positioned to produce large amounts of green hydrogen. Indeed, the Namibian government recently launched a new Green Hydrogen and Derivatives Strategy, which aims to produce up to 10-12 Mt of hydrogen annually by 2050.<sup>28</sup> Scaling up this production capacity would require an investment of up to 181 billion euros by 2040, according to estimates by the Namibian government. Germany is involved in the first planned project for hydrogen exports from Namibia, estimated to cost 10 billion euros.<sup>29</sup> The plant is expected to produce 125 000 tonnes per year of ammonia starting in late 2026, which will eventually be scaled up to 700 000 tonnes to be exported to Europe.<sup>30</sup> A German energy company recently announced a deal to buy 300 000 tonnes per year of ammonia from the project.<sup>31</sup>

25 Eicke and Blasio, 'The future of green hydrogen value chains,' 20.

26 Hydrogen Central, 'Scholz ups global hydrogen ambitions, dwarfs EU initiative, plan to invest more than €4 billion into h2global,' *Hydrogen Central* (blog), 10 November 2022, <https://hydrogen-central.com/scholz-ups-global-hydrogen-ambitions-dwarfs-eu-initiative-plan-invest-more-e4-billion-h2global/>.

27 Fridolin Pflugman and Nicola De Blasio, 'The geopolitics of renewable hydrogen in low-carbon energy markets,' *Geopolitics, History, and International Relations* 12, no. 1 (2020): 7, <https://doi.org/10.22381/GHIR12120201>.

28 Republic of Namibia, 'Green hydrogen and derivatives strategy,' 2022, <https://gh2namibia.com/wp-content/uploads/2022/11/Namibia-GH2-Strategy-Rev2.pdf>.

29 Arne Delfs, 'Germany weighs aid for €10 billion hydrogen plant in Namibia,' *Bloomberg*, <https://www.bloomberg.com/news/articles/2022-12-05/germany-mulls-aid-for-10-billion-hydrogen-plant-in-namibia?leadSource=uverify%20wall>.

30 The Energy Year, 'Namibia readies to deliver green ammonia to Germany,' 8 December 2022, <https://theenergyyear.com/news/namibia-readies-to-deliver-green-ammonia-to-germany/>.

31 Iain Esau, 'RWE signs deal to buy green ammonia from \$10 billion Namibia project,' *Upstream Online*, 6 December 2022, <https://www.upstreamonline.com/hydrogen/rwe-signs-deal-to-buy-green-ammonia-from-10-billion-namibia-project/2-1-1367974>.

Turkey has recently appeared on the list of potential green hydrogen suppliers to Germany.<sup>32</sup> On 11 October 2022, Turkish Minister of Energy and Natural Resources Fatih Dönmez and German Federal Minister for Economic Affairs and Climate Action Robert Habeck signed the 'Joint Declaration of Intent for Cooperation in the Field of Green Hydrogen.'<sup>33</sup> The declaration was signed during the fourth meeting of the Turkish-German Energy Forum, established in 2012.<sup>34</sup> While there are no details available at this time regarding the timeline and goals of hydrogen cooperation between Germany and Turkey, the memorandum is significant as it highlights the growing interest in bilateral cooperation on hydrogen.

## Hydrogen sector in Turkey

Where does Turkey stand in terms of the development of the hydrogen sector? What are the advantages of Turkey as a hydrogen producer and a potential exporter? As a major energy consumer dependent on oil and gas imports, Turkey has prioritized the diversification of its energy mix over the past few years. Turkey's efforts to reduce dependence on Russian gas have resulted in greater utilization of domestic energy sources. Ankara has intensified efforts to formulate a long-term energy transition and climate strategy, partly in preparation to ratify the Paris Agreement, which it eventually did in 2021. It is within this context that hydrogen emerged as a key point of discussion in Turkey.

In January 2020, the Turkish Ministry of Energy and Natural Resources organized a kick-off meeting to bring together stakeholders. In consultation with officials, sector representatives like the Hydrogen Technology Association<sup>35</sup> and the National Gas Distributors Association (GAZBİR)<sup>36</sup> started publishing roadmaps<sup>37</sup> for a hydrogen transition in Turkey. The first step in the hydrogen transition according to these roadmaps is mixing hydrogen with natural gas in the distribution grid by 2030. This would be followed by sector

32 'Germany considering green hydrogen imports from Turkey,' *Anadolu Agency*, 2021, <https://www.aa.com.tr/en/energy/finance/germany-considering-green-hydrogen-imports-from-turkey/33406>.

33 Auswärtiges Deutsche Vertretungen in der Türkei, 'JETCO und Energieforum tagen in Berlin,' 2022, <https://tuerkei.diplo.de/tr-de/themen/wirtschaft/-/2559590>.

34 'Energy Partnership,' 2022, <https://www.energypartnership-turkiye.org/home/>.

35 Hidrojen Teknolojileri Derneği, 'Hidrojen Teknolojileri Derneği - National Hydrogen Association,' accessed 14 December 2022, <https://www.hidrojenteknolojileri.org/>.

36 GAZBİR, 'GAZBİR (Türkiye Doğal Gaz Dağıtıcıları Birliği),' accessed 14 December 2022, <https://www.gazbir.org.tr/>.

37 'Roadmap for hydrogen technologies in Turkey' published by Hydrogen Technology Association: [https://www.hidrojenteknolojileri.org/HTD/Turkiye\\_icin\\_Hidrojen\\_Teknolojileri\\_Yol\\_Haritasi\\_Raporu\\_2021.pdf](https://www.hidrojenteknolojileri.org/HTD/Turkiye_icin_Hidrojen_Teknolojileri_Yol_Haritasi_Raporu_2021.pdf), and 'Roadmap recommendations for hydrogen transition' published by GAZBİR: [http://www.cleangascenter.com/upload/tr/dosya/haberyonetimi/1/DOGAL-GAZ-SEKTORU-HIDROJENE-GECELCI%59ETE-YOL-HARITASI-ONERILERI\\_30062022130006-3.pdf](http://www.cleangascenter.com/upload/tr/dosya/haberyonetimi/1/DOGAL-GAZ-SEKTORU-HIDROJENE-GECELCI%59ETE-YOL-HARITASI-ONERILERI_30062022130006-3.pdf).

diversification of hydrogen use between 2030 and 2040, and a transition to a hydrogen economy by 2050, assuming a significant decline in cost.

There have been various tests to blend hydrogen in gas grids, with a target of 5 % blending, which would reduce energy costs.<sup>38</sup> While the initial tests are promising, the actual use of blended natural gas would depend on technical factors such as acceptable levels of hydrogen concentration for consumer appliances. Industry experts remind us that higher levels of blending would require costly recalibration or replacement of household devices, such as combi boilers. There are also pilot programs for green hydrogen. Bandırma Energy Base, jointly established by governmental development agencies and private companies, houses a production and storage facility for green hydrogen. The northwestern part of the country where this facility is located is not only well-endowed in terms of renewables and water but is also close to industrial facilities where the locally produced hydrogen could be used. The location is also suitable for hydrogen exports to Europe due to its proximity to shipping ports and the Turkey-Greece gas pipeline.<sup>39</sup>

Given that the hydrogen sector in Turkey is in the early phases of development, it is difficult to estimate the timeline and potential volume available for exports. The most comprehensive study of Turkey's export potential has been conducted by the SHURA Energy Transition Center. The study estimates a production capacity of up to 3.4 Mt per year of green hydrogen, given favourable investments and policies, by 2050. It is also projected that domestic demand for hydrogen will be at 1.9 Mt per year, assuming that 10 per cent of fossil fuel consumption would be substituted with green hydrogen. This would leave Turkey with a hydrogen export potential ranging from 1.5 to 1.9 Mt per year in 2050.<sup>40</sup>

As a potential hydrogen exporter, Turkey has a few key advantages. Turkey has considerable renewable resources. In addition to wind and solar capacity, Turkey has significant hydropower which can be channeled toward green hydrogen production.<sup>41</sup> Turkey's renewable energy installed capacity has been increasing steadily over the last decade (Figure 2).

38 SHURA, 'Techno-economic study of Turkey's production and export potential for green hydrogen' (Istanbul: SHURA Energy Transition Center, 2021), 24, <https://shura.org.tr/en/techno-economic-study-of-turkeys-production-and-export-potential-for-green-hydrogen/>.

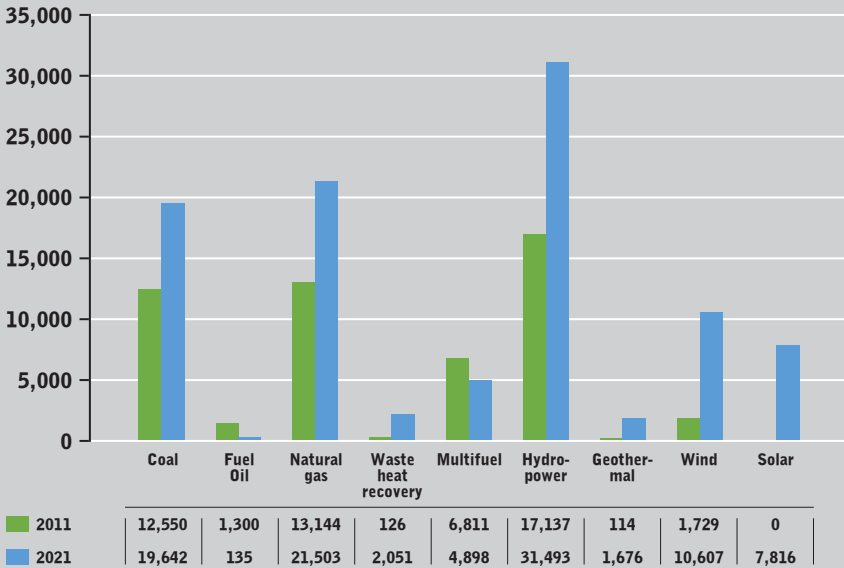
39 'Enerjisa üretim, Bandırma Enerji Üssü'nde yeşil hidrojen üretimine başladı,' *Anadolu Agency*, 5 July 2022, <https://www.aa.com.tr/tr/ekonomi/enerjisa-uretim-bandirma-enerji-ussunde-yesil-hidrojen-uretimine-basladi/2630360>.

40 SHURA, 'Techno-economic study of Turkey's production and export potential for green hydrogen,' 61.

41 G. Kubilay Karayel, Nader Javani, and Ibrahim Dincer, 'Hydropower energy for green hydrogen production in Turkey,' *International Journal of Hydrogen Energy*, 6 May 2022, <https://doi.org/10.1016/j.ijhydene.2022.04.084>.

**Figure 2: Installed power generation capacity in Turkey, 2011-2021**

(MW)



Source: TEİAŞ, <https://www.teias.gov.tr/turkiye-elektrik-uretim-iletim-istatistikleri>

As of November 2022, hydropower had by far the largest share among renewables, with 31 GW, followed by wind (11.3 GW) and solar (9.3 GW).<sup>42</sup> In terms of the installed capacity growth rate, solar and wind are the main drivers. Between 2021 and 2026 about 48 per cent of capacity additions are expected to come from solar and 30 per cent from wind.<sup>43</sup>

Proximity to Europe is another major advantage of Turkey as a potential hydrogen exporter. This matters for several reasons. First, existing trade and investment ties between Turkey and Europe will have a positive impact on establishing new linkages based on hydrogen. The EU is Turkey's largest trade partner, as well as its main source of inward foreign investment; whereas Turkey is the EU's sixth biggest trade partner.<sup>44</sup> The pre-ex-

<sup>42</sup> TEİAŞ, 'Kuruşu güç raporu, Kasım 2022,' 2022, <https://www.teias.gov.tr/kuruşu-guc-raporlari>.

<sup>43</sup> 'Turkey's renewable power capacity to grow by 53% by 2026,' *Anadolu Agency*, 3 December 2021, <https://www.aa.com.tr/en/economy/turkeys-renewable-power-capacity-to-grow-by-53-by-2026/2437571>.

<sup>44</sup> European Commission, 'EU trade relations with Türkiye,' 2022, [https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/countries-and-regions/turkiye\\_en](https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/countries-and-regions/turkiye_en).

isting channels of trade and investment, and harmonization of the regulatory environment, will help reduce the transaction costs of hydrogen trade. Second, Turkey is already integrated into European gas and power networks, which will put Turkey a step ahead of other potential hydrogen exporters that currently have limited transport capacities. Turkey's natural gas infrastructure, the sixth-longest in Europe, can be retrofitted for hydrogen.<sup>45</sup> Turkey's position on the Southern Gas Corridor is of critical importance. The Trans Anatolian Pipeline (TANAP), the interconnectors between Turkey, Bulgaria, and Greece, and the Trans Adriatic Pipeline (TAP) can be, in principle, used for sending blended gas or pure hydrogen.<sup>46</sup>

Depending on the cost and availability of supply, dedicated hydrogen pipelines could also be constructed between Turkey and Europe. A recent example is the H2MED project, an undersea pipeline between Barcelona and Marseille, which will be completed by 2030 and be exclusively dedicated to hydrogen (as opposed to earlier reports that it would initially carry natural gas). The project will be submitted to the European Commission to have it declared a 'project of common interest' which would allow up to 50 per cent of the costs to be covered by EU funds.<sup>47</sup> H2MED could potentially be a model for dedicated hydrogen pipeline projects involving Turkey. However, depending on the distance, maritime transport may be a more cost-effective and flexible option than pipelines. Transporting cryogenic hydrogen, however, is a very energy-intensive option. Moreover, there are serious technical impediments to shipping liquid hydrogen.<sup>48</sup> Thus, for maritime transport, ammonia is the best option currently. Turkey has several regional ports on the Aegean and Mediterranean coasts with good road and railroad connectivity for shipping hydrogen products.

45 OIES, 'What role for hydrogen in Turkey's energy future?' (Oxford Institute for Energy Studies, 2021), 17, <https://www.oxfordenergy.org/publications/what-role-for-hydrogen-in-turkeys-energy-future/>.

46 SHURA, 'Priority areas for a national hydrogen strategy for Turkey' (SHURA Energy Transition Center, 2021), <https://energy.mit.edu/wp-content/uploads/2021/02/Priority-areas-for-a-national-hydrogen-strategy-for-Turkey.pdf>.

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# Policy challenges and next steps

Hydrogen is a promising technology, which, if fully developed, can be the missing link for the energy transition. For industrialized economies, hydrogen offers greater security of supply and a pathway to the net zero world by 2050, assuming that they can produce and/or import enough hydrogen at competitive prices. For the select few countries that are well-endowed in terms of renewable energy resources, water, and land, hydrogen could also be a major export commodity, depending on production capacity and transport infrastructure.

The arrival of hydrogen could significantly alter the dynamics of energy cooperation between Turkey and the EU. The shared interests of the two actors, not only in terms of climate change but also energy supply security post-Ukraine, suggest that hydrogen could be the basis of a new, win-win scenario in Turkey-EU energy relations.<sup>49</sup> Yet, while the potential is there, there are also significant hurdles to establishing hydrogen-based energy cooperation between Turkey and the EU.

First, Turkey's policy choices regarding the prioritization of exports over domestic consumption will matter. Currently, Turkey seems to consider domestic hydrogen production primarily as a means to reduce reliance on imported energy.<sup>50</sup> Turkey has made great strides in renewables over the past decade, taking advantage of its favorable resource endowments, strong domestic demand, and supportive government policies. Nonetheless, the Turkish economy is still dependent on fossil fuels, most of which are imported (import dependence is 93 per cent for oil and 99 per cent for natural gas).<sup>51</sup> Since the government prioritized coal-fired power stations to reduce dependence on imported gas, the share of coal in electricity generation has also increased considerably over the past decade. In 2021, the share of coal in electricity generation was 31 per cent (Figure 3).

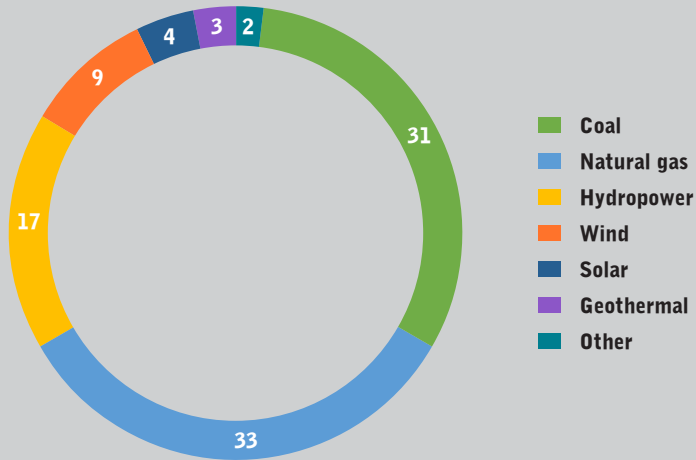
49 Kadri Tastan, 'Decarbonising EU-Turkey energy cooperation: challenges and prospects,' *SWP Comment*, 2022, 8, <https://www.swp-berlin.org/10.18449/2022C23/>.

50 OIES, 'What role for hydrogen in Turkey's energy future?', 20.

51 Turkey had a series of natural gas discoveries in the Black Sea since 2020. The total reserves are estimated at 710 bcm. Assuming a production of up to 15 bcm per year, these reserves can possibly reduce Turkey's gas imports by as much as 25 per cent.



**Figure 3: Electricity production by primary energy source in Turkey, 2021 (%)**



Source: The Ministry of Energy and Natural Resources, <https://enerji.gov.tr/bilgi-merkezi-enerji-elektrik>

As Turkey seeks to decarbonize its energy mix, phasing out coal will be the key. Turkey's installed renewable capacity is projected to grow, but it is unclear what percentage of this additional capacity can be realistically channelled into electricity earmarked for green hydrogen, as opposed to electricity to supplant fossil-generated power. Given potential trade-offs, the decision-makers would have to balance various interests such as maximizing export revenues and deepening energy ties with the EU on the one hand and lowering domestic energy prices and reducing import dependence on the other.

Second, developing a diversified and export-capable hydrogen sector would require a policy approach laid out in a national strategy and embedded in a comprehensive regulatory framework. Other countries seeking to become hydrogen exporters, such as Australia, Chile, and Morocco, have already announced their long-term hydrogen strategies. Turkey is yet to finalize a national hydrogen plan. As previously noted, since 2020, there has been strong governmental and private sector interest in developing a domestic hydrogen sector. While there have been a few studies by think tanks and sector associations, the government has not officially announced a long-term vision for hydrogen, which would include the infrastructure investment needed to achieve production goals. A robust and realistic national strategy would include a clear timeline for the transition

to a green hydrogen economy. Moreover, the hydrogen strategy should also be in sync with broader policy goals and instruments, including the diversification of Turkey's energy mix which will likely involve imported and domestically produced gas and nuclear power.

At the Green Energy Summit in November 2022, the Turkish Minister of Energy and Natural Resources, Fatih Dönmez, said the following on the country's hydrogen strategy: 'We have clear targets. Our electrolyser capacity will be 2 GW in 2030 and 70 GW in 2053. At the same time, we will lower hydrogen production costs from 2.4 to 1.2 dollars by 2035. Thus, we will speed up energy transition, reduce energy imports and increase our competitiveness.'<sup>52</sup>

Third, in addition to finalizing a national hydrogen plan, Turkey will need a comprehensive legal framework to regulate the production, consumption, and trade of hydrogen. As Turkey and the EU work toward creating a suitable regulatory environment for hydrogen, the two actors would benefit from harmonizing their standards and practices. A key factor here would be Turkey's EU accession process. Over the past two decades, Turkey has undertaken various reforms, particularly in the electricity and (partially) gas sectors to allow for integration into European markets and regulations. A new 'positive agenda' between Turkey and the EU would facilitate establishing a hydrogen-fuelled interdependence between the two actors.

At the same time, it should be noted that key differences between the Turkish and European policymakers regarding the role of energy cooperation in the accession process have in the past adversely affected bilateral relations. On several occasions, such as negotiations on the ill-fated Nabucco pipeline project, Turkish policymakers sought to leverage energy cooperation to move the accession process faster, whereas EU officials dismissed any linkage between energy and EU membership.<sup>53</sup> The mismatch between expectations proved detrimental to both energy cooperation and accession. Going forward, as Turkey and the EU seek to establish hydrogen-based interdependencies, the two actors will have to make an effort to manage political implications and mutual expectations.

Fourth, developing an export-capable hydrogen sector in Turkey would require massive investment in surplus renewable generation as well as infrastructure for hydrogen production, storage, and transport. In the absence of a national hydrogen plan with clear

52 '2035'e kadar hidrojen üretim maliyetini düşüreceğiz,' *Anadolu Agency*, 2022, <https://www.aa.com.tr/tr/yesilhat/yesil-ekonomi/bakan-donmez-turkiye-enerji-zirvesinde-konustu/1818848>.

53 Tolga Demiryol, 'The geopolitics of energy cooperation between Turkey and the European Union,' *Journal of Studies on European Integration and Federalism (Revue 'L'Europe en Formation')* 367 (Spring 2013): 109-37.

policy priorities and timelines, it is very difficult to estimate the investment required to develop Turkey's hydrogen sector. SHURA estimates that an annual investment of 3 to 4 billion dollars is required until 2050 to produce 3.4 Mt of hydrogen.<sup>54</sup> Investments in long-distance hydrogen pipelines and other transport infrastructure would further require considerable up-front capital expenditure. Turkey, like other hydrogen producers, would need to achieve economies of scale to make production feasible.

This would indicate the need for extensive government involvement both directly through public investment and subsidies, and indirectly through securing financing for various elements of the hydrogen supply chain. Private investors would seek revenue security to recoup capital expenses for building hydrogen projects. Buyers on the other end of the value chain would be looking for the security of supply. Long-term purchase agreements would serve well to reduce investment risk and increase the security of supply and demand. In this regard, it would be advisable for Turkey and the EU to start working on joint financing mechanisms for the long-term purchase of green hydrogen.

Lastly, Turkey can potentially play a role in hydrogen-based regional cooperation in the Eastern Mediterranean. The region is rich both in terms of natural gas and renewable energy resources. Some of the gas discovered in the Eastern Mediterranean remains undeveloped for a variety of reasons, including geopolitical disputes and uncertainty of European gas demand. The growing demand for alternative energy sources in Europe after Ukraine has resuscitated interest in Mediterranean gas, despite lingering environmental and climate concerns. The arrival of hydrogen will likely have a crucial impact on the Mediterranean energy scene, putting blue hydrogen on the table as a viable option. There are several possible storage solutions around the region, which can be used for the carbon capture and storage needed to decarbonize hydrogen produced from gas. In terms of transport, an often-discussed option is to build 'transition pipelines,' which first utilize natural gas and then transition to hydrogen exports. This would, in principle, allow regional countries to use natural gas revenue to subsidize hydrogen exports.<sup>55</sup>

Most importantly, the Eastern Mediterranean is endowed with considerable solar and wind potential, which suggests that the region may be a supplier of green hydrogen for the EU.<sup>56</sup> While countries like Greece and Egypt have shown strong interest in developing their hydrogen sectors, the biggest potential lies in multilateral cooperation, which

<sup>54</sup> SHURA, 'Techno-economic study of Turkey's production and export potential for green hydrogen,' 8.

<sup>55</sup> Laurent Ruseckas, 'Europe and the Eastern Mediterranean: The potential for hydrogen partnership' (Stiftung Wissenschaft und Politik, 2022), <https://www.swp-berlin.org/en/publication/europe-and-the-eastern-mediterranean-the-potential-for-hydrogen-partnership>.

<sup>56</sup> Raimondi, 'The scramble for Mediterranean hydrogen.'

would allow regional players to pool their resources for infrastructure investment and market access. The East Mediterranean Gas Forum (EMGF), established in 2018 as a platform for regional gas cooperation, can play a focal role in harnessing the region's hydrogen potential. The Eighth Ministerial Meeting of the EMGF, which took place in Cairo on 7 December 2022, evidenced the growing salience of energy transition for EMGF members. In his opening speech, the new President of the EMGF, Egyptian Minister of Petroleum and Mineral Resources El-Molla, stressed the importance of cooperation between producers, consumers, and transit countries to develop infrastructure projects for gas, hydrogen, and renewable energy. Conceivably, the expected benefits from bilateral and multilateral cooperation on renewable energy and hydrogen development could incentivize regional states to resolve some of the outstanding political disputes as well.

## Conclusion

The coming of the hydrogen economy is clouded by various uncertainties. The technology underlying hydrogen production and consumption is still developing. How fast and how much production costs will decline will in larger part determine the pace and scope of transition. Government policies conducive to innovation and investment will be crucial, as will the presence of a comprehensive regulatory framework for hydrogen markets. While no process of social and economic change is irreversible, the pace at which the hydrogen sector has grown over the past few years suggests that it will be an important part of the energy policies going forward. In addition to facilitating the decarbonisation of national economies, hydrogen will also be a critical component of the new geopolitics of energy transition as interdependencies emerge between haves and have-nots.

This article focused on the EU's emergent hydrogen strategy and Turkey's potential role as an exporter. The primary finding is that while Turkey has considerable endowments that could be used to develop an export-capable hydrogen sector, the realization of this potential is contingent on several factors, including Turkey's domestic energy consumption, the implementation of a feasible national hydrogen plan, the establishment of a proper regulatory framework and market structures, the creation of infrastructure investment schemes, and lastly, the extent of regional cooperation on hydrogen development and trade.

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