Istituto Affari Internazionali

The Geopolitics of Clean Hydrogen – Opportunities and Challenges for Italy

by Marco Giuli

ABSTRACT

The emergence of clean hydrogen as an energy carrier promises to shape the future geography of the energy trade. Under growing contestation of interdependence, such a geography should be read through political lenses alongside commercial and technological ones. Generally, hydrogen is likely to reduce the geopolitical sensitivity of energy trade with respect to a fossil-fuel-based energy order by increasing the share of energy produced domestically, shifting geostrategic competition from a focus on grabbing resources to a focus on mastering technology and setting standards, and offering petrostates opportunities for economic diversification. Italy can exploit the opportunities offered by a hydrogen economy for enhancing its energy security and positioning in the regional energy trade. However, it should be careful with monitoring how geopolitical barriers such as regional instability may affect its hydrogen ambitions.

Italy | Pipelines | Energy | Hydrogen | External trade

keywords

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Introduction

The energy transition is expected to bring about a structural change in many socio-technical foundations of our civilisation,[1] including the way in which power and influence are allocated and exerted on the international stage. It is expected to reduce those interdependencies born around fossil fuel trade, and to give rise to emerging interdependencies where technology, infrastructure and regulation count more than geological endowments.[2] Similarly, as electrification grows and since electricity is not an efficient carrier over long distances, the energy transition is expected to define a world that is less global – at least within the energy issue area – and more regional, or even national,[3] laying the groundwork for major geopolitical shifts.

The entry of clean hydrogen into the global energy transition equation may at least to some extent challenge these assumptions. Clean hydrogen includes hydrogen produced via electrolysis from non-emissive electricity from renewables (green hydrogen) or nuclear (pink hydrogen), and hydrogen produced through

[1] Gavin Bridge et al., "Geographies of Energy Transition: Space, Place and the Low-Carbon Economy", in *Energy Policy*, Vol. 53 (February 2013), p. 331-340, https://doi.org/10.1016/j.enpol.2012.10.066.

[2] Tom Casier, "The Geopolitics of the EU's Decarbonization Strategy: A Bird's Eye Perspective", in Claire Dupont and Sebastian Oberthür (eds), *Decarbonization in the European Union. Internal Policies and External Strategies*, Basingstoke/New York, Palgrave Macmillan, 2015, p. 159-179.

[3] Daniel Scholten et al., "The Geopolitics of Renewables: New Board, New Game", in *Energy Policy*, Vol. 138 (March 2020), Article 111059.

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methane reforming with the addition of carbon capture and storage (blue hydrogen) By offering the possibility of turning electrons into molecules and then back to electrons, hydrogen promises to become a carrier for clean energy over long distances, potentially reproducing infrastructural and geographical interdependencies that were typical of the fossil-fuel-based order, depending on its generation route. The export of green hydrogen – generated via electrolysis – might give rise to emerging *electrostates*. The export of blue hydrogen – produced from methane reforming processes with the addition of carbon capture and storage (CCS) – could allow gas exporters to preserve some role in the new energy map.

However, at a closer inspection, hydrogen's distinctive technological features may also call into question the possibility for such a carrier to become a "new oil" in the broader global political picture. Hydrogen's geopolitical dimension will be largely defined by what choices states and commercial actors will take with respect to: producing it domestically or importing it; producing it for export, or using it domestically and attracting final users from abroad; privileging its use in essential hard-to-abate sectors such as the steel, chemical or refining industries, or as a substitute for electrification in residential heating or road transport.[4] In turn, the broader geopolitical environment is also expected to play a role in orienting actors to make their choices. These questions oblige us to think about hydrogen in distinctive geopolitical terms.

This paper examines the potential geopolitics of hydrogen, looking first at what type of geography the emergence of hydrogen technologies is likely to produce, then exploring the potential elements of geopolitical contestations associated with hydrogen interdependencies, and finally reflecting on geopolitical opportunities and barriers that Italy could meet as it seeks to become an international hydrogen actor. This work complements a previous paper that inquired about Italy's prospective collocation in an emerging international economy of clean hydrogen.[5]

1. Defining clean hydrogen geography

At present, hydrogen is not an internationally traded commodity. Hydrogen is produced nationally by its consumers mostly from natural gas, while cross-border trade infrastructures are largely non-existent. While production and consumption of clean hydrogen are likely to maintain a national dimension in the short term, elements of regionalism or even global trade may emerge over the long term, reflecting the evolution of material conditions such as production cost differentials and dynamics in transportation cost, and the will of actors to engage

[4] Thijs Van de Graaf et al., "The New Oil? The Geopolitics and International Governance of Hydrogen", in *Energy Research & Social Science*, Vol. 70 (December 2020), Article 101667, https://doi.org/10.1016/j.erss.2020.101667.

[5] Marco Giuli, *Italy in the International Hydrogen Economy*, Rome, IAI, February 2022, https://www.iai.it/en/node/14708.

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in international hydrogen relations. However, as the geopolitics of fossil fuels cannot prescind from their pervasiveness in the global economy, understanding the geopolitical implications of a hydrogen economy would require first to make assumptions about the size of hydrogen trade.

1.1 Assuming the size of clean hydrogen trade

Considering the uncertainties with respect to policy, technology and consumer preferences, scenarios about the future demand for hydrogen show remarkable divergences. According to BloombergNEF, hydrogen may account between 4 and 24 per cent of global final energy consumption by 2050.[6] According to the IEA net zero scenario, hydrogen consumption would rise from 87 million tonnes of hydrogen (MtH_2) in 2020 to 528 MtH_2 in 2050, 68 per cent of which would be produced via electrolysis and 38 per cent via fossil fuels.[7] According to a scenario elaborated by the Hydrogen Council, in 2050 hydrogen will account for 18 per cent of final energy consumption, corresponding to 641 MtH_2.

On the basis of these estimates, one could consider a global production of about 600 MtH_2/yr by 2050 (72 exajoules of energy) as a reasonable central estimate from the most optimistic scenarios. Assuming that the international trade of hydrogen and hydrogen products would amount to 25 per cent of global production – based on the current proportion of internationally traded natural gas with respect to total natural gas production – the internationally traded volume of hydrogen would correspond to about 18 exajoules (EJ). This amounts to a fraction of traded volumes of fossil fuels in 2019, totalling 217.72 EJ. At the same time, it is not a negligible amount if compared to currently traded volumes of natural gas, amounting to 37.2 EJ in 2019.

1.2 Geography of costs and comparative advantages

Several conditions can be identified for the emergence of international hydrogen value chains: the existence of comparative advantages between different economies, structuring the incentives for the emergence of interstate trade of both hydrogen-related products and associated technologies; and the political will, at a national level, to identify opportunities for importing or exporting hydrogen and hydrogen-related products and technologies, adapting national industrial policies and international partnerships accordingly.[8]

[6] BloombergNEF, *Hydrogen Economy Outlook. Key Messages*, 30 March 2020. https://data.bloomberglp.com/professional/sites/24/BNEF-Hydrogen-Economy-Outlook-Key-Messages-30-Mar-2020.pdf.

[7] Which modelled hydrogen demand in order to fill gaps where electricity cannot economically replace fossil fuels and where limited sustainable bioenergy supplies cannot cope with demand. International Energy Agency (IEA), *Net Zero by 2050. A Roadmap for the Energy Sector*, Revised version (4th revision), October 2021, https://www.iea.org/reports/net-zero-by-2050.

[8] Thijs Van de Graaf et al., “The New Oil?”, cit.

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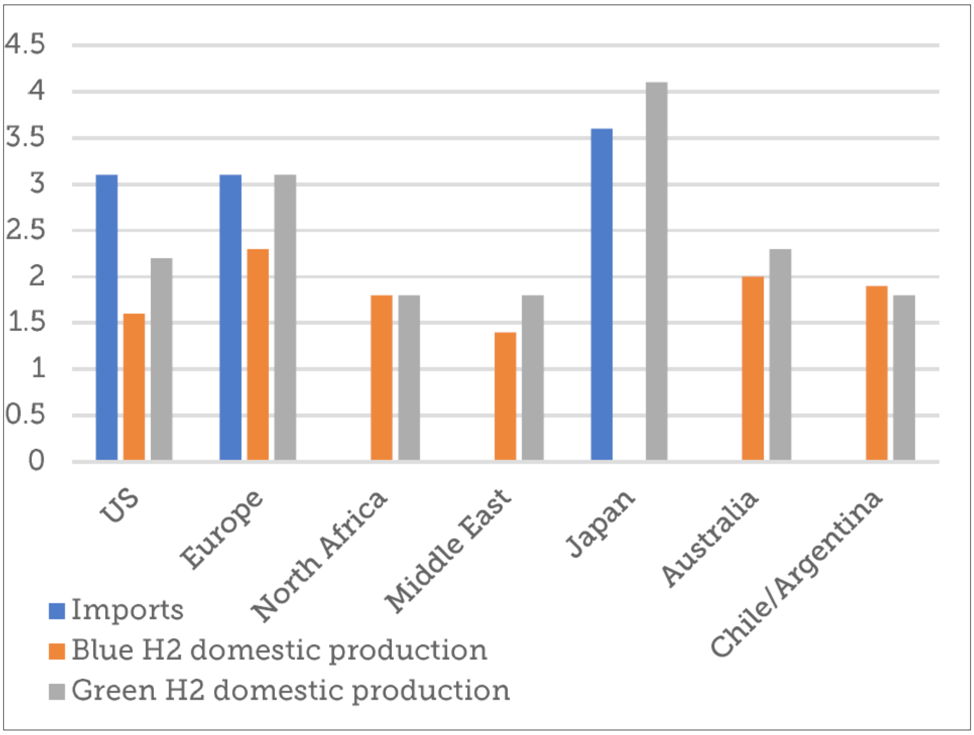
Figure 1 | Cost of hydrogen supply by location (US dollars/kgH_2)



Source: Author's elaboration on IEA 2020 data.

The determinants of comparative advantage in the hydrogen trade include a low-cost availability of renewable energy sources (RES) and/or potential and freshwater availability as for green hydrogen; and low-cost natural gas availability and CCS potential as for blue hydrogen.[9] Existing gas interconnections identify market access potential for future hydrogen producers, while demand centres are expected to develop in large clusters of emission-intensive industries. The IEA foresees that the long-term cost of imported hydrogen is likely to be unattractive for the United States with respect to the domestic production of both blue and green hydrogen, while a larger rationale for clean hydrogen imports is present in Europe and Japan (see Figure 1). On the other hand, low-cost producers are expected to emerge in Australia, the Middle East and North Africa, and Chile. Taking into account transport costs, cost differentials create ideal synergies between North Africa and Norway as exporters and Europe as an importer via pipeline trade; and between Australia and East Asia via ships. On the other hand, countries like Chile or the Gulf states would be in a position of playing arbitrage between different regional markets – with an option, for Chile, also to serve the Latin American market if it were to develop.[10]

[9] Fridolin Pflugmann and Nicola De Blasio, "Geopolitical and Market Implications of Renewable Hydrogen", in *Belfer Center Reports*, March 2020, https://www.belfercenter.org/node/128441.

[10] Pipeline trade of pure hydrogen in gaseous form is more convenient than shipping hydrogen via ammonia for up to 3,000 km (US dollars 1.3/kgH_2), via liquid organic hydrogen carriers (LOHC) for

Such a geography would to a notable extent reproduce the current geographical trajectories of gas trade.

1.3 Political will

A second element to consider when looking at the future geography of hydrogen trade is the political will to domestically develop hydrogen demand and/or supply and opening up to the opportunity of international hydrogen trade. National hydrogen strategies, although often lacking sufficient detail, constitute a predictor of countries' self-perception of the potential role they could play in an international hydrogen economy.

Among prospective exporters, the most ambitious strategies have been released by Australia,[11] Chile,[12] Morocco,[13] Russia,[14] Saudi Arabia,[15] the United Arab Emirates (UAE)[16] and Oman,[17] while opportunities for clean hydrogen exports are also mentioned in the strategies of New Zealand,[18] Canada[19] and such Latin American countries as Colombia, Argentina and Brazil. Other strategies underline the need for importing clean hydrogen from abroad. These include the EU, Germany,[20] the

up to 4,000 km (US dollars 1.6/kgH_2) and in pure liquid form for up to 4,600 km (US dollars 1.9/kgH_2). IEA, *The Future of Hydrogen. Seizing Today's Opportunities*, June 2019, p. 78, https://www.iea.org/reports/the-future-of-hydrogen.

[11] COAG Energy Council, *Australia's National Hydrogen Strategy*, 2019, https://www.industry.gov.au/node/69001.

[12] Chile, *National Green Hydrogen Strategy, Ministry of Energy*, November 2020, https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf.

[13] Luca Franza, *Clean Molecules across the Mediterranean. The Potential for North African Hydrogen Imports into Italy and the EU*, Rome, IAI, April 2021, p. 13-17, https://www.iai.it/en/node/13116.

[14] Yana Zabanova and Kirsten Westphal, "Russia in the Global Hydrogen Race", in *SWP Commentaries*, No. 34 (May 2021), https://doi.org/10.18449/2021C34.

[15] Jan Frederik Braun, "Saudi Arabia's Clean Hydrogen Plans for Converting Ambitions into Action", in *Energy Post*, 19 March 2021, https://energypost.eu/?p=32318.

[16] Watson Farley & Williams, "Hydrogen in the UAE", in *WFW Articles*, 2 June 2021, https://www.wfw.com/articles/hydrogen-in-the-uae.

[17] James Burgess, "World's Largest Renewable Hydrogen Developer Adds 25-GW Oman Export Project", in *S&P Global*, 18 May 2021, https://www.spglobal.com/platts/en/market-insights/latest-news/petrochemicals/051821-worlds-largest-renewable-hydrogen-developer-adds-25-gw-oman-export-project.

[18] New Zealand, *A Vision for Hydrogen in New Zealand. Green Paper*, Ministry of Business, Innovation & Employment, September 2019, https://www.mbie.govt.nz/dmsdocument/6798.

[19] Canada, *Hydrogen Strategy for Canada*, Ministry for Natural Resources, December 2020, https://www.nrcan.gc.ca/node/23080.

[20] Germany, *The National Hydrogen Strategy*, Federal Ministry for Economic Affairs and Energy, June 2020, https://www.bmwk.de/Redaktion/EN/Publikationen/Energie/the-national-hydrogen-strategy.html; Bernd Radowitz, "World's Largest Hydro Dam Could Send Cheap Green Hydrogen from Congo to Germany", in *Recharge News*, 8 September 2020, https://www.rechargenews.com/transition/2-1-871059.

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Netherlands, Japan,[21] and South Korea.[22] Yet, not every strategy is outward-looking. The United States,[23] France,[24] Poland, Spain, Portugal, and China[25] emphasise the prospects of developing a domestic supply chain, seeking industrial primacy and security gains. Table 1 summarises the targets and technological preferences of the main national strategies, at the time of writing.

Table 1 | National hydrogen strategies

Country	Electrolysis target (2030)	Domestic use target (2030)	Production route	Final use	Committed public investment (bn dollars)
Australia	-	-	Coal+CCUS Gas+CCUS RES+electrolysis	Buildings, electricity, exports, industry, shipping, road transport	0.9
Canada	-	4 MtH2/y	Biomass by-product RES+electrolysis Gas+CCUS Oil+CCUS	Buildings, electricity, exports, mining, refining, shipping, road transport	0.019
Chile	25 GW	-	RES+electrolysis	Buildings, exports, chemicals, mining, refining, road transport	0.05 (2021)
China	-	0.1-0.2 MtH2/y (2025)	RES+electrolysis	Transport, industry	-
Czech Rep.	-	0.1 MtH2/y	Nuclear+electrolysis	Chemicals, road transport	-
EU	40 GW	-	RES+electrolysis	Industry, refining, road transport	4.3
France	6.5 GW		Nuclear, RES+electrolysis	Industry, refining, road transport	8.2
Germany	5 GW	-	RES+electrolysis	Aviation, electricity, industry, refining, shipping, road transport	10.3

[21] Monica Nagashima, "Japan's Hydrogen Society Ambition. 2020 Status and Perspectives", in *Notes de l'Ifri*, September 2020, https://www.ifri.org/en/node/17801.

[22] Sichao Kan, "South Korea's Hydrogen Strategy and Industrial Perspectives", in *Édito Énergie Ifri*, 25 March 2020, https://www.ifri.org/en/node/17067.

[23] US Department of Energy, *Hydrogen Strategy Enabling a Low-Carbon Economy*, July 2020, https://www.energy.gov/node/4497695.

[24] France, *Stratégie nationale pour le développement de l'hydrogène décarboné en France. Dossier de presse*, 8 September 2020, https://www.entreprises.gouv.fr/fr/node/212551.

[25] Michal Meidan, "China's Emerging Hydrogen Strategy", in *ISPI Commentaries*, 21 May 2021, https://www.ispionline.it/en/node/30431.

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Hungary	240 MW	0.03 MtH2/y	Nuclear, RES+electrolysis Gas+CCUS	Electricity, industry, road transport	-
Japan		3 MtH2/y	Nuclear, RES+electrolysis Gas, coal+CCUS	Buildings, electricity, steel, refining, shipping, road transport	6.5
South Korea	-	1.94 MtH2/y	Nuclear, RES+electrolysis Gas+CCUS	Buildings, electricity, road transport	2.2
Netherlands	3-4 GW		RES+electrolysis Gas+CCUS	Aviation, buildings, electricity, industry, refining, shipping, road transport	0.08
Norway	-	-	RES+electrolysis Gas+CCUS	Industry, shipping, road transport	0.021
Portugal	2-2.5 GW		RES+electrolysis	Electricity, industry, road transport	1
Russia	-	2 MtH2 (export)	Electrolysis Gas+CCUS	Electricity, industry, chemicals, exports	-
Spain	4 GW	-	RES+electrolysis	Aviation, electricity, chemicals, refining, shipping, road transport	1.8
UK	5 GW	-	Nuclear, RES+electrolysis Gas+CCUS	Aviation, buildings, electricity, industry, refining, shipping, road transport	1.3

Note: CCUS = Carbon capture utilisation and storage; GW = Gigawatts.
Source: IEA (2021) and China's National Energy Administration (2022).

1.4 Three scenarios for hydrogen trade

However, material complementarities and political will do not necessarily guarantee the development of a large-scale hydrogen trade and interstate interdependencies. Policy and institutional contexts, market dynamics and the overall geopolitical context may affect the future geography of hydrogen. Different scenarios could develop – partly excluding each other, but also partially overlapping.

National scenario. Under a "national" hydrogen scenario, countries would mostly procure the clean hydrogen they need domestically – also implying for many of them a reduced share of hydrogen in final energy consumption and privileging alternatives where possible. A national scenario could become dominant as a result of increasing power rivalry and contestation of economic interdependence and/or sharp reduction in hydrogen production costs among large consumers. In technological terms, it might be favoured by breakthroughs in CCS in large industrial economies, which would continue to import natural gas to produce fossil-based hydrogen domestically – a solution that would have the advantage of

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not requiring the refurbishment of existing gas import infrastructures. Similarly, markets for green hydrogen will remain national in those contexts where renewable electricity production continues to expand and undergo cost reduction. Another dynamic that could play in favour of a national scenario – but not necessarily alternative to a future of abundant trade interdependence – is that natural gas or low-cost renewable electricity suppliers and potential suppliers – i.e., Russia, Norway, Chile, Australia or the Gulf countries – develop in-house lead markets and demand for hydrogen, attracting an industrial base from Organisation for Economic Cooperation and Development (OECD) countries.

Regional scenario. Under a "regional" scenario, international hydrogen trade would mostly occur within regions, via pipeline over short distances, reproducing the current state of cross-border electricity trade or the early international trade of natural gas. Low-cost producers would directly ship hydrogen and derived products to nearby industrial regions, which could retain an energy-intensive industrial base and provide core and ancillary technology for hydrogen production to prospective suppliers. Under such a scenario, European hydrogen clusters would be supplied clean hydrogen from the North Sea, the former Soviet Union and North Africa by making use of existing pipeline networks. This scenario requires investment in the repurposing of cross-border gas pipelines, to make them viable for pure hydrogen transport. Regional markets are also likely to emerge in East Asia, as Australia is adopting an export-driven hydrogen strategy, properly matching the import-driven strategy of Japan and Singapore – poor in natural resources and with limited RES potential. Such a trade route requires the development of seaborne trade, paving the way for a possible global scenario. A regional scenario will also be driven by geopolitics, when some form of regional multipolarity emerges around large economic blocs, with trade denominated in currency of regional reference.

Global scenario. Under a "global" scenario, different regions would integrate thanks to technological developments reducing barriers to long-distance shipping trade. In political terms, a global scenario would be best served by a globalised order supporting multilateral trade institutions and securing worldwide flows across critical chokepoints. However, it may also occur under contested interdependence, whereby states question connectivity with unfriendly nearby partners and politically select more distant nations to exchange energy with. To this extent, prospective low-cost green hydrogen producers such as Chile, Australia or Norway could supply different world regions.

While these scenarios constitute ideal-types, there is a chance that their different elements may coexist. Also, moving from a dominant national scenario towards a more internationalised one is a pattern foreseen by most projections. To this extent, one can assume an interstate hydrogen trade to develop alongside the geographical articulations outlined in this section over the long term, pending a large number of technological and geopolitical unknowns.

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2. The geopolitical aspects of clean hydrogen trade

Now that the geographical trajectories of hydrogen interdependence have been defined, this section identifies the potential elements of political contestation associated with such trajectories. These include interstate competition to secure supply and achieve technological primacy, from the point of view of prospective importers; the political fallout of hydrogen exports from the point of view of hydrogen producers; and the potential elements of North-South rivalry in the context of production outsourcing.

Supply security. By replacing amounts of imported hydrocarbons with a largely domestic resource, national production of clean hydrogen is expected to improve the supply security of today's large energy importers. Notably, an acceleration of hydrogen deployment was seen in Europe as an answer to the mounting political unease associated with dependence on foreign gas.[26] A question emerges, therefore, whether hydrogen trade provides opportunities for manipulating interdependence with coercive aims. Hydrogen's gaseous state and complex logistics show similarities with the technical features of natural gas and may reproduce the geopolitical concerns associated with it. The emergence of an interstate trade is likely to require long term supply contracts securing returns to very capital-intensive investments. This means that in the short-to-medium term, consumers might get entrenched in close sectoral interdependence with a small number of suppliers, waiting for technology to allow more flexibility and optionality in supplies. As a general assumption, a return to a geopolitical framing of energy security may push large consumers to limit as much as possible contested connections, privileging domestic supply and selecting partners based on geopolitical, rather than commercial, factors.

Derived-resources geopolitics. As an energy carrier, hydrogen relies on certain natural resources for its generation. To this extent, forms of political contestation associated with the distribution, transport and use of such additional resources (inputs) should be considered. As for green hydrogen, a source of concern relates to the amount of freshwater needed in electrolysis.[27] Especially in geographical contexts where this resource is scarce, hydrogen generation may give rise to domestic contestation or interstate competition for the control of water resources. While desalination can pave the way for the use of saltwater, the process is also energy-intensive and raises the costs of green hydrogen production, potentially inducing reconsideration with respect to locational choices. Blue hydrogen relies on the use of natural gas, arguably raising geopolitical concerns with respect to this resource. The current dynamics in gas prices and the gas market outlook, alongside the tarnished geopolitical reputation of gas following Russia's aggression

[26] European Commission, *REPowerEU: Joint European Action for More Affordable, Secure and Sustainable Energy* (COM/2022/108), 8 March 2022, https://eur-lex.europa.eu/legal-content/en/TXT/?uri=celex:52022DC0108.

[27] About 9 litres of water are needed to produce 1 kgH_2, amounting to about 33.3 kWh of energy.

of Ukraine, may significantly complicate the uptake of such technology – already perceived as controversial in Europe.

Technological mastery. The geopolitics of the energy transition will be defined less by access to resources than by mastery of innovation in process and products, complex infrastructure, and influence on processes of standardisation and regulation.[28] Those actors that are better placed in terms of innovative ecosystems, market size, financial availabilities and administrative capacity will be more likely to set the rules of the game, in a process that itself becomes an arena of cooperation and/or competition. Research, intellectual property, industrial policy, trade and tax and carbon pricing policies along with their surrounding bureaucratic-industrial ecosystems are expected to achieve strategic centrality in the energy order. Innovation agencies and public procurement authorities are also going to provide resources, design policies and practices and create lead markets critical to the achievement of global primacy in clean energy systems. The EU and some European member states such as Germany are trying to achieve such primacy by way of becoming early adopters of clean hydrogen technologies and using the EU regulatory power to set standards for reference.[29] However, other actors are also in the race, following different approaches. Australia, South Korea and Japan, for instance, are establishing trade partnerships aimed at first developing fossil-based hydrogen into final uses even without decarbonising it first. These countries calculate that clean hydrogen is too expensive at the moment, so that in order to dominate technology and set future standards, a market needs to be developed by way of the more affordable grey or brown/black hydrogen – produced via methane reforming or lignite/coal gasification without carbon capture. These differences may complicate international cooperation and encourage fragmentation.

Resource curse? The risk of emergence of the resource curse (defined as the tendency of resource-rich countries to experience less long-term economic growth, less democracy and less development than countries with fewer natural resources) would be arguably less pronounced with hydrogen than with fossil fuels. Several exporters of oil and gas show adequate conditions for becoming low-cost producers of clean hydrogen, clean ammonia or hydrogen-based e-fuels. This is especially the case for Gulf countries such as Saudi Arabia, Oman and the UAE, as well as North African countries. A question is, however, whether in these economies hydrogen can play a role comparable to the one played by fossil fuels as a defining feature of i) the social contract, preserving local regimes' output legitimacy by providing them with sufficient material and ideational resources to allocate and distribute among their constituencies; and ii) the framing of energy exports as critical for national sovereignty and power. These expectations largely

[28] Meghan O'Sullivan, Indra Overland and David Sandalow, "The Geopolitics of Renewable Energy", in *Columbia Center on Global Energy Policy Working Papers*, June 2017, https://www.energypolicy.columbia.edu/node/2004.

[29] European Commission website: *Hydrogen and Decarbonised Gas Market Package*, https://europa.eu/!YPpd33.

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depend on the size of the trade. Hydrogen's lower traded volumes make it unlikely that it will play a role comparable to oil in producing countries. Hydrogen is more about an industrial challenge than a geological bonanza, requiring high skills and system integration. To this extent, the hydrogen industry promises to rest on different socio-technical foundations than those supporting oil and gas. Instead, hydrogen should be seen by oil and gas suppliers as a springboard for industrial diversification, allowing for a more mixed economy specialising in hydrogen-consuming sectors such as steel, fertilisers or production of e-fuels. It is therefore less likely for hydrogen to provide a lifeline to petrostates' rent economies, acting instead as an opportunity for industrial transformation and a more balanced economy.

The risk of green neocolonialism. Potential interstate geopolitical grievances may arise with respect to North-South dualism, and notably with reference to the notion of "green colonialism". While this concept was originally used in reference to the marginalisation of the Global South's local communities in the context of Global North–driven conservation initiatives, a question is whether green colonialism could take new, extractive forms in the context of the energy transition. Of particular concern are cases where advanced economies extract in the South the resources functional to reaching their objectives in an exploitative manner or at the expense of local communities. As seen in section 2, hydrogen interdependence is likely to first arise among OECD countries. Yet, Europe's appetite for winning the technological race has been pushing a frantic hydrogen diplomacy with several Sub-Saharan African countries, raising the risk that local elites may find more profitable to sell clean electricity via hydrogen to foreign markets than providing electricity to their own population. A particularly contested case is the expansion of the Inga III dam in the Democratic Republic of Congo (DRC), eyed by the German government as a possible source of green hydrogen. Factors of major controversy include the fact that the DRC is one of the least electrified countries in Africa, and that the construction would require the relocation of thousands of locals, in a context plagued with corruption and human rights abuses. However, this case's peculiarities are unlikely to be replicated in most other prospective hydrogen exporters.

3. Italy in the geopolitics of clean hydrogen

Italy has shown support for hydrogen initiatives. The primary guidelines for a national hydrogen strategy aim at reaching a 2 per cent hydrogen share of final energy consumption by 2030, amounting to about 700,000 tH_2 per year – and up to 20 per cent by 2050 – in the elaboration of its recovery and resilience plan. According to the guidelines, these targets require up to 10 billion euro between 2020 and 2030. A first step is Italy's National Recovery and Resilience Plan (PNRR), which allocates 3.19 billion euro to hydrogen. Several Italian actors suggest a role for the country as a regional hub for clean hydrogen.

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From a geopolitical perspective, hydrogen can affect Italy's power position in two different ways. The introduction of hydrogen can reduce Italy's exposure to the geopolitical risk associated with dependence on imported fossil fuels. In a low-demand scenario Italy could cope with its hydrogen needs through the domestic production of green hydrogen.[30] However, taking a more expansive use of hydrogen (estimated at 20 per cent of a total final energy consumption of 70 million tonnes of oil equivalent, Mtoe, in 2050) into consideration,[31] the import of up to 2 MtH_2/y was estimated. This would suggest a rate of external reliance of about 30 per cent, considerably lower than Italy's current external dependence on natural gas (95 per cent in 2019), oil (93.9 per cent) or coal (98.4 per cent).[32] In addition, hydrogen can enhance Italy's centrality within a decarbonised regional energy system, thanks to Italy's geographical position, abundant infrastructural connections and vast diplomatic-corporate networks across the Mediterranean region and the African continent. However, the value of these assets needs to be understood in the context of geopolitical opportunities and barriers.

Opportunities to develop Italy's centrality in the forthcoming hydrogen trade arise from a combination of infrastructural endowments and some geopolitical factors. Italy's assets could allow the country to act as a bridge between prospective low-cost clean hydrogen production regions and core demand regions in north-west Europe. Such a development would provide Italy with geostrategic centrality, also offering gas suppliers in the Mediterranean a future of economic diversification and connectivity that could mitigate the geopolitical risk associated with Europe's phase-down of fossil fuel imports from North Africa.[33] So far, cooperation in the field of hydrogen was mentioned in the context of an agreement between Eni and Algeria's Sonatrach aimed at increasing Algerian supplies of natural gas via the Transmed pipeline as of 2023.[34] At the same time, regional cooperation in the field of renewable energy – where Italian firms are active in several North African countries – can help create the basis for trade in green hydrogen in the future. The current security predicament in eastern Europe might support these ambitions. Italy's external hydrogen policy has been so far largely a by-product of energy diplomacy efforts to reduce imports of Russian natural gas. At the same time, other core demand regions in Europe have to reconsider plans to get future hydrogen supplies (or gas supplies to convert to hydrogen) from Russia. A system

[30] Marco Giuli, *Italy in the International Hydrogen Economy*, cit.

[31] Ricardo Energy & Environment, *Assessment of the Long-term Strategies of EU Member States – Italy*, October 2021, https://ec.europa.eu/clima/sites/lts/lts_it_summary_en.pdf. See also European Commission website: *National Long-term Strategies*, https://ec.europa.eu/info/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-long-term-strategies_en.

[32] European Commission website: *Energy Union Indicators Webtool: Net Import Dependcy - Hard Coal*, https://ec.europa.eu/energy/data-analysis/energy-union-indicators/database_en?indicator=SoS1&type=bar&subindicator=SoS1-A3.

[33] Luca Franza, *Clean Molecules across the Mediterranean*, cit.

[34] Eni, *Eni and Sonatrach Agree to Increase Gas Supplies from Algeria through Transmed*, 11 April 2022, https://www.eni.com/en-IT/media/press-release/2022/04/eni-and-sonatrach-agree-to-increase-gas-supplies-from-algeria-through-transmed.html.

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reconfiguration required by the interruption of Russian gas supplies – like the one advocated by the European Commission's roadmap to respond to the geopolitical turbulence unleashed by Russia's invasion of Ukraine – might not be reversed easily. To this extent, the new-found centrality of Mediterranean energy could constitute a geopolitical opportunity for Italy to develop its hydrogen diplomacy.

Alongside opportunities, geopolitical challenges for Italy's hydrogen diplomacy are present. First, the North African region is affected by severe political instability. Algeria has been experiencing a protracted tension between the political-military complex's desire to maintain stability and societal pressures from a young, growing population demanding reforms and economic opportunities. Externally, tension has been growing with Morocco over a multi-decade rivalry in the Western Sahara issue, which has re-ignited with severe consequences on the energy business across the region. Algeria's shutdown of flows to Morocco and threats to shut down gas exports to Spain signal the willingness of the country's leaders to weaponise energy in inter-state controversies. In the central Mediterranean, Libya – also connected to Italy via vast infrastructures and corporate presence – is plagued by factional rivalries that have proved disruptive for energy operations. Such an environment raises political risks for the sizeable investment that a hydrogen partnership would require, and once in place the risk of supply disruptions with a political origin cannot be neglected. Second, the security crisis in eastern Europe has raised a reconsideration on the role of gas in the energy transition due to a growing political risk associated with it and the impact it has on prices and therefore competitiveness. To this extent, the prospect of a transitional role for fossil-based hydrogen could also be reconsidered, as the prospect of "higher for longer" gas prices would arguably shift the political and economic favour towards electrolysis – with unclear consequences on the timetable of hydrogen uptake, as most scenarios are still based on the assumption of gas prices lower than 10 US dollars per million British thermal units (mmBTU).

Conclusions and recommendations

The international clean hydrogen trade is expected to be less geopolitically sensitive than the hydrocarbon trade. Traded amounts are expected to be lower than oil and gas today, and to a large extent domestically generated hydrogen is expected to replace imported fossil fuels, improving energy security. Nevertheless, depending on hydrogen uptake, forms of geopolitical contestation may persist regarding resources needed for hydrogen generation, potentially affecting locational choices. Competition is expected to focus on the mastery of technology and standards, where Europe or East Asian countries hold an advantageous position. For petrostates, hydrogen could be a source of industrial diversification, unlikely to reproduce the economic and political downsides associated with fossil-based rent economies. However, hydrogen's reproduction of certain physical features of natural gas suggests caution about developing interdependences with countries prone to manipulate them or characterised by domestic political risk.

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Italy's hydrogen ambitions and the technological and political contexts are still too unclear to allow an elaborated mapping of geopolitical opportunities and risks. In a context affected by deep uncertainty, it is therefore recommended to focus on no-regret options. Italy should:

• Achieve a clearer picture of technological and geopolitical opportunities, to ensure that its hydrogen diplomacy can reconcile as much as possible economic, geopolitical and sustainability priorities in line with broader EU objectives. Risks exist that in the pursuit of geostrategic centrality, a race for potentially expensive infrastructural adaptation ends up with stranded assets as technology moves towards privileging alternative solutions. Seeking connectivity cannot be separated from a careful appreciation of technological developments and geopolitical developments.

• With respect to infrastructure connectivity, privilege in the short to medium term a distributed model, without committing from the start to the expensive creation or refurbishment of international transport infrastructures before achieving more clarity on long-term demand prospects – both in Italy and in Europe.

• Minimise geopolitical risks by privileging domestic supply to dedicate to hard-to-abate sectors, keeping demand at the low end of ranges. If, however, Italy chooses an expansive pathway to hydrogen development, classical supply security measures to reduce exposure to political risk should include maintaining sufficient domestic back-up capacity, and securing sufficient integration with European partners. In particular, promoting connectivity with the Iberian Peninsula would help Italian industry access hydrogen from safe sources and through safe routes, within a common regulatory space.

• Support the development of renewable energy capacities across the Mediterranean as an option that in any case will contribute to regional decarbonisation, regardless of the export potential for hydrogen. In consideration of the specific challenges of the Mediterranean region, particular attention should be devoted to safeguarding water security and local access to renewable electricity.

• As geopolitical tensions may nevertheless persist in connection with resource exploitation, climate and energy diplomacy will play an important role in minimising the potential for conflict. Especially international organisations should be mobilised to favour dialogue on hydrogen geopolitics between institutional and business actors.

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