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The International Dimensions of Germany's Hydrogen Policy

Kirsten Westphal, Susanne Dröge and Oliver Geden

Hydrogen is a highly versatile source of energy that has attracted growing interest among policymakers and industry players within the context of energy and climate policy. By drawing up its own strategy, the German government wants to promote the future use of this energy carrier in various sectors of the economy. However, a German hydrogen strategy cannot be drawn up independently from what is happening at the EU level and in other member states; rather, it must be conceived as an integral part of a Europe-wide policy. Since Germany currently imports more than 70 per cent of its primary energy sources, the market roll-out of hydrogen will inevitably have international dimensions. Therefore, it is important that this policy be anchored accordingly. In order to gradually create a market for hydrogen, the EU and Germany should push ahead with forming bilateral partnerships and developing multilateral governance.

Already in the months before the outbreak of the coronavirus crisis, hydrogen (H_2) has been seen more or less as the silver bullet with which national climate and energy targets could be met. Since then, the idea of a hydrogen-based energy future has emerged as a focal area for energy and industrial policies. Accordingly, H_2 was included in the German stimulus package of June 2020 as a key element to reboost and restructure Germany's economy. The National Hydrogen Strategy adopted on 10 June 2020 puts an emphasis on green hydrogen, promotes its rapid market rollout and the establishment of the necessary value chains. It contains plans to build industrial-scale hydrogen demonstration and production plants with a total capacity of up to 5 Gigawatts (GW) by 2030, which corresponds to 14 terawatt-hours (TWh) of green hydrogen production and will require 20 TWh of (additional) renewables-based electricity. Seven billion Euros have been earmarked for the development of a hydrogen value chain in all industrial sectors, as well as heating and transport. Furthermore, the strategy expresses the belief that "both a global and European hydrogen market will emerge in the coming ten years and that carbon-free (for example blue or turquoise) hydrogen will be traded on this market."

Amid sky-high expectations, there is the risk of a hard landing. Those expectations are founded on H_2 being deployable in a number of sectors and having a diverse value chain. The stages of this value chain,

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which can be interlocked at the political, economic, technical and regulatory levels, span both the various steps of the value added process and national borders. In the end, expectations will be met only if all parties involved stay the course and act pragmatically as well as strategically.

H_2 and the debate in Germany

The H_2 value chain can cover very different production steps. The conversion of H_2 into various synthetic fuels takes place in highly complex modules; these vary according to the form of energy and technology deployed, the physical states during transport (liquid or gaseous, pure or as admixture) and the means of transport. The final result is either pure H_2 or — if combined with carbon dioxide (CO_2) or nitrogen (N_2) — synthetic fuels such as methane, methanol, Fischer-Tropsch products and ammonia.

Owing to this range, H_2 downstream products can be deployed throughout the energy system. Hydrogen can also be used as a storage medium and raw material. Today H_2 produced from fossil fuels such as natural gas and coal is already being used at oil refineries and in the chemical industry. Since more than 70 per cent of Germany's primary energy needs are currently being met by imports, there are good reasons to rely on international trade alongside domestic production.

Because Germany is aiming for climate-neutral energy supplies, the focus of the German debate is green hydrogen. This is produced by electrolysis from renewable electricity, a process in which no greenhouse gases are emitted. Other factors in its favour are that the cost of generating power from renewable sources has plummeted and surplus electricity obtained from wind and solar energy is periodically available. For this reason, there is much discussion in Germany about using H_2 as a storage medium and feeding it into existing gas networks and/or converting some of those networks into H_2 ones. However, according to various studies, the amount of green hydrogen produced in Germany will not suffice in a climate-neutral energy system to meet the demand for H_2 and the synthetic fuels produced from it.

While the German debate is concentrated on green hydrogen, the colour spectrum is broader at the international level. At present, the largest volumes are produced from coal and natural gas — this product is referred to as grey hydrogen — but the resulting CO_2 is not captured and stored. There is particular focus on blue hydrogen, which is obtained from natural gas by means of steam reforming, whereby, in this case, the carbon capture and storage (CCS) process is used. Turquoise hydrogen is produced from natural gas by means of pyrolysis, and solid carbon is obtained as a by-product. Both processes yield comparatively low emissions. There is also pink hydrogen, which is obtained from nuclear energy, and hydrogen produced from biomass. Finally, electrolysers could simply run on a country's power mix. In 2019 the cost of producing green and blue hydrogen was 360 per cent and 40 per cent higher, respectively, than that of producing grey hydrogen.

The "Gas Dialogue Process 2030", which was launched by the German government in December 2018 to clarify the role of gases in a decarbonizing energy economy, sent a clear signal: Molecules that are "CO_2 free or neutral" will continue to play an important role in the energy system in the long run. And H_2 is seen as key, not least in those processes and end-use applications whose complete decarbonization is regarded as very complex technically and too expensive. Accordingly, the 29 measures in the Action Plan of the National Hydrogen Strategy range from production, applications, industry, heat, transport and infrastructure to research and education.

Hydrogen and climate policy

The discussion about the role of hydrogen — which is taking place in a similar form in many other OECD countries — is a result of more comprehensive climate action plans.

In accordance with the Paris climate agreement, which provides for global net-zero greenhouse gas emissions to be achieved in the second half of the century, many governments have adopted national zero-emission targets since 2016, including Sweden, the United Kingdom and New Zealand. Meanwhile, both the EU and Germany have taken this route, too. Consequently, all branches of industry are under great pressure to indicate how they intend to achieve net-zero emissions.

Energy-intensive companies — for example, in the steel industry — are already planning or operating the first H_2 pilot plants. Their goal is to reduce emissions and eventually achieve climate-neutral production. In order to incorporate these activities into a national climate strategy, they should be embedded in an overall concept for a climate-neutral energy system. In Germany, this is linked not only to the increased production of renewable energy but also to infrastructure planning and the interconnecting of diverse economic sectors in the areas of energy use and production (sector coupling). Depending on whether hydrogen is used in a targeted manner or more widely in the industrial, transport or heating sector, there will be not only different emission reductions but also different dynamics for a market roll-out as well as, ultimately, different import scenarios.

Until the adoption of the German Climate Protection Act in late 2019, there had been agreement on a reduction of at least 80 per cent by 2050 and the policy focus had been much more on the electricity sector than on industry or long-distance transport. A clear trend can be recognized in energy system modelling: the smaller the scope for "residual emissions" in industry and transport, the more important the coupling of sectors and the use of hydrogen. However, Germany will not be able to produce all of the climate-friendly hydrogen that will be required. And while studies have come up with different estimates, there is no doubt that imports will be needed on a significant scale.

The German government still has to adopt changes to the national Energy Industry Act and the Gas Network Access Regulation. It also has some leeway in promoting the preferred methods for the production of hydrogen or its application, which, in turn, will have an impact on imports. However, decisions about new gas market rules and fundamental regulatory issues will have to be taken at the EU level: these include certification systems and verification of origin/emission intensity of hydrogen, quotas for synthetic fuels, adjustments in the EU Emissions Trading System (EU ETS) and technology-specific changes in competition law. Furthermore, EU gas market regulation has to be adapted to take into account the decarbonization of gas, reduction of methane emissions and the introduction of H_2 in a defined sequence and interlocking steps. Last but not least, hydrogen should become part of the EU's integrated Ten-Year Network Development Plans (TYNDP) for electricity and gas and the related scenarios.

Hydrogen in the EU climate-neutral energy system

The Commission's proposal on the European Green Deal did not discuss hydrogen, while its industrial strategy only touched upon the subject. The Commission's proposal for an EU recovery plan — yet to be negotiated with member states and the European Parliament — foresees financial and regulatory support for the creation of a climate-friendly hydrogen economy. The hydrogen strategy of the EU Commission will be released in July 2020.

Cooperation within the EU would enable regional industrial clusters to quickly switch to hydrogen. This would pave the way for the gradual development and interlocking of the individual production modules and/or imports, transport and storage, processing and demand. If the EU were to draw up such roadmaps, it would also be necessary to provide a more detailed outline of how a market roll-out could be achieved. The regions along the borders of North Rhine-Westphalia, Lower Saxony, Belgium and The Netherlands could be used for this purpose. Step by step, the chemical plants and refineries in these regions could be linked via a transport network connecting ports and wind parks by using (to some extent) already existing infrastructure — namely, pipelines and waterways. Last but not least, pipelines currently still used for transporting low-calorific gas could be transformed and integrated into a hydrogen network.

From an industrial policy perspective, the EU should not only promote the hydrogen chain in order to assume technology leadership in the Clean Hydrogen Alliance, on which the Commission has set its sights; it should also establish norms and standards. Above all, the emission intensity of individual processes will determine the role that hydrogen plays in climate policy within the EU. For this reason, it is crucial that the EU rapidly introduces quality standards and H_2 certification in order to ensure the acceptance of hydrogen both in Germany and throughout Europe.

Certification is also important for international trade. It already exists for biofuels under the Renewable Energy Directive in combination with EU-wide minimum quotas. Among other things, the revised version of the directive (RED II) provides for the share of renewable energies in transport to increase to 14 per cent by 2030. Germany plans to set a higher target when applying the directive at the national level. This paves the way for promoting, for example, the increased use of electricity-based synthetic fuels and the use of green H_2 at refineries. However, the European Commission should first determine precisely what the life-cycle accounting rules are.

The EU is facing other challenges in international cooperation. For one thing, the foreign-trade activities of individual member states with third countries need to be harmonized more closely (see below). At the same time, in order to ensure the competitiveness of energy-intensive industries — which, in the long run, want to become climate neutral through the use of H_2 — the EU has to find a way to reduce the cost of launching hydrogen-based production. Several options for achieving this exist, and they will matter when the European Green Deal is implemented.

First, the legal framework for state aid should be designed in such a way that direct subsidies for hydrogen-based production would be temporarily permissible. Second, the cost pressure for the investing company could be reduced if the EU ETS provided free carbon allowances for the investment. Third, a levy for imports (border carbon adjustment), which the Commission is currently considering, could ensure that European goods produced "cleanly" would not be squeezed out of the market by products that were manufactured using emission-intensive processes and power sources. Fourth, a financing tool called "Carbon Contracts for Difference", which is known from renewable energy project development, can help to reduce the financial risks for hydrogen investors. It guarantees a minimum CO_2price and thus establishes a long-term low-carbon investment incentive, while hedging against the hiking of CO_2 costs in the EU emission trading scheme.

For the German government, it is essential to cooperate with the EU if the pilot projects are to lead to a market roll-out. Larger plants are needed to help ensure increases in supply— currently, around 35 power-to-gas installations are operating in Germany with a total combined capacity of around 30 MW. The Megawatt output of the individual installations remains in single digits, and the recently announced 5 GW objective would mean an almost 170fold increase within less than 10 years in Germany alone. In order to scale up demand, there should be concerted efforts to achieve an EU-wide critical mass that encourages investment. As clean hydrogen is likely to be an important part of the EU's recovery plan, synergies should be used to finance the market roll-out.

Interaction with pioneers

A global and European gas market will not simply emerge. It requires joint efforts to kick-start demand and supply. In order to prioritize, the following could serve as criteria for the selection of partner countries: 1) the current level of deployment of hydrogen technologies; 2) membership of a common regulatory and economic area; 3) existing infrastructure and cooperation at the company level; 4) the potential for and the existing deployment of renewable energies; and 5) existing energy partnerships and trade relations. A critical mass of supply and demand can be rapidly created only if the various value creation stages and modules are aligned with one another — in which case, a market for H_2 and its downstream products can be developed step by step.

In the Asia-Pacific region, the international pioneers include Australia and Japan. In summer 2020, the first shipload of liquefied hydrogen is planned to depart from down under to Japan. Owing to the vast size of its territory and its huge potential for renewable energies, Australia is regarded as a sleeping giant in a global green hydrogen economy. Moreover, with its terminals for liquefied natural gas exports, the country has the infrastructure and know-how to liquefy molecules and transport the gas in liquid form. However, it currently produces hydrogen from coal.

South Korea and California stand out as potential partners, too, owing to projects planned and targets announced. And another promising partner is Chile on account of its enormous renewables and raw materials potential. While from a European perspective the transport routes are long, these countries are nonetheless important technology and trade partners not least because they are open to multilateral regulations and agreements. In order to promote multilateral governance, it is important to cooperate with those pioneers that are implementing actual projects.

Cooperation with neighbours

Norway and United Kingdom are the partners of first choice for the EU. Norway is not only the most advanced in the development of blue H_2 technology; it is also an important supplier of oil, gas and electricity as well as part of the European Economic Area. Great Britain already has flagship projects and is a pioneer in conversion to local H_2 networks. Green hydrogen, which is produced using offshore wind, could become the focus of cooperation between these neighbouring North Sea states. And the expertise of local wind generators and oil & gas companies could be used in the development of this production cluster.

Two billion Euros are earmarked in the German National Hydrogen strategy for partnerships with countries where, owing to their geography, green hydrogen can be produced efficiently. Geographically and politically, the countries of the Mediterranean region are potential partners, too, insofar as energy partnerships are already in place. They could become suppliers of green hydrogen as there is considerable potential for these countries to use wind and solar energy. Moreover, they would profit both from the installation of facilities and from export revenues. But it remains the case that the demand for renewable energy in the countries of origin must first be met. It is only in this way that climate change mitigation can be taken into account and a situation prevented whereby green hydrogen is exported while fossil fuels are used to ensure local power supplies. Moreover, the water-energy-food nexus is playing out in North Africa. Morocco will need huge renewable capacity to be installed and enormous volumes of water in order to “green” its current ammonia production alone.

To date, the discussion in Germany has tended not to focus on southern and southeastern Europe and Ukraine, all of which are integrated into the common energy market at the regulatory level and all of whose infrastructure networks and existing trade mechanisms could be used. In this respect, they are as well suited to take part in the Europe-wide development of green hydrogen as are the countries of the eastern Mediterranean and Turkey. Moreover, given the increased influence of Russia, China and the United States, it is of geostrategic importance that they maintain strong ties with the EU. The Hydrogen Europe's *2x40 GW Green Hydrogen Initiative* presents a road-map to simultaneously roll-out hydrogen in the EU and the neighbourhood.

Already existing cooperation at the company level is an important competitive and time-saving advantage. In this context, Russia is an interesting potential partner — one that offers many opportunities with regard to the development of an international hydrogen economy. Indeed, the country could convert to H_2 technology and become one of the largest producers worldwide. Not only would it be able to produce both blue and turquoise hydrogen from natural gas; it also has abundant wind potential, which could be used to produce green hydrogen. Furthermore, infrastructure for the transport of gas from Russia to the EU already exists.

At the same time, the case of Russia shows that opinions currently diverge over where and at what stage of the value chain hydrogen should be produced. Right now, Gazprom continues to focus on the export of natural gas; as far as the Russian company is concerned, gas should be used for hydrogen production only when it reaches Germany. While this is the easiest way for Gazprom to keep its own business model in step with the times, there are also technical arguments in favour of its approach. Meanwhile, the Russian nuclear energy company Rosatom is already engaged in the production of hydrogen. The example of Russia illustrates the thorny issues related to certification and the organization of production networks and the individual stages of that process. However, political relations are currently strained: the EU as a whole should endorse cooperating with Russia on the decarbonization of gas and, above all, provide a credible regulatory framework that could remain in place long term. In this way, the EU would emphasize mutual interdependence and achieving a balance of interests in this area with Russia.

Finally, it is also clear from the Russian case that the geopolitical consequences of a global hydrogen economy (see below) must be taken into account from the outset and that the energy diplomacy of Germany and the EU should be aligned accordingly.

Shaping global cooperation

Further international cooperation on the part of Germany and the EU is crucial to increase the supply of H_2, on the one hand, and to achieve technological progress, on the other. Besides forming bilateral partnerships, it is important to strengthen plurilateral and multilateral initiatives that would promote the hydrogen market, define the necessary standards and develop certification schemes.

The existing governance structures underscore the fact that hydrogen has been a niche technology so far. There is no one single body to address all H_2-related issues: the platforms for dialogue, partnerships and research cooperation are the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA) and the Clean Energy Ministerial and its hydrogen initiative (in which the EU is represented but not Germany). IEA and IRENA offer topical analyses on the subject of hydrogen. The relevant technical committee of the International Organization for Standardization (ISO/TC 197) establishes technical standards, while the Hydrogen Council, which comprises many leading global companies, focuses on the commercialization and roll-out of industrial-scale solutions.

Thus, the problem is not so much that there is an organizational void but that so far coherence and direction have been lacking. It is not necessary to create any new institutions. Rather, what is needed is to give more weight to the subject of hydrogen and, ideally, provide a clearer definition of the respective competences of the individual organizations. This requires co-operation between first movers.

The International Energy Forum (IEF) could be another venue for a dialogue about, for example, the switch from fossil fuels to H_2 and synthetic fuels. The Energy Charter Treaty, meanwhile, could provide the opportunity to regulate trade, transport and investment if the treaty modernization process proved successful and hydrogen were reincluded on the list of energy sources. Germany and the EU could play a role in making progress on both of these fronts.

A hydrogen market can be physically developed via clusters with supply structures (hubs and spokes). In combination with cargo and shipping routes, it would be possible to establish the first hydrogen corridors; and as a "captive market", shipping (first and foremost the cruise industry) could be a key customer. This initiative could be promoted within the International Maritime Organization (IMO). At the same time, it is clear that trade in hydrogen will require harmonized approaches, standards and certificates for H_2-based fuels and chemical products.

Vertically integrated projects could serve to organize demand and supply internationally across the individual value creation stages. At the same time, earlier contract models that have balanced emerging risks throughout the value chain could help in the market launch. Take, for example, the Groningen model for a long-term contract: the price was linked to that of a competing energy source and both minimum-purchase and payment obligations were stipulated. This allowed natural gas to be introduced into the energy mix in Continental Europe from 1962 onwards, to build the necessary infrastructure over time, to increase demand and to diversify the suppliers.

The geopolitics of hydrogen

If hydrogen is to become a key component of a more climate-friendly energy system, it is strategically important for Germany and the EU to develop and maintain technology leadership. New networks, industrial linkages and trade relations result in winners and losers. At the same time, H_2 and the fuels derived from it are substitutes for other energy carriers. But, above all, the geoeconomics of hydrogen encourage competition and change the international division of labour.

With regard to the market ramp-up, the most important competitor is the People's Republic of China, which brings the sheer size of its market to bear. The country is already the largest producer of hydrogen derived from coal, and H_2 is part of its "Made in China 2025" and "China Standards 2035" industrial strategy. Over the long term, China intends to develop its connectivity strategy around the hydrogen component, among others, and tailor the production clusters accordingly. As in the case of projects aimed at the use of concentrated solar power, China will pursue joint ventures to advance its technology and innovation leadership. Germany and the EU should create partnerships worldwide based on "Made in the EU" technologies.

Among the obvious losers in the energy transformation are the oil and gas industries as well as those countries that have large oil and gas reserves. But they could become important players in developing the H_2 value chain on the strength of their experience in handling and liquefying gases and through their offshore platforms. Thus, petrostates might be able to tap into new revenue sources, too. This is very important from the perspective of foreign and security policy in order to prevent the destabilization of individual countries and entire regions. But there is also good reason from a climate-policy perspective to have Russia, Saudi Arabia & Co. on board for the energy system transformation. Offering these countries the prospect of being part of a climate-neutral energy system could yield a three-fold dividend: in climate policy, in boosting the potential of hydrogen and in foreign policy.

Interestingly, the focus of the Desertec industrial initiative has shifted eastward to the Gulf, where the United Arab Emirates and Saudi Arabia are seeking pole position in developing a hydrogen value chain. European companies, meanwhile, have lost their key position in an important future-oriented project. It is, above all, China that is now combining infrastructure projects with a strategic industrial and foreign trade policy in its Belt and Road Initiative. The experience of the Desertec initiative offers lessons to be learned: in the first phase, it is important to get individual flagship projects up and running quickly using market-ready technologies. Moreover, there must be cautious expectation management that is geared towards the long implementation phases.

In a world of geoeconomic rivalries, it is necessary to take the industrial policy implications into account. That is because the interests of many potential hydrogen producers in deepening their own value chains conflict with the interests of those countries that want to import large amounts of carbon-neutral hydrogen for their own domestic industries. Australia and Russia, for example, could export green steel instead of low-emission hydrogen. If that were to happen, Germany and the EU would have to weigh climate protection against industrial policy. The debate about these conflicting objectives has not yet even begun.

Conclusion

Currently, Germany and the EU have a technology base for H_2 that spans the entire value chain. Germany, in particular, could use this favourable position to secure competitive advantages and export opportunities. That is why both the industrial policy impact and the international competitive situation must be considered when drawing up the regulatory framework. Furthermore, the strategic significance of H_2 technologies should be taken into account and the hydrogen industry protected against takeovers from third countries.

A reliable and transparent EU framework is a prerequisite for both industry and potential partners. For this reason, it is of central importance to work towards establishing a level playing field not only in the EU but, above all, in the global context. Especially right now, when supply has to be increased and demand boosted, the dilemma of collective action arises at the various economic and political levels.

First of all, it is crucial to expand the Clean Hydrogen Alliance at the EU level and to draw up a European roadmap for kick-starting a hydrogen economy. This would create a reliable framework for projects and allow larger pilot projects to be implemented and the first hydrogen clusters and corridors established across Europe.

But flexibility will be required to get concrete pilot projects up and running quickly at the international level and through the use of mature technologies. In what happens next, it will not be hydrogen colour theory that is decisive but reducing greenhouse gas emissions in production and transport chains. The dilemma between working towards market roll-out and pursuing climate targets can be resolved in such a way that during the first stage, several types of production are approved and thereafter climate-neutral ones are sequentially prioritized and/or manufacturing processes with higher emissions-intensity are phased out. These different stages could be reflected in relevant certification schemes. From the perspective of industrial as well as foreign and security policy, such an adaptive model would be advantageous. The EU could then also include, on a temporary basis, low-emissions hydrogen derived from natural gas by means of CCS and pyrolysis, or based on successively decarbonizing national power mixes.

Last but not least, the Covid-19 crisis poses a challenge for the policy-driven transformation of energy markets. If policymakers are not to lose sight of the long-term goal of a globally decarbonized energy system, the development of a hydrogen economy is a key priority for recovery programmes.

Dr Kirsten Westphal, Senior Associate in the Global Issues Division, heads the "Energy Transformation and Geopolitics" project. Dr Susanne Dröge is a Senior Fellow in the Global Issues Division. Dr Oliver Geden is head of the EU/Europe Division.

SWP
Stiftung Wissenschaft und Politik
German Institute for International and Security Affairs

Ludwigkirchplatz 3 — 4
10719 Berlin
Telephone +49 30 880 07-0
Fax +49 30 880 07-100
www.swp-berlin.org
swp@swp-berlin.org

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