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Germany's Hydrogen Strategy: Securing Industrial Leadership in a Carbon-Neutral Economy

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Part of a series edited by Yana Zabanova and Rainer Quitzow

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Summary

This chapter provides a review of Germany's ambitious import-oriented hydrogen strategy. It places the German policy approach in the context of its broader Energiewende (energy transition) strategy, aimed not only at a transition of Germany's energy and industrial system to carbon neutrality by 2045 but also at the promotion of the German Energiewende approach abroad. The chapter begins by providing a short review of the German Energiewende policy legacy, relating it to it emerging hydrogen policy. On this basis, it provides a comprehensive review of Germany's National Hydrogen Strategy (NHS) with a particular focus on its outward-oriented elements. It discusses Germany's external hydrogen policy along the following five dimensions: political dialogue and diplomacy (both bilateral and multilateral); interventions aimed at building international supply chains; cooperation in research and innovation; capacity building and skill development; and activities aimed at addressing questions of sustainability.

The chapter closes with discussion of key strengths and weaknesses of the strategy and highlights areas for its further development. While Germany's outward-oriented approach is identified as an important strength of the strategy, it could place greater emphasis on cooperation with partners in the EU. Moreover, collaboration with partner countries, both in- and outside the EU, should go beyond the relatively narrow focus on the promotion of hydrogen production and trade. Rather, it should take a broader perspective, aimed at promoting competitive and resilient industrial value chains centered on the EU and its policy and regulatory model. In particular, countries in the European Neighborhood represent important partners in such a strategy. Broadening the scope of cooperation with these countries will also increase the incentives for these countries to engage in partnership development.

Finally, the chapter points out that Germany has taken an ambiguous stance on the role that blue hydrogen should play in a future hydrogen economy. While its strategy comes out strongly in favor of green hydrogen, it is also pursuing partnerships for the import of blue hydrogen. This has resulted in a mismatch. While analytical capacities and standardization-related activities are being advanced for green hydrogen production, the government also needs to clearly define its stance on blue hydrogen imports and develop the needed analytical tools and policy instruments for this purpose.

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Contents

1. Introduction

In June 2020, Germany joined a group of hydrogen frontrunners, including Japan, France, South Korea, Australia, Netherlands and Norway, to become the seventh country to adopt an official government strategy for the promotion of hydrogen. Along with Korea and Japan, it stands out from this group, due to the important role that the strategy assigns to the development of hydrogen imports (Albrecht et al., 2020). Since launching the strategy, the German government has put in place not only a large portfolio of measures targeting its domestic hydrogen sector, but also for the development of international hydrogen partnerships and supply chains.

This chapter provides a review[1] of Germany's ambitious import-oriented hydrogen strategy. It places the German policy approach in the context of its broader Energiewende (energy transition) strategy, aimed not only at a transition of Germany's energy and industrial system to climate neutrality by 2045 but also at the promotion of the German Energiewende approach abroad. The chapter begins by providing a short review of the German Energiewende policy legacy, relating it to it emerging hydrogen policy. On this basis, it then provides a comprehensive review of Germany's National Hydrogen Strategy (NHS) with a particular focus on its outward-oriented elements. It discusses Germany's external hydrogen policy along the following five dimensions: political dialogue and diplomacy (both bilateral and multilateral); interventions aimed at building international supply chains; cooperation in research and innovation; capacity building and skill development; and activities aimed at addressing questions of sustainability. The chapter closes with a brief discussion of the geopolitical and geoeconomic implications of Germany's hydrogen strategy.

[1] The review is based on publically available documents as well as interviews with representatives from the main German federal ministries involved in the implementation of Germany's hydrogen strategy.

2. Energiewende as industrial modernization strategy: the emerging role of hydrogen

Accounting for 27 percent of the EU's industrial production in 2021 (Eurostat, 2021), Germany retains a large and robust industrial sector. Led by its automotive sector, this includes Germany's famous Mittelstand[2] as well as a range of industries supplying basic materials. The former consists of highly specialized, small and medium-sized enterprises (SMEs), many of them engaged in the manufacturing of machinery and production equipment. The latter comprises, among other things, the production of chemicals and related derivatives as well as mineral- and metal-based materials and products. Together these basic materials account for over 20 percent of German industrial output (Destatis, 2020).

Germany's strong industrial performance is matched by a pioneering climate and energy policy, known as the German Energiewende. Aimed at promoting decarbonization while retaining German industrial and technology leadership, this policy approach was initiated by the so-called Red-Green coalition government, consisting of the Social Democrats and the Green Party in the period from 1998 to 2005. At the time, this policy was driven by the Greens' historic mission to phase-out nuclear energy, the struggle that originally gave rise to the party in the late 1970s (Quitzow et al., 2016). To realize this goal while fighting climate change, the government engaged in a market and industry support program for wind and solar energy. Underpinned by the concept of ecological modernization (A. Mol & Jänicke, 2009), this policy vision built on the idea that Germany could translate environmental policy success into an export-oriented strategy for innovation and industrial development (Quitzow et al., 2016; Quitzow & Thielges, 2020).

Since this initial period, this strategy has developed into an increasingly comprehensive approach for the transformation of the energy and, more recently, the industrial sector. Based on the continued deployment of renewable energy, the Energiewende is now the backbone of a strategy aimed at climate neutrality by 2045. Its current interim climate targets, adopted in the Climate Change Act passed in its current form in 2021, aim at a reduction of greenhouse gases by 65 percent by 2030 and 88 percent by 2040 (compared to the 1990 levels) (BMF,2021). These are underpinned by legally binding targets for the deployment of renewables, enshrined in the Renewable Energy Act. In its most recent revision, following Russia's invasion of Ukraine, the law stipulates that 80 percent of Germany's electricity demand should come from renewable sources by 2030 (BMWK, 2022a). To achieve this goal, Germany will have to more than double the generation of renewable electricity from 240 TWh annually in 2021 to approximately 600 TWh.[3]

The elimination of GHG emissions from German industrial production will require the use of significant volumes of hydrogen, most prominently in the steel and chemical sectors (IEA, 2019). Together these sectors account for close to 50 percent of industrial greenhouse gas (GHG) emissions or over 10

[2] The term Mittelstand is used in reference to Germany's large number of export-oriented small and médium-sized enterprises, many of them in the machine tool and production equipment sector.

[3] This estimate accounts for rising electricity demand, which will result from the decarbonization of transport and industry.

percent of Germany's total emissions.[4] Safeguarding German industrial production in these sectors while meeting its increasingly ambitious climate targets represents a major motivation for Germany's NHS. In addition to stakeholders in these hard-to-abate sectors, the strategy is supported by an emerging electrolyzer industry as well as firms engaged in the operation of its natural gas grid. The latter stand to gain from the development of hydrogen-related transport and storage infrastructure, while maintaining few direct stakes in the extraction of natural gas. Parts of the German automotive industry are also keen on the development of fuel cell vehicles as well as hydrogen-based synthetic fuels. The former offer the promise of larger shares of domestic value creation and employment than battery-electric vehicles, while the latter represent a potential lifeline for high-end vehicles based on the traditional internal combustion engine.

This constellation of economic interests combined with Germany's well-developed Energiewende policy approach have provided fertile ground for an ambitious hydrogen strategy to support industrial decarbonization along with leadership in hydrogen-related technologies and components. The NHS (Federal Government of Germany, 2020) is composed of 38 measures in support of the following strategic objectives:

- Fostering the competitiveness of hydrogen produced from renewable energy and establish it as a viable option for replacing fossil-based energy carriers and industrial feedstocks
- Developing Germany's domestic hydrogen market, including related transport, distribution and quality assurance infrastructure, that is able to absorb imports
- Strengthening German industry and securing global market opportunities for German firms in the sector
- Fostering science and skilled labor
- Establishing international markets and cooperation

The NHS foresees two main phases for the development of the hydrogen economy: the first aims at establishing the foundation and ramp-up of a functioning market, and the second one, expected to start in 2024, is focused on the consolidation of the domestic market and the increased usage of European and international hydrogen resources for the German economy. The strategy clarifies that it considers electricity-based hydrogen from renewable sources (i.e. green hydrogen) the only long-term option and that it seeks to prioritize hydrogen uses that do not lend themselves to direct electrification (i.e. industrial applications and long-distance transport). At the same time, the strategy does not exclude the use of so-called "carbon-free" hydrogen, including hydrogen produced from natural gas in combination with carbon capture and storage (CCS) technologies (also known as blue hydrogen) in the medium-term. Despite giving priority to uses in hard-to-abate sectors, it also signals continued support for the development of other hydrogen applications, such as fuel cell vehicles, that will be in competition with direct electrification.

[4] Percentages are based on calculations by the authors based on data provided by the German Federal Environmental Protection Agency in the National Greenhouse Gas Inventory and sector-specific data in the German government's Steel Action Concept (BMWI, 2020) and a study on the decarbonization of the chemical industry (de Visser et al. 2021).

3. Germany's outward-oriented hydrogen strategy

The German Federal Government expects that Germany will require between 90 to 130 TWh[5] of hydrogen for the uses targeted by the strategy by 2030 (BMWK, 2020b). To cover part of this demand, the NHS aims at establishing up to 5 GW of domestic production capacity, which corresponds to 14 TWh of renewable hydrogen production and 20 TWh of renewable energy generation. It seeks to increase capacity by an additional 5 GW no later than 2040. This implies a gap of around 72 TWh of hydrogen. This has to be acquired from outside Germany, meaning that the country aims to import large volumes of hydrogen by 2030. Therefore, the NHS foresees international cooperation as a key enabler of the strategy. Of the 9 billion euros originally assigned to the implementation of the NHS, 2 billion euros were reserved for international partnerships (BMWK, 2020b). In the context of an upcoming strategy update, the government has announced that it plans to develop a dedicated import strategy, providing further weight to the issue moving forward.

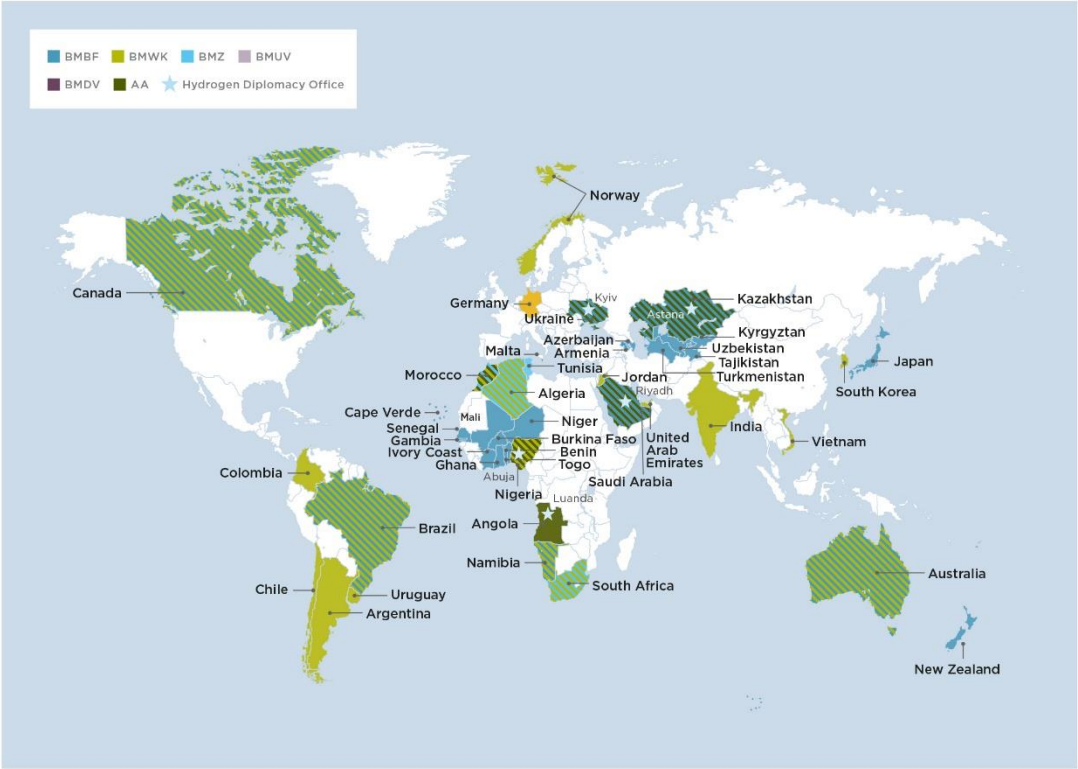
The outward orientation already received an important boost with the new coalition government, composed of Social Democrats, Greens and the Liberal Party, which took office in December 2021. The coalition decided not only to transfer the domestic climate portfolio from the Ministry for the Environment (Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz, BMUV) to the expanded Ministry for Economic Affairs and Climate Protection (Bundesministerium für Wirtschaft und Klimaschutz, BMWK). It also created a consolidated portfolio for climate foreign policy in the Federal Foreign Office (Auswärtiges Amt, AA). The agenda has been backed up by an expanded staff for international climate and energy policy at both BMWK and AA and a newly appointed Special Representative for International Climate Policy within AA. The various federal ministries have a large portfolio of activities around the globe achieving a presence in 37 non-EU countries (see Figure 1 on the following page for a map indicating the presence of the five ministries in partner countries). Increasingly, the German government is also seeking to overcome its tradition of strict ministerial boundaries and is attempting to coordinate its international climate and energy policy more actively across key ministries. Labelled the „Team Germany“ approach (Federal Foreign Office, 2022), BMWK, AA; BMUV and the Ministry for Economic Cooperation and Development (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung, BMZ) have established an interministerial coordination mechanism for this purpose. Similarly, the NHS is coordinated at the level of State Secretaries (vice-ministers), including all ministries.

3.1 From energy partnerships to hydrogen partnerships

At the political level, Germany’s external hydrogen policy can build on a well-developed set of bilateral partnerships focused on energy-related matters, developed and expanded to more than twenty partner countries over the course of the past fifteen years. They include major industrialized and emerging economies as well as a number of countries in the Middle East and North Africa. Known as Energy Partnerships and Dialogues, depending on their degree of formalization, these partnerships are

[5] While the original strategy document refers to a range of 90 to 110 TWh, the government now estimates up to 130TWh of hydrogen demand by 2030

Figure 1: Engagement of German federal ministries in partner countries outside Europe



Source: Author's own, based on official government sources.

in most cases led by BMWK[6] and provide an institutionalized forum for dialogue and exchange at both the political and the expert-level (Quitzow et al., 2019; Quitzow & Thielges, 2020). Generally organized along thematic working groups, these partnerships provide the German government with an entry-point for cooperation with a series of potential hydrogen exporters. In that vein, a series of existing partnerships have added hydrogen-related questions as an important pillar of their thematic portfolio, including countries like Australia, the United Arab Emirates or Chile. In addition, new partnerships have been formed with a particular – though not exclusive - focus on hydrogen cooperation. Countries in this group include Canada, Saudi Arabia and Namibia (see annex for a full list). The government has placed particular attention on the latter, appointing former State Secretary Rainer Baake as Special Commissioner of the BMWK for German-Namibian Climate and Energy Cooperation. Notably, despite Germany's strong stance in favor of green hydrogen, these diplomatic efforts have also included support for the import of blue hydrogen and related derivatives in cooperation with partners from the United Arab Emirates and Norway (BMWK, 2022c,d).

These activities, led mainly by BMWK, have been supplemented by the H2 Diplo initiative, sponsored by AA. With offices in Angola, Kazakhstan, Nigeria, Saudi-Arabia and Ukraine, it focuses on dialogue with fossil fuel exporting countries, aiming to utilize hydrogen and related industrial opportunities as an entry-point for discussing their transition to a climate-neutral future. This is part of a larger initiative aimed at enhancing awareness and understanding of geopolitical dimensions of the energy transition. To this end, AA has initiated two flagship reports under the umbrella of the International Renewable

[6] The only exceptions are the partnerships with Angola and Nigeria, which are led by the Federal Foreign Office, and the partnership with Namibia, led by the BMBF.

Energy Agency (IRENA), first on the geopolitics of the energy transformation with a focus on renewables (IRENA, 2019) and second on hydrogen (IRENA, 2022b).[7]

3.2 Multilateral engagement

Germany is also engaging in political dialogue on hydrogen-related issues in the EU and in a number of multilateral fora. At the EU-level, Germany's most prominent engagements, launched during its Presidency of the European Council, have been an initiative to support so-called Important Projects of Common European Interests (IPCEI)[8] on Hydrogen Technologies and Systems and an Agenda Process Green Hydrogen for the development of a Strategic Research and Innovation Agenda (SRIA). The former was officially kicked-off with the signing of a Manifesto for the development of a European "Hydrogen Technologies and Systems" value chain in December 2020[9] and has yielded 62 projects in Germany with funding commitments in excess of 8 billion euros from federal and state-level budgets (BMWK, 2021). The SRIA, published in March 2022 (Expert groups of the agenda process, 2022), sets out a research agenda to be supported in joint activities by EU member state governments.

In addition, to these EU-level processes, the German government has also engaged in targeted dialogue with a number of its European neighbors with coastal areas in the North Sea. In the "Esjberg Declaration on the North Sea as a Green Power Plant of Europe" of May 2022, the leaders of Belgium, Denmark, Germany and the Netherlands have committed to develop at least 65 GW of offshore wind and 20 GW of green hydrogen production in the North Sea by 2030.[10] Similarly, Germany has supported the call for accelerated hydrogen development made in a joint declaration by the Pentalateral Energy Forum,[11] which encompasses the Benelux countries, France, Austria, Switzerland and Germany.

Beyond Europe, the German government has promoted the market ramp-up for green hydrogen via both the UN and the G7. During its G7 presidency, it supported the launch of the G7 Hydrogen Action Pact and sponsored an IRENA report to define possible areas of cooperation in that context (IRENA, 2022a). It is also a founding member of the Green Hydrogen Catalogue, an initiative launched within the UN High-level Dialogue on Energy . The initiative provides a forum for publishing hydrogen-related commitments, thereby aiming to motivate countries and other stakeholders to contribute to the green hydrogen market. The German government is also engaged in working groups of the International Partnership on the Hydrogen Economy (IPHE) on Regulations, Codes, Standards, & Safety (RCSS), Trade Rules, and Production Analysis. The most tangible result, coming from the Production Analysis Task Force, has been the development of a methodology for determining the greenhouse gas emissions associated with the production of hydrogen (IPHE, 2022). Here, however, German participation was limited to an observer role, reflecting Germany's focus on green hydrogen.

[7] The project „Geopolitics of the Energy Transformation: Implications of an International Hydrogen Economy", which this report is a part of, represents an additional part of this initiative.

[8] IPCEI projects represent large-scale investment projects in support of EU objectives that are exempt from certain restrictions within EU State Aid rules. To receive the exemption, the projects need to fulfill a number of eligibility criteria, including the participation of at least four EU member states

[9] Find the manifestó here https://www.bmwk.de/Redaktion/DE/Downloads/M-O/manifesto-for-development-of-european-hydrogen-technologies-systems-value-chain.pdf?__blob=publicationFile&v=8

[10] Find the declaration here https://kefm.dk/Media/637884617580584404/The%20Esbjerg%20Declaration%20(002).pdf

[11] Find the declaration here https://www.permanentrepresentations.nl/binaries/nlatio/documenten/publications/2020/06/12/penta-declaration-on-hydrogen/Penta+Declaration+Signed.pdf

3.3 Promoting international hydrogen supply chains

The political efforts outlined above are underpinned by a number of programs aimed at supporting the development of European and international hydrogen supply chains. In terms of total funding volume, the 62 projects (as part of IPCEI)(BMWK,2021) supported by the German government represent the largest funding effort in this regard. They include nineteen projects in support of a total of 2 GW of electrolysis capacity in Europe, fifteen projects in support of storage and transport infrastructure, sixteen projects for green hydrogen use in industry (most prominently in steel but also chemical production and refineries) and twelve projects for hydrogen use in the mobility sector. All these projects are located in Germany, albeit with participation of companies from other member states, as stipulated by the EU rules governing IPCEIs.

Outside of the EU, the BMWK is promoting not only the development of production capacities for green hydrogen in potential export countries but also the supply chains needed to deliver them to the German market. For this purpose, the BMWK has supported the creation of the H2 Global Foundation for the implementation of an auction mechanism to support investments in both the supply of hydrogen (and its derivatives) and their use. The foundation operates an auction mechanism, in which the so-called Hydrogen Intermediary Network Company (HINT.CO) enters into long-term (10-year) contracts for the purchase of hydrogen or hydrogen derivatives and short-term (2-year) sales contracts with corresponding users. The supply contracts are based on a price for its delivery to a port in the Netherlands, Belgium or Germany, thus stimulating private investments along the entire supply chain. The H2 Global mechanism represents a system of Contracts for Difference (CfD's) where the difference between the prices offered by both the producers and the users are compensated by HINT.CO with funding from the BMWK. The first round of auctions focuses on the procurement of hydrogen-related products from partner countries outside the EU and the European Free Trade Association (EFTA) (Bollerhey et al., 2022). For this, H2 Global counts on 900 million euros of public financing to be expanded by an additional 3,5 billion in a second phase starting in 2023 (BMWK, 2022b). Its first auction was launched in November 2022 for the delivery of green ammonia. Others are to follow for green methanol and jet fuel.

In addition to H2 Global, the German government operates a number of additional initiatives and funding schemes to support hydrogen-related investments outside the EU. The BMZ has sponsored the Business Alliance Energy (Unternehmensallianz Energie) to engage German firms in a dialogue on how to best support investments in the Power-to-X value chain in developing and emerging economies. It is also building on long-standing energy cooperation with Morocco and Tunisia to launch so-called Hydrogen Alliances for development of the sector. Moreover, the funding program “Internationale Wasserstoffprojekte” (International Hydrogen Projects) provides grant-based funding of up to 15 million euros per project delivered cooperatively by the BMBF and the BMWK (BMWK & BMBF, 2021) for hydrogen projects outside the EU along the entire supply chain, i.e. production, storage, transport and use. Jointly administered by BMWK and BMBF, it not only provides funding for the projects themselves but also for related research activities (see below for more details on research and innovation-related activities). BMWK’s International Hydrogen Ramp Up program (H2Uppp) supports SMEs from Germany and other EU Member States with the preparation of hydrogen projects in developing and emerging countries. In coordination with the German Energy Solutions Initiative, H2Uppp provides technical advice for the identification, preparation and implementation of hydrogen projects. Finally, BMWK has supported a number of larger-scale efforts. For instance, BMWK is supporting Siemens Energy’s Haru Oni project in Chile for the integrated production of hydrogen-based synthetic fuels with 8,23 million euros (BMWK, 2020a). It has also committed US$968 million in the form of grants and concessional lending for energy-related investments within the multi-donor Just Energy Transition Partnership with South Africa, which will partially go to green hydrogen projects (International Partners Group, 2022).

3.4 International cooperation in hydrogen-related research

Complementing its efforts to stimulate the ramp-up of an international hydrogen market and supply chain, the German government is promoting international cooperation to promote research and innovation. This includes support for technology development as well as analysis to support broader knowledge development related to a future hydrogen economy. The BMBF is the central ministry in this field, with additional activities in applied research and development sponsored by the BMWK. The BMBF has placed particular attention on research collaborations with other European frontrunners as well as Australia. Cooperation with Australia has been the most prominent, receiving support via the high-profile projects HySupply which counts on 1,7 million euros of funding provided by the BMBF (BMBF, 2021, a) and HyGate with 50 million euros of funding (BMBF, 2021, c), two collaborative research efforts related to the development of a hydrogen supply chain between the two countries. As mentioned above, the BMBF has also sponsored an agenda process for defining a joint research program for the European Research Area. In addition to this, the ministry has supported a joint call for research proposals with the Netherlands as well as a multi-country call for proposals with a number of EU countries and Canada under the EUREKA umbrella, a public network for research collaboration. The BMBF has also launched hydrogen-related research cooperation initiatives with Ukraine and Central Asian countries, Canada, New Zealand, South Korea, Japan, and Namibia. The latter is part of a larger scheme to forge a hydrogen partnership with the country, led by the BMBF. In this vein, the two countries signed a Memorandum of Understanding to form a partnership for research and development on green hydrogen in 2021. In addition, under the framework of the International Future Labs, BMBF has funded scholars from around the world to conduct research visits in Germany on hydrogen-related topics, and it has created the Redefine H2 Economy project to bring international researchers to Germany to conduct research on high-temperature electrolyzers, gasification methods as well as the synthesis of basic chemicals and energy sources, providing 5 million euros of funding for the latter project (Technical University of Munich, 2021).

Complementing these BMBF-led activities, the BMWK has sponsored a number of large-scale R&D projects with private sector participation. These include include thyssenkrupp's project "Element One" in Saudi Arabia for the development of electrolyzer technologies supported by BMWK with 1,5 million euros of funding (BMWK, 2020), and a joint project for the development of transport solutions based on liquid-organic hydrogen carriers (LOHC), involving among others Uniper, the Emirati oil company ADNOC (Abu Dhabi National Oil Company) and Japan's largest power generation company, Jera.

3.5 Capacity building and skill development

In addition to engagement on cutting-edge research and innovation, the German government has also supported capacity and skill development in developing and emerging countries. This includes activities sponsored by BMZ within its broad portfolio of energy-related cooperation activities as well as activities led by the BMBF and the BMWK. The latter is the sponsor of the International PtX Hub,[12] a knowledge and training center on Power-to-X technologies and hydrogen. It has developed training modules on green hydrogen basics, production processes, logistics, economic aspects, regulation, and sustainability. It has country-based activities to support knowledge and skill development in thirteen countries across Asia (3), Africa (4), the Middle East (1) and South America (5). The BMBF is also supporting capacity and skill development with a focus on African countries. Among the most relevant initiatives are a Master's Graduate Program in West Africa on green hydrogen technologies, based on collaboration between research institutions in Germany and the West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL) graduate schools, providing funding of 8

[12] The PtX Hub was orignally created under the previous administration by the Federal Ministry of the Environment, but was transferred to the BMWK along with the overall climate change portfolio.

million euros (Jühlich Aachen Research Alliance, 2021). It has also funded a research project for the assessment of hydrogen production potentials in Africa, starting with West Africa. Additionally, the partnership activities in Namibia, which builds on 40 million euros of funding from BMBF (BMBF, 2021, b), include training and skill development. Finally, BMZ is funding capacity building within its Hydrogen Alliances with Morocco and Tunisia as well as in Brazil and South Africa.

3.6 Promoting a sustainable hydrogen economy

The German government is a very vocal supporter of green hydrogen as its preferred solution for building a climate-friendly hydrogen economy. As a result, its activities to ensure the sustainability of a future hydrogen economy are focused on the sustainability of green hydrogen rather than alternative forms of low-carbon hydrogen production, i.e. hydrogen from natural gas in combination with CCS technologies or "blue hydrogen". Questions of sustainability represent one of the main pillars of work at the PtX Hub. It has developed a conceptual framework for PtX sustainability, which distinguishes four sustainability dimensions: Environmental, Economic, Governance, and Social. It incorporates the related issues in its training programs and is promoting them as the possible basis for sustainability standardization and certification. Moreover, the first auction launched under the H2 Global scheme includes not only requirements to ensure that the electricity utilized for the production of hydrogen is from renewable sources but also additional sustainability requirements pertaining to the use of environmental management systems, water and land use, biodiversity, labor standards as well as local skill development.

Beyond these focused engagements, the German government has not engaged in any major effort to promote the development of internationally recognized sustainability standards or certification schemes. Rather, it has been revealed that the BMWK intervened at the EU-level to request a more gradual phase-in of so-called additionality rules (i.e. rules proposed by the European Commission to ensure that the renewable energy used for the production of green hydrogen would be additional to existing renewable energy capacities in the power mix) (Kurmayer, 2022). Rather than the proposed 100 percent by 2027, the German government requested a much lower share of 20, 25 and 30 percent by 2026, 2028 and 2030, respectively. Moreover, as mentioned above, the German government has not actively engaged in the definition of standards for the production of blue hydrogen, despite the fact that it has already concluded agreements for the import of blue hydrogen from UAE and Canada (Quitzow et al., 2023).

4. Conclusion

Germany's external hydrogen strategy represents a comprehensive effort to promote an international hydrogen economy, focused on securing German technology leadership as well as imports to meet future hydrogen demand. It is seeking to achieve these goals by supporting cooperation with international hydrogen technology leaders, including Australia, Canada and a number of European countries, as well as potential exporters, most notably Namibia, UAE, Chile and Morocco. In doing so, Germany has assumed a very prominent international leadership role on green hydrogen. Its H2 Global initiative in particular represents an innovative and highly visible effort in this regard. Similarly, its partnership with Namibia has attracted significant international attention. Within EU policy-making, Germany has taken a more passive role in comparison, focusing efforts primarily on smaller groupings of like-minded countries, such as the set of North Sea countries, rather than advancing more ambitious schemes to promote hydrogen production across the EU as a whole. German leadership and visibility at the international level paired with a more cautious approach at the EU-level is reminiscent of past efforts around renewable energy. Although German renewable energy policy was highly successful at inspiring other countries to follow its policy model, its European policy engagement was mainly focused on defending its domestic support schemes under pressure from the Commission (Solorio et al., 2014). Nevertheless, Europe's hydrogen strategy is well-aligned with Germany's import-oriented ambitions, though the EU still lacks a strong framework for implementation. As a result, initial hydrogen production capacities in Europe are likely to be clustered in those Member States with the needed financial capacity to support investments, rather than financially weaker Member States with relatively abundant renewable energy resources. This means that potential imports from other EU Member States may remain underexploited, relative to their potential.

Another pronounced characteristic of Germany's outward-oriented hydrogen strategy is its strong focus on promoting the production of hydrogen (and derivatives like ammonia and synthetic fuels) in partner countries. The strategy does not explicitly aim to build broader industrial development partnerships based on value-added products, such as hydrogen-based direct-reduced iron as an input for steel making. While it is in the interest of Germany's incumbent industries as well as the corresponding industrial work force to retain value creation in Germany, there may also a be a case for exploring broader green industrial partnerships, especially with countries in the European Neighborhood. Such partnerships could provide the basis for the development of climate-friendly industrial value chains centered on the EU market. The strong focus on hydrogen imports may distract German policy makers and businesses from building broader industrial alliances. These are not only important for securing German and European industrial leadership and influence in a future climate neutral economy. They may also be the key to sustaining the interest among potential hydrogen exporters, including those in the EU. It would also provide opportunities for a more active promotion of German and European standards in these emerging green industrial value chains, an area that has not figured prominently in the strategy to date.

Finally, a challenge for Germany is its ambiguous stance on the role of blue hydrogen. Despite its vocal support for green hydrogen, it has maintained tacit support for blue hydrogen, including agreements in support of blue hydrogen imports from Norway and the UAE. In light of this, it is essential that the German government develops a more nuanced position on blue hydrogen and supports the build-up of related analytical capacities. This is needed to engage with partners and ensure that investments in blue hydrogen are aligned with German and international climate targets. A more open yet nuanced and principled approach to blue hydrogen would also provide the basis for engaging more actively with the US and other EU partners, offering opportunities to influence global developments.

5. Annex

Germany's official Energy Partnerships and Dialogues with a focus or component on hydrogen

Country	Year	Type of partnership and role of hydrogen cooperation
Algeria	2015	Energy Partnership, with hydrogen-related activities and dialogue
Angola	2011	Energy Partnership led by Federal Foreign Office with an additional Hydrogen Diplomacy Office
Australia	2017	Energy Partnership with an additional "Hydrogen Accord" signed in 2021 and a German-Australian Hydrogen Innovation and Technology Incubator
Brazil	2008/2017*	Energy Partnership, with hydrogen-related activities and dialogue
Chile	2019	Energy Partnership, with hydrogen-related activities and dialogue and support from the government's PtX-Hub
China	2006	Energy Partnership with hydrogen-related activities and dialogue
India	2006	Energy Partnership with a planned task force on hydrogen and support from the government's PtX-Hub
Japan	2019	Energy Partnership with a working group on "clean hydrogen"
Canada	2021	Energy Partnership, including MoU to create a Hydrogen Alliance
Jordan	2016/2019*	Energy Partnership with hydrogen-related activities and dialogue and additional support from the government's PtX-Hub
Kazakhstan	2022	Energy Dialogue, including hydrogen-related activities and dialogue and a Hydrogen Diplomacy Office sponsored by the Federal Foreign Office
Korea	2019	Energy Partnership, including hydrogen-related activities and dialogue within the working group on "new green technologies"
Marocco	2012	Energy Partnership, including an additional Memorandum of Understanding for the development of an "Alliance for the Development of the Power-to-X Sector" and additional support from the government's PtX-Hub
Mexico	2019	Energy Partnership, including hydrogen-related activities and dialogue at the sub-national level

Country	Year	Type of partnership and role of hydrogen cooperation
Namibia	Planned	Memorandom of Understanding for the creation of a hydrogen partnership to be led by BMBF and additional support from the government's PtX-Hub
Nigeria	2008	Energy Partnership led by Federal Foreign Office with an additional Hydrogen Diplomacy Office
Oman	2017	Energy Dialogue with hydrogen-related activities and dialogue
Qatar	2022	Energy Dialogue with hydrogen-related activities and dialogue
Saudi-Arabia	2019	Energy Partnership with an additional Memorandum of Understanding on hydrogen cooperation and a Hydrogen Diplomacy Office sponsored by the Federal Foreign Office
South Africa	2013	Energy Partnership, including a focus on green hydrogen and additional support from the government's PtX-Hub and financial support committed in the Just Energy Transition Partnership investment plan
Tunisia	2021	Energy Partnership, including hydrogen-related activities and dialogue
Turkey	2012/2018*	Energy Partnership with a focus on hydrogen in the working group on "sector coupling"
Ukraine	2020	Energy Partnership with a working group on hydrogen and a Hydrogen Diplomacy Office sponsored by the Federal Foreign Office
United Arab Emirates	2017/2022*	Energy and Climate Partnership with hydrogen-related activities and dialogue
United States of America	2019/2021*	Climate and Energy Partnership including activities and dialogue on hydrogen
Vietnam	Planned	Planned Energy Dialogue with hydrogen-related activities and dialogue supported by the government's PtX-Hub

Sources: Information based on https://www.bmwk.de/Navigation/DE/Wasserstoff/Internationale-Wasserstoffzusammenarbeit/internationale-wasserstoffzusammenarbeit.html ; BMWK (2022) Fortschrittsbericht zur Umsetzung der Nationalen Wasserstoffstrategie; Quitzow & Thielges (2020, p.11) and internal government documents.

* If more than one year is listed, the energy cooperation has experienced a relaunch or upgrading to a more formalized or more comprehensive partnership.

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