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STATEMENT

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Hydrogen supply – maturity transformation, coordination and product structuring as essential elements of an ambitious and efficient hydrogen ramp-up

BACKGROUND

Following phase 1 at the outset of the hydrogen ramp-up, the update of the National Hydrogen Strategy from July 2023 now focuses on phase 2 of its implementation. In addition to the development of an efficient infrastructure, creating suitable framework conditions and establishing Germany as a leading supplier, objectives include making hydrogen and its derivatives available in sufficient quantities and enabling hydrogen applications in industry, heavy commercial vehicles and increasingly in aviation and shipping. Hydrogen and green gases should also contribute to energy supply security in the electricity sector. In the future, hydrogen will also secure the decentralised and centralised heat supply.[1] With regard to hydrogen derivatives, it should be noted that, in addition to direct use (as a basic chemical, for example), they can serve as a transport option for long-distance import via existing and new import infrastructures.

The financial and regulatory framework for the core hydrogen supply network has been established. Initial large-scale IPCEI-funded projects are being implemented and the climate protection contracts are about to be put out to tender in order to secure demand in the energy-intensive industry. The GHG quota in Germany has been amended and improves the competitiveness of hydrogen in the transport and refinery sectors. Purchase tenders via H2Global for ammonia, synthetic kerosene and methanol are ongoing. Not least, the first legally binding requirements for certification have been established.

Derivatives such as ammonia, SNG or synthetic LNG, for example, are not only basic chemicals and raw materials for the chemical industry, but also import, transport and energy vectors.

However, the funding landscape is segmented, fragmented, complicated and only partially consistent. In view of existing funding silos, it is also questionable whether expansion along the entire value chain and the market ramp-up will occur to the necessary extent and at the required speed.

[1] Update of the National Hydrogen Strategy, pages 3–4.

This position paper focuses on an important function that is essential for the ramp-up of a hydrogen supply and market to succeed. The function is crucial for a self-sustaining market. It requires key players who take on a coordinating, aggregating and acting role between producers and consumers in order to ensure the physical supply of hydrogen and its derivatives and also to link supply and demand commercially. This means that an appropriate supply must be secured for the market over time in order to meet demand in the place, at the time, in the quantity and in the form required. The supply can be provided via imports, own production or additional purchases, that is through the aggregation/pooling of quantities and a portfolio structure. In developed markets, this is achieved by players in the middle segment *(midstream)*, who take on a coordinating role and assume the risk of building up long-term options in the market. The corresponding supply chains do not yet exist for hydrogen, which is a new commodity coming onto the market. Supply relationships already exist for some hydrogen derivatives (particularly in the area of existing markets for 'grey' or similar products, that is, ammonia, methanol, methane and kerosene), resulting in a more differentiated picture in some cases. The interaction along the chain must be tested, the technologies scaled and developed on an industrial scale. Establishing the entire supply, logistics and value chain is a major technological and commercial challenge.

PROBLEM: TECHNICAL AND PROCEDURAL ORGANISATION AND RAMP-UP

At present, the market environment for the hydrogen economy is still viewed as highly uncertain since economic opportunities and the future role of hydrogen remain rather abstract. According to the IEA, a final investment decision has been made for just four per cent of all hydrogen production projects announced until 2030[2]. The main challenge for the use of hydrogen as an energy source and raw material is that it is currently more expensive than fossil alternatives. This is because comprehensive internalisation of the external costs of greenhouse gas emissions is lacking to date. In this context, robust and effective emission pricing therefore needs to be the basis for a rapid ramp-up of a hydrogen economy, in Europe within the framework of European emissions trading. A sufficiently high CO_2 price improves the competitiveness of climate-neutral[3] hydrogen and its derivatives compared to fossil alternatives. That makes it a key instrument for initiating liquid hydrogen trading, while at the same time overcoming the challenge of effectively protecting industrial users in the gradual transformation from carbon leakage. Applicable price signals are lacking as well.

Thus there is currently a lack of realisable business models along the stages of the value chain. In Germany and the EU, it is also challenging to advance the development of the supply, logistics and value chain in parallel and synchronised across all stages, but to do so under the conditions of a competitive environment.

Due to the uncertain market environment, there is an extremely limited willingness to enter into liabilities and build up long-term positions and product portfolios. Grey hydrogen and derivatives (methane, ammonia, methanol, kerosene and so on) are already being traded and sold today. However, there is no liquid, large-scale market for climate-neutral hydrogen based on transparent price signals and indices.

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[2] International Energy Agency (2023): Global Hydrogen Review 2023 – Executive summary.

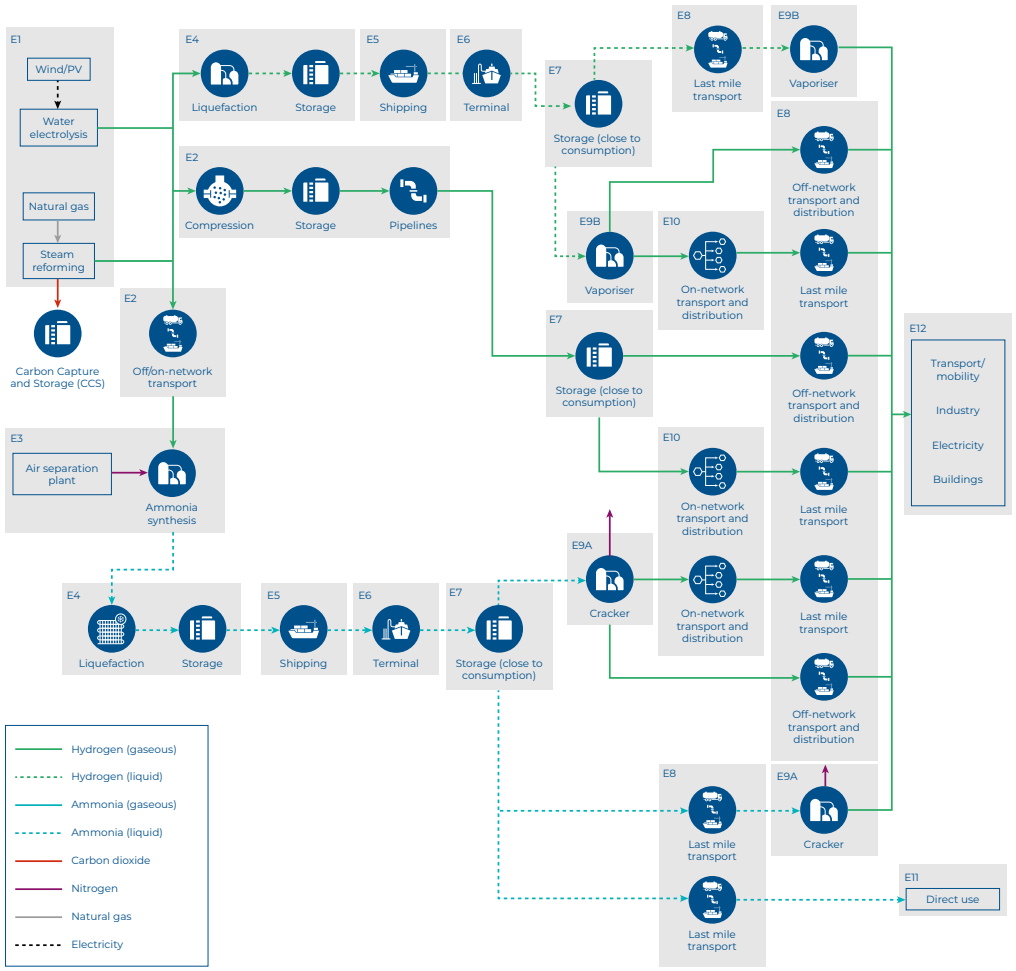
[3] The majority of the NWR defines hydrogen as climate-neutral when no greenhouse gases are released into the atmosphere during production, regardless of the production process and raw material used. This can safely be assumed to be the case if the hydrogen is produced using additional emission-free energy sources or if the carbon released during production is completely and permanently prevented from entering the atmosphere. Another part of the NWR defines climate-neutral hydrogen as hydrogen that is exclusively produced using renewable energy sources.

In addition to concrete prospects for business models and corresponding investment incentives, there needs to be the prospect of a certain reliable 'volume availability' in the system, in other words, the purchase of larger quantities from Germany and abroad. It is therefore crucial to ensure a rapid and predictable build-up of demand for hydrogen and to support investments in plants in areas where large quantities of hydrogen can be used early on and as flexibly as possible.

Building a hydrogen economy is still in its infancy. The individual technologies are available with different maturity levels and must be differentiated according to production type, size scale and product. Depending on the product, however, the major challenges lie in realising and scaling the entire chain and implementing it in a timely manner. Individual segments and stages of the value chain are currently in a critical phase, transitioning from small research and demonstration projects to projects on an industrial and commercial scale. A market outlook beyond the period of state funding is essential for them due to their high investment volumes. Establishing the entire value chain and systemic interaction, however, still needs to be achieved. Figure 1 illustrates the complex and long supply chains as well as the challenges for organisation and commercial risk management.[4]

[4] H2Global (2023): Commercial interfaces as a challenge for the development of hydrogen supply chains; based on a presentation by H2Global. The overview illustrates the situation for green and blue hydrogen and the derivative ammonia. It does not claim to be exhaustive or to fully cover the situation for the large number of other derivatives or import routes.

Figure 1: Exemplary illustration of the international value chain for blue and green hydrogen and ammonia. The necessary technical and process-related organisational units (E1–E12) are also shown.[5]



E1: Hydrogen producer
- Owner/operator of renewable electricity production and electrolyser or natural gas reforming plant
- Foreign site

E2: Foreign carrier (on-network/off-network)
- Owner/operator of the transport infrastructure
- Distribution network: natural monopoly

E3: Ammonia producer
- Owner/operator of an ammonia synthesis plant with upstream air separation
- Foreign site

E4: Export terminal operator
- Owner/operator of plants for the
- liquefaction of hydrogen or ammonia
- and storage tanks in the harbour
- Foreign site

E5: Shipping company
- Owner/operator of ships for the transport of ammonia or liquid hydrogen
- Can be located anywhere (headquarters)

E6: Import terminal operator
- Operator of a terminal facility
- Location in north-west Europe

E7: Storage facility operator
- Operator of a storage facility for gaseous or liquid hydrogen or ammonia
- Location in north-west Europe or close to consumption

E8: Transport company (last mile)
- Owner/operator of the transport infrastructure/ a transport system (for H_2 or NH_3)
- On-network: natural monopoly
- Off-network: open to competition

E9A: Cracker operator
- Owner/operator of an NH_3 cracking plant

E9B: Vaporiser operator
- Owner/operator of a plant for the vaporisation of liquid H_2

E10: Domestic carrier (on-network)
- Owner/operator of an H_2 network
- Natural monopoly

E11: NH_3 direct consumer
- Industry

E12: H_2 user
- Industry: Energy or raw material
- Mobility, electricity: Energy

Icons © Energy Systems of the Future (ESYS); illustration by Ellery Studio.

[5] Staiß, Frithjof et al. (2022): 'Optionen für den Import grünen Wasserstoffs nach Deutschland bis zum Jahr 2030: Transportwege – Länderbewertungen – Realisierungserfordernisse' (Options for importing green hydrogen to Germany up to 2030: transport routes – country assessments – realisation requirements) (Energy Systems of the Future publication series).

Supply chains for climate-neutral hydrogen and the corresponding derivatives are long, complex and complicated, often spanning two or more jurisdictions.[6] The exemplary analysis of supply chains (see Figure 1) shows the enormous challenges that exist for building the chain across all value-added steps.

Due to the technically complex and long supply chain, which comprises several production and conversion stages and various organisational units, numerous contractual relationships are necessary to map the commercial interfaces. The value chain is driven by technology and innovation. It requires high upfront investments in generation plants, infrastructure and utilisation processes. While capital costs in conventional oil and gas production have traditionally decreased from source to destination, comparatively large investments in technologically complex facilities are required here at almost all stages. Differing views exist within the German National Hydrogen Council on whether and to what extent the technical, process-related and organisational challenges described for blue hydrogen in the production and midstream segments can be overcome more quickly in the short term and how additional process steps (long-term CO_2 storage and transport) should be classified.

The highly uncertain market environment results in a number of problems. The information problem arises because potential future trading partners need to know and analyse the needs and opportunities of the other side of the market to align their own activities. For producers, demand-related information is important with regard to, among other things, the required quantity, time of purchase profile, batch sizes, security of supply requirements, product quality standards, 'green' verification requirements or greenhouse gas savings and the willingness of individual consumers to pay. Conversely, customers need supply-related information about, among other things, the deliverable quantity and its development over time (scalability), delivery reliability, product quality and price demands of individual (potential) suppliers. This problem is even more pronounced in international supply chains. The supply chain gets longer, production and consumption are geographically far apart and located in different jurisdictions. This entails high transaction and search costs when initiating hydrogen marketing or procurement. These challenges and inconsistencies can be addressed through appropriate contract design. Harmonised contractual frameworks could help to significantly reduce associated transaction costs. Further uncertainties exist with regard to the infrastructure available in the future, including transport capacities and costs as well as the network access regime. Investment risks resulting from the information problem are therefore very high.

There is an abstract acknowledgement of this and also an understanding that climate-neutral hydrogen and its derivatives form a pillar of the energy transformation. Concrete investment incentives are however lacking. The profitability gap prevents self-sustaining development. There are no business models for large-scale import and trade. There is a lack of willingness and ability to pay to cover the costs of supplying hydrogen. Existing incentives via CO_2 pricing are not yet sufficient. Although costs can be expected to fall over time as a result of industrialised production and scaling, first movers run the risk of seeing their early investments devalued when innovation and scaling leaps occur. Thus the initial phase is still characterised by a specific incentive and motivation problem that encompasses the entire chain.

In addition, the 'chicken-and-egg problem' arises, which refers in particular to the wait-and-see attitude when players who want to make investments along the value chain lack confidence in simultaneous (co-)investments by other players, which are needed to realise the value of their own investments. Thus a wait-and-see position is assumed. The lack of established players who can assume a long-term coordinating and structuring position in the market is particularly aggravating.

[6] See also: H2Global (2023): 'Kommerzielle Schnittstellen als Herausforderung für den Aufbau von Wasserstoff-Lieferketten' (Commercial interfaces as a challenge for the development of hydrogen supply chains).

FINANCING, BANKABILITY AND RAMP-UP

The hurdles for establishing the supply, logistics and value chain are high and financing this chain is a challenge.[7] Due to a lack of concrete references, lenders and investors will base their assessment of hydrogen projects on other sectors such as the LNG industry and offshore wind power, both of which are technically complex large-scale projects. However, the LNG ramp-up was able to build on existing regional markets and pricing mechanisms, making it economically viable in its own right. Offshore wind turbines, on the other hand, are generally intended for the domestic market but also require government support.

The production and trade of climate-neutral hydrogen will only become an economically attractive option in individual cases or on a small scale in the coming years. Considerable uncertainty also exists with regard to the quantities available and in demand. Price signals are lacking as well. References will be needed for the foreseeable future – such as price indices or the first prices achieved within the framework of funding programmes like the climate protection agreements or H2Global (currently for derivatives and in the future for hydrogen). A price indexation of green hydrogen against competing fossil fuels could be considered. Since climate-neutral hydrogen should contribute to the gradual elimination of these raw materials, however, this does not appear to make much sense or be expedient. It may also lead to additional exogenous risks and higher costs.

The main problems that need to be solved to make large-scale and export projects for climate-neutral hydrogen and its derivatives bankable are the political risks, acceptance and completion of the projects. For import projects, profitability depends on the support of the importing country's government in terms of both market and price. Thus contractors and lenders must first and foremost be able to rely on a stable legal and funding framework. A standardised and consistent legal framework is particularly important in this context in order to eliminate uncertainties in future regulation that slow down private sector investment. In the interest of a rapid ramp-up, requirements for hydrogen volumes to be traded should therefore be designed as consistently and simply as possible, albeit with reliable and ambitious regulatory adjustments over time.

With regard to customers, it is important that they have a high credit rating, which is supported by existing funding instruments such as the longer-term (IPCEI) subsidies or climate protection contracts. H2Global is also a key instrument for promoting the hydrogen ramp-up, enabling customers to procure hydrogen and its derivatives at attractive prices. Price and demand risks also need to be eliminated over a longer period of time. The time frame of the funding instruments is crucial here. Lenders will want assurances that they are not being exposed to unproven technology and that the cost and schedule overrun risk of the project is satisfactorily mitigated. Completion and repurchase guarantees as well as cover for default risks play a major role here. A solid contract structure is needed to leverage large parts of the value chain in order to manage the complex risks at the interfaces in the chain. The coordinating and mediating 'midstream' function described above is of instrumental importance to guarantee purchases for producers on the one hand, but also to build up long-term positions in the market and offer product structuring for changing and fluctuating demand on the other. Large companies with connections to initial anchor customers, ties to the German market and market knowledge are needed to take on the system-supporting role of a midstream portfolio player and aggregator.

[7] Craen, Stephen (2023): Financing a world scale hydrogen export project (The Oxford Institute for Energy Studies).

Most lenders and investor groups are highly incentivised to invest in energy transition projects.[8] Provided that the above-mentioned bankability requirements are met, one can assume that there will be more than sufficient liquidity to finance first-mover projects and even more so follow-up projects. It is obvious in this context that leverage must be utilised as much as possible during the entire project term. The debt-to-equity ratio should be as high as possible and the debt repayment instalments as long and low as possible. This is the only way to reduce capital costs, which are critical in the start-up phase. 'Midstreamers' can act as known borrowers here.

MATURITY TRANSFORMATION AND PRODUCT STRUCTURING AS IMPORTANT FUNCTIONS FOR THE MARKET

Climate-neutral hydrogen demands a funding policy and regulatory framework in the start-up and market development phase until well into the 2030s. There is also a need for supporting companies that act as contractual partners for both producers and buyers of green and climate-neutral hydrogen.

Coordination is necessary to ensure synchronisation of investments along the supply chain. In the past, this traditionally happened during the ramp-up and expansion of the gas industry through point-to-point contracts, joint ventures or vertical integration, forwards or backwards along the value chain. The market ramp-up for other energy commodities also occurred predominantly under the framework conditions of vertically integrated companies, and in some cases under monopoly conditions. The multiple risks and costs are currently too high, and competition law and the unbundling regime in the EU stand in the way of pipeline-based hydrogen transport. Mechanisms and a market design are therefore needed to align long-term contracts with purchase guarantees and physical delivery. This raises the question of how long-term contracts, which underpin industrial conversion processes on the demand side and have to simultaneously provide the basic supply in the system, can be harmonised with a competitive market at an early stage. Binding contracts (supply contracts or capacity bookings) also help build confidence in synchronised investments. The state will therefore be called upon to promote confidence in simultaneous co-investments along the supply chain through stable framework conditions over long periods of time and appropriate funding mechanisms (liquidity).

Long-term contracts reduce the volume-specific transaction and search costs through large total delivery volumes over the term of the contract. This establishes an important basic supply in the system. Companies that engage in procurement, proprietary trading and portfolio management, allowing them to aggregate or pool significant volumes, play a key role in supply and market development.

Maturity transformation and product structuring are a central function for the market in this regard. This means that companies build up a differently structured and diversified portfolio over time. Then they market a commodity that is as fungible as possible in the form of different products through various channels (exchange, OTC), where all network users are given equal access to virtual trading points. This supply function is necessary above all to secure electricity (and heat) generation, but also to supply medium-sized industrial enterprises, that is, where an on-site or near-site supply of hydrogen and derivatives is not effective. In addition to this physical supply performance, the function for the market ramp-up is also important since product structuring is fundamental for fungible trading.

[8] Craen, Stephen (2023): Financing a world scale hydrogen export project (The Oxford Institute for Energy Studies).

Midstreamers have a decisive role to play in gradually building up a liquid market. Securing early investments can be solved by a purchase guarantee within the framework of long-term contracts (15–25 years). This will not completely eliminate the risks, but at least some of them will be passed on to customers via take-or-pay. The initial profitability gap will have to be closed by funding the differential costs (for a limited term, but with sufficient liquidity).

In this context, the focus should be on the most efficient possible use of resources when funding the differential costs. Competitive instruments that specify this funding on the basis of auctions, on both the supply and demand side, can play an important role here in order to minimise the funding of differential costs. Nonetheless, significant funding will be needed to initiate the ramp-up and bring the required quantities to market quickly, nationally and ideally at the European level.

In addition to the establishment of long-term contracts, however, exchange-oriented trading should always be considered in order to generate one or more liquid marketplaces for hydrogen as quickly as possible based on initial first-mover investments and long-term contracts. Appropriately organised bidding rounds for hydrogen can provide initial price signals for this. Indices can be derived on this basis in order to negotiate long-term and large-scale supply contracts in the private sector. In addition, listed trading in the medium and long term makes it possible to compensate for shortfalls in the short term. When liquid physical trading is established, existing financial products can be transferred from commodity markets to hydrogen markets to hedge price risks.

It should be noted that considerable residual risks remain that require government action.

RECOMMENDATIONS

The NWR believes that the main objective of developing policy options and instruments is to design the framework conditions so that the risks associated with performing the midstream function described above are reduced and mitigated. Here the idea of market-based instruments serves as the guiding principle:

- Mechanisms should be established to generate sufficiently reliable price signals at a very early stage, for example, by making actual prices transparent in aggregated form as part of funding projects or by supporting corresponding energy exchange initiatives in order to provide initial references for the market.
- Mechanisms should be created that initially secure the execution of the midstream function for the market and mitigate the first-mover disadvantages (improvement of bankability, etc.):
  - Granting of default guarantees for take-or-pay contracts.
  - Creation of a hedging instrument that establishes an intertemporal equalisation and hedging mechanism for the price difference between producers and consumers at the beginning of the hydrogen market ramp-up, while at the same time stimulating the possibility of diversifying the portfolio and ensuring the repayment of future profits in the event of a successful ramp-up. Such hedging can create great confidence in the ramp-up on the market side. This incentivises massive investments that ultimately result in urgently needed economies of scale, increasing the available quantity and thus leading to a reduction in the price difference.

- In order to strengthen the midstream function in the market, one should also examine whether and under what conditions or prerequisites a competitive approach can be established that bridges the price difference between the producer and consumer side and supports competing market participants. The aim of the approach should then be to create diversity of midstream players and products, thus increasing liquidity and competition in the market.
- Flexibilities and fall-back options must be made available to minimise liability cases and increase fungibility (financial, physical and swaps).

THE GERMAN NATIONAL HYDROGEN COUNCIL

On 10 June 2020, the German Federal Government adopted the National Hydrogen Strategy and appointed the German National Hydrogen Council. The Council consists of 26 high-ranking experts in the fields of economy, science and civil society. These experts are not part of public administration. The members of the National Hydrogen Council are experts in the fields of production, research and innovation, industrial decarbonisation, transportation and buildings/heating, infrastructure, international partnerships as well as climate and sustainability. The National Hydrogen Council is chaired by former Parliamentary State Secretary Katherina Reiche.

The task of the National Hydrogen Council is to advise and support the State Secretary's Committee for Hydrogen with proposals and recommendations for action in the implementation and further development of Germany's National Hydrogen Strategy.

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