tki nieuw gas
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EXECUTIVE SUMMARY

# Innovation Agenda Hydrogen

Executive English summary of the report published in December 2022 (date: May 2023).

The development of hydrogen as part of the energy transition is a task of extraordinary proportions that is being taken up by many players around the world at the same time. It will be useful, then, to consider developments around hydrogen in the Netherlands within this global context. As we look back over the past three years, we see a number of milestones. An Integrated Knowledge and Innovation Agenda (IKIA) was published by Topsector Energie in 2019. It was developed further in the months that followed into 13 Multi-Year Mission-Driven Innovation Programs (MMIPs) for the power-generation, built-environment, industry, agriculture, and mobility sectors. Hydrogen has been identified as a cross-cutting theme that interfaces with several MMIPs. TKI Nieuw Gas acts as the coordinating TKI for innovation in this area.
The first "Hydrogen for the Energy Transition" Innovation Agenda" was published in early 2020. The Dutch Government's vision for hydrogen followed in March 2020. In mid-2021, the work plan of the National Hydrogen Program (*Nationaal Waterstof Programma*) was created. It took up, and elaborated on, a number of topics on the Innovation Agenda. The ECCM Committee released its Second National Agenda in late 2021. It links hydrogen to chemistry. Also, in 2021 and 2022, two applications from the GroenvermogenNL program in the context of the National Growth Fund were approved, with an operating subsidy of €838 million.
In view of the considerable momentum around the energy transition, the new coalition agreement to form a government in the Netherlands, the European Fit for 55 and RePowerEU plans, the European hydrogen strategy, and the experience of the past few years with mission-driven innovation, the wish was expressed to recalibrate the MMIPs and cross-cutting programs sooner than had been planned under the usual system of the Knowledge and Innovation Covenant (KIC), which would have meant a recalibration only at the end of 2023.

**This report includes a proposal for how the hydrogen Innovation Agenda should be shaped in the coming years. In this summary, the main sections are presented according to a six-question format:**

1 What hydrogen innovations does the Netherlands need to make so that it can meet European energy policy requirements?
2 Which hydrogen innovations best fit the characteristics of the Netherlands in terms of location and infrastructure?
3 Which hydrogen innovations fit the strengths and ambitions of Dutch industry and Dutch knowledge institutions?
4 Which innovation projects have been carried out in the Netherlands in recent years, and in which areas are we lagging behind?
5 Which hydrogen innovations are already supported by other national and European programs, and what additional efforts are needed with Dutch instruments?
6 Over what timeframe can hydrogen innovations be expected to contribute to reductions in emissions?

**Based on this "assessment," there are five innovation priorities.**

- Priorities 1 and 2 concern innovation issues related to the large-scale initiation of the **production, import, and use of hydrogen and hydrogen-containing energy carriers in industry**, together with the **integration** of these chains via the development of the **infrastructure and storage** required**.** Offshore wind from the North Sea is ideal for our own hydrogen production, and the associated system integration for optimally matching production and utilization is key. That will maximize the potential that offshore wind represents. It will serve industry clusters that are important to the Netherlands. And it will effectively deploy infrastructure, both existing and that has yet to be built—ports, pipelines, roads, waterways, rail, and so on—so that the Netherlands can develop into a Northwest European hydrogen hub.
- Priority 3 concerns the **sustainability of heavy transport and mobility in particular** (road transport, earth-moving, inland and coastal shipping, and aviation) as well as the necessary refuelling points, in order to meet the national commitment to sustainable transport, while at the same time mobilizing the manufacturing industry in this area.
- Priority 4 relates to the **decentralized regional development of hydrogen production and deployment,** which will make hydrogen locally available for such purposes as mobility, local industry, and the built environment. At the same time, this will facilitate the rollout of renewable energy production, which is hampered at the moment by congestion in the electrical grid.
- Priority 5 focuses on the development of **manufacturing in the Netherlands**, ranging from electrolysis and the supply of the technology for it, through the supply of components, to the production of heavy vehicles, for instance. This will contribute regionally, for the most part, to earning power at the national level.
- Finally, intersecting themes such as the **human-capital agenda, digitization, and societal impact** are important and should be addressed in an integral manner.

**These priorities are detailed below. The questions on innovation are developed in the chapters that follow.**

**PRIORITY 1**

**The development of sustainable hydrogen chains in industry, consisting of hydrogen production with offshore wind, infrastructure, and storage, and utilization in industry for energy purposes and as feedstock, with the system integration that is required**

The production of green hydrogen from electrolysis and its utilization must simultaneously be accelerated, so that hydrogen can contribute significantly to emissions-reduction targets by 2030. In addition to the onshore production of green hydrogen, offshore electrolysis is becoming increasingly important: given the limited space on land, offshore electrolysis offers by far the best opportunities for the Netherlands to produce green hydrogen on a large scale. The Dutch Government has announced an innovation program for the development of offshore hydrogen with research and large-scale demonstration projects before 2030. These will pave the way for GW-scale projects in the years that follow. To achieve scale, the development of sustainable hydrogen chains intended for use in industry is a top priority. In addition to replacing the current high demand for grey hydrogen, low-carbon hydrogen can also directly replace natural gas, for instance to generate high-temperature heat, and also offers opportunities for the development of new chemical processes. The innovation challenge on the user side is how to develop these new industrial uses of hydrogen. Large-scale transport and storage infrastructure is required in order to connect production and use. This is where system-integration issues come up. Examples include the integration of offshore wind and electrolysis and of different energy infrastructures, the connection with end users, and the role of seasonal storage.

**PRIORITY 2**

**The importation of hydrogen-based energy carriers, such as derivatives and liquid organic hydrogen carriers (LOHCs), and hydrogen in gaseous and liquid form**

The second priority is the importation of hydrogen, whether in pure form as a gas or a liquid, bonded to a carrier (notably LOHCs or in powder form), or as a hydrogen derivative (such as ammonia, methanol, and synthetic fuels). Demand for hydrogen in the Netherlands and neighboring countries is expected to exceed production capacity, and because of its location, the Netherlands will play an important role in the import and transit of renewable energy and raw materials, just as it does now for fossil-fuel resources. At the moment, several countries that are expected to experience high demand for hydrogen are deciding how to position themselves. Because of the position the Netherlands can occupy in view of its location, its ports, and its infrastructure, importation and export/transit are an important theme for the Innovation Agenda. This topic has emerged strongly only in recent years, and there are still some questions to be answered about what forms hydrogen can best be imported in, and what that implies for means of transport, transshipment and storage, and for processing and subsequent integration into the energy system.

**PRIORITY 3**

**The use of hydrogen in heavy transport, such as road transport, construction and earthworks, inland and coastal shipping, and aviation**

The third priority is the use of hydrogen in heavy transport, such as roads, construction and earthworks, inland and coastal shipping, and aviation. These are sectors in which Dutch companies have a strong position, and where a considerable reduction in $CO_2$ emissions can be achieved. And there are also other drivers for innovation, such as air-quality standards and nitrogen policy. Battery-powered mobility is a suitable and attainable solution for many applications. In mobility applications where heavy loads need to be transported and/or where the distances involved are considerable, and/or where electric charging is difficult to plan or takes too long or is not possible because of limitations related to infrastructure, the use of hydrogen may be a better alternative when it comes to achieving far-reaching reductions in $CO_2$ emissions. The innovation challenge here is to achieve economies of scale for hydrogen delivery and refuelling facilities, and thus to improve total cost of ownership (TCO) through demonstrations of compelling use cases across a range of modes of mobility as well as mobile equipment.

**PRIORITY 4**

**Decentralized hydrogen production and use in regions where grid congestion hinders the rollout of renewable-energy projects, or where local hydrogen demand can be met efficiently.**

The fourth priority is the decentralized regional production and use of hydrogen. In addition to the large-scale, centralized production of hydrogen, its decentralized regional production through electrolysis can help, on the one hand, to make it available locally for mobility, regional industry (the dispersed “sixth cluster”), and the agriculture and horticulture sectors, for example. On the other hand, it can potentially alleviate grid congestion in areas where the capacity for incorporating renewable electricity from solar farms and wind turbines is limited. Conversion to hydrogen is one of several options in this regard. There is a need for research and pilot studies to determine what combination of renewable-energy supply (wind and solar) and storage/conversion options will work, at what scale, and under what conditions. The realization of complete chains (production, infrastructure, and demand) is

also relevant here. The likelihood that such chain innovations will succeed is actually higher thanks to regional clustering in what the EU is calling “hydrogen valleys”. The idea is that, if all kinds of hydrogen projects are concentrated in a limited area, cross-connections will emerge, ecosystems will grow more easily because of short lines of communication, and knowledge will be better secured and spread, than if every city were to start a demo involving a refuelling station and a few cars or homes.

**PRIORITY 5**

**The development of technology clusters for hydrogen components and chains, linked to the manufacturing industry**

The fifth priority is the incipient and further development of various components and supporting techniques for the value chains, where positioning is driven by the manufacturing industry. The aforementioned priorities relate primarily to creating, and connecting to, whole value chains. However, there are still many technical questions at play in these chains. The questions concern all kinds of components that are used as well as related factors such as safety, the measurement of the quality of gas, sensor technology, materials research, and so on. The incipient and further development of fuel cells and combustion engines, gas turbines, and burners is also needed to support these priorities. It is also important here that innovations by Dutch manufacturing industry be valorized. A high degree of self-sufficiency, albeit on a European rather than on a Dutch scale, is required, not only for hydrogen but also for these technologies, so that there is less of a dependency on countries outside Europe.

**The human-capital agenda, social impact, and digitization:** In addition to the previous topics, there are several overarching themes—such as the human-capital agenda, social impact, and digitization—that have a place on the Innovation Agenda. These overarching themes are also addressed in the National Hydrogen Program, which covers such areas as policy, laws and regulations, safety, social embedding, the hydrogen market, and certification. The development of a human-capital agenda for hydrogen is a major part of GroenvermogenNL’s activities. These issues are an integral part of the priorities set out above.