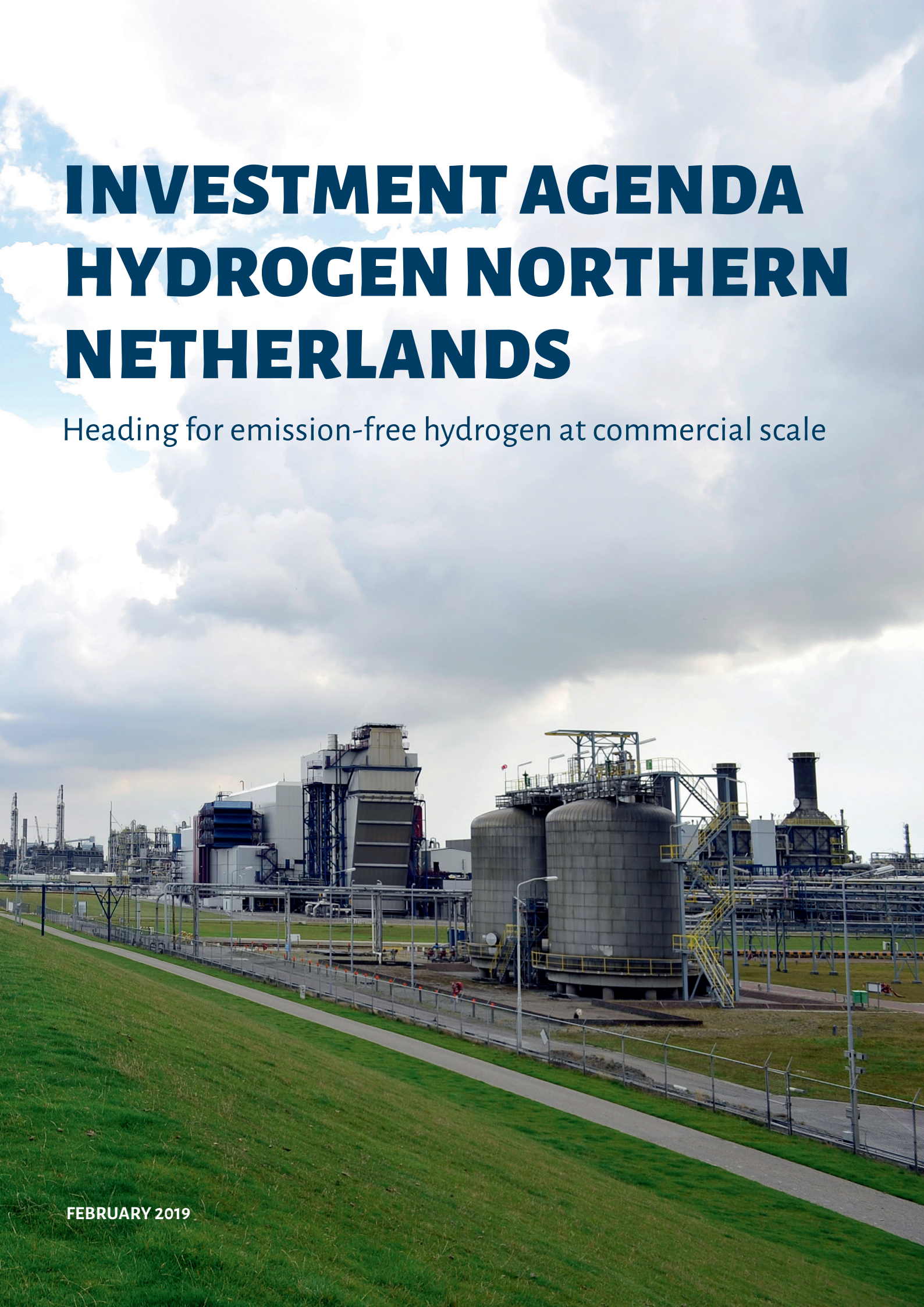
# INVESTMENT AGENDA HYDROGEN NORTHERN NETHERLANDS

Heading for emission-free hydrogen at commercial scale



FEBRUARY 2019

# EXECUTIVE SUMMARY

## Green industry of the future

The Northern Netherlands is actively building on the green industry of the future. Hydrogen has a vital role to play in this transition, both as an energy carrier and as feedstock. The green industry creates and retains jobs, ensures that our knowledge position is maintained and makes a concrete contribution to the Netherlands' climate objectives for 2030. That is why we, companies and governments in Groningen and Drenthe, have established an investment agenda for the development of the hydrogen system in the Northern Netherlands. To realise these investments, we have requested the central government to finance part of the financial gap of hydrogen production.

## Emission-free hydrogen

The hydrogen plan outlines the large-scale plans for production, infrastructure and use of emission-free hydrogen. The term 'emission-free hydrogen' designates green and blue hydrogen, which is respectively hydrogen production using renewable electricity and hydrogen production using natural gas in combination with $CO_2$ capture and storage. The companies have their own focal areas: some companies in this plan focus on green hydrogen projects, while others also focus on blue hydrogen projects. However, they all see the opportunities linked to scaling up the hydrogen system in the Northern Netherlands. A joint investment agenda has been written for this purpose.

## Growth of hydrogen to commercial scale

The investment agenda includes an increase in scale, which takes the annual production of emission-free hydrogen to an order of magnitude of billions of cubic metres. To give an impression: 1 billion cubic metres has an energy content of approximately 10.8 petajoules (PJ). Replacing one billion $m^3$ of grey hydrogen with emission-free hydrogen will save approximately 600 kilotonnes of $CO_2$ emissions. This will be achieved through investments in green hydrogen production clusters, a blue hydrogen production site, hydrogen and $CO_2$ infrastructure and the conversion of existing industry. The increase in scale is needed in the short term for cost reduction in technology and infrastructure. As a result of this cost reduction, the cost-effective production of emission-free hydrogen is expected to be possible in 2030. Until 2024, the part of the investment which is not cost-effective, the financial gap, averages 100 million euros a year.

## Cover for financial gaps

Companies in the Northern Netherlands are very ambitious with the projects in this document and are prepared to accept part of the financial gap. Investments will not get underway without coverage of the remaining part of the financial gap. We are therefore asking the national government to set up a subsidy for hydrogen production. This has a positive effect on green chemistry and employment. The economic and sustainable opportunities in the region are thus exploited. The Northern Netherlands is ready!

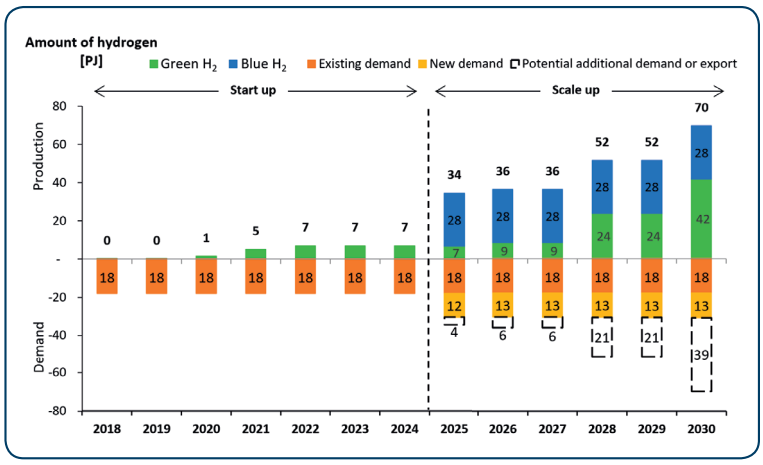



***Figure 1***
*gives an overview of the expected development of hydrogen supply and demand in the Northern Netherlands based on the projects in this investment agenda.*

## The following parties contributed to this plan:

Avebe | BioMCN | EMMTEC services | Eneco | Engie | Equinor | ESD-SIC
Groningen Seaports | Lagerwey | Nederlandse Gasunie | NAM | Nedmag | Nouryon | Nuon/Vattenfall
Provincie Groningen | Shell | Suikerunie | Teijin Aramid | Waterbedrijf Groningen

# WHY HYDROGEN?

**A transition to a sustainable energy system and a circular and sustainable industry is necessary to achieve a society that is (almost) completely $CO_2$ neutral by 2050. The emissions released by the use of energy and feedstock must therefore be significantly reduced. Production, transport and storage must also be emission-free within such a system. This calls for emission-free energy carriers. These energy carriers are electrons or molecules. Electrification and energy efficiency alone are not sufficient to achieve this.**

These energy carriers must have the following characteristics:

- **Time** – they should always be available and not be affected by day-night or seasonal cycles.
- **Location** – they must be economically viable for short and long distances.
- **Use** – they must be economically viable for small and very large needs.

Emission-free hydrogen is the most obvious way to achieve this. Of course, other systems also form part of the energy transition: sustainable electricity and heat from residual heat or geothermal energy. Carbon chains will also continue to exist for industrial products; the carbon will be of non-fossil origin as far as possible.

Hydrogen can be used for numerous and demanding applications, both as an energy carrier and as a renewable feedstock for the chemical industry. Hydrogen can be transported inexpensively, allowing it to be transported over longer distances. Since hydrogen is convenient to store in large volumes, it can be used at any time. Hydrogen is therefore an ideal, clean energy carrier and feedstock. The Northern Netherlands can become the centre of the Netherlands' hydrogen system. Northern industry, companies and governments fulfil this role together. This investment plan creates the necessary foundation for this.

## Why the Northern Netherlands?

The Northern Netherlands has been actively working for years on a green energy system and the industry of the future. This is how the Northern Netherlands manifests itself as a leader and looks to seize the opportunities this position brings with it: the Northern Netherlands extends the acquired knowledge position and retains and creates employment. This is a route that the northern industry itself has initiated and continues to be developed.

Other reasons include the process involved in industry making a Northern Netherlands contribution to the Dutch energy and climate agreement, the many projects currently being developed in the region, the prospects for Groningen and the Regiodeal in which hydrogen plays an important role.

Because of its history with natural gas, the Northern Netherlands is the energy region of the Netherlands and a driver behind our prosperity. Even now, the Northern Netherlands qualifies as a centre for a sustainable energy system with an important function for hydrogen because:

- There is physical space for the production of electricity to hydrogen via electrolysis and via natural gas conversion.
- There are also sufficient coupling opportunities to make good use of the residual heat.

### Hydrogen in mobility

Projects already realised or in progress:

- Groningen - Leeuwarden hydrogen train
- 22 hydrogen buses in the Groningen region - Assen in addition to 159 electric buses
- 8 hydrogen refueling stations
- Municipal road sweeping vehicles and garbage trucks

[1] *See for example: The Hydrogen Coalition (2018), "Vier pijlers onder een duurzame waterstofeconomie in 2030" and Industrietafel Noord-Nederland (2018), "Noord-Nederland geeft gas op CO2-reductie"*

[2] *See also: Northern Innovation Board (2017), "The Green Hydrogen Economy in the Northern Netherlands"*

- There is already a lot of knowledge about producing green hydrogen by electrolysis (chloralkali and water electrolysis). Hydrogen is already produced on a large scale as a by-product of chlorine.
- The existing natural gas transport system makes it possible to create simple and cost-effective connections for the transmission of hydrogen. Not only within the region, but also for the export of hydrogen to other regions at home and abroad, and at a later date also the import of hydrogen.
- Hydrogen can conveniently be stored due to the presence of salt caverns near EnergyStock, Veendam.
- There are important clusters in the region where the hydrogen can be used in the economy. These clusters are the chemical industry, electricity generation and logistics.
- The region has unique research and test sites (including the Hydrohub test centre) at the EnTranCe field lab in the city of Groningen. Here, hydrogen applications can be developed.
- Cooperation between companies and knowledge institutions takes place within the New Energy Coalition and training courses from vocational education to scientific education in the field of energy transition and hydrogen are offered or developed.
- The presence of seaports could provide alternative hydrogen transport, import of hydrogen and a base of operations for the offshore wind industry.
- Eemshaven is a hub for the electricity grid in the Netherlands: various power stations, the landing of interconnectors and offshore wind farms and an existing high-voltage grid to the rest of the Netherlands.
- The region is an excellent location for a hydrogen related industry.

## The necessary increase in scale of production

The development of the hydrogen system in the Northern Netherlands calls for an increase in scale to billions of cubic metres of emission-free hydrogen production a year. To give an impression: one billion cubic meters of hydrogen has an energy content of approximately 10.8 PJ and saves more than 600,000 tonnes of $CO_2$ a year when replacing natural gas in energy processes. This is approximately the amount of hydrogen that is envisaged for the conversion of the Magnum plant to hydrogen as part of the ('Hydrogen to Market') project of Equinor, Nuon and Gasunie **[project 29]**. Increasing hydrogen production to this extent will make it worthwhile to replace fossil fuels and invest responsibly in hydrogen transport and storage.

The increase in scale could make a concrete contribution to the climate objectives of the Netherlands (49-55% $CO_2$ reduction) by achieving it in 5 to 7 years. Investments in the necessary infrastructure also remain affordable due to economies of scale. This will also contribute to a cost reduction in the required technology such as electrolysis devices. This requires a quick decision to invest in:

- Clusters for the production of green hydrogen of at least 100 MW;
- A blue hydrogen production site of at least 1.2 GW, needed for the baseload volume for industry;
- Infrastructure for hydrogen storage and transmission and for $CO_2$ capture and transport;
- Conversion of existing industry and electricity generation to hydrogen.

The above forms the necessary and indispensable core for the rapid growth of hydrogen production and use. This investment plan gives substance to this. The increase in scale can be achieved on the basis of economic added value and government support for innovation, economic development and the reduction of greenhouse gas emissions.

The plan calls for an entrepreneurial approach. The parties are aware of the special risks: major investments and innovations are needed and there is a high degree of interdependence. The parties will therefore jointly develop and verify this plan in the coming months. This guarantees that the projects and the plan as a whole are significant and affordable. The parties want to keep the social costs along the entire chain as low as possible.

### 20 MW Electrolyser Delfzijl

Nouryon and Gasunie New Energy plan to develop a plant that - with the aid of a 20 megawatt water electrolysis unit, the largest in Europe - converts sustainably produced electricity into 3 kilotonnes of green hydrogen per year (30 million $m^3$). The planned 20 megawatt facility is a major step in the successful further scale-up of electrolysis technology. The ultimate aim is to build installations that convert and store sustainable electricity in the form of hydrogen on an even larger scale (from 100 megawatts). The investment decision will be taken in 2019.

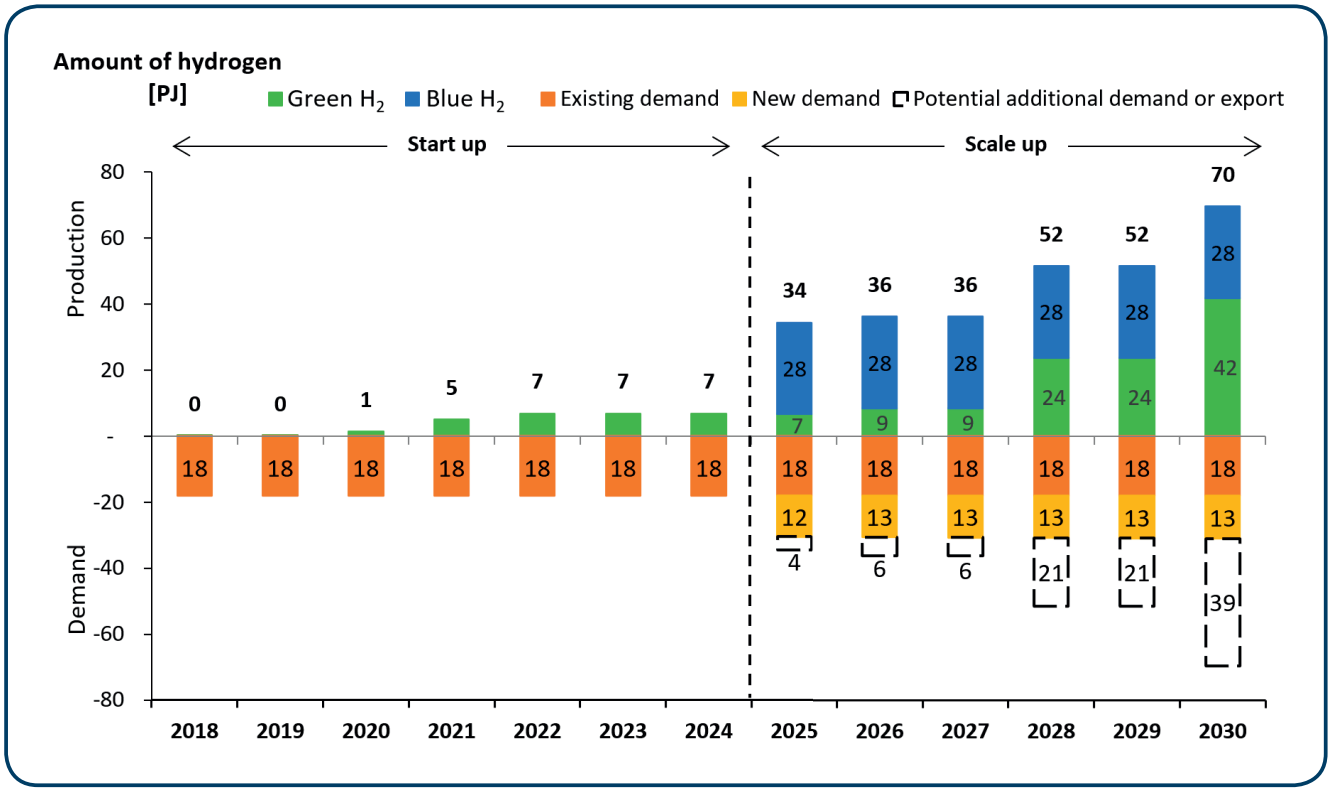



***Figure 1***

*Indication of hydrogen supply and demand in the Northern Netherlands. This figure is based on currently known quantities. Additional supply and demand are foreseen, but not yet quantified. Green hydrogen is produced from sustainable electricity and blue hydrogen is made emission-free by capturing $CO_2$.*

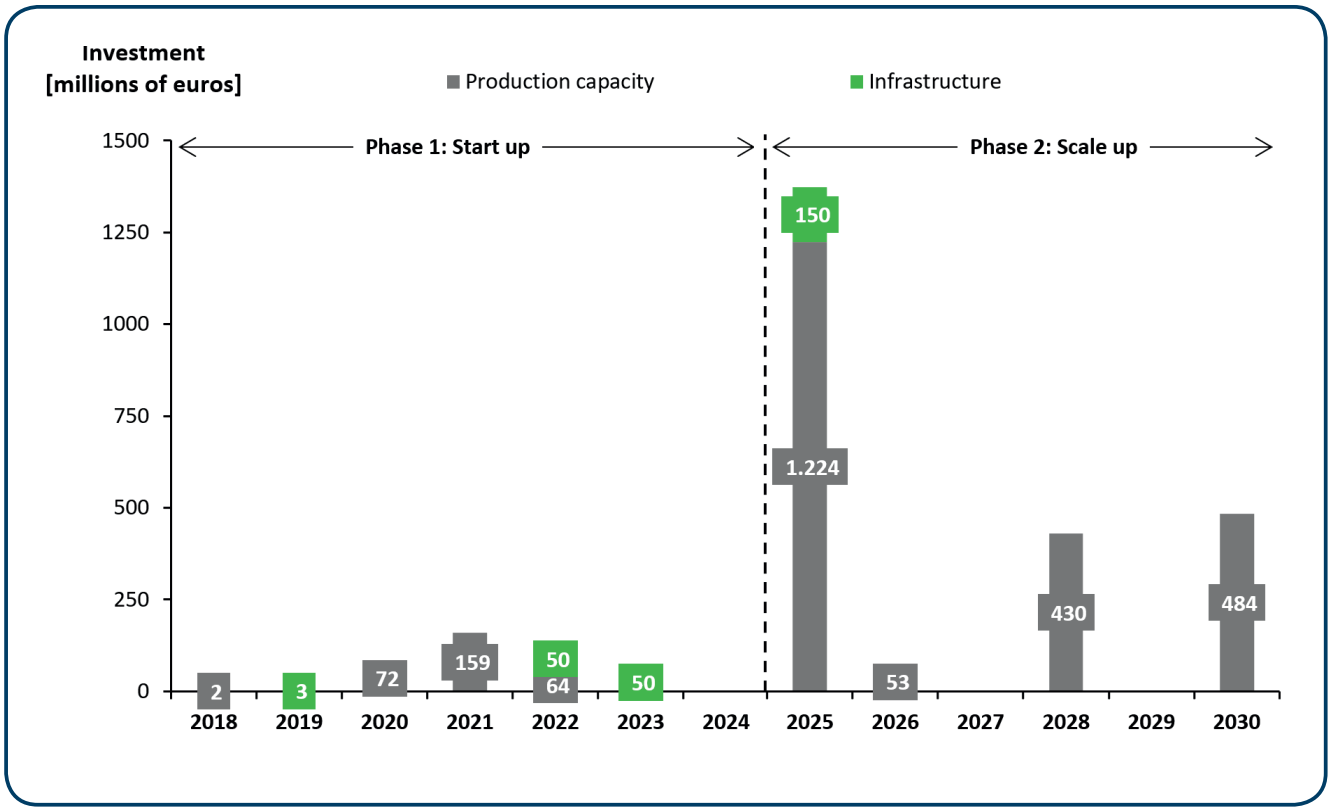



***Figure 2***

*Indication of the investments required to implement the hydrogen investment agenda in the Northern Netherlands for currently known projects.*

## Investment agenda Northern Netherlands

The cooperating parties have drawn up an investment agenda in order to realise the plan. The figure below shows how the hydrogen production and demand will be if the investments are made. The necessary increase in scale is clearly visible around the year 2025.

The hydrogen demand can be met in various ways. The total demand for hydrogen is highly dependent on price. For example, not all hydrogen will be green at first, since the construction of both green electricity production and electrolysers will start at small scale. In phase 2 there are opportunities to export hydrogen via pipelines to other areas in the Netherlands or to attract new green industry locally. There are therefore sufficient potential customers.

Companies have decided to invest in this plan. Up to 2030, these investments amount to EUR 2.8 billion. The following figure shows how they are planned over the years.

The planned volumes of green hydrogen will reach 7 PJ per year in 2024. This hydrogen is of course more expensive than grey hydrogen or natural gas. The cost price of hydrogen is determined by the investments and operational costs, including energy costs. The difference between the cost price and the market price is the financial gap. For the years 2019 up to and including 2024, this averages 100 million euros a year. The financial gap will have to be covered partly by the companies themselves and partly by government subsidies. Of course, this amount is still uncertain due to possible technological and economic developments in the future. This is even more true for the period from 2025 onwards.

[3] *Assuming the cost price of green hydrogen in 2023 at 4 EUR/kg (source: CE Delft (2018), "Waterstofroutes Nederland"). The natural gas price for 2023 is assumed to be 25.5 EUR/MWh, assuming a linear course between the current wholesale gas price of about 22 EUR/MWh and the estimated wholesale price from the National Energy Outlook of almost 32 EUR/MWh in 2030. By comparison, the SDE+ budget for 2019 is expected to amount to €10 billion.*

## Hydrogen production

Hydrogen only occurs on earth as a compound, mainly in water, but also in fossil fuels. Hydrogen can therefore be produced in various ways; currently mainly from fossil sources (grey hydrogen). For a $CO_2$ neutral energy system it is important to produce hydrogen emission-free.

Hydrogen produced by electrolysis with green electricity or from biomass, is often called green hydrogen. Blue hydrogen refers to hydrogen produced from fossil fuels in combination with $CO_2$ capture and storage. Blue hydrogen can be produced on a larger scale, as a transition, but is less modular than the production of green hydrogen. Equinor and Shell, among others, are looking into the possibilities of producing blue hydrogen. **[Projects 1 and 9]** For the production of green hydrogen it is important that sufficient sustainably generated electricity is available. The planned developments for the expansion of offshore wind form an important source for this. The route taken by industry in the Eems Delta to negative $CO_2$ emissions by 2050 shows that, in addition to biomass (as fuel, but also as feedstock), 7 GW of wind energy is needed for this alone. Furthermore, there must also be sufficient (clean) water available for electrolysis. **[Projects 2 to 8, 10 and 11]**

[4] *BLIX Consultancy BV (2017), "Offshore wind boven de Wadden"*

[5] *Industrietafel Noord-Nederland (2018), "Eindrapport Industrietafel Noord-Nederland - Reductie $CO_2$-emissie"*

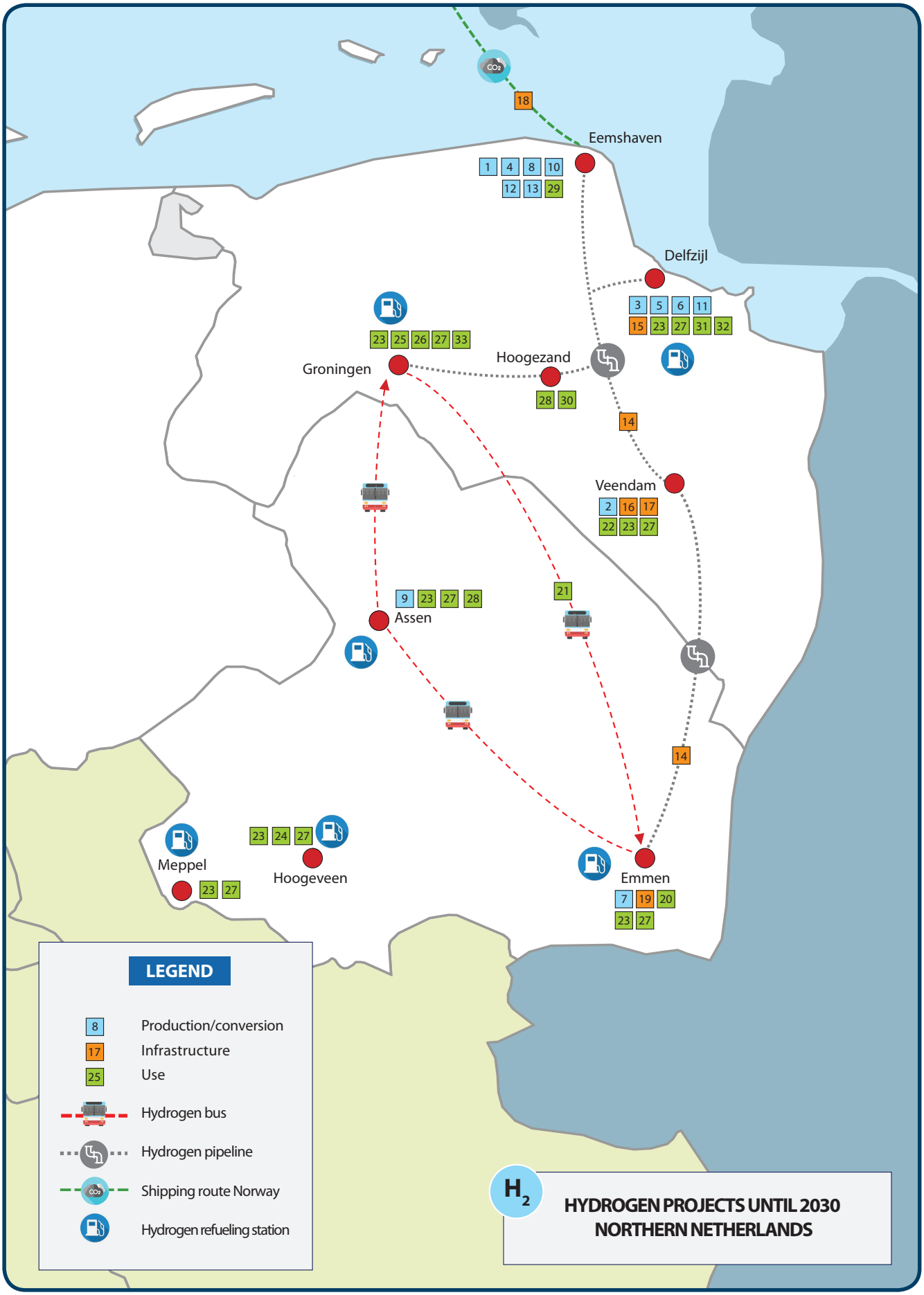



***Figure 3*** *Overview of hydrogen projects up to 2030*

## Infrastructure

Infrastructure is necessary to transport hydrogen from production to demand locations. The existing natural gas infrastructure in the Northern Netherlands can partly be used for the cost-effective and efficient transport of hydrogen **[projects 14 and 15]**, also to other industrial clusters in the Netherlands (e.g. Rotterdam or Geleen) or Germany (e.g. Ruhr area) and to the built environment. For new transmission pipelines, work is also being done on the development of plastic reinforced pipelines [project 32]. In addition, the salt caverns present in the region could provide storage for hydrogen **[project 16 and 17]**. The routes in Figure 3 are the direct result of the projects now identified, but it does not have to stop there; the infrastructure will also have to keep pace with the growing demand for hydrogen at various locations.

## The hydrogen market

From the increase in scale onwards, industry will be the main consumer of hydrogen. The chemical industry will green the current hydrogen consumption **[projects 31 and 32]**. The availability of emission-free hydrogen will also attract new chemical companies, creating new value chains. Other industries can use hydrogen as an energy carrier to produce high temperature heat **[project 22]**. Industrial off-take will be baseload and require a high security of supply.

Electricity generation from hydrogen supports electricity production from wind and sun. Consumption fluctuates, but can largely be planned (winter) and is predictable (windless periods). Electricity generation will therefore also demand hydrogen from the increase in scale onwards. A concrete plan is to convert the Magnum plant to hydrogen **[project 29]**. The planned growth in wind and solar energy and the phasing out of coal will increase the demand for controllable capacity and therefore for hydrogen-fuelled power stations.

Not only industry and electricity production are foreseen in the plan. The regional logistics sector will make the transition to hydrogen in phases. This mainly calls for a widely distributed infrastructure of hydrogen refueling stations **[project 27]**; Holthausen, Green Planet and PitPoint are already building 8 hydrogen refueling stations **[project 28]**. After an initially limited demand for hydrogen, its use in this sector could increase substantially. Three phases are planned, in which the regional government can play an important role as launching customer, among other things:

1. Initially, the emphasis will be on city buses and utility vehicles with a long-term and often continuous load. The first projects are already being developed, for example by the OV Bureau Groningen and Emmen **[project 21]** and the Municipality of Groningen **[project 25]**.
2. In the second phase, light truck transport and passenger transport for longer distances will also be transferred **[project 28 and 30]**.
3. At a later stage, heavy truck transport and part of shipping and rail transport can also be developed.

The logistics sector will require specific support in the initial phases given the level of costs and the innovation required. The use of hydrogen - in combination with battery-electric vehicles and bioLNG for heavy transport - results in a logistics sector without greenhouse and particulate matter emissions, minimal $NO_x$ emissions and acceptable noise levels. This contributes to the liveability of the region.

There are also opportunities for making the built environment emission-free by using hydrogen. An ongoing project for this is the hydrogen neighbourhood in Hoogeveen **[project 24]** and Groningen **[project 26]**.

## A mission-driven approach

The success of the increase in scale and further development depends on the availability and cost price of green hydrogen. This plan must therefore be part of a broader approach to vigorously pursue the development of offshore wind in the North Sea and to land the available energy in the region in the form of electricity and later also in the form of hydrogen.
The parties foresee, as in the Hydrogen Coalition charter, that electrolysis will significantly reduce cost price and increase efficiency. However, this calls for a national mission-driven

### Hydrohub / MW test centre

#### Industrial-scale hydrogen technology

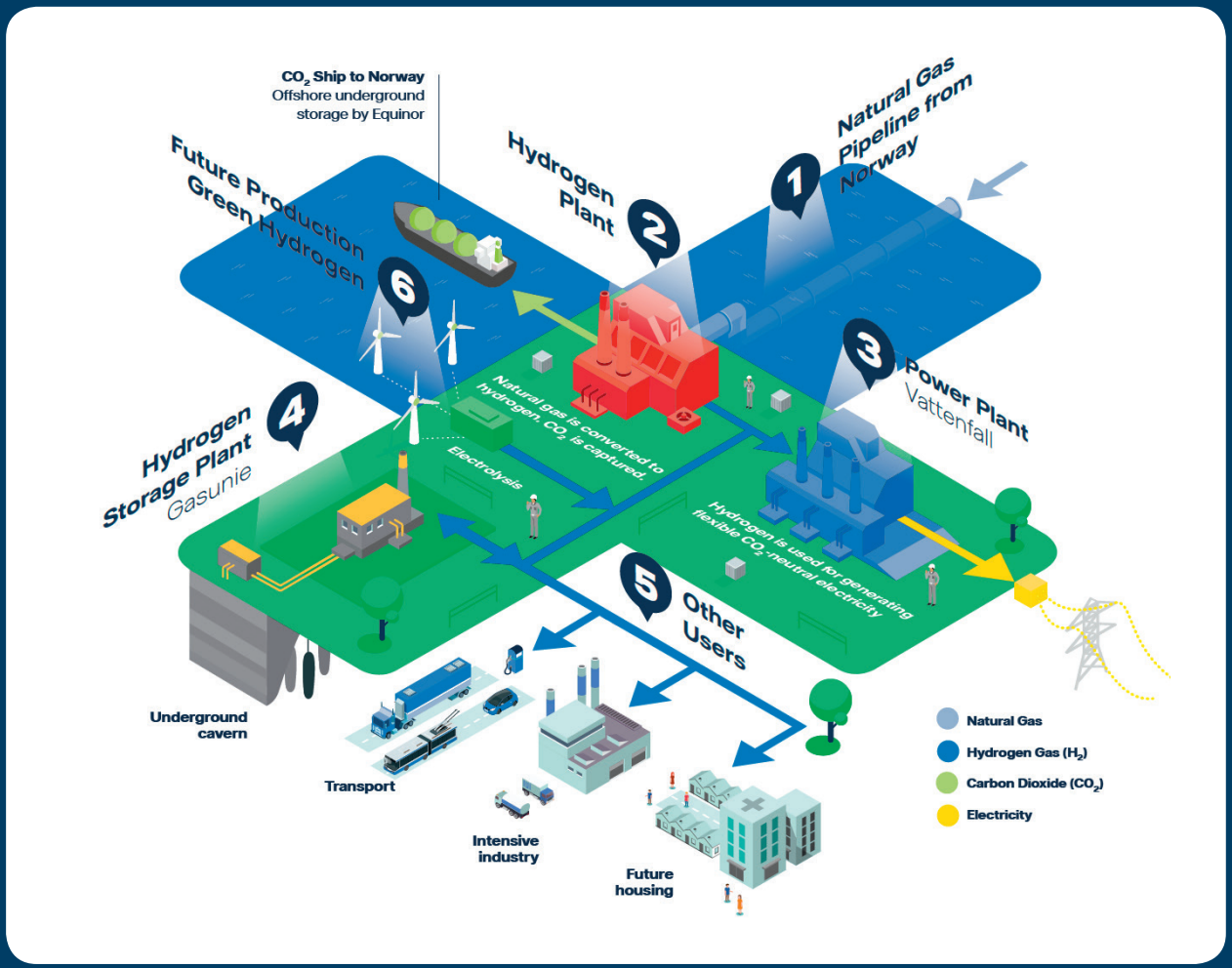
The Hydrohub is an open test centre, where the partners of the consortium, but also other knowledge institutions and companies, can test innovations from their own lab in electrolysis plants of half a megawatt. Tests on this scale show whether new problems arise and how the technology will behave when scaled up. The research in the Hydrohub will lead to a standard for the design of large-scale electrolysis processes.

approach similar to that for the development of offshore wind. The region offers good opportunities to contribute to the necessary innovation and thus cost price reduction. The parties want to focus on scaling up the production systems in a smart way. The first step is to jointly realise a demonstration project for 20 MW of electrolysis capacity **[project 3]**. Together with the 1 MW demonstration project at the underground storage facility in Zuidwending **[project 2]**, the next steps can be taken in scaling up to 50, 100 and 200 MW **[project 4 and 8]** to even 1 GW **[project 10]**. The projects for the production of hydrogen will go hand in hand with the development of hydrogen components in the Hydrohub in the city of Groningen [project 33] and with the development of large-scale production of components in the region **[project 28]**. The production of blue hydrogen **[project 1 and 9]** ensures that the upscaling goes even faster and gives customers the assurance of a sufficient supply. In addition, the parties want to focus on the decentralised combination of wind turbines and electrolysis. This will enable the development of local hydrogen clusters and optimisations between the development of sustainable production and the development of energy networks. Above all, it could open up the way to applying the conversion to hydrogen immediately at the offshore in the longer term. To this end, Lagerwey is developing a hydrogen wind turbine **[project 5 and 6]**.

The production and use of hydrogen have common ground with other utilities. For example, hydrogen production cannot be considered separately from the availability of (green) electricity and clean water, and residual heat is produced both in electrolysis and in a fuel cell. Also, electrolysis produces pure

## H2M: large-scale production and off-take

The Hydrogen to Market (H2M) project of Nuon, Gasunie and Equinor aims to use hydrogen on a large scale as fuel for the Magnum power station in Groningen's Eemshaven. They are starting an innovation project aimed at switching one of the plant's three units to hydrogen from 2023. This is an important step towards a 100% $CO_2$-free energy supply. The feasibility study will be completed in 2019.



oxygen. The development of large-scale hydrogen technology thus offers opportunities for the integration of other energy and feedstock flows.

## Regionale economie en werkgelegenheid

The investments will not be without result. Not only is the North bringing about a substantial acceleration in the energy transition and greening of the chemical industry, employment will also be given a major boost by this investment agenda. Recent studies show that the hydrogen economy could lead to 16500 structural jobs for the Netherlands as a whole by 2030. The Hydrogen to Market project alone **[project 29]** in Eemshaven provides 6,000 direct and 3,000 indirect jobs during construction and, once in operation, provides employment for approximately 500 people. In addition, the plan will attract new businesses, which will also create jobs. Further economic growth can be achieved by becoming a major trading hub for green energy, including hydrogen. This is how the Northern Netherlands is working towards a green and economically sustainable future.

## Policy and regulation

The implementation of this plan depends not only on the investments and public support to cover the financial gap compared to the alternative with the right mix of instruments. Regional and national policy also plays an important role. Policy and regulation can support the implementation of this plan in the following areas:

- Inclusion of hydrogen production in an SDE+ type of scheme (subsidy for financial gap of renewable energy): there will be a financial gap for hydrogen production in the coming years. At this moment, companies are not able cover the full financial gap, but this can be quickly reduced by investing on a large scale. Therefore, support is needed to cover the operational costs of hydrogen production and distribution. A subsidy for the financial gap seems the most appropriate for this purpose.
- Consideration of the whole value chain instead of individual parts in the granting of aid.
- Clarification of the different functions of hydrogen in regulation (e.g. storage medium, transport, production/ conversion, renewable fuel or feedstock). For example, we need an appropriate legal framework for hydrogen. Unambiguous certification framework for emission-free hydrogen, for example by implementing CertifHy, the European certification system for green hydrogen.
- Setting up new instruments to stimulate the demand for hydrogen. The Netherlands may choose to promote the use of hydrogen in mobility through a legal framework, for example in the implementation of the Renewable Energy Directive II (RED II). Member States have discretionary freedom in implementing this Directive.

## Starting the scale-up is crucial

Companies in the Northern Netherlands show great ambition with the projects in this document. This is for a reason; the energy transition and the greening of chemistry will not succeed without a serious role for hydrogen. This role can be fulfilled quickly if all parties in the chain have the confidence to make the necessary major investments. In addition, the regional economy and employment and the quality of life of the region will increase. The Northern Netherlands is ready!

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[6] *The Hydrogen Coalition (2018), "Waterstof essentiële bouwsteen energietransitie – manifest waterstof coalitie", May 2018*

[7] *See for example: CE Delft (2018), "Werk door Groene Waterstof"*

## CertifHy

Hydrogen consumers from industry and transport can use renewable energy in their processes and reduce the greenhouse gas footprint by purchasing CertifHy Green or Low Carbon Hydrogen Guarantees of Origins now. CertifHy GOs allow end-users to consume Green and Low Carbon Hydrogen across the EU, regardless of their location. The CertifHy Guarantee of Origin scheme is essential for labelling the origin of the product providing transparency to consumers and creating market pull for Green and Low-carbon hydrogen.


The CertifHy pilot dispatched 75 000+ Green and Low Carbon Guarantees of Origin that are issued into the registry. The four hydrogen producers including the industrial gas companies Air Liquide and Air Products, specialty chemicals company Nouryon, the retailer Colruyt Group and the energy utility Uniper are participating in the pilot and issuing GOs.

# PROJECTS IN THE NORTHERN NETHERLANDS

The projects are divided into a first phase (white, up to and including 2024) for starting up the hydrogen economy and a second phase (light blue, from 2024 up to and including 2030) for scaling up the hydrogen economy.

## PRODUCTION/CONVERSION

| Lead company | Plan/Project | Location | Year of completion |
|---|---|---|---|
| 1. Equinor/Gasunie | Blue hydrogen produced from an ATR (H2M) | Eemshaven | 2025/2026 |
| 2. Gasunie/HyStock | 1 MW electrolyser | Zuidwending | 2018 |
| 3. Nouryon/Gasunie | 20 MW electrolyser | Delfzijl | 2020/2021 |
| 4. Engie/Gasunie | 100 MW electrolyser | Eemshaven | 2022 |
| 5. Lagerwey | 2-3 MW hydrogen wind turbine | Eemshaven/Delfzijl | 2020 |
| 6. Lagerwey | 4 hydrogen wind turbines | Eemshaven/Delfzijl | 2020/2022 |
| 7. Emmen partnership | 2-5 MW electrolyser | Emmen | 2020 |
| 8. Nouryon | 200 MW electrolyser | Delfzijl | 2025 |
| 9. Shell & Partners | Blue hydrogen | to be determined (part of larger chain) | after 2024 |
| 10. Engie | Scaling up 100MW --> 850MW --> 1GW electrolyser | Eemshaven | 2026-2030 |
| 11. To be announced shortly | 40 MW electrolyser | n.t.b. | 2020 |
| 12. Nuon/Proton Ventures/ BASF/Yara/Orsted/TU Delft | Battolyser (15 kW testinstallation) | Eemshaven | 2019 |
| 13. SCW/Gasunie | 300 MW Supercritical water gasification | Eemshaven | n.t.b. |

## INFRASTRUCTURE

| Lead company | Plan/Project | Location | Year of completion |
|---|---|---|---|
| 14. Gasunie | Pipeline Eemshaven-Delfzijl-Zuidwending-Emmen | Eemshaven-Delfzijl-Emmen | 2022/2023 |
| 15. GSP | Hydrogen Distribution Network Chemical Park Delfzijl | Delfzijl | 2019 |
| 16. Gasunie/EnergyStock | Hydrogen cavern | Zuidwending | 2023 |
| 17. Gasunie/EnergyStock | Hydrogen cavern | Zuidwending | 2025/2026 |
| 18. Shell, NAM & Partners | $CO_2$ infrastructure, offloading, shipping and (offshore) storage | to be determined | after 2025 |
| 19. NAM & Partners | Small chain: Reusing infrastructure and energy locations to connect renewable energy sources | Emmen and other clusters in the Northern Netherlands | to be determined |

## USE

| Lead company | Plan/Project | Location | Year of completion |
|---|---|---|---|
| 20. Emmtec and customers | High temperature proces heat and power from hydrogen | Emmen | 2020 |
| 21. Public transport Groningen/ Emmen | Hydrogen-electric buses | Groningen/Emmen | 2020 |
| 22. Nedmag | Conversion of burners and furnaces | Veendam | 2023 |
| 23. Holthausen/Green Planet/ Pitpoint | 8 hydrogen refueling stations | Provinces Groningen, Drenthe, Fryslân | 2019-2022 |
| 24. Hydrogreenn | Newly build residential area; space heating on hydrogen | Hoogeveen | early 20ies |
| 25. Gemeente Groningen | Street sweepers and garbage trucks on hydrogen | Groningen | 2018 |
| 26. Shell & Partners | 050Buurtwarmte Paddepoel - small-scale district heating | Groningen | to be determined |
| 27. Shell & Partners | Multiple hydrogen refueling stations | Provinces Groningen, Drenthe, Fryslân | to be determined |
| 28. Holthausen | Fuel cell component factory | Hoogezand | 2020 up to 2025 |
| 29. Nuon | Magnum power plant partially converted to hydrogen use | Eemshaven | 2025/2026 |
| 30. Holthausen | Conversion of 5000 cars into fuel cell electric cars | Hoogezand | 2020 up to 2025 |
| 31. BioMCN | Production of biomethanol from $CO_2$ free hydrogen | Delfzijl | 2021 |
| 32. Teijin Aramid | Development of enhanced synthetic pipematerial for hydrogen | Emmen | 2018 |
| 33. ISPT & Partners | HydroHub: Testing and development centre on EnTranCe | Groningen | 2019 |

## The following parties contributed to this plan:

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