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Example of a national scheme to link gas and electricity using renewable hydrogen

The document attached to this message shows a national plan from Holland to create a renewable hydrogen system that links the electricity and gas sectors seamlessly.
This type of approach leverages existing gas assets and uses them strategically to avoid curtailment of renewable electricity and achieve zero carbon energy transitions for the gas, heat, transportation and chemical feedstock industries simultaneously.

Hydrogen energy storage, Power to gas, is the ONLY way to impact all of these sectors at the same time.

ITM Power urges California to include hydrogen as a renewable gas, include it int he workshop discussions and create a framework to allow projects to be built that show the benefits of this technology in California.

Thank you,
Stephen Jones - ITM Power

Additional submitted attachment is included below.

Noordelijke InnovationBoard

The Green Hydrogen Economy in the Northern Netherlands

Noordelijke InnovationBoard

The Green Hydrogen Economy

in the Northern Netherlands

Toyota Mirai, hydrogen fuel cell vehicle

In Short

- Green hydrogen will facilitate the energy transition in terms of chemistry, transportation and electricity. It is necessary for the realization of the Paris climate goals, as well as to make the economy stronger and greener.

- The Northern Netherlands is uniquely positions to develop a green hydrogen economy because of its large-scale green electricity production (especially offshore wind), its knowledge infrastructure, its large-scale chemical cluster, its importation of green electricity and its existing gas infrastructure, which can be retrofitted easily and cheaply to transport green hydrogen.

- A high-level roadmap has been developed in conjunction with industry, researchers and various levels of government. This roadmap still needs to be worked out in detail in a masterplan, a process which will be led by an influential Green Hydrogen Ambassador.

Executive Summary

By 2050, the Netherlands is aiming to achieve a carbon emission free economy.

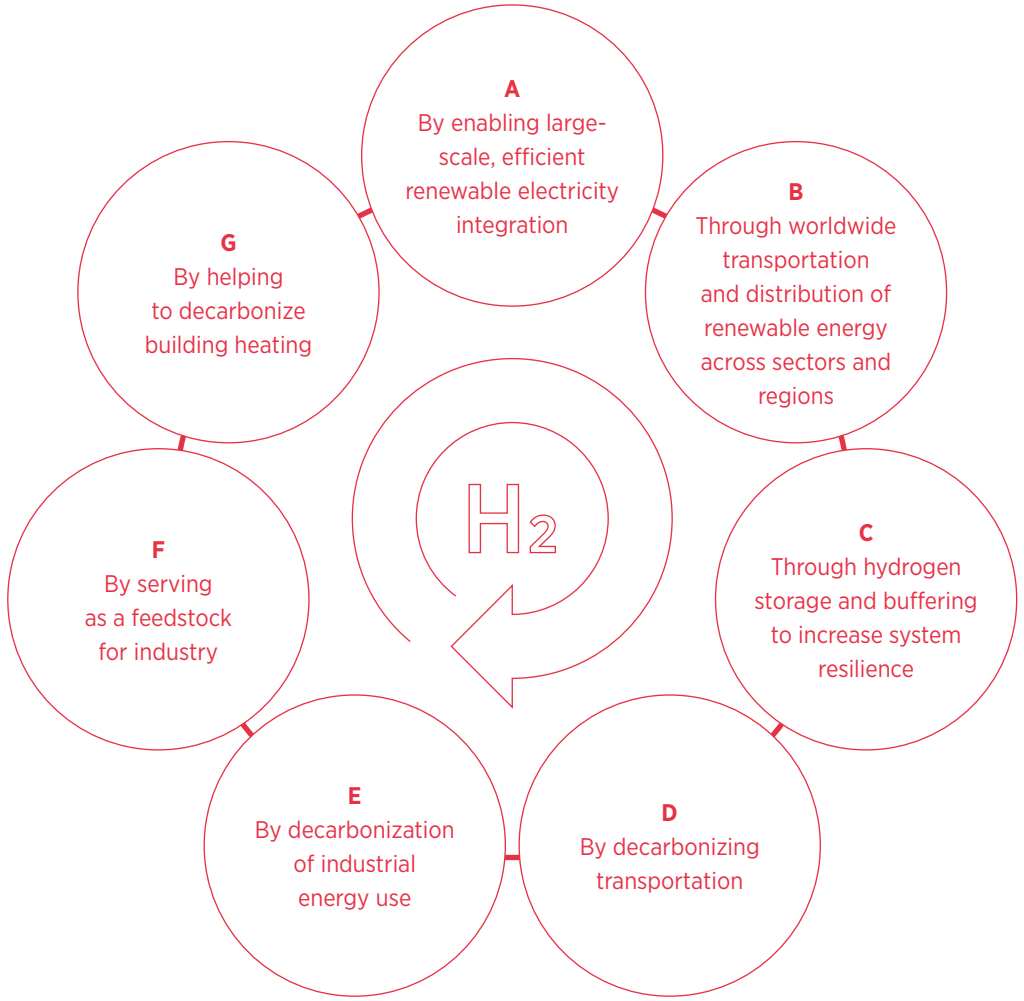
This fits into broader international endeavors as put forward in the Paris agreement to mitigate greenhouse gas-induced climate change. Such a radical change towards a carbon emission free economy by 2050 requires a mentality shift toward embracing the need for radical transformations in the energy system because incremental changes alone will not be sufficient.

The Northern Netherlands is facing not only the urgent need to move towards a carbon emission free economy but also the urgent need to reduce gas production because of the gas extraction-induced earthquakes. However, the Northern Netherlands is uniquely positioned to provide an excellent opportunity to contribute to a carbon emission free economy while simultaneously reducing gas extraction-induced earthquakes. Developing a green hydrogen economy could eventually replace the natural gas economy in the Northern Netherlands. It will take courage and perseverance to shift mentalities in order to realize such a drastic transformation.

Green hydrogen empowers a sustainable energy system worldwide

1

Green hydrogen (H_2) will play an important future role in a sustainable energy system:



The Northern Netherlands is uniquely positioned to develop a green hydrogen economy

2

The Northern Netherlands is uniquely positioned to develop a green hydrogen economy because:

A
The Paris Agreement has made the realization of a fully sustainable energy system inevitable. In the Northern Netherlands, the need for this change is even more pronounced because of the earthquakes due to natural gas extraction operations.

B
The Slochteren gas field has contributed to a strong gas industry being located in the Northern Netherlands. This industry could switch to hydrogen with relative ease as the required knowledge, infrastructure and industrial activities for both gasses are fairly comparable.

C
There is a large future supply of electricity from Norwegian hydropower, Danish wind and Dutch and German offshore wind, whereas the electricity transport grid already has limited inland capacity today.

D
Chemical and agricultural companies present in the Northern Netherlands could profit from a green hydrogen supply in combination with a green syngas (synthesis gas) and green carbon dioxide supply.

E
Rapid development of electric transportation with batteries and hydrogen fuel cells in Europe is creating extra demand for green hydrogen, especially in neighboring Germany.

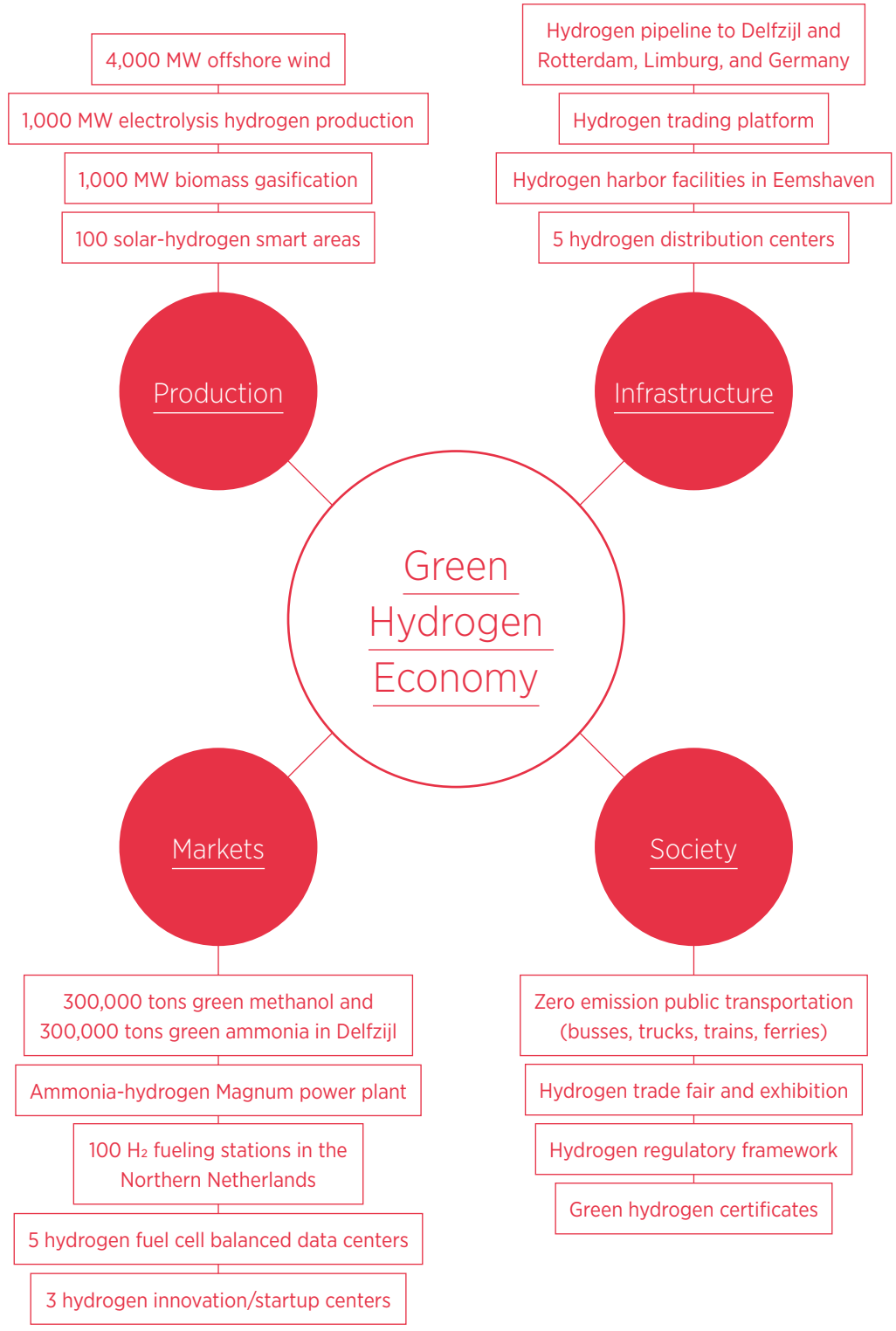
Ameland solar farm

A green hydrogen economy encompasses production, markets, infrastructure and societal aspects

3

A green hydrogen economy can only be realized when green hydrogen production, markets, infrastructure and societal aspects are developed interdependently.

During an initial phase, the following projects, activities and systems – described in the scheme on the next page – must be achieved in the Northern Netherlands by as early as 2025 or by 2030 at the latest. Although all of these projects are important, the projects that can most meaningfully accelerate the green hydrogen economy are large-scale green hydrogen production by electrolysis and biomass gasification in combination with retrofitted gas pipelines to transport the hydrogen to be used as a feedstock in the (petro)chemical industry in Delfzijl and in Rotterdam, Limburg and/or Germany. Using the existing gas infrastructure to transport hydrogen has the advantage that it can be provided to existing hydrogen feedstock markets at low costs. The transportation of hydrogen via retrofitted gas pipelines therefore offers a unique opportunity for a second life for the gas infrastructure.



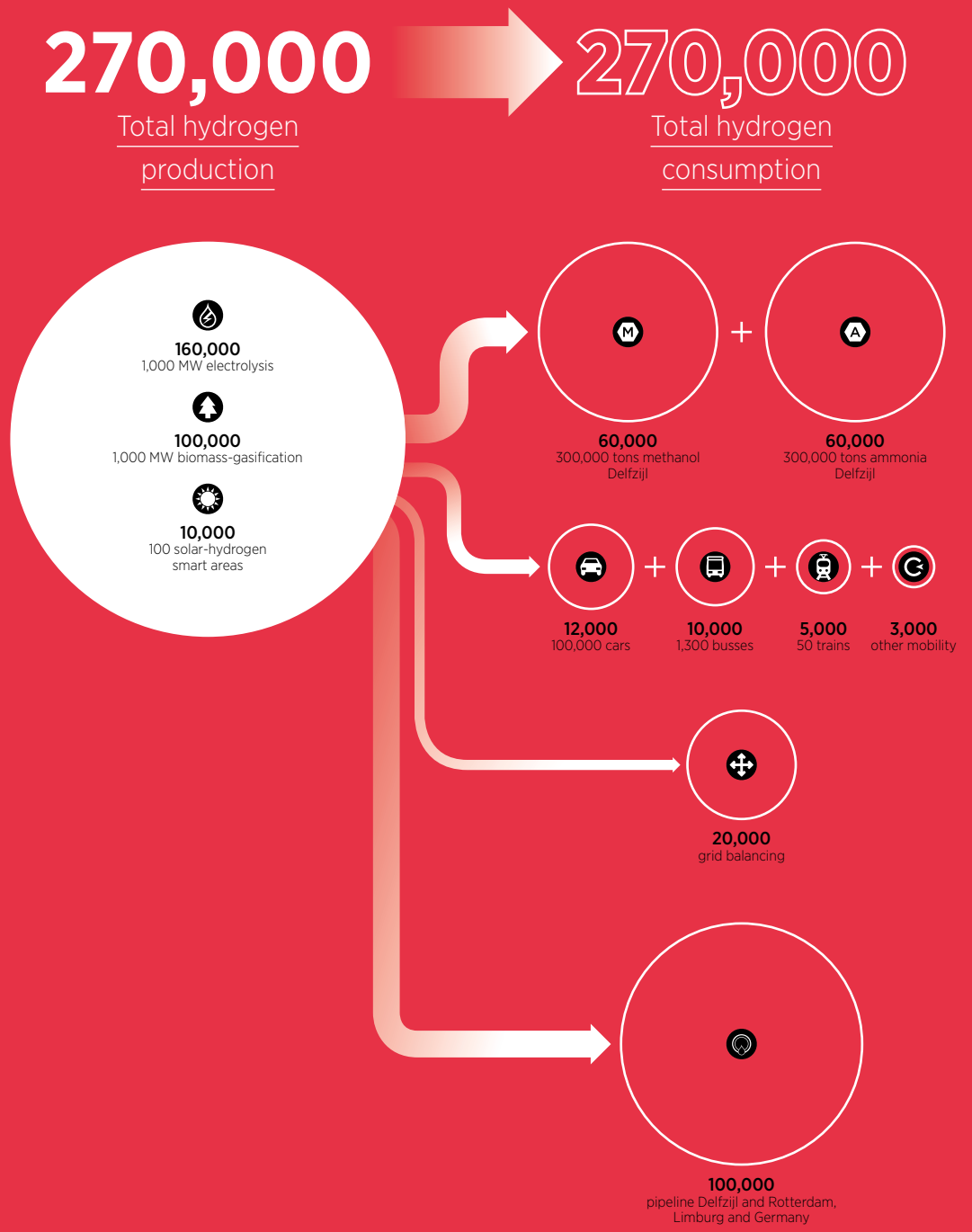
Large-scale green hydrogen production is necessary to realize a dedicated hydrogen infrastructure

4

Through these projects, activities and systems in the period between 2017 and 2030, about 270,000 tons of hydrogen (38 petajoules) will be produced annually in the Northern Netherlands.

This large-scale hydrogen production is necessary to realize low hydrogen production costs of 2 to 3 euros per kilogram, which is more or less competitive with present fossil-based hydrogen prices. However, the emerging markets for hydrogen in mobility (modes of transportation with hydrogen fuel cells) and grid balancing can by no means absorb this hydrogen volume. The main markets for hydrogen are the feedstock markets in the chemical and the petrochemical industries. In the Netherlands, the total hydrogen market is about 2,100,000 tons. In the Northern Netherlands, the existing chemical industry can produce green ammonia and green methanol by using large quantities of green hydrogen. Hydrogen transportation facilities also need to be developed, including gas pipelines retrofitted into dedicated hydrogen pipelines to Rotterdam, Limburg and Germany which connect to the existing (petro)chemical hydrogen markets. Harbor facilities for hydrogen import and export worldwide by ship is a next step in hydrogen infrastructure development. These facilities can only be realized and run economically if a sufficiently large volume of hydrogen is being produced. However, such large hydrogen production volumes will only be achieved if there is a dedicated hydrogen infrastructure, trading opportunities and access to these markets.

Hydrogen production and consumption in tons



In the Northern Netherlands, the existing chemical industry can produce green ammonia and green methanol by using large quantities of green hydrogen.

Large-scale green hydrogen production could create competitive hydrogen prices (2-3 euros/kg)

5

Rabobank has prepared an initial financial model to assess the financial viability for the construction and operation of two electrolysis plants and two biomass gasification units (500 MW each).

Model assumptions have been provided by stakeholders involved in the ‘Green Hydrogen Economy’ project and have neither been tested nor externally validated. Additional due diligence is recommended once detailed information becomes available about contracts and cash flows.

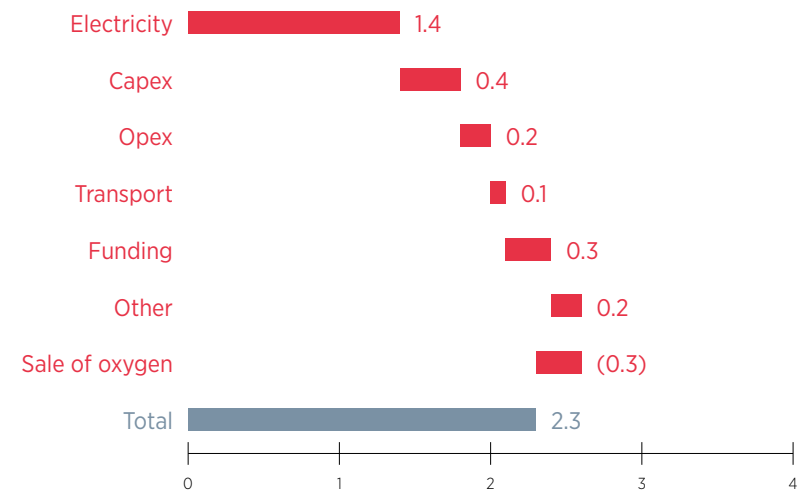
The model assumes limited recourse financing with a long debt maturity (up to 20 years) and relatively high leverage (60 percent). To accommodate such a structure, first of all, cash flows must be contracted with experienced, credit-worthy and reliable counterparties. Risks related to construction, production, offtake (price and amount of hydrogen) and feedstock supply (price, quality and amount of electricity and torrefied biomass) need to be allocated to those that are best positioned to assess and manage risk. Secondly, large-scale electrolysis and biomass gasification hydrogen production is not yet considered proven technology. A sufficient track record will need to be built to allow each project to operate as a baseload production unit (efficiency, availability and economies of scale). Third, parties like Gasunie and Groningen Seaports are presumed to incur certain capital expenditure, e.g. for modifying gas infrastructure and upgrading harbor facilities. It is considered fair to assume at this stage that these investments will become operational expenses, which reflects the situation in many other types of (renewable) energy production.

Gemini offshore wind farm, under construction

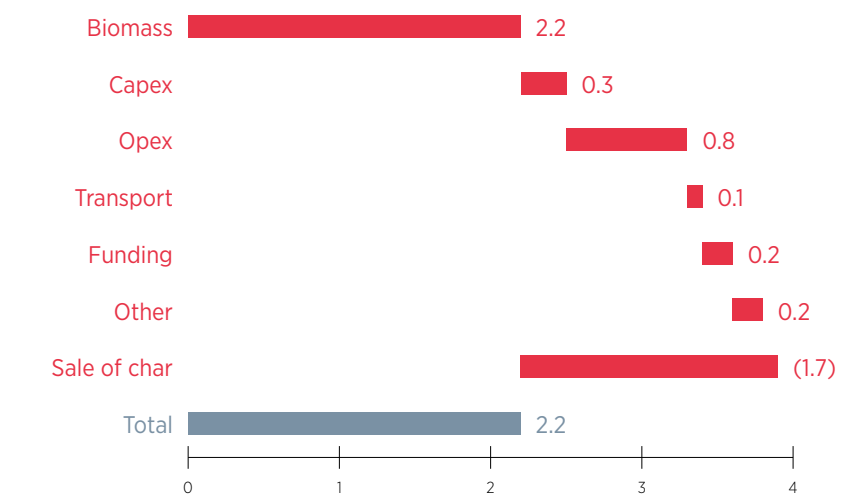
Profitability and cash flows depend on a strong correlation between hydrogen sales and input costs (electricity and biomass). Such correlation will therefore need to be embedded into a project and financing structure and is a prerequisite for assessing financial viability. When assuming such correlation in combination with a cost of debt of 4 percent, a Debt Service Cover ratio of 1.5x and a Leverage of 60 percent[1], the calculations demonstrate that debt in most scenarios can be repaid within an assumed economic lifetime of about 20 years. As illustrated on the next page, the model supports the initial assessment that, given an electricity price of roughly 20 to 30 euros per MWh and a torrefied biomass feedstock price of eight euros per GigaJoule, it will be possible to sell hydrogen for 2 to 3 euros per kg. Rabobank understands that such a hydrogen price could potentially be contracted with external parties on a long-term basis and could also be competitive with current hydrogen production derived from gas.

[1] A Debt Service Cover (debt service over cash flow, "DSCR") and Leverage (debt to equity) ratio are typical constraining ratios in project finance. Rabobank considers a Leverage of 60percent and a minimum DSCR of 1.5x reasonable at this stage.

Electrolysis
Exemplary cost build-up of hydrogen
(electricity: 25 EUR/MWh, EUR per kg)



Biomass gasification
Exemplary cost build-up of hydrogen
(torrefied biomass: 8.3 EUR/GJ, EUR per kg)



Magnum power plant, to be fueled by green ammonia-hydrogen

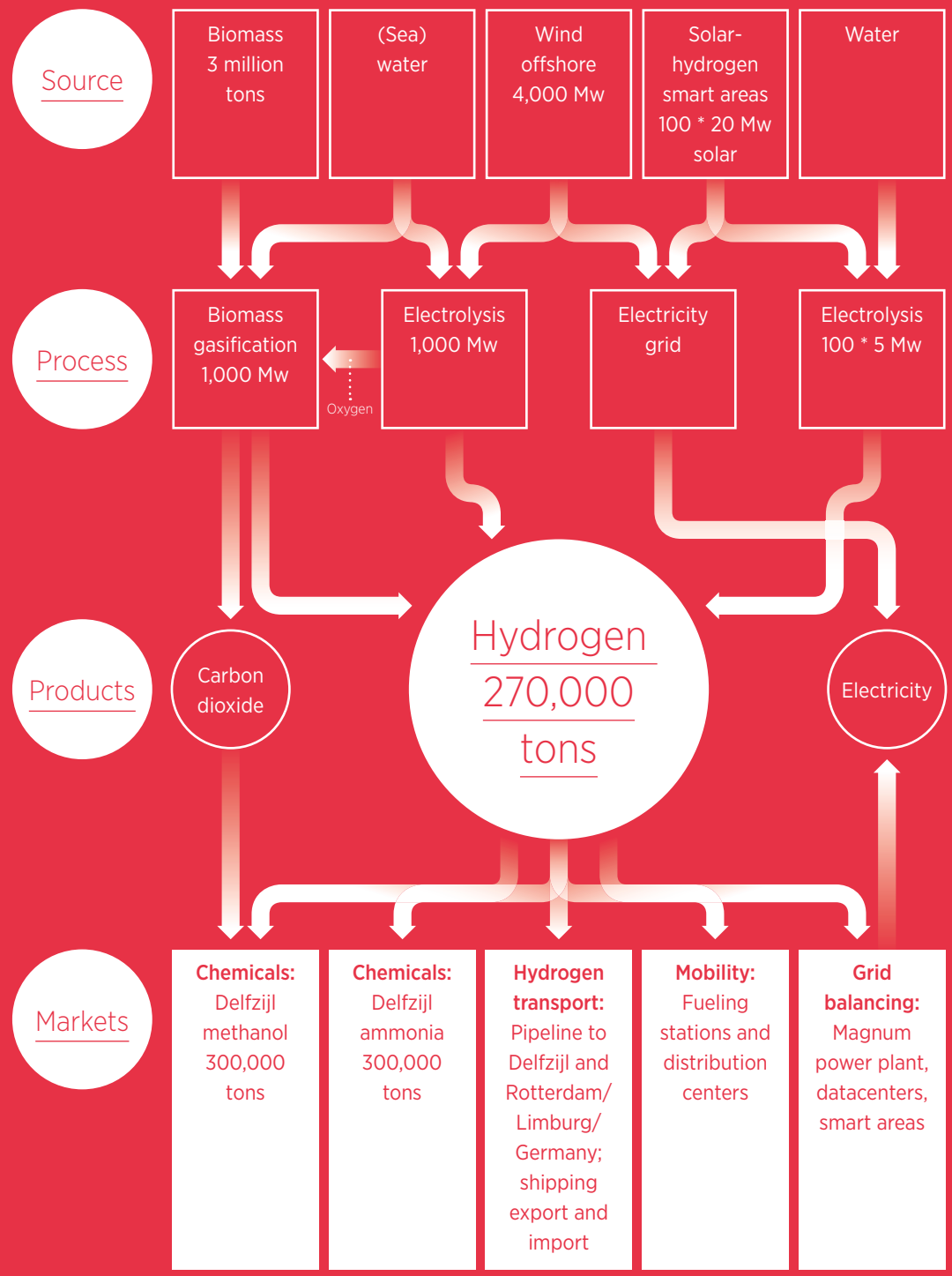
A green hydrogen economy generates green hydrogen and many additional green products

6

The development of a green hydrogen economy will not only generate green hydrogen: Many other green energy products, such as green electricity, green syngas, green carbon dioxide, green char (85 percent carbon), bio pellets, pure water and oxygen will also be produced.

In 2030, about 24 billion kWh of green electricity per year will be generated in the Northern Netherlands according to this plan. Via the NorNed and Cobra cables, an additional 5 to 10 billion kWh of green electricity per year could be imported. Only about 8 to 9 billion kWh will be used to produce green hydrogen by electrolysis. Green hydrogen, green oxygen, green carbon monoxide and green carbon dioxide are produced by electrolysis and biomass gasification. With these elements, almost all chemicals could be produced, including green chemicals such as ammonia and methanol. Byproducts such as char could be used in the agricultural sector and in the chemical industry. Imported carbon-free ammonia will be cracked into hydrogen to supply the flexible Magnum power plant. New, clean modes of transportation could be developed based on fuel cell hydrogen technology for the maritime, automotive, and rail transport sectors, as well as in new applications such as robots and drones. Green electricity and green hydrogen are the basic elements for creating clean energy and mobility systems in smart areas in cities, villages and on the Wadden islands. In this respect, innovation is crucial, and the development of a large-scale green hydrogen economy offers a strong influx and plethora of opportunities for innovative SME's and startups. In the future, far offshore wind farms could produce electricity which will be transported via cables to an offshore platform where an electrolysis plant will convert it into hydrogen. That hydrogen will in turn be transported via an existing offshore gas pipeline to land. The flow chart on the next page shows the basic interactions and system integration.

Green Hydrogen Economy in the Northern Netherlands



A high-level roadmap shows projects and activities needed up to 2030 in order to realize a green hydrogen economy

7

A high-level roadmap for the period up to 2030 lists the projects and activities necessary for the realization of green hydrogen production, infrastructure, markets, regulatory framework, research and education, and societal awareness.

The most important projects to kick start the green hydrogen economy are the large-scale production of green hydrogen from green energy (mainly offshore wind, hydropower and biomass) together with a pipeline transport infrastructure to an industrial offtake cluster in Delfzijl and Rotterdam, Limburg and Germany. The hydrogen is then used as a feedstock in the (petro)chemical industry. Markets for hydrogen as a fuel for transportation, together with the hydrogen fueling infrastructure, needs to be developed in a second phase. Third, markets for power balancing can be developed, both on a large scale via the Magnum power plant which will be fueled by ammonia-hydrogen and on a local scale via solar-hydrogen smart areas. After 2025/2030, markets may include hydrogen for industrial steam production, heating and cooling in developed areas and international import/export of green hydrogen.

Two important projects that will contribute to the unique opportunities in the Northern Netherlands for a green hydrogen economy are already under construction. The Gemini offshore wind farm will be fully operational in 2017 and the COBRA offshore electricity cable to Denmark will be operational in 2019. Furthermore, the first hydrogen fueling station using the ‘waste’ hydrogen from AkzoNobel, located next to the chemical site in Delfzijl, will be operational by the end of 2017 and will initially be used to fuel two busses. Many other green hydrogen projects in the Northern Netherlands are in development, including hydrogen fueling stations, busses, garbage trucks, cars, hydrogen production by small scale electrolysis, storage and infrastructure, among others.

High level Roadmap for the green hydrogen economy in the Northern Netherlands up to 2030

Under construction *A* **A** Priority to realize

Included in investments A **A** (A) Not included in investments

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Wind offshore	*600 MW Gemini*				1,000 MW		1,000 MW		1,000 MW		1,000 MW		(Far offshore wind)
Electrolysis			**20 MW**		**480 MW**		**500 MW**			(1,000 MW)			(1,000 MW)
Biomass gasification					**20 MW**		**480 MW**		500 MW				
Solar-hydro areas		**Ameland**	**1 icon area**	**1 icon area**		5 areas	5 areas	10 areas	10 areas	15 areas	15 areas	15 areas	20 areas
Offshore cable	*600 MW Gemini*		*700 MW Cobra*		1,000 MW wind		1,000 MW wind		1,000 MW wind		1,000 MW wind		(1,000 MW NorNed 2)
Ammonia					(Magnum Nuon First import)	**Delfzijl 150,000 tons production**		Delfzijl 150,000 tons production		(Magnum Nuon 1.3 million tons Import)			
Methanol								Delfzijl 150,000 tons		Delfzijl 150,000 tons			
Pipeline					**Delfzijl, Rotterdam, Limburg**		Ruhr area, Harlingen, Emmen				Bremen-Hamburg		(Offshore gas/ hydrogen pipeline)
Fueling stations	**Delfzijl**	**2**	**4**	**6**	**8**	**10**	10	10	10	10	10	10	10
Distribution centers					**Harlingen i.e. trains**	Groningen i.e. trains	Emmen	Leeuwarden		Hoogeveen		Harlingen electrolysis	Emmen electrolysis
Fuel cell balancing									100 MW	100 MW	100 MW	100 MW	100 MW
Harbor facilities			**Truck loading**		Ammonia import		Biomass import						(Hydrogen shipping)
Busses	**2**	**6**	**20**	**20**	**20**	**20**	50	50	50	50	50	50	50
Trains			**Groningen-Leeuwarden**		**10**	**20**	**20**						
Trucks	**2**	**6**	**10**	**20**	**30**	**50**	50	50	50	100	100	100	100
Cars		20	100	500	1,000	3,000	6,000	10,000	10,000	15,000	15,000	20,000	20,000
Boats			**Ecolution**	Sail boats	Sail boats	First ferry	First yacht	First fishing boat	First freight ship				
Others		Forklifts	Drones	Robots	Mobile								
Research, innovation centers	Energy Academy Europe, research universities, universities of applied sciences, EnTranCe (Groningen), Wetsus (Leeuwarden), Emmtec (Emmen)						Energy Academy Europe, research universities, universities of applied sciences, EnTranCe (Groningen), Wetsus (Leeuwarden), Emmtec (Emmen)						
Trading platform													Established
Trade fair		Shows	Shows	First time	1	1	1	1	1	1	1	1	1
Green certificates					Established NL	Established Germany			Established Europe				
Regulations		**Provisionally established**			Fully implemented								
Education	MBO, HBO, universities, high schools, primary schools, etc.						MBO, HBO, universities, high schools, primary schools, etc.						
Training	Automotive, fire department, police, installation technicians, builders, technicians, regulators, etc.						Automotive, fire department, police, installation technicians, builders, technicians, regulators, etc.						

NorNed Cable between Eemshaven and Feda, Norway

Green hydrogen related investments up to 2030 will be between 5.5 and 10 billion euros

8

The total investments for the development of a green hydrogen economy in the Northern Netherlands up to the year 2030 are estimated to be between 17.5 and 25 billion euros.

These investments include 12 to 15 billion for offshore windfarms. The investments in hydrogen-related projects are estimated to be between 5.5 and 10 billion euros over the next 10 to 12 years. The priorities are large-scale green hydrogen production by electrolysis and biomass gasification, together with investments in hydrogen pipeline infrastructure to Delfzijl and Rotterdam, Limburg, and Germany. These large investments are expected to be made by a combination of electricity, oil and gas, industrial gasses, chemical, gas infrastructure and harbor companies.

Green Hydrogen Economy in the Northern Netherlands	Investment (million €) Period: 2018 to 2030
Production	**15,000-20,000**
4,000 MW offshore wind	12,000-15,000
1,000 MW electrolysis hydrogen production	500-1,000
1,000 MW biomass-gasification hydrogen production	500-1,000
100 solar-hydrogen smart areas	2,000-3,000
Markets	**1,000-1,800**
300,000 tons green methanol and 300,000 tons green ammonia Delfzijl	600-1,000
Ammonia-hydrogen Magnum power plant	not included
100 hydrogen fueling stations in Northern Netherlands	100-200
5 hydrogen fuel cell balanced data centers	200-400
3 hydrogen innovation/SME/startup centers	100-200
Infrastructure	**700-2,000**
Hydrogen pipelines to Delfzijl and Rotterdam, Limburg, Germany	200-1,000
Hydrogen trading platform	50-100
Hydrogen harbor facilities in Eemshaven	400-800
5 hydrogen distribution centers	50-100
Society	**800-1,200**
Zero emission public transportation (busses, trucks, trains, ferries)	800-1,200
Hydrogen trade fair and exhibition	0-10
Hydrogen regulatory framework	0-10
Green hydrogen certificates	0-10
Total including offshore wind farms	**17,500-25,000**
Total hydrogen related investments	**5,500–10,000**

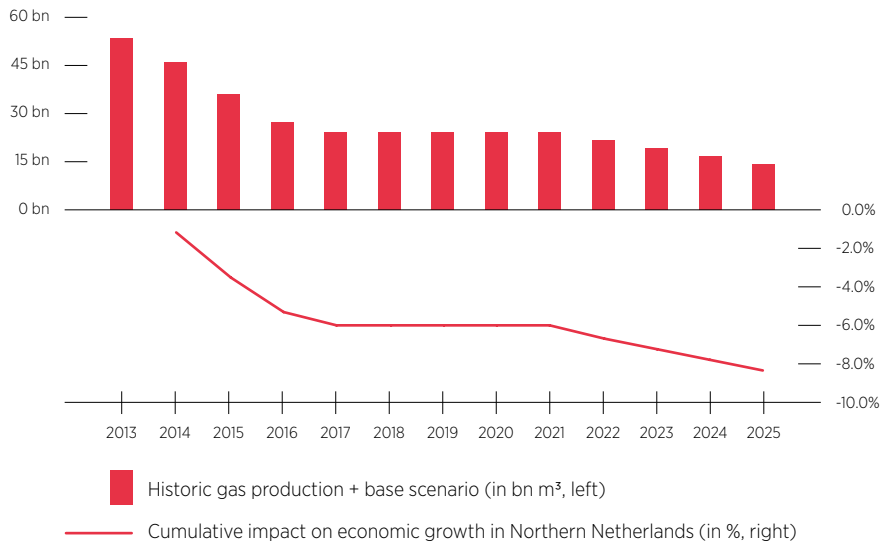
In the period from 2014 to 2025, gas production reduction is projected to cause economic contraction of 8 to 10 percent in the Northern Netherlands

9

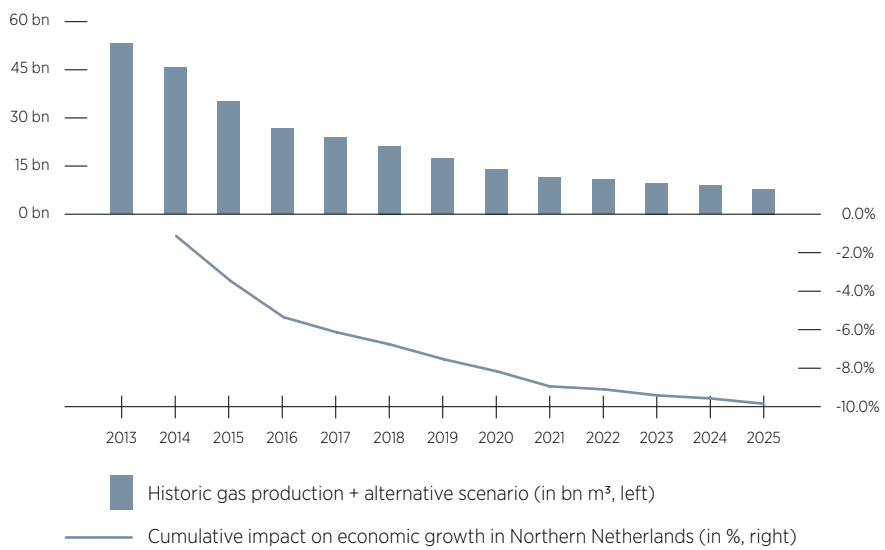
The Economics Department of ING analyzed the effect of decreasing gas production on the Northern Netherlands economy.

In 2014, gas, oil and minerals production contributed about 11.7 billion euros to the Northern Netherlands economy, which is roughly 20 percent of the total Northern Netherlands economy. However, due to the earthquakes caused by gas production, operations have already been reduced in recent years and will be further reduced in the future. The Economics Department's rule of thumb is that a decrease in gas production of 5 billion m^3 gas will cause the northern economy to contract by one percent. In 2017, gas production is capped at 24 billion m^3 gas, which is down from a production level of 53 billion m^3 gas in 2013. The official government policy is that the gas production can be kept at the same level up to 2021 and will be reduced further in the years thereafter. However, the Dutch parliament decided in February 2017 that gas production must already be further reduced from 2017 onwards. The chart on the next page shows the cumulative impact on the economy if gas production is further reduced in the future, both according to official government policy (baseline) and accord to the Dutch Parliamentary decision (alternative). As the charts reveal, it will severely affect the economy of the Northern Netherlands. A contraction of the Northern Netherlands economy in 2025 of more than 8 percent is expected in the baseline, and a contraction of around 10 percent is expected in the alternative, either of which would negatively affect employment.

Gas production and cumulative economic impact - **baseline**



Gas production and cumulative economic impact - **alternative**



Due to the earthquakes caused by gas production, operations have already been reduced in recent years and will be further reduced in the future.

The green hydrogen economy is expected to compensate for economic and employment losses

10

The realization of a green hydrogen economy in the Northern Netherlands will contribute to economic growth and employment.

The phase up to 2030 will contribute to economic growth and employment in all the provinces, cities and communities in the Northern Netherlands. Investments and economic activities will be both on large and small scales in local communities. Large-scale green hydrogen, oxygen, syngas, carbon dioxide, char, pure water and heat production, together with harbor transportation and storage facilities, will be located at Eemshaven, and green chemical production will be located in Delfzijl. Small-scale solar-hydrogen production will take place in various cities, villages and on the Wadden islands. Hydrogen distribution centers and fueling stations will be located strategically to supply hydrogen to fuel cells for busses, trucks, trains, boats and cars across the region. Hydrogen pipelines (retrofitted gas pipelines) will connect and supply Delfzijl, Rotterdam, Limburg and Germany with green hydrogen produced and/or transported via the Northern Netherlands. Hydrogen innovation centers will be developed in Leeuwarden, Groningen and Emmen, resulting in new and innovative business for green hydrogen technologies, systems and applications. Education and training in green hydrogen technologies, applications and economics will be developed and implemented, resulting in a well-educated work force and society.

Port of Eemshaven: the Energy port

Chemical site Delfzijl: green chemicals production

Based on these achievements being realized through 2030, from that point forward, strong further growth of the hydrogen economy in the Northern Netherlands is certainly realistic. It is the expectation that in the end, the realization of a green hydrogen economy in the Northern Netherlands as one of the first in Europe could compensate for the economic contraction and employment losses caused by the reduction in gas production.

In the Northern Netherlands, the existing chemical industry can produce green ammonia and green methanol by using large quantities of green hydrogen.

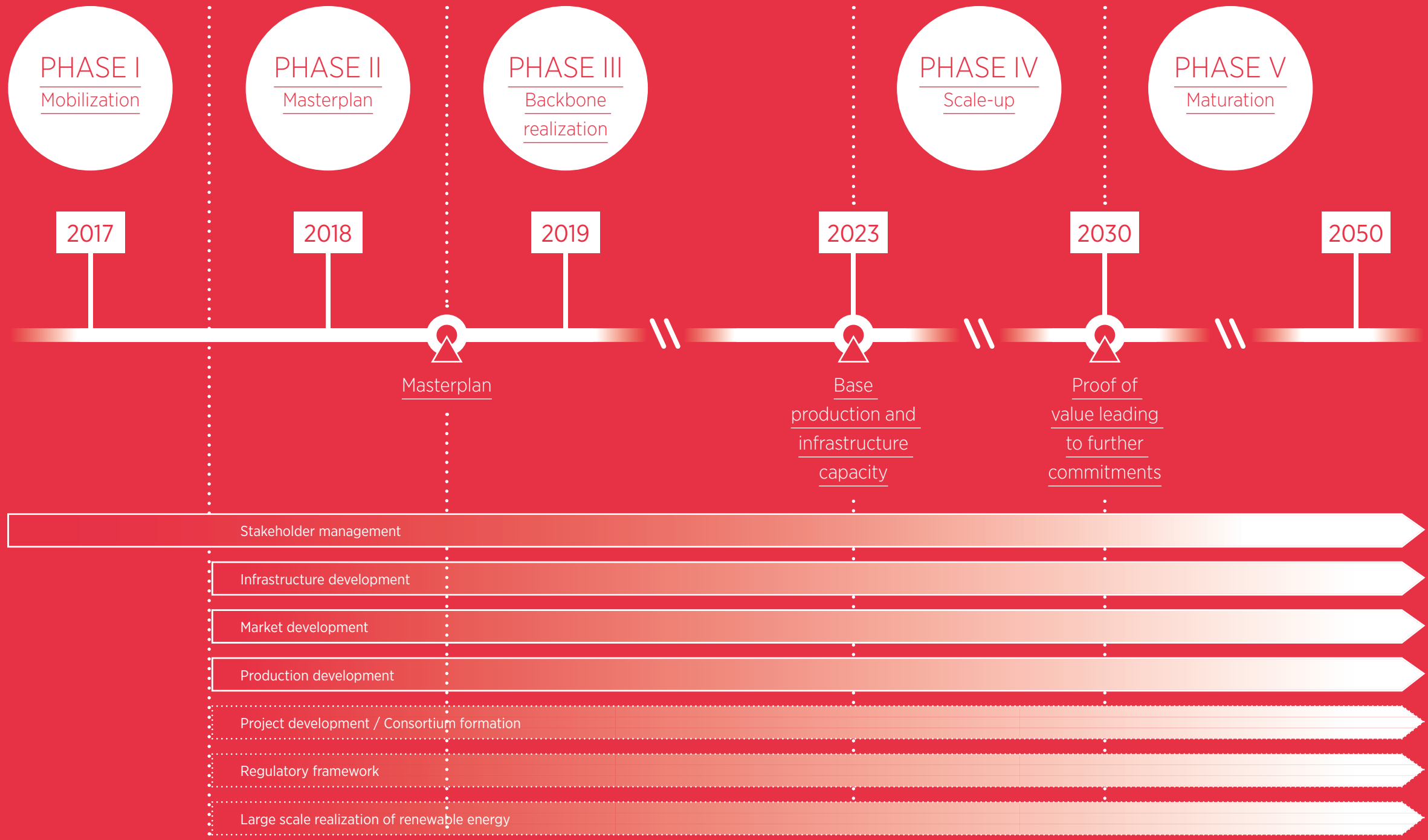
Green hydrogen economy realization needs a well-coordinated and tightly directed approach

11

Accenture has analyzed how the realization of a green hydrogen economy in the Northern Netherlands should be organized.

Although the vision to realize a green hydrogen economy in the Northern Netherlands as one of the first in Europe is realistic, it will not happen by itself. In this vision, the rationale for why a green hydrogen economy could develop in the Northern Netherlands is explained. This vision also includes a high-level roadmap for the development of production, infrastructure, markets and societal activities in order to realize a first phase of the green hydrogen economy up to 2030, together with a rough estimate of the necessary investments. Accenture concluded that a green hydrogen economy can only be realized by a well-coordinated and tightly directed approach by companies and governments together. Companies need to do the investments, but governments need to create the right conditions. To realize this large-scale green hydrogen economy, Accenture proposes the following phased approach consisting of: I) current phase focused on ideation and mobilization; II) masterplan phase; III) backbone realization phase; IV) scale up phase; and V) maturation phase.

Development phases for the green hydrogen economy realization in the Northern Netherlands



Next step: Master Plan development led by a Green Hydrogen Ambassador

12

To realize the shift to the green hydrogen economy, a range of initiatives needs to be agreed upon and executed in parallel.

Accenture therefore proposes to develop a Master Plan within a strong governance structure and in alignment with multiple stakeholders. This Master Plan needs to be developed from mid-2017 to mid-2018 and should be headed by a Green Hydrogen Ambassador in tandem with strong program coordination. The main elements of this master plan are as follows (in order);

A
A plan with business cases for the realization of initial projects: the creation of large-scale production facilities, hydrogen transport infrastructure and the development of industrial offtake markets for hydrogen feedstock.

B
The plan and the projects need to be developed in the context of a wider green hydrogen economy. Many aspects, such as a regulatory framework, research, education and training about hydrogen needs to be developed also. In addition, other initiatives, projects and developments should be considered that focus on the transition to a sustainable energy system and a green economy.

C
A signed covenant by stakeholders from industry, politics, civil society and knowledge centers.

A green hydrogen economy for a clean, safe and prosperous Northern Netherlands

13

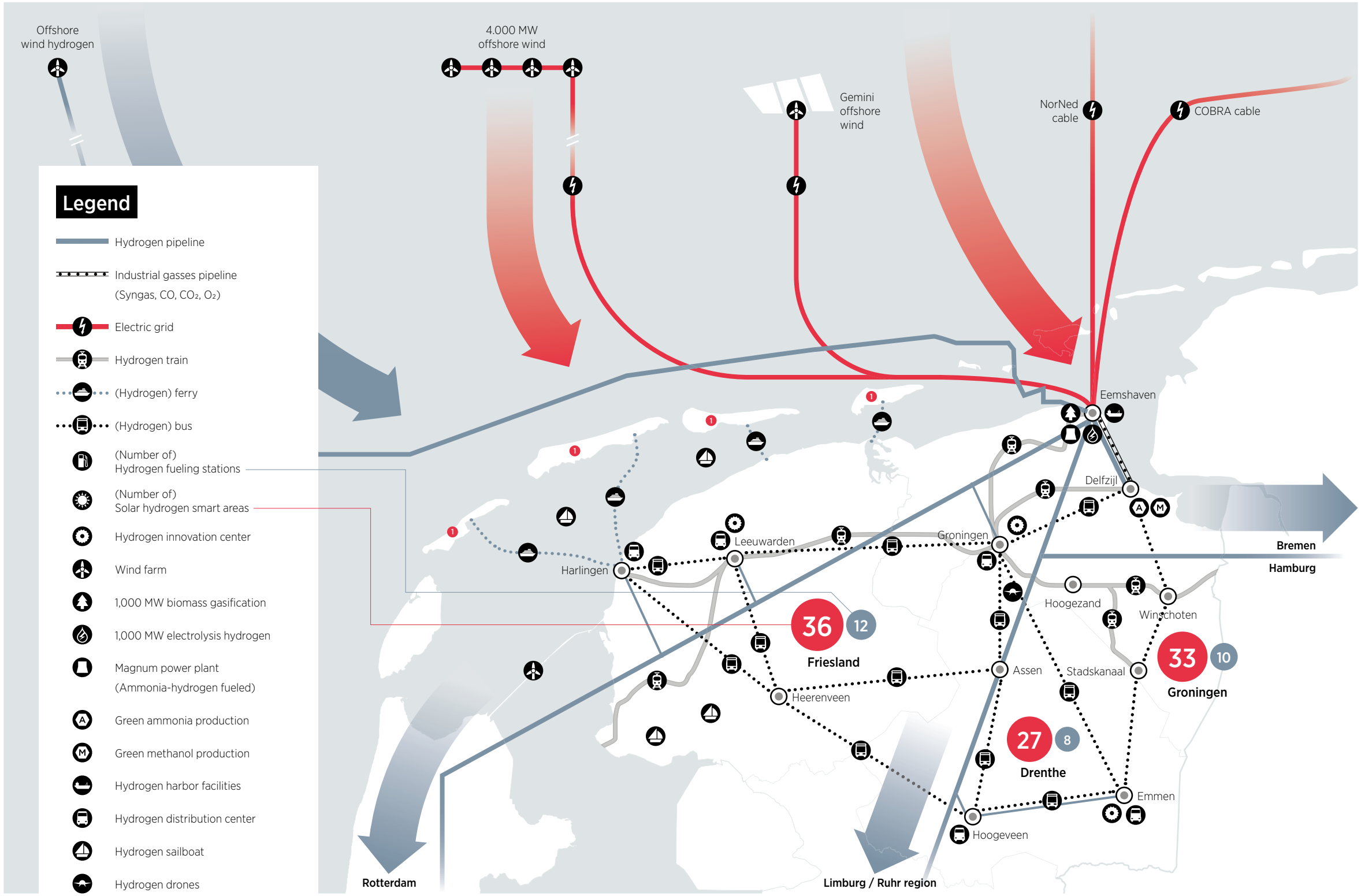
The realization of a green hydrogen economy could significantly contribute to economic growth and more employment in the Northern Netherlands.

The conditions in the Northern Netherlands are uniquely suited to produce green hydrogen and other green energy products at globally competitive prices. The green energy industry can be the cornerstone for economic growth and employment in the Northern Netherlands. It will create opportunities for growth of other companies in the Northern Netherlands by producing green chemicals, materials, equipment and products for competitive prices. Moreover, local areas will develop into clean and prosperous communities which are generating their own green electricity, using hydrogen for clean transportation and balancing the electricity system. Above all, because the green hydrogen is produced on land, at sea or imported, it offers the inhabitants of the Northern Netherlands a sustainable alternative which builds on the regional strengths of an existing infrastructure and expertise.

Alstom, electric fuel cell hydrogen train

April, 2017

The Northern Netherlands Innovation Board


Offshore
wind hydrogen
4.000 MW
offshore wind
Gemini
offshore
wind
NorNed
cable
COBRA cable
Legend
Hydrogen pipeline
Industrial gasses pipeline
(Syngas, CO, CO2, O2)
Electric grid
Hydrogen train
(Hydrogen) ferry
(Hydrogen) bus
(Number of)
Hydrogen fueling stations
(Number of)
Solar hydrogen smart areas
Hydrogen innovation center
Wind farm
1,000 MW biomass gasification
1,000 MW electrolysis hydrogen
Magnum power plant
(Ammonia-hydrogen fueled)
Green ammonia production
Green methanol production
Hydrogen harbor facilities
Hydrogen distribution center
Hydrogen sailboat
Hydrogen drones
Eemshaven
Delfzijl
Leeuwarden
Groningen
Harlingen
Bremen
Hamburg
Hoogezand
Winschoten
36
12
Friesland
33
10
Groningen
Assen
Stadskanaal
Heerenveen
27
8
Drenthe
Emmen
Hoogeveen
Rotterdam
Limburg / Ruhr region

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Groningen, the Netherlands
April 2017

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ING Economics Department (economic development)
Rabobank (financing)
Accenture (organization)

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The Northern Netherlands is determined to realize a Green Hydrogen Economy

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