H-vision: a unique approach to low-CO_2 hydrogen

H-vision

Air Liquide

bp

Deltalinqs

ebn

equinor

ExxonMobil

gasunie

Port of Rotterdam

ONYX POWER

Shell

uniper

Vopak

How industry can achieve its climate targets

Many regard hydrogen as indispensable in helping the Netherlands to achieve its ambitious climate targets. H-vision will enable industry to significantly reduce its CO_2 emissions in the short term by a unique process for large-scale production of low-CO_2 hydrogen manufactured mainly from refinery gas.

The companies in the Rotterdam industrial and port area have a joint share in the current CO_2 emissions, hence in realising a major CO_2 reduction target. A large number of partners in the hydrogen chain have joined forces in this project to initiate the large-scale use of hydrogen as a fuel in industry, with space for a wider number of customers in the future. H-vision is the perfect example of collaboration.

In the first phase, H-vision is aiming for a regional network between locations for hydrogen production and customers. The infrastructure is dimensioned in such a way that there is space for additional customers in the future. The H-vision partners foresee further integration with the heralded open-access hydrogen backbone of Gasunie and the Port of Rotterdam, which will connect the port to the future national hydrogen backbone.

H-vision is helping to initiate the hydrogen value chain that will ultimately consist of production, use, trade, import and transit activities. Thanks to this project, industry can make the necessary technical adjustments in the short term, such as to industrial furnaces, ensuring they will be prepared ahead of time for a much wider integration of hydrogen in the economy. In this way, H-vision is supporting Rotterdam's ambition to grow into an international hydrogen hub.

Facing a huge challenge

Ambitious climate targets

With the Climate Agreement that was concluded in Paris in 2015, countries have agreed to limit global warming to well below 2°C – and preferably even 1.5°C. The EU and the Dutch government have committed themselves to this target. And they are taking it seriously! In the Netherlands, for example, we have set the bar higher than the commitment to a 49% CO_2 reduction made by the EU[1]. The Netherlands wants to reduce CO_2 emissions by 55% by 2030 (compared to 1990), on the way to a 95% CO_2 reduction by 2050. Speed is of the essence because the global carbon budget in the atmosphere is limited[2]. To achieve this ambitious target, the European Commission has launched the 'European Green Deal', an ambitious plan to make the European economy sustainable in an innovative way.

Substantial CO_2 reduction in industry

The climate targets represent an enormous challenge for industry in Rotterdam. Compared to other EU countries, the Netherlands has built up a considerable industrial sector with an international connection function in Rotterdam. With 385,000 jobs and 6.2% of GDP (gross domestic product), this has numerous advantages. At the same time, the scale of the industrial sector also means that a significant CO_2 reduction is required to achieve national and European climate targets. Besides contributing to the climate targets, companies also have other social responsibilities. They must meet the increasing demand for energy, provide basic products for other industries and provide employment for many people. They also play an important role in maintaining and expanding the internationally prominent position of the Port of Rotterdam.

1 Climate Agreement June 2019
2 The maximum amount of CO2 that may be emitted worldwide from now on in order to achieve the targets of the Paris Climate Agreement

CO_2 reduction targets for industry:

- According to the Rotterdam Climate Agreement[1], more than 20% of CO_2 emissions in the Netherlands originate from Rotterdam, of which almost 90% originate from the port industrial area.
- The Netherlands wants to reduce CO_2 by 55% per year, which is an additional reduction of 49 Mtonnes of CO_2 emissions compared to the previous plans.
- More than a third of this must come from industry, which means an indicative reduction of an additional 19.4 Mtonnes of CO_2 annually.
- Industry must therefore achieve a 59% CO_2 reduction compared to 1990[2].
- Industry's contribution to achieving the national climate targets is not only significant in absolute terms, but also in comparison to other sectors.

1 Industry Cluster Rotterdam-Moerdijk. Source: Rotterdam Climate Agreement, November 2019
2 This is a combination of existing policy and the additional specification (5.1 + 14.3 Mtonnes). Climate Agreement Chapter Industry, Netherlands Environmental Assessment Agency, June 2019.

A large-scale industry infers a significant CO_2 reduction.

Rotterdam leaving no stone unturned

Industry in the region has already achieved a great deal in recent years. Energy savings and electrification have reduced CO_2 emissions from refineries by 20% over the past 10 years. Steps have also been taken to develop infrastructure for, among other things, the use of residual heat[3] and the sharing of steam with the surroundings[4]. These are important steps towards a new energy system, but they are not enough. The port industrial complex of Rotterdam is therefore leaving no stone unturned in order to achieve the climate targets. In November 2019, the municipality and various institutions and companies signed the Rotterdam Climate Agreement. With this agreement, the parties want to launch a large number of projects that achieve the agreed climate targets, create opportunities for a new economy, create many jobs and maintain a strong competitive position for Rotterdam. Hydrogen production, use and infrastructure is an important part of this.

Hydrogen is an important part of the Rotterdam Climate Agreement to create opportunities for a new economy.

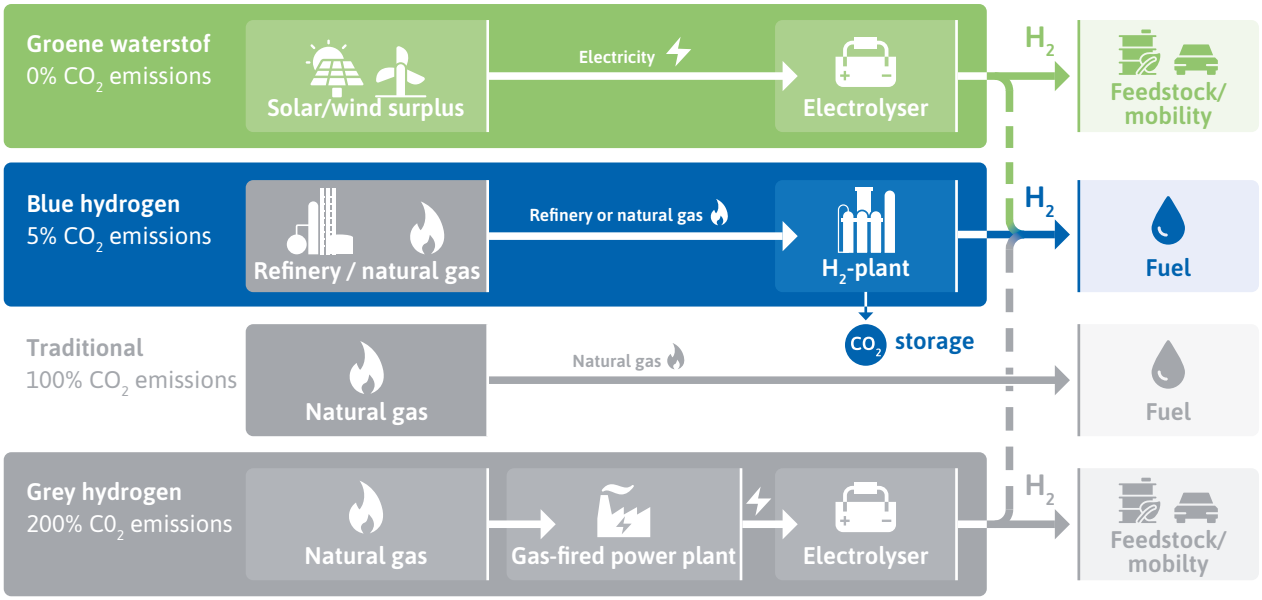
3 Such as WarmtelinQ, the heat infrastructure between Rotterdam, greenhouses in Westland and The Hague for the supply of heat and Leiding over Noord, a heat transport network running from Rozenburg to Rotterdam.
4 Such as the Steam Pipe project.

The large-scale reduction of CO_2 in industry is a complex process:

- In the Netherlands, we still mainly generate our electricity, fuels and heat from coal, oil and natural gas[1]. In the coming decades, CO_2-neutral and renewable sources will have to take over this task.
- Electricity from wind and solar energy will play an increasingly important role in the energy supply of the Netherlands, particularly in terms of the supply of electricity and the manufacture of hydrogen. This also applies to the industrial sector. However, the pace at which this is happening is too slow. We still have far too few wind and solar farms in the Netherlands to meet the country's electricity needs for households and transport, let alone the total energy needs of industry.
- The weather-dependent production of electricity by wind and solar farms does not match the constant energy demand from industry to run its processes. It is also expected, as we get closer to 2050, that this will not be enough to meet the total energy requirement[2]. Besides green electricity, we will therefore also need other CO_2-free or low-CO_2 energy sources, such as hydrogen.
- Although electrification is a sustainable solution for many applications, not everything is easy to electrify. Factories and refineries, for example, need very high temperatures, which are currently difficult to generate with electricity. Hydrogen, on the other hand, is ideal for this purpose.

1 EBN, Energy in figures 2020
2 International Energy Agency, World Energy Outlook 2019, October 2019.

Figure 1: CO_2 emissions from hydrogen depend on the electricity source



Climate targets are achievable with hydrogen

The role of hydrogen in the future energy system

Today, hydrogen is central to every story or conversation about the energy and raw material transition. Hydrogen will play an important role in a climate-neutral energy supply. The Dutch Government and the EU have a vision for hydrogen and the provinces and municipalities are also passionate about hydrogen. We are already seeing an increase in the use of hydrogen for mobility and buildings. Industry also wants to use hydrogen to reduce CO_2 emissions.

CO_2-free and low-CO_2 hydrogen

CO_2-free hydrogen from electrolysis (also called renewable or green hydrogen) is expected to play a fundamental role in our energy system by around 2050. Given the slow growth rate of the environmentally friendly energy produced by wind and solar farms and the necessary scaling-up of electrolysers, the transition to an industrial scale that supplies the volumes required by industry could take several more decades. If the electrolysers run on electricity from a gas-fired power station and therefore have a fossil source, this will lead to at least 200% emissions compared to direct combustion[5]. Due to its higher purity (almost 100%), this green CO_2-free hydrogen can initially be more suitable as a raw material in the chemical industry, for mobility applications and for the production of cleaner fuels (desulphurisation). For the moment, this hydrogen is not sufficient for industry.

By using low-CO_2 hydrogen in the energy supply, industry can quickly make a significant contribution to the climate targets. At present, industry is already using large quantities[6] of hydrogen (also called grey hydrogen) as a raw material in the chemical and refinement industries, but not yet to supply energy. The CO_2 of grey hydrogen is released into the air.

In order to substantially reduce greenhouse gases in industry in the short term, the use of low-CO_2 hydrogen (also known as blue hydrogen) offers a low-carbon solution for the energy supply. In this variant, almost 100% of the released CO_2 is captured and stored before burning. This technique can already be used on a large scale before 2030 as a low-carbon energy carrier for part of the energy supply to industry and for the production of electricity[7]. H-vision uses this technique to turn refinery gases into hydrogen. This hydrogen is extremely suitable as a fuel for attaining the high temperatures that the process industry requires to manufacture products. It also provides a strong foundation for the constant and flexible supply of energy to the energy system (adjustable capacity for both heat and electricity).

5 Depending on the source of electricity when using an electrolyser, the degree of conversion loss in the conversion process is different. Assuming the smallest possible conversion losses, the loss when using natural gas as a source of electricity is: 37%. When converting electricity to hydrogen: 20%. The total conversion loss can therefore be ~ 50%. In that case, double the amount of natural gas is required, which leads to double CO2 emissions.
6 At present, 800,000 tonnes of hydrogen per year is being used as a raw material in industry in the Netherlands.
7 Netherlands Environmental Assessment Agency, Analysis of the proposal for the outline of the Climate Agreement, 28 September 2018.

Gray Hydrogen	Blue Hydrogen	Green Hydrogen
Split natural gas into CO_2 and hydrogen	Split natural gas into CO_2 and hydrogen H-vision uses mainly refinery gases	Convert water into hydrogen by electrolysers powered by solar and wind energy
CO_2 vented into the air	CO_2 captured and stored or re-used Link H-vision and Porthos for subsea storage	No CO_2 emissions

H-vision

We need it all

There is no competition between different hydrogen grades. One is a fuel and the other is a raw material for the chemical industry or an energy carrier in mobility. We need all the CO2-reducing solutions. When we set up the system properly, the different types of hydrogen will even accelerate the energy transition and the development of the hydrogen economy.

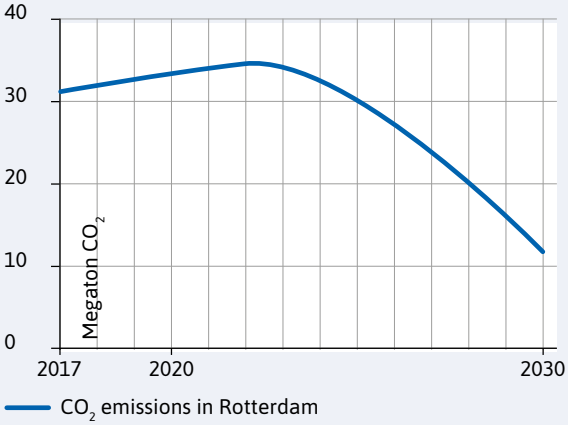
We can only achieve the climate targets with hydrogen

Without the use of low-CO_2 hydrogen as a fuel in industry, the ambitious climate targets for 2030 appear to be unattainable. We cannot wait for a sufficient supply of renewable electricity to make CO_2-free hydrogen. And as we move towards 2050, we must already install the infrastructure and develop the market for the future if we want to achieve the 2050 targets. To do this, we need projects that can quickly help to significantly reduce CO_2 emissions in the Netherlands and prepare the way for a sustainable and climate-neutral energy supply by 2050. H-vision is exactly that type of project!

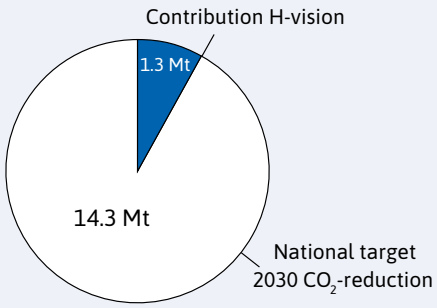
We need low-CO_2 hydrogen to achieve our climate targets.

H-vision's contribution

- The Rotterdam Climate Agreement is aimed at breaking the trend in CO_2 emissions within four years: from an annual increase to a sharp decrease. If all of its plans are realised, CO_2 emissions will be reduced by 49.6% by 2030 compared to 2017. In figures: Rotterdam emitted 31.2 megatonnes of CO_2 in 2017. By 2030, this should be reduced to 11.8 megatonnes of CO_2, a saving of almost 20 megatonnes of CO_2 per year.



- Industry's national target is a reduction of 14.3 megatonnes of CO_2 per year. In terms of CO_2 savings, H-vision can deliver almost 20% of the entire industry specifications (2.7 versus 14.3 Mt). The first factory will deliver a CO_2 reduction of up to 1.3 million tonnes annually. With the second factory, the total net CO_2 reduction will be 2.7 million tonnes per year.



- The first plant will produce approximately 750 MW. Its completion is planned for the end of 2026. A subsequent hydrogen plant will take the total capacity to over 1500 MW or more.

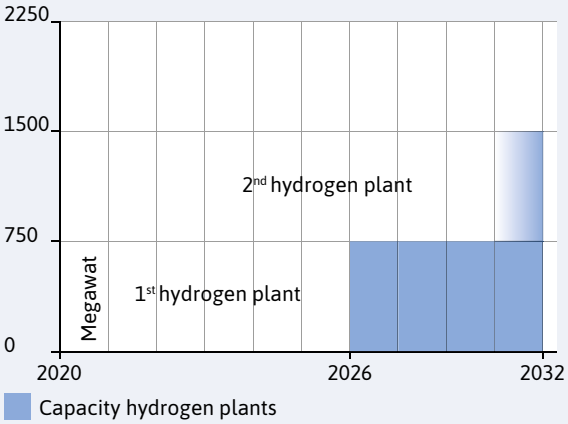
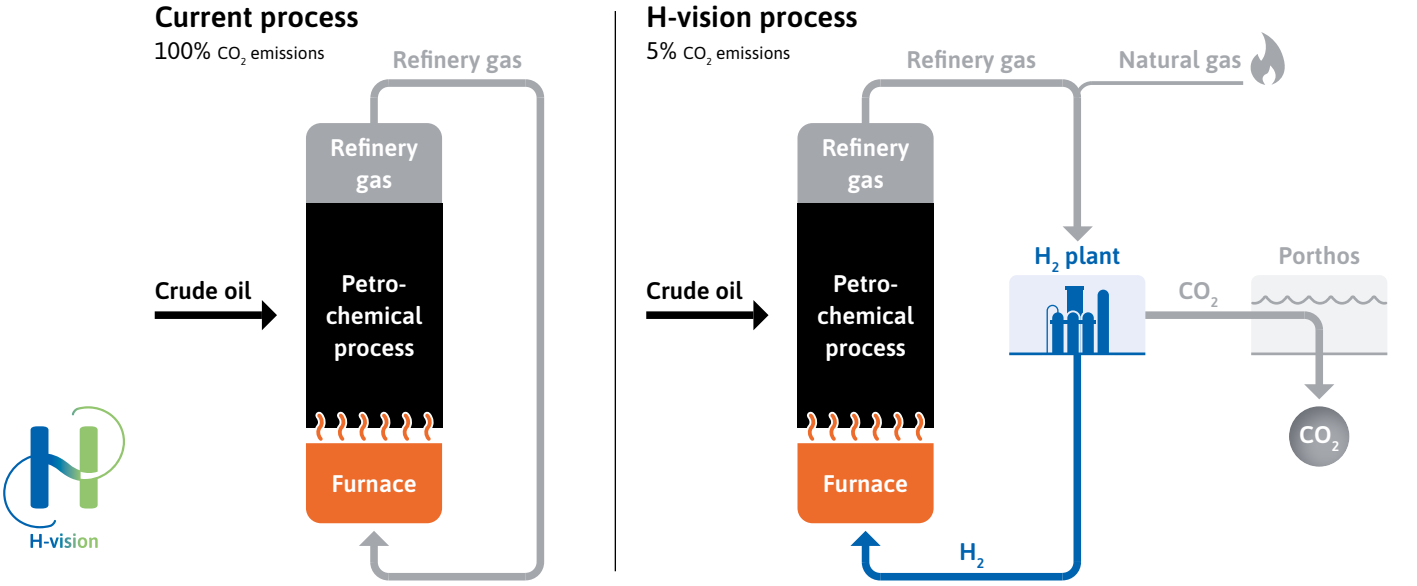


Figure 2: H-vision process



With H-vision, industry can achieve its climate targets

Large volumes of hydrogen produced quickly

In the short term, H-vision can supply industry with the large quantities of hydrogen it requires to drastically reduce CO_2 emissions. The idea is to build several factories in Rotterdam that produce large quantities of low-CO_2 hydrogen from the gas that is released during the refinement process. The CO_2 released[8] during the production of the hydrogen will be captured and stored under the sea. This will be done in cooperation with the Porthos project. The fuel that is manufactured produces only 5% of the emissions compared to the current situation.

Unique process

H-vision uses a unique process. Around 90% of H-vision's hydrogen is manufactured from refinery gases, while the remainder of around 10% is supplemented with natural gas. We use that hydrogen as fuel. For example at refineries in order to generate the heat required to manufacture products. H-vision's hydrogen production is based on proven technology. It is not dependent on the generation of sustainable electricity and can therefore be produced on an industrial scale before 2030. The H-vision process with refinery gas creates space for other innovations – for example in the fields of electrification and hybrid burners.

H-vision delivers what industry needs

- H-vision supplies the volumes that industry needs for its energy demand.
- With H-vision, industry in Rotterdam can reduce CO_2 quickly and substantially.
- H-vision is scalable according to demand.
- H-vision has a control function in times of less wind and sun.
- H-vision can lead to negative emissions in conjunction with bio-based raw materials.
- The unique process based on refinery gases stimulates innovation in electrification and hybrid burners.

H-vision is helping to accelerate the energy transition.

8 The CO_2 formed when fossil fuels are burned can be captured at two places in the combustion process: before and after combustion. At H-vision, it is all about carbon capture before incineration.

Figure 3: H-vision in the biogenec process

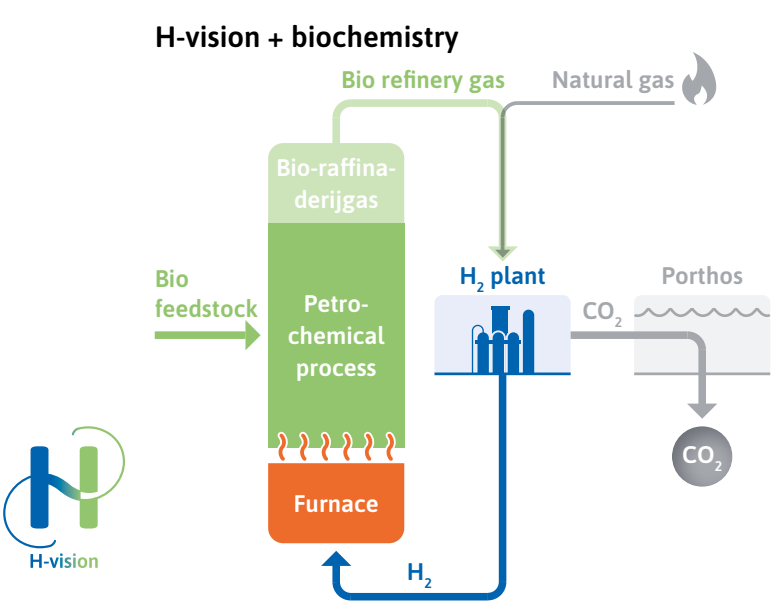
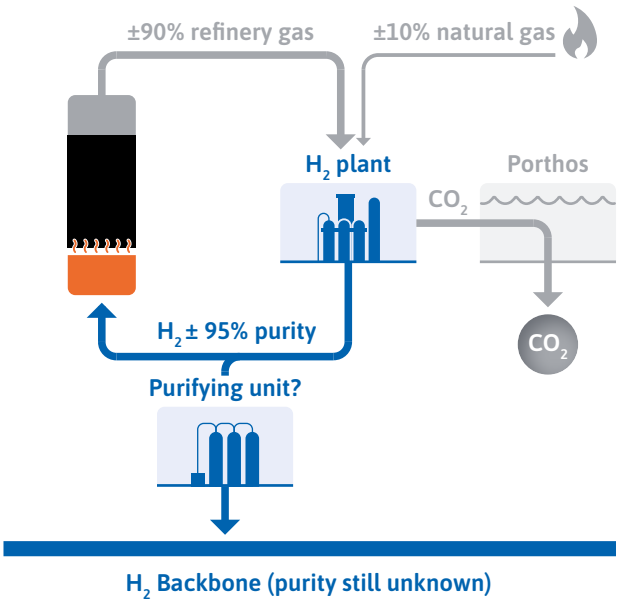


Figure 4: H-vision's scope



Investing collaboratively in the future

Role for H-vision

In the longer term, H-vision will continue to contribute to a climate-neutral energy system, with the option of a back-up function in times of less wind (adjustable capacity). Because H-vision works as a large gas washing facility, it can help realise negative emissions when switching from petroleum to biogenic raw material for the production of biochemical fuels and raw materials. In the short term, H-vision will process petrochemical refinery gases, but in the future it will also be able to process biogenic refinery gases. This will lead to net negative emissions in the production process. This shows that H-vision is well prepared for the fuel and raw material transition.

Connection to the national backbone

In the first phase of the project, H-vision wants to create a regional network between hydrogen production locations and customers. The idea is to dimension the infrastructure in such as way that there is space for additional customers. In the current project scope, the inclusion of a unit to further purify the surplus of the H-vision hydrogen to the quality of CO_2-free hydrogen is also being considered. H-vision can therefore serve more customers and function as a vital backup for the regional open access infrastructure that is connected to the conversion parks in the port of Rotterdam and is aimed at transporting more pure hydrogen (98-99.5%). H-vision therefore also foresees further integration with the hydrogen backbone through the port announced by Gasunie and the Port of Rotterdam using one or more pipeline connections. This open-access backbone in Rotterdam will in turn be connected to the national backbone so it will also serve as the connection to neighbouring countries and the rest of Europe.

Value chain and investments

In the short term, H-vision will give the region a sustainable economic boost, while in conjunction with other Rotterdam projects it will attract follow-up investments that have an even greater economic impact. Because H-vision produces and supplies hydrogen, it will also help to initiate the hydrogen chain that will eventually consist of production, use, trade, import and transit. This also means that industry can make the necessary technical adjustments in the short term – to industrial furnaces, for example. This will enable industry to prepare for the broader hydrogen economy in good time. In addition, knowledge is currently being acquired that can be used for further development outside H-vision and can contribute to CO_2 reduction in other European industrial clusters. In this way, H-vision is helping to improve the business climate, temporary employment and the development of a knowledge advantage in the Netherlands[9].

9 At the behest of the Port of Rotterdam Authority, in 2020, consultancy firm Rebel validated the impact of 12 projects in the areas of employment, economic growth and energy and raw material transition. This survey also included H-vision.

Collaboration and support

We will have to work together!

No party can develop a hydrogen system on its own. It is a joint task, both in the Netherlands and in Europe. H-vision is a good example of this type of cooperative venture. A large number of partners from the hydrogen chain have already joined and there is space for even more. The partners are helping to accelerate the development of Rotterdam into an international hydrogen hub and are stimulating market parties to invest in hydrogen projects in Rotterdam. H-vision can count on broad support from the Dutch Government, the municipality of Rotterdam, the province, the European Commission and a number of leading knowledge institutes. H-vision is open to cooperation and knowledge-sharing with other European industrial clusters.

Plenty of backing, more support

The H-vision project is making good progress. However, broader cooperation is needed in order to achieve the targets. So far, the necessary regulation is lagging behind as there is no support for low-CO_2 hydrogen as a fuel. This needs to be clarified as soon as possible.

In H-vision, parties in the hydrogen chain are working together.

The H-vision partnership

- H-vision is a partnership between parties that are predominantly based in the port industrial area of Rotterdam. They share their knowledge, to make existing hydrogen chains more sustainable and realise integrated solutions for the future.
- H-vision is made up of parties that represent the entire hydrogen chain, from production and infrastructure to end use. Deltalinqs, which represents the interests of logistics, port and industrial companies in Rotterdam, plays a coordinating role. H-vision can count on the support of the municipality of Rotterdam, the province of South Holland and knowledge institutes such as TNO and Berenschot.
- Under the leadership of Deltalinqs, the H-vision parties conducted a pre-feasibility study in 2018-19 into the technical, economic and financial feasibility of blue hydrogen as an energy supply for industry. The results of this study were presented at the symposium 'The start of the hydrogen economy in Rotterdam' and enthusiastically received by the Minister of Economic Affairs and Climate Policy Eric Wiebes. The study showed H-vision's substantial contribution and quick results by which it can pave the way for the hydrogen economy and accelerate the energy transition. The full report of the H-vision feasibility study is available on the H-vision website.
- In 2020, further research was conducted into the technology, integration into the industry cluster, the requisite infrastructure and the financial impact.