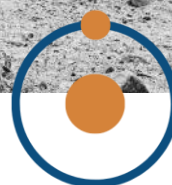




Drivers of Change



IMPACT.
HYDROGEN

From HEAVENN to Sustainable Hydrogen Valleys

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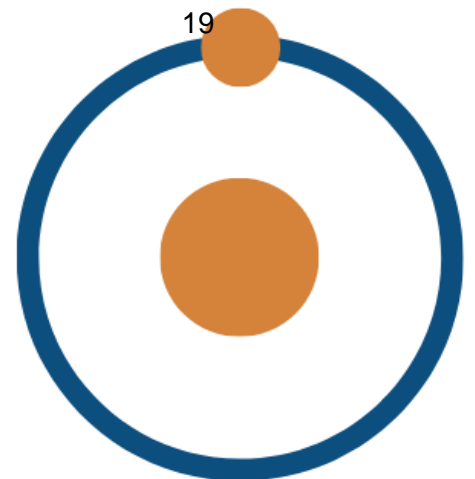
2022

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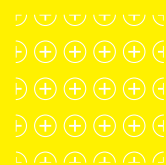
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Summary

This report provides an answer to an important question—*what change can Hydrogen Valleys bring to countries and regions and how can this impact Dutch trade relations*—based on the success of the Northern Netherlands' energy transition.

This is the 'Dutch Hydrogen Story' that started in the Northern Netherlands, which has one of the largest onshore natural gas fields in Europe ideally situated there. Consequently, almost all business in this region has historically been geared to natural gas. However, extraction of natural gas came at the price of frequent earthquakes sparking protests from both local and regional residents. In turn, this has led to the decision to drastically reduce the extraction of natural gas in the region. As such, the region needed an alternative to provide for energy, jobs, and prosperity—Hydrogen was the answer, being embedded in a hydrogen ecosystem and fitting the profile of the Hydrogen Valley model. This 'Hydrogen Valley' received support from the Clean Hydrogen Partnership and the European Union after a strong bid and thus the project H2 Energy Applications in Valley Environments for Northern Netherlands (HEAVENN)—the first Hydrogen Valley in Europe—was born.

A Hydrogen Valley is a defined geographical area (e.g., city, region, island, industrial cluster) where several hydrogen applications are combined into an integrated hydrogen ecosystem that consumes a significant amount of hydrogen, improving the economics behind the project. It should ideally cover the entire hydrogen value chain—production, storage, distribution, and final use. HEAVENN turned out heavenly indeed. It appears to have become a magnet that attracts business to the region and brings prosperity to the Northern Netherlands. There are five key success factors that have made HEAVENN a success: (1) a convincing project concept with a value chain coverage and technology choices that leverage local assets and address local needs, (2) a viable commercial structure that enables first real business cases for developers, (3) public-private financing from multiple sources that includes enough public funding to close all gaps, (4) partnering and stakeholder cooperation that covers the entire project scope and ensures continuous commitment from all parties involved, and (5) political backing and buy-in of the general public to achieve smooth and continuous project development.

To create more Hydrogen Valleys worldwide, Valleys that bring green energy to Europe and sustainable business development to other countries, we must consider adding an extra success factor to our proposition: impact by design. Impact by design means using a perfect blend of the following elements from the start of building a Hydrogen Valley: technical innovation, enabling environment, and sustainable development. These three elements together create a guarantee for a smooth transition towards creating a new business proposition for the region and make sure that the welfare generated from the produced hydrogen is distributed equally in the region of the Hydrogen Valley.

The Netherlands can play a key role in setting up Hydrogen Valleys and secure sustainable international trade. Important here is to secure sustainable success by (1) asking contract conditions in alignment with a Sustainable Hydrogen Valley set up, (2) creating mutual benefits, whereby The Netherlands can function as a knowledge expert using the far advanced expertise acquired through the realization of HEAVENN (i.e., the first Hydrogen Valley in Europe). There are also important next steps for The Netherlands to take in order to accelerate a worldwide transition to green hydrogen, setting up Hydrogen Hubs is one of them.

1. Introduction

Hydrogen Valleys unlocking the potential of the region

Climate change is a significant aggravating factor in the rapidly changing world we live in. Its solution asks for an energy transition towards a decarbonized world. This energy transition presents both opportunities and challenges for countries, governments, and society, and comes with innovation. Producing green hydrogen in geographical areas where several hydrogen applications are combined and integrated within the region's ecosystem—also known as a Hydrogen Valley—is one of these innovations. The Netherlands has developed the first Hydrogen Valley in Europe: H₂ Energy Applications in Valley Environments for Northern Netherlands (HEAVENN). Being the first brings responsibilities because the lessons learnt in the Northern Netherlands are valuable lessons for other regions.

It is noteworthy to mention that having just one Hydrogen Valley can bring great prosperity to a region but connecting Hydrogen Valleys to other Hydrogen Valleys in the world can bring prosperity globally. The Netherlands aims to lead the way in hydrogen and is eager to share its knowledge and assist others in setting up sustainable trade relations; the best way to multiply is to share.

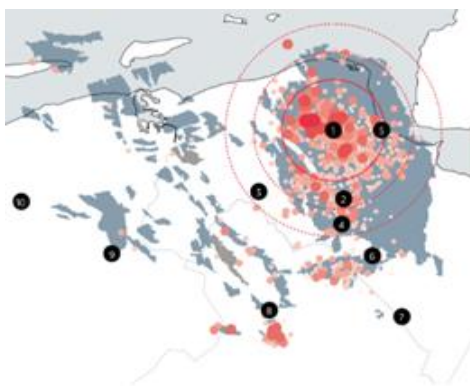
This report will highlight:

What change Hydrogen Valleys can bring to countries and how this can change the Dutch trade relations.

In this report below, the 'Dutch Hydrogen story' is shared on how the first Hydrogen Valley in Europe was set up, a project called HEAVENN. Specifically, the report looks in-depth on how HEAVENN was designed and built, what other countries can learn from HEAVENN, how HEAVENN could be made even stronger (lessons learned), and how a Hydrogen Valley 2.0 would look like. It was given the name sustainable Hydrogen Valley, where social, economic, and environmental impact are at the centre of the Hydrogen Valley and can be at the centre of trade to unlock hydrogen potential all over the world.

A region needs a business

The map below depicts the Northern Netherlands. Grey areas are natural gas fields and red dots indicate minor earthquakes caused by the extraction of natural gas. The Northern Netherlands is since its discovery in 1959 home to one of the largest onshore natural gas fields in Europe, the Groningen field, with an initial size of 2.700bcm (billion cubic meters) of extractable natural gas. Nowadays, the estimate for the remaining extractable gas reveals a size of 650bcm.



However, the extraction of natural gas has led to protest from local and regional residents due to the high frequency of earthquakes and the damaging effects on stability and safety of residential houses and commercial property. Again, this has led to the decision of the national government to schedule a closure of the Groningen field as of 2023.

The effect of the planned reduction of the gas production from the Groningen field results in the regional economy and employment in the gas sector of the Northern Netherlands being significantly affected.

This scheduled close down of the Groningen field and its dramatic economic and employment effects made the preparation of an alternative perspective for the region necessary. Therefore, a regional plan published by the Innovation Board North Netherlands and New Energy Coalition in 2017 was developed—The Green Hydrogen Economy in the Northern Netherlands. The plan describes the road to green Hydrogen as a fitting new alternative to counteract the effects of the Groningen field closure.

Unlocking the potential of the region

The transition from natural gas to green hydrogen fits the region like a glove. For over 70 years, the region has been active in natural gas business and given a foundation of knowledge to build upon. One of the key success factors of the development of the Green Hydrogen Economy in the Northern Netherlands is the role of the local and regional government as a kick-starter and supporter of these developments. They embraced the opportunities and created an environment where innovation can flourish and supported SMEs such as the well-known companies Holthausen, Resato, Green Planet and many more. The local and regional government approached the encountered challenges and opportunities integrally.

This supportive and forward-looking environment created perfect grounds for the design and development of a regionally embedded hydrogen ecosystem focused on green hydrogen. This proved to be the perfect fit with the Hydrogen Valley model. This proposition was recognized by Europe and, more specifically, the Clean Hydrogen Partnership (formerly known as the Fuel Cells and Hydrogen Joint Undertaking), which identified the North Netherlands as the first ‘Hydrogen Valley’ of Europe resulting in a subsidy being granted to further develop this Hydrogen Valley, and thus HEAVENN¹ was born.

2. Hydrogen Valleys

2.1 The concept explained

A Hydrogen Valley is defined as an ecosystem embedded in a defined geographical area such as a city, a region, an island, or an industrial cluster. In such valleys, several (green) hydrogen applications are combined together into an integrated hydrogen ecosystem covering the full value chain including the production, transportation, storage, and consumption of significant amounts of green hydrogen, improving the economics behind the project. Mission Innovation² has further defined what constitutes a Hydrogen Valley in four common characteristics:

A - Large in scale: The project scope goes beyond mere demonstrational activities and entails at minimum a two-digit multi-million-euro investment. It typically also includes several subprojects that make up the larger Valley ‘portfolio’.

B - Clearly defined geographic scope: Hydrogen Valleys are hydrogen ecosystems that cover a specific geography. Their footprint can range from a local or regional focus to a specific national or international region.

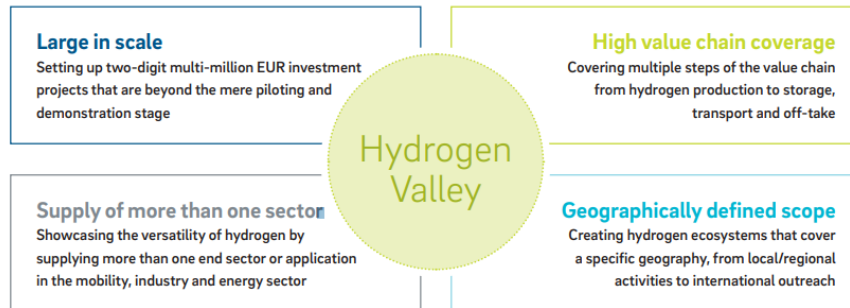
C - Covering multiple steps in the hydrogen value chain: These steps range from hydrogen

¹ <https://www.heavenn.org>

² https://www.fch.europa.eu/sites/default/files/documents/20210527_Hydrogen_Valleys_final_ONLINE.pdf

production (and often even dedicated renewables production) to the subsequent storage of hydrogen and distribution to off-takers via various modes of transport.

D - Supply to various end sectors: Hydrogen Valleys usually showcase the versatility of hydrogen by ideally supplying several sectors in their geography such as mobility, industry, and end-use energy. Thus, Hydrogen Valleys are ecosystems or clusters where various final applications share a common hydrogen supply infrastructure.

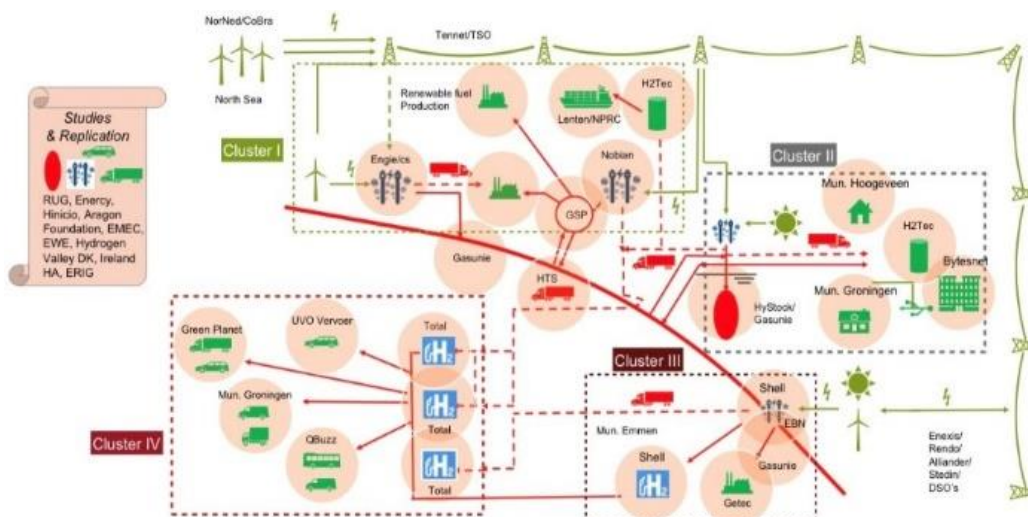


Source: FCH 2 JU, Inycom, Roland Berger

2.2 HEAVENN - The design of the project

HEAVENN will build on both existing and planned projects, and regional plans for hydrogen deployment in the North Netherlands. It is based on a 'cluster methodology' allowing the systemic integration of hydrogen in the region through a cluster concept by incorporating additional Fuel Cell Hydrogen (FCH) applications and achieving a significant scale to foster the creation of a regional hydrogen-based economy. HEAVENN will integrate up to thirteen key individual hydrogen projects in the region of North Netherlands, including local and imported renewable hydrogen production and FCH applications at industrial, commercial, and residential level, demonstrating end-use business cases for transport, energy, and industrial sectors. In this way HEAVENN will comprise a regionally integrated energy system including deployment of hydrogen across the entire value chain.

The scheme presented hereunder depicts the project. The red line is the linking pin of the project, the hydrogen backbone. This connects the four operational clusters—I, II, III and IV. Within these clusters, the projects are organised and integrated with each and amongst each other:



On the top-left, the offshore wind from the North Sea comes in, which will be used to produce green hydrogen via electrolysis. This hydrogen will either be used by the several end-users or stored at the storage facility of the Gasunie—HyStock. The projects are quite diverse. For example, one project focuses on producing green methanol with hydrogen. The e-methanol can be used as a green base chemical or as fuel for sea freight. Another project is the realisation of Sustainable Aviation Fuel

production for aviation; a sector which is quite hard to abate. Also an inland watership powered by hydrogen transporting salt from Delfzijl to Rotterdam is part of the project. To fuel this vessel, a hydrogen fuelling hub is developed in Delfzijl, which is directly coupled to the (polymer) hydrogen ring pipeline on the Chemical Park Delfzijl. An example of applications in the built environment is in Hoogeveen where 100 new homes will be provided with green hydrogen. There is also a large mobility sector where passenger cars (105), heavy duty trucks (12), various light utility vehicles (8), and garbage trucks (4) can be facilitated. Two coaches will be developed for passenger transport on top of the 32 buses which will operate in the Groningen and Drenthe region. To provide fuel to the mobility market, five Hydrogen Refuelling Stations (HRS) are planned of which some are already in operation. In addition to the assets, flanking studies and replication actions are executed. A valuable part of the project, due to it being the first European Hydrogen Valley, is that there is plenty to study, share, and replicate.

Approximately 30 parties originating from seven EU countries are partaking in the project as seen in the picture below. The project benefits from much interest outside Europe such as the USA, Japan, China, Australia, New Zealand, Southern Africa, the Middle East, and Northern Africa (MENA) region, and recently the interest from Northern and Eastern Europe as well as the Mediterranean region. As mentioned before, HEAVENN functions as a magnet for economic interests for the Northern Netherlands region and gives local SMEs a boost.



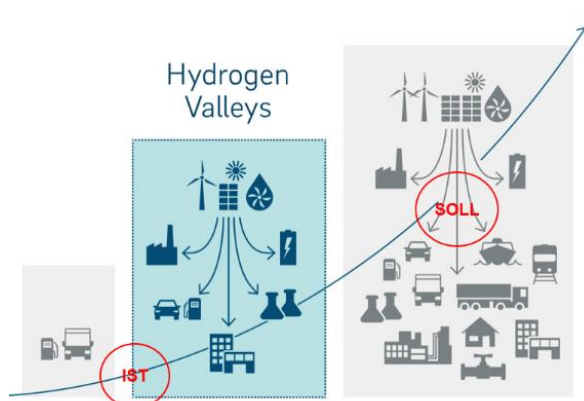
HEAVENN - The spin-off

The Northern Netherlands benefits from being the first Hydrogen Valley of Europe. This position attracts various parties from all over the world. These parties are interested in the workings of the Hydrogen Valley model and its implementation in the region which can act as a blueprint for replication in Europe and beyond. Furthermore, the spin-off results accelerate closer collaborations with both neighboring and distant regions.

Currently, the Hydrogen Valley model, as implemented in HEAVENN, has attracted interest from the following: North Germany, Denmark, EU-13 countries, the Mediterranean, Japan, Australia, USA, Canada, Southern Africa, and more. The model has already been implemented at the Orkney Islands and Mallorca. Again, in terms of new business, the Hydrogen Valley model is functioning like a magnet. SMEs such as Soluforce which brings polymer Hydrogen transport pipelines to the market is demonstrated within the HEAVENN project. Secondly, Resato the Dutch HRS builders benefit from the contacts from HEAVENN. Thirdly, two new electrolysers in Delfzijl are being developed with capacities of 20 and 200 megawatts. Fourthly, Groningen Airport Eelde is aiming to become a Hydrogen Valley Airport attracting interest from KLM and the Ministry of Defense regarding how to develop and operate zero-emission ground equipment. Fifthly, Holthausen and Hyzon Motors Europe

are making lasting impressions with the production of Fuel Cell (FC) trucks. Finally, educational institutions are and will benefit[ing] from the initiation of new educational programs on the topic of hydrogen. All in all, these points again reinforce the evidence that the Hydrogen Valley model such as that of HEAVENN functions as a magnet for regional economic development and growth.

2.3 The status quo of Europe's first Hydrogen Valley



After the publication of 'The Green Hydrogen Economy in the Northern Netherlands' in 2017 the Hydrogen Valley developed rapidly. In 2020, the Northern Netherlands was identified as the first Hydrogen Valley of Europe by the Clean Hydrogen Partnership and the EU.

Across its geographic scope, Hydrogen Valleys cover multiple elements of the green hydrogen value chain, ranging from hydrogen production to storage and transport of hydrogen, and distribution to off-takers in industry, mobility, and the built environment via various modes of transport.

Within Europe's first Hydrogen Valley, the following key aspects have been developed in the past years, and the extension continues with new announcements. The valley acts like a business magnet, attracting interests and investments and triggering innovations and the set-up of educational programs fitting the North Netherlands ambitions while setting an example for Europe.

Production

- Five electrolyzers with a total capacity of 35,7 MW installed capacity
- 220 MW electrolyser capacity at FID phase.
- Several electrolyzers have been awarded permits
- Recent novel announcements were made with a capacity of approx. 200 MW+, this already on top of the ambitions of the large-scale offshore projects

Transport

- Hydrogen Pipeline Chemical Park Delfzijl
- Hydrogen Pipeline Emmen
- Trailers to distribute green Hydrogen to HRS and industrial off-takers
- Recent announcements were made to start the development of the Hydrogen Backbone by Gasunie, supported by the Dutch state
- Several smaller dedicated pipelines (polymer-based) were announced to connect production and off-takers.

Storage

- Successful pilot of storage facility HyStock for injection of hydrogen in salt caverns. Next step is the full-scale development of storage in salt caverns expected to be operational in 2023.

Hydrogen in built environment

- Tiny house on hydrogen
- Substantial support from the national government to start the development of the 100 new built homes on hydrogen in Hoogeveen.

Hydrogen in mobility

- Dozens of passenger cars on hydrogen currently on the road.
- 32 busses on hydrogen.
- Multiple street sweepers, garbage trucks, and delivery vans.
- Five existing hydrogen refueling stations, and five in development.
- Several (small) boats on hydrogen.
- First hydrogen-powered inland waterways transport ship under construction.
- Successful pilot with hydrogen-powered train.
- Trailer hydrogen exit station with HRS for fuelling ships permitted, directly coupled to electrolyser in Delfzijl.
- Development of zero emission ground power units at the Hydrogen Valley Airport.

Hydrogen in industry

- 32 MW Chloro Alkali Nobian (as starting point of HEAVENN for large green hydrogen offtake)
- CHP retrofitted to Hydrogen for industrial Heat and Power supply.

Education and Research

- Waterstof Werkt 1
- HyDelta 1 and follow up on HyDelta 2
- Preparation of the Hydrogen Valley Campus Europe

2.4. Success factors and challenges of HEAVENN

Mission Innovation and the Clean Hydrogen Joint Undertaking (formerly known as Fuel Cell and Hydrogen Joint Undertaking) described in their report on Hydrogen Valleys five success factors of setting up a Hydrogen Valley³. HEAVENN checks all the boxes, demonstrating its versatility and forward-looking characteristics.

- ✓ **First key success factor: A convincing project concept with a value chain coverage and technology choices that leverage local assets and address local needs.** HEAVENN was

³ https://www.fch.europa.eu/sites/default/files/documents/20210527_Hydrogen_Valleys_final_ONLINE.pdf

praised for its convincing project concept as it was the most complete valley covering every single part of the value chain leveraging local assets (see above) and meeting local needs (a region needs a business) – the local circumstances and more specifically benefits and prospects were analyzed thoroughly and are under continuously review.

- ✓ **Second key success factor: A viable commercial structure that enables first real business cases for developers (incl. any public funding).** Mobility helps accelerate the market creation (mobility versus industry), and mobility has a high visibility factor in public society. It is therefore safe to infer that everyone is acquainted with buses and cars. Having them circulate traffic continuously increases visibility, recognition, and acceptance.
- ✓ **Third key success factor: Public-private financing from multiple sources that includes enough public funding to close all gaps.** HEAVENN secured the funding in the initial phase with a combination of both public and private money. The public contribution comprised support from the region and the State. In practice, this appeared to be more challenging than anticipated as the regional funding is already in place. The national funding is under preparation. An important element in the delay is based in the overcomplexity of State Aid regulations. Outdated regulations must be left aside in order to jumpstart the hydrogen economy.
- ✓ **Fourth key success factor: Partner and stakeholder cooperation that covers the entire project scope and ensures continuous commitment from all parties involved.** With a consortium of 30 parties from seven EU countries, stakeholder management and partnering is of utmost importance. HEAVENN has put a dedicated governance mechanism in place and created a project organisation for daily coordination with dedicated project manager(s) and clear rules and allocation of responsibilities within the consortium. Important to note is that the consortium is tight and has a common goal.
- ✓ **Fifth key success factor: Political-backing and buy-in of the general public for smooth and continuous project development.** Perhaps the most influential success factor is the political-backing, advocacy, and buy-in of the general public. In The Netherlands, the project has been recognised in the National Hydrogen Strategy, and in Europe the development of the Hydrogen Valley is spurred actively by current European Commissioner Ursula von der Leyen where she refers to HEAVENN and the Northern Netherlands as a front-runner region. On the regional level, HEAVENN receives great support, while on the national policy level intensification is desired. Discussions with regulators are on a case-by-case basis; environmental agencies are currently showing an increasing amount interest. Local communities are also involved on a case-by-case basis, making it necessary to increase the awareness of Hydrogen's general advantages as a future-oriented.

HEAVENN also faced the following challenges in becoming a Hydrogen Valley:

- **The availability of renewable energy**
Most people embrace the energy transition and embrace hydrogen, however, to produce sufficient renewable energy a high number of solar and windfarms are needed but are not always embraced by society.
- **Permits**
In the initial phase of setting up a Hydrogen Valley, current legislation and regulations are mainly used. However, the limits of current legislation and regulations and setting up additional regulations has a lead time.

- **Old and new infrastructure**
In a region where business is already in place with working infrastructure, it can be challenging to adapt to the required infrastructure (e.g., new processes, procedures, exchange of materials, etc.)
- **Future perspective**
The first period of creating a Hydrogen Valley is unprofitable; much investment is needed. It is only profitable once hydrogen is produced on a large scale which needs time. It is a challenge to convince different kinds of stakeholders as it will take some time to create a return on investment.
- **Connections with other Hydrogen Valleys.**
Connections with other Hydrogen Valleys bring in more business and flexibility in terms of storage and usage. Ideally, Hydrogen Valleys grow along. However, realistically, different regions have different procedures specifically in the beginning when there are a few Hydrogen Valleys.

However, these challenges do not outweigh the fact that Hydrogen Valleys are needed across the globe for decarbonisation as it is the only alternative to fossil fuels.

As Ursula von der Leyen stated in her speech:

“I want Europe to be a front-runner, a front-runner while building a global market for hydrogen. Last spring, the European Commission was part of a coalition of countries pledging to create 100 Hydrogen Valleys around the world. Of course, we want the majority to be in Europe, so clean hydrogen is becoming part of the conversation with all our global partners, of course including our African partners. Africa has the greatest untapped potential for renewable energy production. Turning clean energy into clean hydrogen could be a solution to store that energy, both to sell it abroad and to power Africa’s rising industry. It is with this in mind that I have proposed to invest in Africa’s hydrogen sector, and thus creating a new clean hydrogen market between the two shores of the Mediterranean. It could bring clean energy to Europe, and sustainable development to the African continent.”

In order to create more Hydrogen Valleys worldwide - that bring clean energy to Europe and sustainable development to the African continent– adding an extra component to our proposition *must* be considered, namely: impact by design. Designing a Hydrogen Valley including the United Nation’s Sustainable Development Goals (SDGs) as an underlying and integrated principle creates stability in the regions and offers mutual benefits. **This is called a Sustainable Hydrogen Valley.**

3. Creating mutual benefits with Sustainable Hydrogen Valleys all over the world

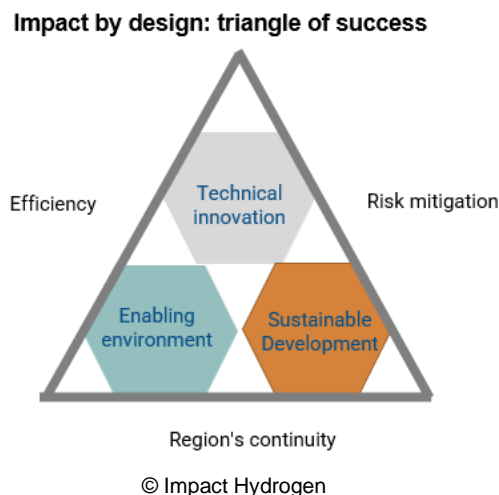
A Small Molecule with a Big Impact

A learning point from HEAVENN is that sustainable success is created by offering the region a business based on its characteristics, its history, and potential. By taking this as a starting point, one can contribute to local needs and create both perspective and stability. This can be done by making it part of the design of Hydrogen Valleys and create sustainable Hydrogen Valleys. In this way, the potential of the region can be unlocked and create business allowing international trade to create mutual benefits.

Impact by design is therefore fundamental to a sustainable Hydrogen Valley and the sixth success factor to be added.

3.1 Impact by design

'A region needs a business' and in order to create or adapt a region's economy towards a green hydrogen economy, it is important to take the three following key elements into account from the start of the Hydrogen Valley design: technical innovation, enabling environment and sustainable development. The perfect blend of these three key elements will bring efficiency, risk mitigation, and continuity, not only in the process of building the Hydrogen Valley but also afterwards, so that economic growth in the region is secured. The picture below visualises this in more detail.



3.2 Technical Innovation

Technical innovation is crucial in creating a Hydrogen Valley. The HEAVENN project showed what it takes to build Hydrogen Valleys and how to learn from challenges and lessons learned as mentioned in section 2.4. Next, when working on technical innovation is important to fully understand the context of the region; become acquainted with its history, geography, and social demographics. This is important because the technical innovation is built on it and understanding the region helps accelerate the technical innovation for the region. Technical innovation is created by launching test projects and experiments stemming from collaboration between universities, private sector companies, and local government. Learning from these test pilots speeds up the innovation process.

3.3 Enabling environment

To build a Hydrogen Valley, a so-called 'enabling environment' is needed and should be incorporated into the set-up and design. These enablers smoothen the implementation of the Hydrogen Valley from start to end and function as growth accelerators for the eco-system (i.e., a purposeful relation between two or more entities to create and share in collective value) of the hydrogen valley. These enablers are:

- Hydrogen Valley Roadmap
- Policy framework
- Financing and investment framework
- Human capital strategy
- Trade Partnerships
- Civil society participation

Hydrogen valley roadmap

A Hydrogen Valley roadmap visualises the path to building a Hydrogen Valley. To come to a Hydrogen Valley Roadmap, objective formulation for the Hydrogen Valley is imperative. Subsequently, the objectives must be broken down into sub-goals for the different hydrogen clusters which allows for the creation of the steps needed to create the roadmap. Key in creating the roadmap is to start small, such as setting up pilot projects, and simultaneously work on the long-term goals (e.g., export). Lastly, to achieve a smooth implementation of the roadmap, it is important to align the different stakeholder groups when creating the roadmap.

Policy framework

A policy framework⁴ helps facilitate the goals and objectives formulated in the national hydrogen strategy. A solid policy framework consists of several actions that need to be carried out, such as:

1) Use as much policies as possible from existing policy frameworks.

Though green hydrogen is a new business, it should make use of existing policies to overcome delays and complexity.

2) Set policy priorities.

Green hydrogen can support a wide range of end-use purposes. Policy makers should identify and focus on those applications that provide the highest value.

3) Scheme origin guarantees.

Carbon emissions should be accounted for over the entire lifecycle of hydrogen. Origin schemes need to include clear labels for hydrogen and hydrogen products to increase consumer awareness and facilitate claims of incentives.

4) Align governance system and enabling policies.

As green hydrogen becomes mainstream, policies should cover its integration into the broader energy system. Civil society and industry must be involved to maximise benefits.

5) Submit permits for a complete hydrogen value chain.

To move the process of building a Hydrogen Valley forward, permits need to be issued for the entire value chain. This will accelerate and support the completion of the Hydrogen Valley.

Financing and investment framework

Setting up a Hydrogen Valley requires big investments over an extended period. Therefore, creating a solid finance and investment framework is an important step. Because Hydrogen Valleys can start small, it is an option to see how you can start by using the existing regulations and policy framework. In order to make it solid the finance and investment framework needs to go hand in hand with risk mitigation management. A few actions need to be implemented before a Hydrogen Valley can be built:

1) A purchase guarantee.

The purchase guarantee, with commitment from one or more off-takers for a longer period, is a starting signal to set up the Hydrogen Valleys. It signals companies, small and big, to start changing their business models to fit the new hydrogen economy. A tool that can accelerate this process are demand-subsidies which will make it easier for parties to purchase green hydrogen at an early stage. As mentioned in chapter 2, in the HEAVENN project the first investment using a purchase guarantee was done by the municipality.

2) Financing and investments for the Hydrogen Valley as a whole.

When a Hydrogen Valley is financed as a whole - this means that all stakeholders with different roles in the hydrogen value chain will be financed along with it. This will mitigate the risks for all individual players involved, as the risks are spread across several actors within the value chain. At the same time, financing the Hydrogen Valley as a whole, is also less risky for

⁴ <https://www.irena.org/publications/2020/Nov/Green-hydrogen>

financial institutions. This is because the investment doesn't depend on just one single entity but instead is spread amongst everybody involved.

3) Set up of structured procurement mechanisms.

Auctions for carbon contracts for differences (CCfDs) would allow selected, hard-to-abate industries under the ETS scheme to secure a stable income for an agreed period, provided they commit to using green hydrogen. The selected winners, who bid for a certain strike price, would receive the difference between the strike price and the market price of the emission allowances from the government. This would cover the costs of green hydrogen investments and attract financing for green hydrogen projects. CCfD auctions are already being considered in various hydrogen strategies.

4) Guidance for business change and adaptation to the new hydrogen economy.

Often times a region's economic basis, such as the mining industry in South Africa or Ghana, has operated in the same manner for decades. Consequently, the entire region's business landscape has grown alongside this business model and made to fit and facilitate it. Therefore, extra guidance is required for SMEs and large corporations to help them towards a model where hydrogen is part of their business. This long-term guidance can also be setup and executed by the project organisation.

5) Embedding financing in the value chain small and big.

Acceptance from civil society accelerates the process of building the Hydrogen Valley and helps it flourish after completion which is why subsidies must flow both to the power sector and towards end users such as the transport, cooking, heating, and cooling sectors. It is critical that communities large and small receive tangible benefits from the energy transition as it will fasten processes and build strong partnerships between the stakeholders in the Hydrogen Valley ecosystem.

Human capital strategy

The strategy serves as a plan for building talent and [re-]creating jobs in a region to facilitate hydrogen developments. Starting a human capital strategy, starts with analysing the current situation of employment in the regions and the sectors most people are working in. If you are aware of the current situation, it is easier to see what skilled energy crafts with practical knowledge and outstanding scientists with specific professional knowledge and a broad understanding of the energy system are needed and set up a plan around this.

Building capacity in the region will be accomplished through means of education programmes at all levels of society in soft skills (e.g., collaboration) and in hard skills (e.g., technology). An example of this is so-called 'learn and work spots' where people put into practice what they have learned about energy. It is also about sharing and exchanging knowledge which helps create a strong knowledge economy in the hydrogen-producing regions with its own people as main contributors to the hydrogen ecosystem, which should be an overall goal. In this way, people themselves are the greatest asset in letting their own region flourish and creating an abundance of new jobs, as it is important to educate people, create awareness, train them, and create roles for them in the new hydrogen economy. Over the years knowledge will be built and innovation will grow.

Trade Partnerships

As the world is preparing for green hydrogen, setting up partnerships and collaborations at an early stage is important. Firstly, in order to secure trade relations⁵. Secondly, to build strong relationships for

⁵ <https://www.irena.org/newsroom/expertinsights/2021/Sep/Auctions-for-Green-Hydrogen>

the sake of a strong Hydrogen Valley ecosystem. The first step in setting up strong partnerships is to create a stakeholder map to get an overview of existing stakeholders, networks and partnerships that could be relevant for the development of a Hydrogen Valley. The second step is to identify which partnerships are missing. Finally, in the third step, one needs to ensure that those partnerships develop into strong networks. Through this approach, Hydrogen Valleys can become strong independent eco-systems that can connect to other strong hydrogen eco-systems in the future by connecting Hydrogen Valleys.

Civil society participation

Imbedding the new green hydrogen approach in the society of the region is a key element to realise a thriving hydrogen economy. As hydrogen will make use of life essential sources, water and electricity, civil society needs to know and learn about the hydrogen-story and the benefits it can bring. Only when people feel involved will the adaptation of hydrogen in a region's economy be successful. It is when people know that it brings prosperity and people know there is a role for them that they will promote, protect, and advance the Hydrogen Valley in their region. Letting the civil society participate in the transformation to a hydrogen economy is therefore key. This can be done through structural dialogue, opportunity programs where people can expand their role in the hydrogen economy and involving the NGOs active in the region.

3.4 Sustainable Development

Stability in a region is necessary in order to guarantee economic security, mitigate the complexities in a region, secure good (international) cooperation and trade, and secure the necessities of life of the local population. Sustainable development can help make the Hydrogen Valley a success over the long term as it raises equity amongst society and creates opportunities for people in terms of jobs, business, and education. The UN's SDGs give good guidance to create this sustainable development.

'Distance-to-SDG' assessment

It is important to understand how a hydrogen value chain can contribute to reaching the sustainable development goals in the region. This can be done by a so-called 'Distance-to-SDG' assessment to provide a zero measurement on how the regions scores on all 17 SDGs. The outcome of the assessment is an overview of the current levels of SDGs in the region. It provides guidance on what positive impact can be made for the region and in which way. The impact that comes from the Hydrogen Valley will grow alongside the valley itself. Starting with small impact and ending with impact for an entire region.

SDG projects as a derivative of the hydrogen value chain

To make the hydrogen economy thrive, stability in the region is an important pre-condition. Aligning the development of a hydrogen economy with reaching SDGs will accelerate the lever effect of bringing prosperity to a region significantly and thus provide stability for business and society. For that reason, building the Hydrogen Valley needs to go hand-in-hand with the launch of projects that benefit the community where hydrogen is produced. As mentioned earlier, a 'Distance-to-SDG' assessment needs to be completed at the start of the project. The outcome of that assessment must be combined with the 'hydrogen end-products' of the clusters mentioned in chapter 2.2. This way, all levels of society will benefit from the prosperity hydrogen brings by observing SDG projects that will be executed throughout the Hydrogen Valley.

3.5 Impact by design, what it will bring

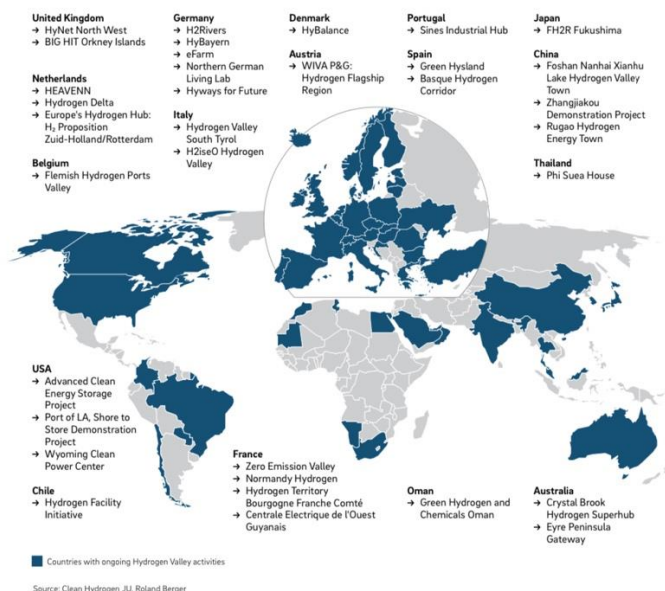
Starting a Hydrogen Valley with the key success factor: impact by design, will make out of a Hydrogen Valley, a Sustainable Hydrogen Valley. A Hydrogen Valley where three key elements are blended in a perfect way so that they bring, efficiency (combining all elements will make that all connect fast and smooth), risk mitigation (organizing all parts of the hydrogen value chain at the same time brings

challenges, but with the three elements, the risks that are coming along will be mitigated and region's continuity (continuity can be created when every stakeholder has 1) a benefit from the hydrogen production and 2) a role in the Hydrogen Valley) will bring stability.

4. The Netherlands as preferred partner for global Sustainable Hydrogen Valleys – the Dutch way

The Netherlands unlocks hydrogen potential

The Netherlands has traditionally had a strong international orientation and the Dutch economy is largely driven by trade with foreign countries. Moreover, energy and knowledge are important pillars of the Dutch economy. Dutch companies and knowledge institutions have a great deal of experience with and knowledge of gases, including hydrogen. They are prepared to share that knowledge and expertise to unlock the potential of regions with which they trade.



4.1 International trade

Green hydrogen as part of the energy system to make industry and heavy transport more sustainable and to balance the electricity grid is a global trend. Plans for the production and/or use of green hydrogen are being drawn up in many different places around the world. Mission Innovation has as its goal to realise over 100 Hydrogen Valleys worldwide in 2030, of which at least 10 in emerging economies.

The characteristics of these plans vary from locations where mainly green hydrogen is produced to locations where use exceeds production and all the variants in between. For this reason, the development of international trade in green hydrogen has taken off in recent years. Locations with a high demand for green hydrogen are looking for potential suppliers and dozens of MOUs and LOIs have been signed just to be sure of a role in the green hydrogen economy. Since the emergence of the global gas crisis following Russia's attack on Ukraine, the search for green hydrogen has intensified. Whereas global trade in oil and natural gas grew organically for 80 years, global trade in hydrogen seems to be taking shape in a few years. Old trade relationships are being reshaped, moving from fossil fuels to renewables, and many new trade relationships are also being established. In both cases, new terms of trade are being drawn up and new contracts concluded. These new

contracts shape, as it were, the new energy world: what will the trade look like and what mutual benefits are there. In addition to the availability of hydrogen and the money in return, more mutual needs can be fulfilled that promote good trade relations and thus security of supply. The trade in hydrogen can bring more than just energy and money. It can bring prosperity to the regions that needs it the most and has the potential because of the optimal solar and wind conditions.

4.2 Contracts for difference conditions for Sustainable Hydrogen Valleys.

To achieve this, conditions for creating sustainable business out of Hydrogen Valleys for both the exporting country and the importing country need to be set. These conditions must cover conditions to accelerate technical innovation, path the way to establish an enabling environment, and guarantee sustainable development. The conditions set in the H2global starting points also give valuable guidance. It is also important to include these conditions in the beginning of making agreements and creating contacts such as LOIs, MOUs, and contracts as part of a business case.

Several countries, such as Germany and The Netherlands, are busy establishing an auction-based mechanism with the objective to promote a timely and effective ramp-up of green hydrogen on an industrial scale. This mechanism concludes long-term purchase contracts on the supply side and short-term sales contracts on the demand side. It is based on a Contracts for Difference approach, which means the difference between the supply prices and demand prices will be compensated by the government. In this way, enough security is provided for large-scale investments, which will kick-start the hydrogen economy.

Since governments and banks have also indicated that they want to contribute to the achievement of the Sustainable Development Goals and the EU and UN want to realise at least 40 Hydrogen Valleys, this is a enormous opportunity. A condition for the strategic purchase of hydrogen is that part of the hydrogen is made available for the area to build a Sustainable Hydrogen Valley. In the short term, this requires an investment, but in the longer term it sets the standard.

Because it is merely the beginning of the hydrogen economy, The Netherlands can set the trend and become a desirable party to do business with; $1 + 1 = 2$.

4.3 Knowledge and expertise as a unique selling point

Trading with other countries goes hand-in-hand with knowledge-sharing. As working with the best knowledge will accelerate building Hydrogen Valleys. The Netherlands has a unique position building a Hydrogen Valley where existing hydrogen projects are operational and flourishing, a frontrunner position with access to scarce practical knowledge.

This frontrunner position originated from the availability of gas in Groningen and led to an expertise in the field of gases. In contrast to many countries, The Netherlands has a great deal of knowledge and expertise in the field of molecules, in terms of safety, application, production, and transport. This meant that the Netherlands could quickly help other countries to take the first steps towards a hydrogen economy. In terms of technical knowledge but also on how to set up an enabling environment and let the local community benefit from this new economy by creating sustainable development.

The rapid rise of the hydrogen economy means that many governments, companies and training and educational institutions are looking for information about hydrogen and the various applications; both the technology and how you organise the value chain and facilitate training and education.

The Sustainable Hydrogen Valley approach combines education, training, technology, and organisation based on the needs of the region. Dutch companies, training programmes and knowledge institutions can play a major role in securing and accelerating trade. Both with practical and

scientific knowledge. Therefore, The Netherlands can offer knowledge of Hydrogen Valleys as part of a trade deal. If you trade on hydrogen with The Netherlands, you will be granted access to the latest innovations, practical knowledge on setting up an enabling environment, and how to let hydrogen contribute to sustainable development for the region.

5. Next steps

The hydrogen economy is only at the start of what is becoming a grand transition which will endure for many decades. Based on decades of experience with natural gas, The Netherlands has acquired enormous expertise in the handling of molecules. This means that The Netherlands was and is able to start the hydrogen economy quickly and effectively. From this position, The Netherlands can also share expertise with other regions and countries and help them with this energy transition as many countries and regions will generate hydrogen and use and/or export it. For the Netherlands, it is a huge opportunity to utilise the knowledge and expertise of Dutch companies involved with and within the hydrogen value chain.

To position The Netherlands as an expert-hydrogen country, accelerate international trade relations, and position Dutch companies as “first choice” for exporting countries, it is important to create so-called “Hydrogen Hubs” at these selected locations. Hydrogen Hubs function as support points for trade and in parallel create visibility for The Netherlands in the producing country. The Hydrogen Hubs can also initiate and develop new projects and facilitate business opportunities for the producing region and The Netherlands. The Ministry of Trade and Development and the Ministry of Climate and Energy are referring to this suggestion in the National Climate Strategy.

Following the Hydrogen Hubs as suggested above, it is advisable to establish dedicated offices and functions in frontrunner countries when it comes to hydrogen. For example, by installing Hydrogen Attachés in these Hydrogen Hubs, that are working closely with Attachés from other disciplines where the production of hydrogen will be used for (e.g., mining, agriculture, fisheries, etc.). However, the Hydrogen Hub can also help set-up and tap into financing instruments in order to help companies and knowledge institutions to position themselves in these strategic countries and regions in the high risk phase—before there is a contract for trade.

Lastly, to give the Netherlands a major role in the international hydrogen economy, from which Dutch companies and regional companies or organisations benefit contributing to international stability and prosperity benefit, it is advisable to develop a government-wide international hydrogen strategy.