Nederland gidsland voor innovatie van groene waterstof

groen vermogen nl | Innovatiemotor van de groenewaterstofeconomie

Inhoudsopgave

Innovatie als sleutel

Met in totaal ruim € 2 miljard is GroenvermogenNL een van de grootste groene waterstofprogramma's wereldwijd. We zijn trots dat we hiermee bijdragen aan de toekomst van Nederland als belangrijke, duurzame speler op het wereldtoneel. Het GroenvermogenNL-programma versnelt het gebruik van groene waterstof in de Nederlandse industrie, versterkt het innovatieve ecosysteem en zorgt voor voldoende goed geschoold personeel.

Circa 200 partners zijn actief in onze vijf grote R&D-programma's. Het zesde en zevende programma zijn onderweg. Met budget van GroenvermogenNL zijn 10 demonstratieprojecten gestart (DEI+) en eveneens 10 FEED- en haalbaarheidsstudies (TSE Industrie Studies). Er is een nieuwe regeling speciaal voor de Nederlandse maakindustrie geopend (IMKE), waarvoor de eerste projecten aan de slag kunnen. Bovendien heeft GroenvermogenNL een aantal maatwerksubsidies gegeven, bijvoorbeeld voor lekkagemetingen en een waterstofbeurs.

Een belangrijk speerpunt voor GroenvermogenNL is een nationaal ecosysteem voor testen. We werken aan een Community of Practice Electrolysis, samen met TNO, die Nederland ook internationaal op de kaart zet. Belangrijk onderdeel is een nationale duurtestfaciliteit voor elektrolyse die nog lang na het bestaan van GroenvermogenNL impact zal hebben.

Onze focus op innovatie in groene waterstof is extra belangrijk in de momenteel lastige markt voor groene waterstof met hoge elektriciteitsprijzen in Nederland. Via innovatie vergroten we de kansen om op het juiste moment groene waterstof in de Nederlandse industrie te gebruiken en versterken we de Nederlandse maakindustrie. Ook ondersteunen wij de import van groene waterstof(dragers). Daarmee jagen we meer gebruik aan, dragen we bij aan de infrastructuur voor de energietransitie en bieden we de randvoorwaarden voor snelle introductie van groene waterstof als de markt daar klaar voor is.

Nederland blijft goed gesitueerd om een belangrijke rol te spelen in de transitie naar groene waterstof: havens voor import en doorvoer naar andere landen, offshore wind voor goedkope elektriciteit bij piekproductie (netbalancering door productie groene waterstof), en een sterke maakindustrie voor (onderdelen voor) productie van groene waterstof.

In deze uitgave geven wij je graag een verdere update over de impact van GroenvermogenNL.

Namens het programmabestuur,

Marjan Oudeman
Paulien Herder
Annemarie Manger

Naar een ecosysteem van testfaciliteiten

Wat is de kern van een innovatief ecosysteem voor groene waterstof? Het begint met een vertrouwde omgeving waarin partijen uit de hele keten elkaar weten te vinden, samenwerken en kennis delen. Juist wanneer onderzoek dichter bij marktintroductie en patenten komt, wordt die uitwisseling vaak lastiger. GroenvermogenNL en TNO bouwen daarom aan een veilige setting: een Community of Practice rond testen en standaardisatie. Hier ervaren deelnemers dat de voordelen van samenwerken zwaarder kunnen wegen dan het strikt beschermen van hun eigen kennis.

Slim testen in Nederland

GroenvermogenNL en TNO brengen de testfaciliteiten in Nederland in kaart op alle technology readiness levels (TRL). Welke faciliteiten ontbreken nog en kunnen we daar een rol in spelen? Er zijn verschillende soorten testfaciliteiten nodig in Nederland om ervoor te zorgen dat niet altijd de duurste testen uitgevoerd hoeven worden. Samenwerking tussen die testfaciliteiten is belangrijk voor de testende partijen. Enige overlap is geen probleem, als de klant maar een goed advies krijgt over waar zijn bedrijf het beste kan testen.

Naar een nationale duurtestfaciliteit

GroenvermogenNL werkt samen met Shell en TNO aan een faciliteit voor duurtesten van elektrolyse-apparatuur. Onafhankelijkheid, teststandaarden en de mogelijkheid van certificering van apparatuur staan hierbij voorop. In de laatste fase van de ‘valley of death’ is het voor de maakindustrie belangrijk aan te tonen dat hun apparatuur onder normale bedrijfsomstandigheden goed werkt. Grote afnemers in de industrie vereisen vaak enkele jaren praktijkervaring voor ze een aankoop overwegen. Voor veel maakbedrijven (vaak MKB) is die laatste fase vaak moeilijk vanwege de hoge kosten na al jarenlange investeringen in innovatie.

Internationaal erkende testprotocollen

Standaardisatie van testprotocollen is noodzakelijk. Betrouwbare testresultaten zijn voor zowel afnemers als aanbieders van apparatuur essentieel. In de Community of Practice kunnen beide samenwerken aan uitvoerbare en betrouwbare protocollen, ook met kennisinstellingen en certificerende instanties. Nederland kan hiermee binnen Europa de toon zetten voor internationaal erkende testprotocollen op alle TRL-niveaus.

Beheer van vertrouwelijke informatie

Kennisuitwisseling binnen de grenzen van benodigde vertrouwelijkheid vergt een ‘trusted third party’ voor het beheren van (vaak vertrouwelijke) informatie en afspraken over openbaarmaking op een afgesproken aggregatieniveau. Via standaard-NDA’s kunnen wetenschappers afspraken maken met de eigenaar van vertrouwelijke informatie, wanneer daar van beide kanten behoefte aan is.

Virtueel testen

ICT en virtueel testen zijn ook van belang. In de Community of Practice is aandacht voor de toepassing van testresultaten bij opschaling door virtueel te testen. Een virtueel testcentrum geeft ook nieuwe talenten de kans te oefenen in de virtuele praktijk. Bovendien kunnen testmogelijkheden binnen bestaande infrastructuur worden uitgewerkt.

Veilige route van innovatie naar markt

Deze geïntegreerde aanpak met de Community of Practice maakt Nederland ook voor buitenlandse bedrijven aantrekkelijk. Zij vinden hier een compleet en samenwerkend netwerk van testfaciliteiten, met heldere standaarden en mogelijk internationaal erkende protocollen. De aanwezigheid van een onafhankelijke ‘trusted third party’ voor het beheer van vertrouwelijke informatie geeft bovendien zekerheid bij het delen van gevoelige data. In combinatie met de mogelijkheid om zowel fysiek als virtueel te testen, biedt Nederland een efficiënte, betrouwbare en veilige route van innovatie naar markt – een aanbod dat maar weinig landen kunnen evenaren.

Hoofdstuk 1

Research and development

HyPRO

(Cost-)efficient and sustainable electrolysis systems

Start	2025
Subsidy	€ 34.512.627
Private contribution	€ 15.679.504
Leadership	Arend de Groot (TNO), Guido Mul (University of Twente)

11 universities

1 research institute
2 universities applied science

34 industrial partners

Research Tasks

1

AWE
Improving efficiency, sustainable materials

2

PEM
Improvement, new materials and dealing with intermittency

3

SOEC
New technology with heat integration

4

AEM
and other new electrolysis technologies

5

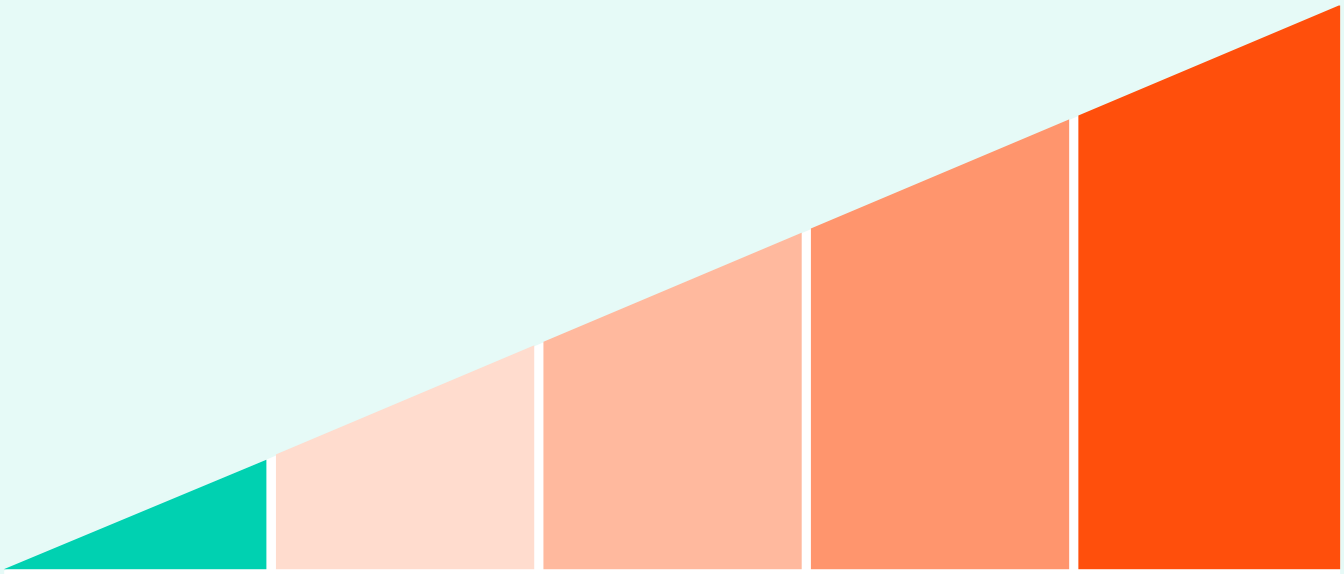
PLASMA TECHNOLOGY
and microreactors

6

INTEGRATION
With power electronics and other production factors

GroenvermogenNL ambitions

Acceleration	☑
Scaling up	
Reducing costs	☑
Innovative ecosystem	☑
New talents	☑



inputs	activities	outputs	outcomes	impact
Experts & state of art **laboratories**, funded talented researchers & resources.	Five technological research tasks; 1. **AWE** 2. **PEM** 3. **SOEC** & **PCCs** 4. **AEM** 5. Electrically Driven Processes for Residual Gas Valorisation (**plasma, microreactors**). One transversal task; 6. **System Integration**.	Advancement and comparison of hydrogen production technologies. Development of advanced characterization tools, digital twins, and accelerated stress test protocols. Establishment of a national hydrogen production technology ecosystem.	**Adoption of developed technologies by industry** across component manufacturers, OEMs, system integrators, hydrogen producers and operators. Informing government & regulatory bodies to make **informed decisions**. Use of these outcomes by academics for **education**.	**Acceleration** both existing and newly developed H2 production technologies. **Reducing costs** of H2 production through innovation (new materials, more efficient electrolysis, system integration). **Innovative ecosystem** with new participants in the consortium. **New talents** because approximately 40 PhD's are recruited and become involved in hydrogen issues.

2024	2025	2026	2027	2028	2029	2030	Beyond
• Start methodology	• Modelling fatigue cracking • Decision framework		• Monitoring tools, risks assessments	• Desalination • Market modelling • Safety protocols		• End phase 1 • TR import • Sensors	

HyTROS

Safe transport and storage onshore and offshore*

Start	April 2024
Subsidy	€ 14.236.764
Private contribution	€ 3.719.524
Leadership	René Peters (TNO), David Smeulders (Eindhoven University of Technology)

11 universities | **1 research institute**, **2 universities applied science** | **19 industrial partners**

Research Tasks

1

INFRASTRUCTURE
Degradation of materials, hydrogen leakage and flow metering

2

SAFETY
Standards

3

OFFSHORE
Infrastructure connected to the onshore grid

4

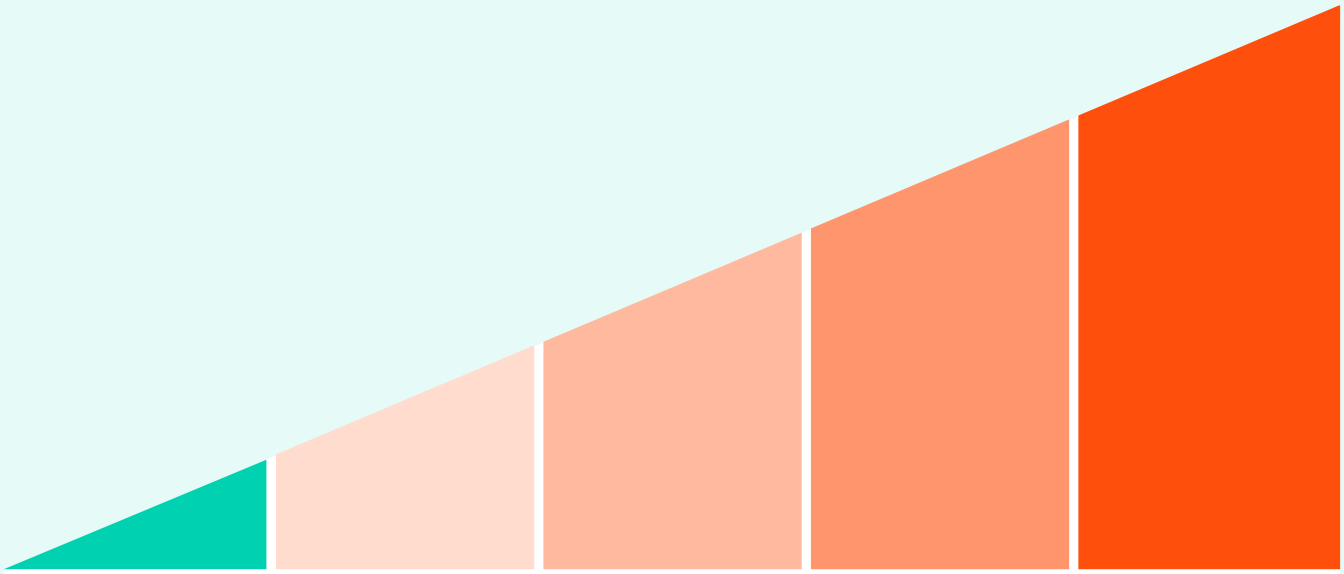
LARGE SCALE STORAGE
Underground H2 storage in empty wells and storage in tanks

5

ANALYSES
Om scaling up and system integration

GroenvermogenNL ambitions

Acceleration	☑
Scaling up	☑
Reducing costs	☑
Innovative ecosystem	☑
New talents	☑



inputs	activities	outputs	outcomes	impact
Experts & modern laboratories, talented researchers & other means.	Three technology based tasks: Infrastructure, Offshore & large-scale storage. Two tasks on integration & supporting aspects: safety standards and system integration.	Development of **tools and methods**. Development of **safety standards**. **Inventory of risks** on the integrity of large scale storage.	**Stimulating** synergy between offshore pipelines & reusing wells together with technical developments and standards for safe conduct. A **roadmap** for scaling a hydrogen system. **Optimizing** storage and reducing risks (real-time data). **Sharing knowledge**.	**Acceleration** enhancing applicable knowledge on infrastructure and storage including degradation of materials. **Scaling up** through analyses helping implementing and accelerating hydrogen infrastructure. **Reducing costs** among others by being able to implement safety standards. **Innovative ecosystem** with new participants in the consortium. **New talents** because approximately 25 PhD's are recruited and become involved in hydrogen issues.

2024	2025	2026	2027	2028	2029	2030	Beyond
• Start methodology	• Modelling fatigue cracking • Decision framework		• Monitoring tools, risks assessments	• Desalination • Market modelling • Safety protocols		• End phase 1 • TR import • Sensors	

HyUSE

Use of hydrogen in combustion technology for industry and mobility

Start	October 2024
Subsidy	€ 14.246.250
Private contribution	€ 2.344.685
Leadership	Frank Willems (TNO), Hamed Aslannejad (Utrecht University)

7 universities

1 research institute
5 universities applied science

12 industrial partners

Research Tasks

1

HYDROGEN AS A FUEL
in the energy intensive industry and for power generation

2

HYDROGEN FOR MOBILITY
and stand-alone energy systems

3

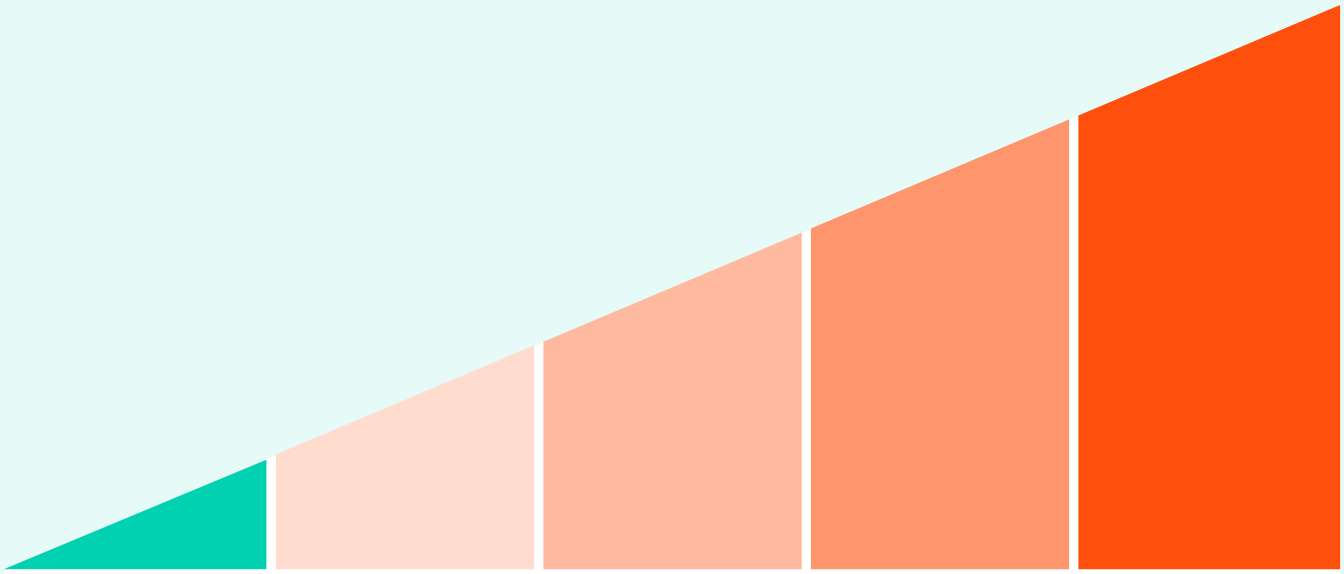
SYSTEM ASPECTS
of hydrogen introduction in various value chains

4

NON-TECHNICAL ASPECTS
of hydrogen introduction (policy, funding instruments and incentives, public support)

GroenvermogenNL ambitions

Acceleration	☑
Scaling up	☑
Reducing costs	☑
Innovative ecosystem	☑
New talents	☑



inputs	activities	outputs	outcomes	impact
Experts & state of art **laboratories**, funded talented researchers & resources.	Activities are structured in three technical tasks and two system-level tasks: Use of **hydrogen as a fuel** in the energy intensive industry and for power generation; Use of **hydrogen for mobility** and stand-alone energy systems; **System aspects** of hydrogen introduction in various value chains; **Non-technical aspects** of hydrogen introduction (policy, funding instruments and incentives, public support).	Improvement of hydrogen **utilization** methods for heat and power. **Optimization** of energy conversion processes. Identification of novel **applications for hydrogen** across various sectors. Modelling and simulation tools for **system evaluation**, and educational materials and practical guide-lines to disseminate findings.	**Adoption of and integrate** hydrogen technologies into existing systems, Valuable **insights** into their technical, economic, and environmental aspects in sectors like energy-intensive industries and power generation. Informing **decision-making** processes and policy development. Enhancing **capacity building** through educational outputs.	**Acceleration** both existing and newly developed H2 production technologies. **Reducing costs** of H2 production through innovation (new materials, more efficient electrolysis, system integration). **Innovative ecosystem** with new participants in the consortium. **New talents** because approximately 20 PhD's are recruited and become involved in hydrogen issues.

2024	2025	2026	2027	2028	2029	2030	Beyond
• Methodology and overview ecosystem	• Combustion systems, fuel cell, and techno-economic research	• Assessment of appli-cations	• Design and prototyping	• Scale up and testing, • Recommendations, policy mix, identification of hydrogen valleys.			• Continue phase 2

HyCARB

Hydrogen and green electrons for carbon-based chemistry

Start	2026
Subsidy	€ 35.313.861
Private contribution	€ 10.352.685
Leadership	Martijn de Graaff (TNO), Marta Costa Figueiredo (TU/e), Bert Weckhuysen (UU)

16 Research organizations
(9 universities, 5 HBOs and 2 research institutes)

22 Clean-tech industries

7 Industrial end users

Research Tasks

1

Thermochemical CO2 conversion
- From CO2 & H2 to syngas & SAF
- From CO2 & H2 to methanol via MTO, DME and olefins
- Structure-composition-performance relationships

2

Electrochemical CO2 conversion
- HT/LT electrolysis to syngas
- LT electrolysis to ethylene
- LT electrolysis to oxalate & formaldehyde

3

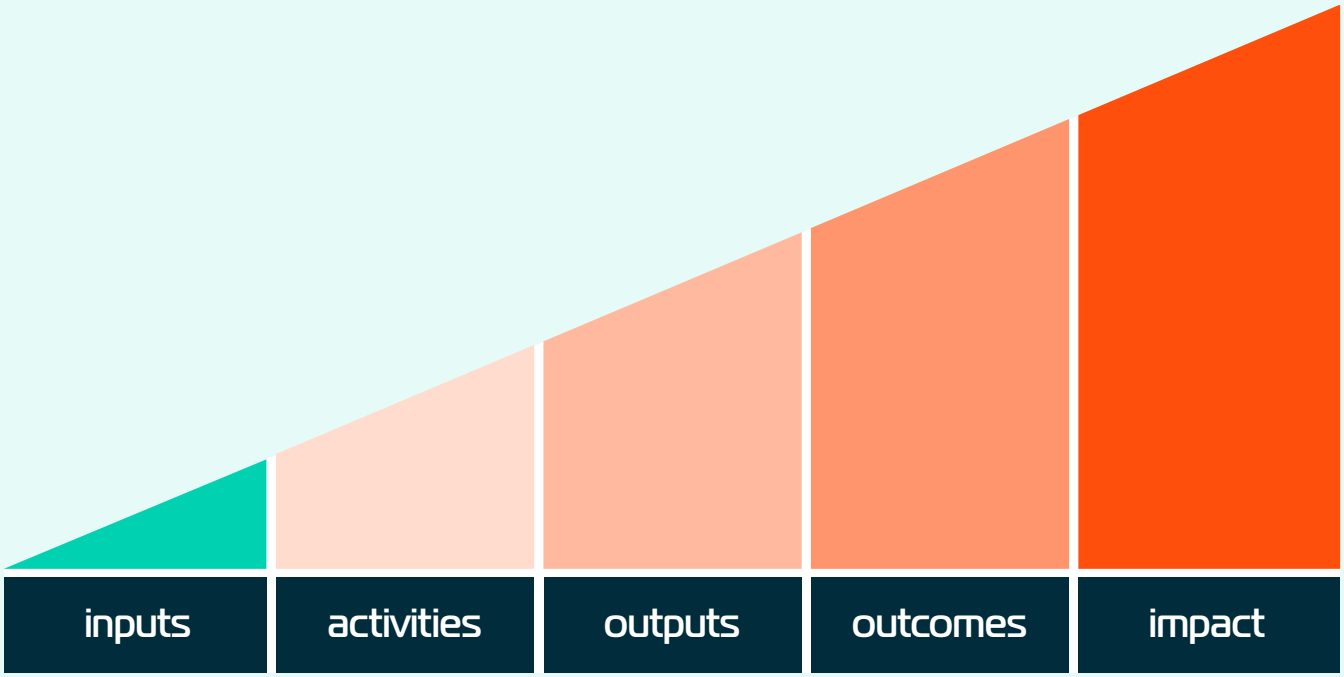
Electric heating
- Resistive heating
- Impedance and inductive heating
- Plasma heating

4

System integration
- Modular model tool
- Containerized pilot for intermittency
- CO2 storage for intermittency

5

Coordination, strategy and dissemination



inputs	activities	outputs	outcomes	impact
Acceleration of carbon-based use cases towards market implementation. **Reducing costs** by focusing on new promising techniques as well as catalysts, electrolyzers and adsorbents. **Innovative ecosystem** fostering collaboration between large and emerging businesses, various types of knowledge institutions and different stakeholders in energy, chemicals, and manufacturing industries. **New talents** raising and educating a highly skilled workforce and ensuring a robust structure for knowledge sharing.	Robust, flexible and efficient **CO2 conversion catalysts and processes** demonstrated. Better **materials, cells, stacks and components** for electrochemical CO2 conversion. **New electrified reactor** types tested for DRM, DCI and rWGS processes. First-of-a-kind **flexible industrial demonstrator of CO2 conversion** with intermittent H2 and e-supply. **Strengthened analytical infrastructure** for future research in CO2 conversion. **Shared knowledge base and strategy** for future implementation of CO2 conversion.	10 key chemical products (Sustainable Aviation Fuels, Syncrude, Syngas, Methane, Methanol, Dimethylether, Propylene, Ethylene, Formaldehyde, and Oxalate) >12 tangible TRL4-6 outputs (new catalysts, adsorbents, prototypes, and pilot demonstrators).	Four technological research tasks; 1. **Thermochemical CO2 conversion** 2. **Electrochemical CO2 conversion** 3. **Electric heating** and 4. (transversal) **system integration** and one overarching; 5. **Strategy, coordination and dissemination**.	**Experts** & state of art **laboratories**, funded talented researchers & resources.

GroenvermogenNL ambitions

Acceleration	☑
Scaling up	
Reducing costs	☑
Innovative ecosystem	☑
New talents	☑

2026	2027	2028	2029	2030 and beyond
• Signing consortium agreement				

HySUCCESS

Non technological aspects of using green hydrogen

Start	December 2024
Subsidy	€ 12.164.310
Private contribution	€ 985.913
Leadership	Linda Steg (RUG), Henk Akkermans (Tilburg University)

10 universities

1 research institute
5 universities applied science

3 industrial partners

Research Tasks

1. **ROLE OF HYDROGEN** in a carbon neutral energy system and assess the environmental

2. Factors hindering and enabling the **economic feasibility** of hydrogen business cases

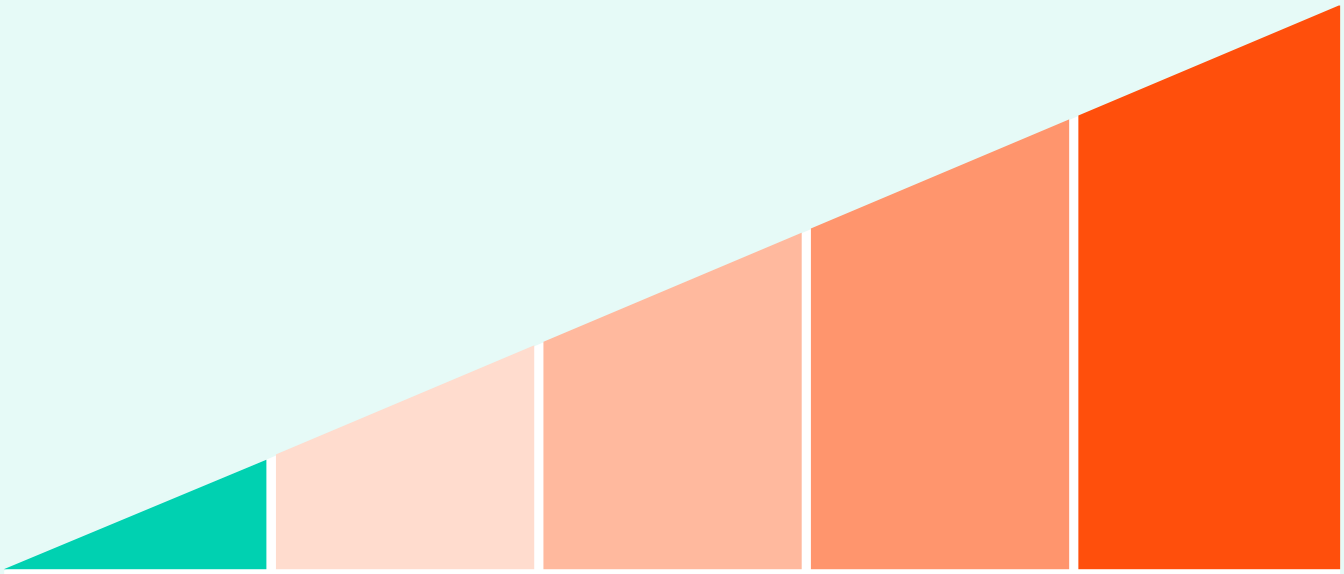
3. **LEGAL FRAMEWORKS** and policy instruments affecting the feasibility of hydrogen options

4. **SOCIOCULTURAL FACTORS** of hydrogen feasibility

5. **INTEGRATION** and microreactors

GroenvermogenNL ambitions

Acceleration	☑
Scaling up	☑
Reducing costs	
Innovative ecosystem	☑
New talents	☑



inputs	activities	outputs	outcomes	impact
Experts, **cross work package collaboration mechanisms, use-cases**.	Examine the **role of hydrogen** in a carbon neutral energy system and assess environmental impact. Assessment of factors hindering and enabling the **economic feasibility** of hydrogen business cases. **Legal frameworks** and policy instruments affecting the feasibility of hydrogen options. Assessment of **sociocultural factors** of hydrogen. Integration of the findings from Task 1-4.	Creation and dissemination of actionable scenarios, lessons, policy recommendations, labor market analyses, and public acceptance insights on how to integrate hydrogen technologies, shape adaptive regulatory frameworks, and inform policy-making for a green hydrogen economy.	**Hydrogen scenarios** to be adopted in policy decision-making; for governments, businesses, and grid operators. **Policy recommendations** on legal and process changes to be integrated into adaptive regulatory frameworks, Labor market effects to be incorporated into relevant policymaking and the GVNL Human Capital Agenda, Effective understanding of the drivers of public **acceptance** of hydrogen.	**Acceleration** by removing policy barriers through better regulatory frameworks. **Upscaling** by strengthening business cases, labour availability & public support. Strong links to the other work packages. **Innovative ecosystem** with new participants in the consortium. **New talents** because approximately 20 PhD's are recruited and become involved in hydrogen issues.

2024	2025	2026	2027	2028	2029	2030	Beyond
• December start	• Laws and policies, vision, • Use-case integration with WP1,2&3.	• Socio-techno-economic and political reports • Just directionality		• Factors influencing public acceptability of H2 systems		• Communi-cation and dissemination	

Hoofdstuk 2

Pilots en demonstraties DEI+ projecten

H2 Hollandia

Start	2022
Subsidy	€ 6.567.117
Private contribution	€ 27.003.256
Project Coordinator	Jeroen Jansen
Expected results	2026

Project partners

novar
REPOWERED
Avitec

Description of the project:
H2 Hollandia's objective is to use some of the solar energy generated at Vloeivelden Hollandia to produce green hydrogen. H2 Hollandia plans to produce around 300,000 kg of hydrogen annually by installing a 5 MW electrolyser at the 115 MWp Vloeivelden solar farm. This could halve that solar farm's curtailment (the electricity that cannot be delivered to the grid and is therefore wasted).

Impact:

Acceleration	☑
Scaling up	☑
Reducing costs	☑
Innovative ecosystem	☑
New talents	

- **Acceleration** by converting solar power curtailment into hydrogen, speeding up the rollout of clean hydrogen infrastructure.
- **Scaling up** by installing 5 MW electrolyser at the 115 MWp solar park, demonstrating the feasibility of scaling green hydrogen production.
- **Reducing costs** by halve the curtailment, using lost energy at low price.
- **Innovative ecosystem** by setting up a user group of stakeholders.

DUWAAL

Start	2022
Subsidy	€ 6,799,126
Private contribution	€ 15,860,874
Project Coordinator	Jan Willem Langeraar
Expected results	2025

Project partners

TNO HYGRO AVIA

Description of the project:
Duwaal is building an integrated green hydrogen chain in Noord-Holland, connecting production at wind turbines with high-pressure storage, distribution, and end-use in mobility. The project includes five refuelling stations and 100 hydrogen trucks, laying the groundwork for a regional hydrogen network. By delivering scale and aligning supply and demand, Duwaal reduces investment risk and opens opportunities for other hydrogen projects.

Impact:

Acceleration	☑
Scaling up	☑
Reducing costs	☑
Innovative ecosystem	☑
New talents	

- **Acceleration:** Drives rapid hydrogen rollout by coordinating the full value chain.
- **Scaling up:** Creates a replicable system for regional hydrogen hubs across the Netherlands.
- **Reducing costs:** Enables economies of scale through bundled production, logistics, and end-use.
- **Innovative ecosystem:** Unites energy, transport, and research partners in a system-wide approach.

XINTC's H2 Experience Centre

Start	2023
Subsidy	€ 1,682,232
Private contribution	€ 2,534,706
Project Coordinator	Thornston Holtmüller
Expected results	2024

Project partners

Description of the project:
XINTC is developing a modular electrolyser system in Kootwijkerbroek, directly connected to an operational solar farm. This demonstration site serves as an experience center for stakeholders and will produce green hydrogen for mobility starting in 2024. The long-term ambition is to scale the system to 2.4 MW, enabling flexible, cost-effective, off-grid hydrogen production.

Impact:

Acceleration	☑
Scaling up	☑
Reducing costs	☑
Innovative ecosystem	☑
New talents	☑

- **Acceleration:** Demonstrates rapid deployment of solar-powered, off-grid hydrogen systems.
- **Scaling up:** Modular design supports straightforward scaling to 2.4 MW and beyond.
- **Reducing costs:** Direct solar-to-electrolyser connection cuts investment and maintenance costs.
- **Innovative ecosystem:** Combines renewable energy, electrolysis, and system integration in one solution.
- **Talent:** Offers a learning platform for technicians and policymakers through the experience center.

TANDEM

Start	2024
Subsidy	€ 3,995,119
Private contribution	€ 5,402,607
Project Coordinator	Alex De Jong
Expected results	2028

Project partners

UNIVERSITY OF TWENTE. BRIGHT HYGEAR

Description of the project:
The TANDEM project is developing a 1 MW E-methanol system that converts biogenic CO2 and renewable electricity into methanol using a new LOGIC reactor technology. The system, designed for decentralised applications, will be tested and demonstrated at HyGear's site, with research support from the University of Twente. TANDEM aims to validate flexible, low-energy methanol production that enables long-term storage of renewable energy.

Impact:

Acceleration	
Scaling up	☑
Reducing costs	☑
Innovative ecosystem	
New talents	

- **Scaling up:** Modular, low-energy design allows replication at other decentralised sites.
- **Reducing costs:** LOGIC reactor cuts energy use and simplifies the methanol synthesis process.

New-generation hydrogen tanks for heavy-duty mobility

Start	2025
Subsidy	€ 1,005,039
Private contribution	€ 2,342,314
Project Coordinator	Bas ten Broeke
Expected results	2026

Project partners

Envalior – Imagine the Future
Alformet
Westport Fuel Systems

Description of the project:
ENVALIOR, Alformet, and Westport Fuel Systems are developing lightweight, recyclable type 4+ hydrogen tanks designed for use in heavy-duty vehicles and other mobile applications. The project includes the production and testing of at least 20 prototypes, along with a full-scale demonstration in a hydrogen-powered truck. These next-gen tanks aim to improve storage capacity, safety, and sustainability, while reducing system weight and costs.

Impact:

Acceleration	☑
Scaling up	☑
Reducing costs	☑
Innovative ecosystem	
New talents	

- **Acceleration:** Enables faster adoption of hydrogen in transport through safer, lighter tanks.
- **Scaling up:** Supports future mass production with scalable design and manufacturing tools.
- **Reducing costs:** Uses recyclable thermoplastics and laser-based production to lower materials and processing costs.

500 kW alkaline elektrolyser for gas-fired ovens

Start	2024
Subsidy	€ 750,250
Private contribution	€ 2,250,750
Project Coordinator	Wilbert Heffels
Expected results	Delivered June 2025

Project partners

NEDMAG

VDL

Description of the project:
Nedmag and VDL are piloting a 500 kW alkaline electrolyser to produce green hydrogen for use in Nedmag's high-temperature gas-fired ovens. The aim is to assess technical, safety, and operational integration in a real industrial setting where electrification is not viable. The project serves as a stepping stone for future scale-up, with significant CO_2 reduction potential.

Impact:

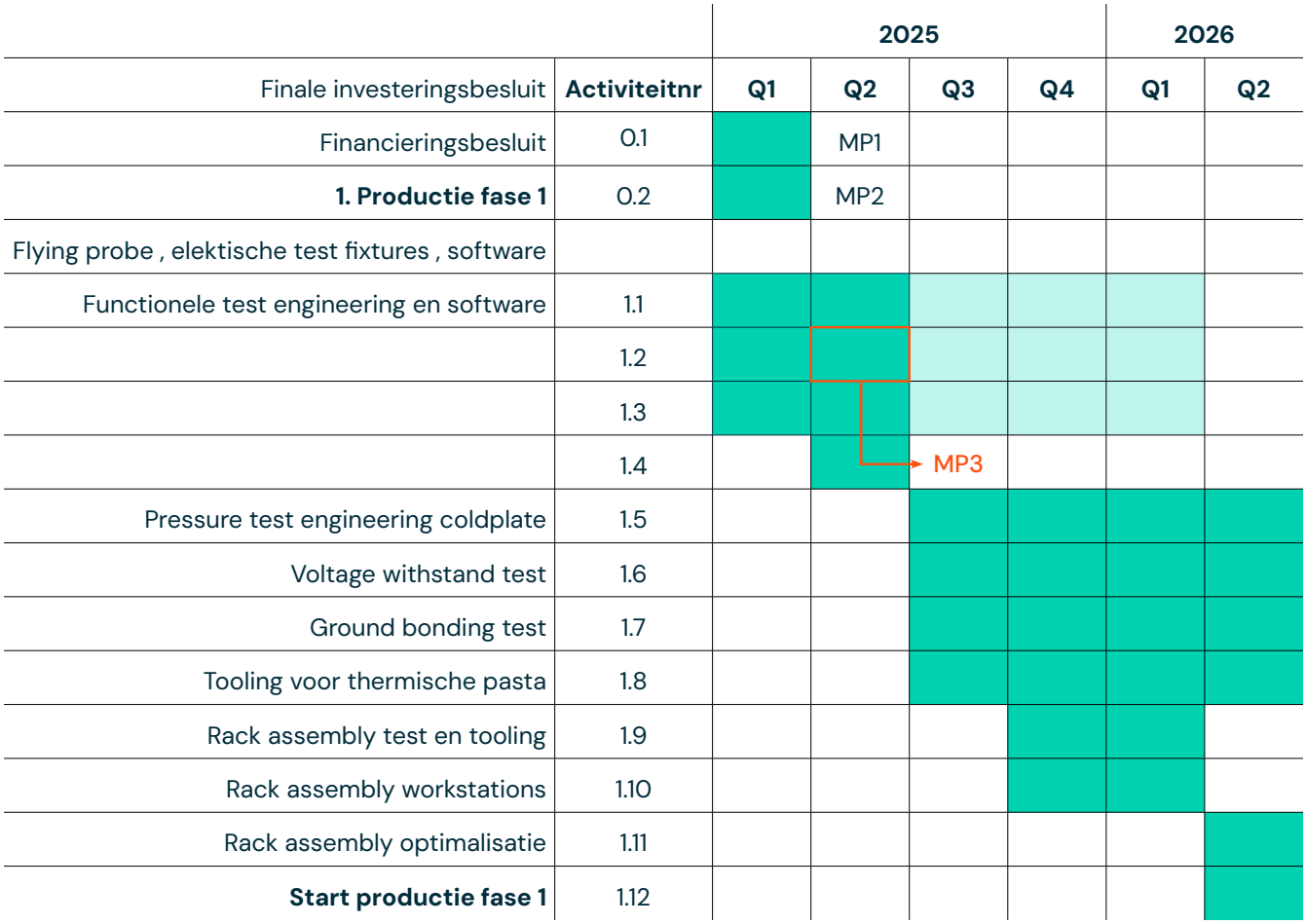
Acceleration	☑
Scaling up	☑
Reducing costs	☑
Innovative ecosystem	
New talents	

- **Acceleration:** Advances hydrogen use in industrial heat.
- **Scaling up:** Prepares for expansion to 20 MW+ hydrogen production for heavy industry.
- **Reducing costs:** Builds operational knowledge to improve system efficiency and investment decisions.

Prodrive Technologies

Setting up a production lines for power electronics

Start	Januari 2025
Subsidy	€ 3.791.167
Private costs	Ca. € 20 mln
Coordination	Karsten Dietvorst
Final results	3GW per year in phase 3 Q3 2029



Milestones:

1. FID and ID taken and approved by RVO (Q1 2025)

2. First Testing hardware being engineered

Updates end of Q2:

According to planning (see table), the overall status looks good. Most activities are on schedule:

1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8
Voor lager volume productie zijn kosteneffectieve programeer-testen ingeregeld voor de verschillende PCBA's. Voor latere versies wordt dit principe geautomatiseerd	Functionele test op laagspanning is ingeregeld voor de eerste versie	Handling tool is af	MP3 zal worden gezien als behaald met de eerste proefhardware al in opstelling	Wordt gestart	Is al gestart	Is al gestart	Zal in eerste instantie met de hand worden gedaan, tooling is nog niet geautomati-seerd maar in mindere mate al wel bekend of aanwezig

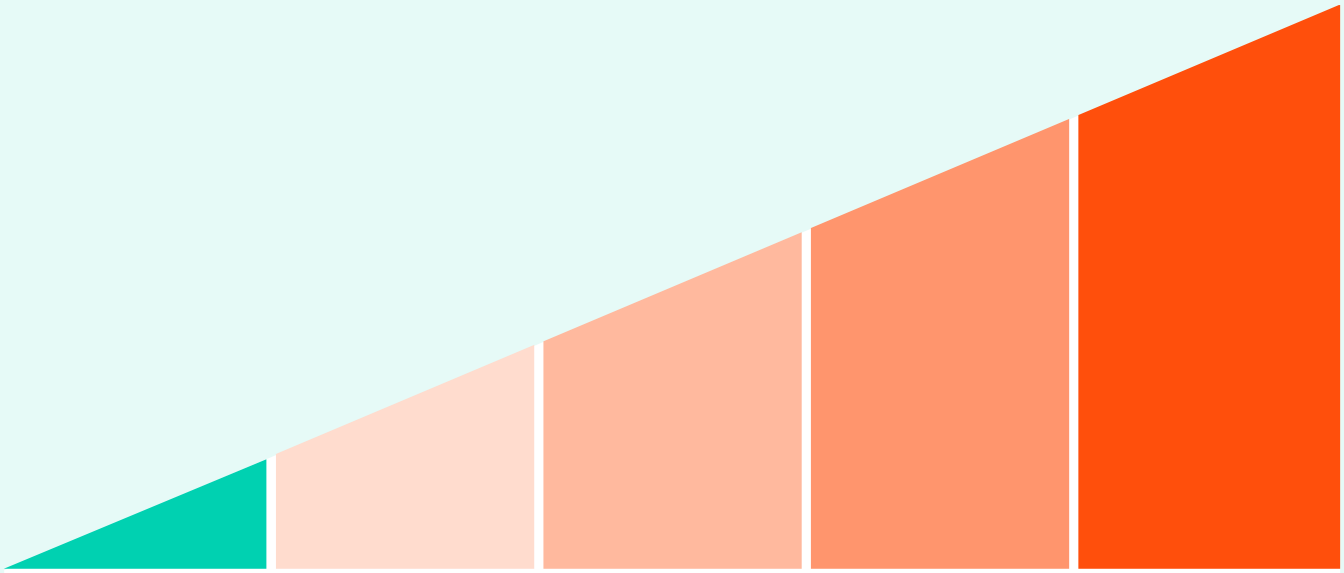
Milestones:

1. FID and ID taken and approved by RVO (Q1 2025)
2. First Testing hardware being engineered

groen vermogen nl

GroenvermogenNL ambitions

Acceleration	☑
Scaling up	☑
Reducing costs	☑
Innovative ecosystem	
New talents	



inputs	activities	outputs	outcomes	impact
Acceleration energy transition with flexible and configurable electronics without the need for specialized auxiliaries. **Scaling up** and speeding up production with new production lines. **Reducing costs** through more efficient, modular power electronics with flexible V-output.	H2 production rectifier manufacturing in The Netherlands. Grid stabilizing SiC-electronics for GW-scale hydrogen production. Single, future-proof electronics solution for all electrolysers.	Three phases of industrialization with increasing production capacity. Dedicated production and assembly lines for H2 production rectifiers. Dissemination of project results.	Test development and automation. Handling tool and assembly solutions development. Setting up production and logistics lines.	Over 4 years of rectifier electronics development. 30+ years experience in electronics design, development and manufacturing. Significant investments and subsidy project results (like Smart Rectifier project).

Hoofdstuk 3

FEED studies TSE industries

Project SOON

Start	2024
Subsidy	€ 525,000
Private contribution	€ 525,000
Project Coordinator	Ruud Swarts
Expected results	2025

Project partners

OCI Methanol Europe

Description of the project:
OCI Nitrogen is conducting a feasibility study that explores the decoupling of its steam methane reformer (SMR) from the ammonia synthesis unit to enable the use of sustainable hydrogen. This environmental and technical study results in a detailed plant design, impact assessment, and techno-economic model. The project supports OCI's long-term goal of carbon-neutral ammonia production by replacing fossil-based hydrogen.

Impact:

Acceleration	☑
Scaling up	☑
Reducing costs	☑
Innovative ecosystem	
New talents	

- **Acceleration:** Provides a study for fossil-free ammonia production using renewable hydrogen.
- **Scaling up:** Intended to retrofit existing plant, offering a scalable decarbonization model.
- **Reducing costs:** Supports a business case by mapping cost and performance impacts.

BioMCN

Start	2024
Subsidy	€ 344.400
Private contribution	€ 351.600
Project Coordinator	Freek Leuveld
Expected results	2025

Project partners

OCI Methanol Europe

Description of the project:
BioMCN is aiming to replace the production of syngas (a mixture of H2, CO and CO2) by their steam methane reformer (SMR) with the direct import of green H2 and biogenic CO2. The goal of this study is to gain more insights in the technical feasibility, efficiency, energy and heat balances and CO2-emission reduction of replacing the current natural gas-based SMR with direct inlet of biogenic CO2 and green H2 for obtaining syngas in case of three different scenarios. Furthermore, the study will provide details on the expected greenhouse gas emission reduction and other environmental impact.

Impact:

Acceleration	☑
Scaling up	☑
Reducing costs	☑
Innovative ecosystem	☑
New talents	

- **Acceleration** by advancing basic engineering to replace fossil SMR with green H_2 and biogenic CO_2.
- **Scaling up** by creating a retrofit model for large-scale industrial decarbonization.
- **Reducing costs** by evaluating CAPEX and performance to find cost-effective decarbonization paths.
- **New talent by** involving engineers in early-stage green fuel integration.

SwitchH2

Start	2024
Subsidy	€ 1.382.000
Private contribution	€ 592.000
Project Coordinator	Bob Rietveldt
Expected results	2028

Project partners

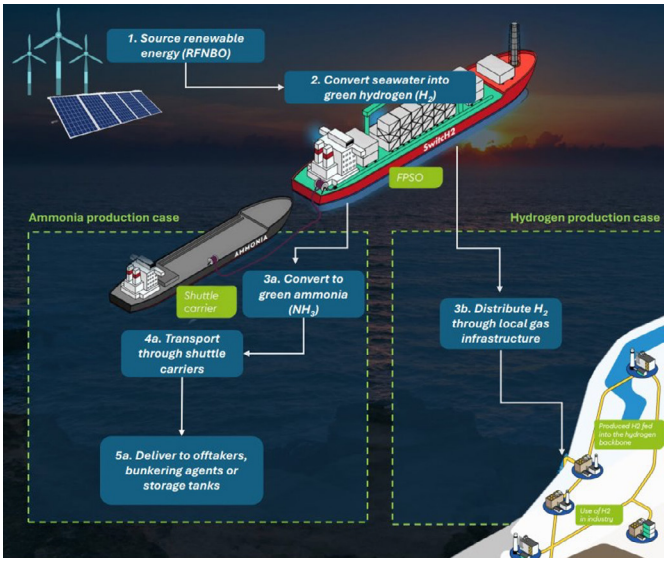
SwitcH2 B.V.
SeaWater into Clean Hydrogen

Description of the project:
SwitcH2's objective is to carry out a preparatory (environmental)study into a demo project that is developing the first FPSO (Floating Production Storage and Offloading Unit) – a floating platform for the production, storage and transhipment of NH3. The study aims to create a technologically validated, economically feasible and organisationally sustainable design for this FPSO in Portugal. The project studies the demonstration of large-scale conversion and energy storage in green NH3 as well as the accompanying (import) transport chain for supplying Dutch industry using shuttle tankers.

Impact:

Acceleration	☑
Scaling up	
Reducing costs	☑
Innovative ecosystem	☑
New talents	

- **Acceleration** by tackling permits and environmental checks early to fast-track deployment.
- **Reducing costs** by producing H_2 & NH_3 in Portugal with cheaper green electricity & by avoiding large investments in infrastructure.
- **Innovative ecosystem** by connecting with local partners for tendering, permitting and system integration.



De Leidingstraat

Start	2024
Subsidy	€ 393.700
Private contribution	€ 192.500
Project Coordinator	Tamara Koeman
Expected results	2027

Project partners

Description of the project:
The research focuses on the technical, economic and spatial planning feasibility and suitability of a green hydrogen installation at three possible locations, within the Energy Landscape ´De Groene Kamers van Rilland´. The congestion issue and the mismatch between supply and demand are currently the main obstacles for the ongoing energy transition. In addition to the necessary reinforcements of the network, the incorporation of buffer capacity and regulating capacity (flexibility) is also necessary to achieve the energy transition goals. The development of this green hydrogen installation can relieve the electricity grid at busy times.

Impact:

Acceleration	☑
Scaling up	
Reducing costs	☑
Innovative ecosystem	☑
New talents	

- **Acceleration** by relieving grid congestion, enabling faster integration of new renewable generation.
- **Reducing costs** by optimizing grid capacity and reducing curtailment or expensive reinforcements.
- **Innovative ecosystem** by connecting energy producers, network operators, and hydrogen users in a pioneering setup.

HyDEER

Start	2024
Subsidy	€ 365.000
Private contribution	€ 156.400
Project Coordinator	Jos Boere
Expected results	2027

Project partners

Description of the project:
The province of Flevoland is facing serious grid congestion issues. Circul8 aims to help solve this problem by converting part of the region's electricity production and curtailment into green hydrogen. This is the goal of HyDeer, a 105 MWe electrolyser. The facility is planned to be built next to a 45 MW solar park. Excess energy can be stored in the form of hydrogen, which Circul8 may also convert into green ammonia to supply local businesses across various sectors. The environmental impact study is aimed at identifying and evaluating technical and financial design options for the electrolyser in combination with several innovations.

Impact:

Acceleration	☑
Scaling up	☑
Reducing costs	☑
Innovative ecosystem	☑
New talents	

- **Acceleration** by speeding up the development of the hydrogen hub by clearing environmental and permitting hurdles early in the process.
- **Scaling up** by stablishing a robust pre-engineering plan.
- **Reducing costs** minimizing both environmental and financial risk by evaluating design options and refining the business case based on real data.
- **Innovative ecosystem** by fostering interdisciplinary collaboration around future renewable hydrogen infrastructure.

H2 op Dreef

Start	2024
Subsidy	€ 212,093
Private contribution	€ 302,990
Project Coordinator	Jorn Lijster
Expected results	2025

Project partners

Description of the project:
H2 Drive BV plans to build 10–20 MW of electrolysis capacity and a hydrogen refuelling station at a former gas extraction site in Gasselternijveenschemond. The goal is to relieve electricity grid congestion by converting regional solar energy into green hydrogen, with the NAM gas pipeline serving as a hydrogen buffer and potential future link to the hydrogen backbone. A comprehensive feasibility study covers technical, legal, ecological, and financial aspects to support an investment decision.

Impact:

Acceleration	☑
Scaling up	☑
Reducing costs	☑
Innovative ecosystem	
New talents	

- **Acceleration:** Unlocks regional flexibility for integrating solar power into the energy system.
- **Scaling up:** Designs a scalable model for decentralised hydrogen hubs using existing assets.
- **Reducing costs:** Maximises use of infrastructure and by-products for cost-effective hydrogen.

TSE Study

3D-Printed Catalytic reactor for LOHCs

Start	2024
Subsidy	€ 115,920
Private contribution	€ 165,600
Project Coordinator	Willem Brekelmans
Expected results	2025

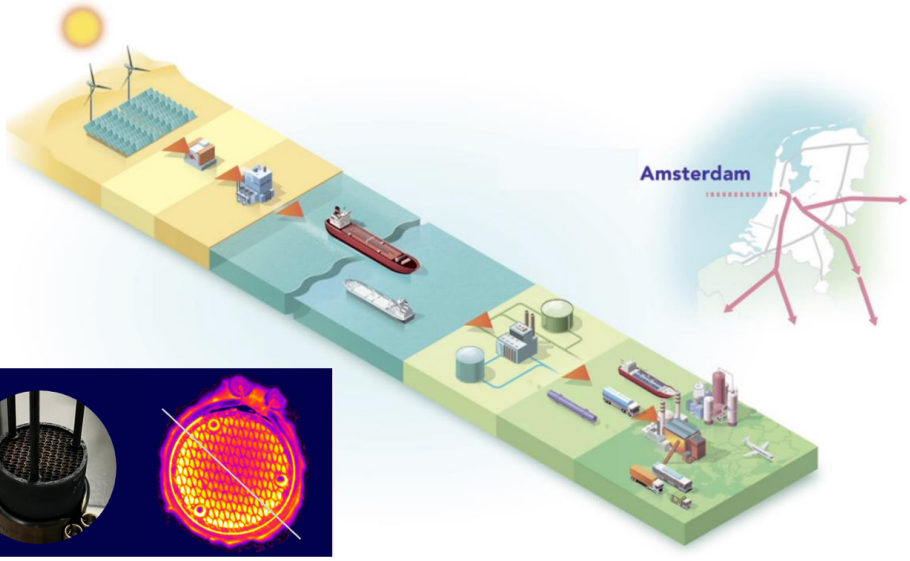
Project partners:
Catalayzer

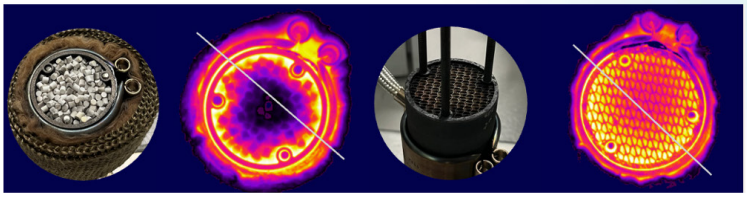
Description of the project:
Catalyzer is developing an efficient 3D-printed catalytic reactor to release hydrogen from liquid organic hydrogen carriers (LOHCs), enabling long-distance, low-cost green hydrogen transport. This study investigates the technical and economic feasibility of building a pilot facility to test and demonstrate the reactor. The project aims to reduce energy use, cut CO_2 emissions, and unlock large-scale hydrogen imports into Europe.

Impact:

Acceleration	☑
Scaling up	☑
Reducing costs	☑
Innovative ecosystem	
New talents	

- **Acceleration:** Supports hydrogen import readiness through more efficient LOHC conversion.
- **Scaling up:** Lays groundwork for pilot deployment and future commercial-scale facilities.
- **Reducing costs:** Improves reactor efficiency, reducing energy use and operational expenses.





ECOLOG

Start	2024
Subsidy	€ 4,000,000
Private contribution	€ 5,869,960
Project Coordinator	Ellen Van Der Veer
Expected results	2027

Project partners

ECOLOG

Description of the project:
ECOLOG is developing a combined hydrogen import and CO_2 export terminal in the Afrikahaven of Amsterdam, creating a key logistics hub for sustainable energy and emissions reduction. The terminal will receive liquid hydrogen from countries like Oman and use its cold energy to liquefy captured CO_2 from the Netherlands, which will then be shipped for underground storage. This dual-function facility enables efficient use of infrastructure while connecting Dutch industry to European energy and climate networks.

Impact:

Acceleration	☑
Scaling up	☑
Reducing costs	☑
Innovative ecosystem	☑
New talents	

Acceleration: Fast-tracks hydrogen deployment and CO_2 reduction through smart infrastructure.

Scaling up: Creates an opportunity for hydrogen imports at a larger scale than local production.

Reducing costs: Makes a new business case for liquid H_2.

Innovative ecosystem: Combines hydrogen import and CO_2 storage in a single, integrated energy port including public authorities.

AMMONEX

Start	2025
Subsidy	€ 4,381,400
Private contribution	€ 10,676,922
Project Coordinator	Sebastiaan de Fuijk
Expected results	2028

Project partners

Duiker CLEAN ENERGY

Description of the project:
Duiker Clean Technologies is building an industrial-scale pilot plant to validate its ammonia cracking reactor (ACR), which converts imported low-carbon ammonia into hydrogen. The technology offers a scalable solution for long-distance hydrogen transport using existing ammonia infrastructure in the Port of Rotterdam. The pilot will provide performance and reliability data to support commercial deployment of ammonia in hydrogen supply chains and industrial decarbonisation.

Impact:

Acceleration	☑
Scaling up	☑
Reducing costs	☑
Innovative ecosystem	
New talents	☑

- **Acceleration:** Unlocks ammonia as a near-term carrier for industrial hydrogen use.
- **Scaling up:** De-risks a modular, scalable technology ready for ports, starting in Rotterdam.
- **Reducing costs:** Targets lower hydrogen production costs through energy-efficient cracking.
- **Talent:** Builds technical expertise in hydrogen conversion technologies in coordination with the Just Transition Fund.

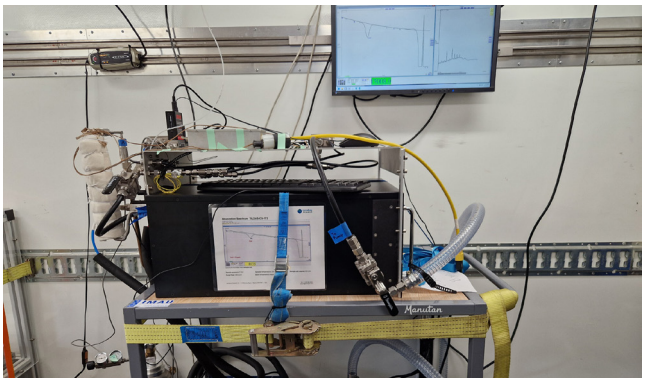
Hoofdstuk 4

Incidentele subsidies

MEETH2

Measuring H2-leakage and setting up protocol for measurements

Start	2025
Subsidy	€ 542.900
Private contribution	€ 34.133
Coordination	Arjan Hensen en Ilse Schoenmaker (TNO)
Final results	Until February 2027



Planning and milestones

These sub-projects are crucial for developing a trading platform for hydrogen as HyXchange envisons it. Each sub-project contributes to the solution of specific market design – and implementation issues.

1

Development of a methodology and set-up of a measurement program (target: January -June 2025):

- Concept measurement protocol – April 2025
- Overview relevant meas–urement sites – April 2025
- Delivery and installation of H2 equipment – April - May 2025
- Workshop with stake–holders – May 2025

2

Selection of potential measurement sites together with stakeholders

(target: February – August 2025)

3

Measurements by TNO's measurement team

(target: May 2025 – May 2026)

4

Analysis of collected data and reporting

(target: September 2025 – December 2026)

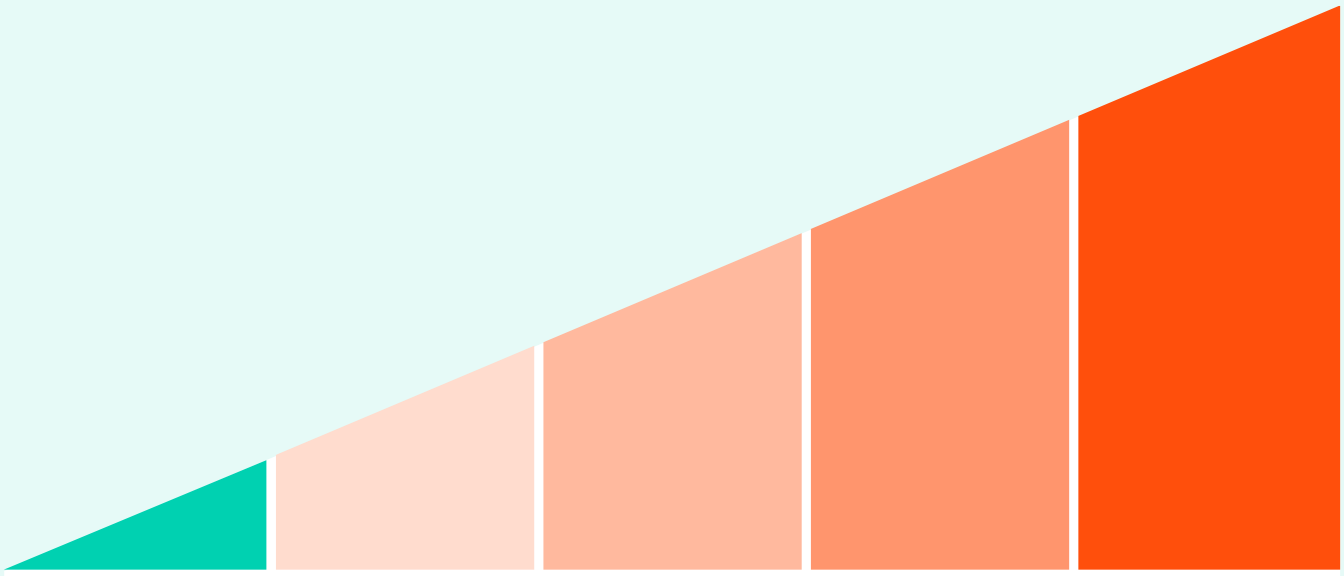
5

Communication and project management

(continuous during project duration)

GroenvermogenNL ambitions

Acceleration	☑
Scaling up	
Reducing costs	☑
Innovative ecosystem	☑
New talents	

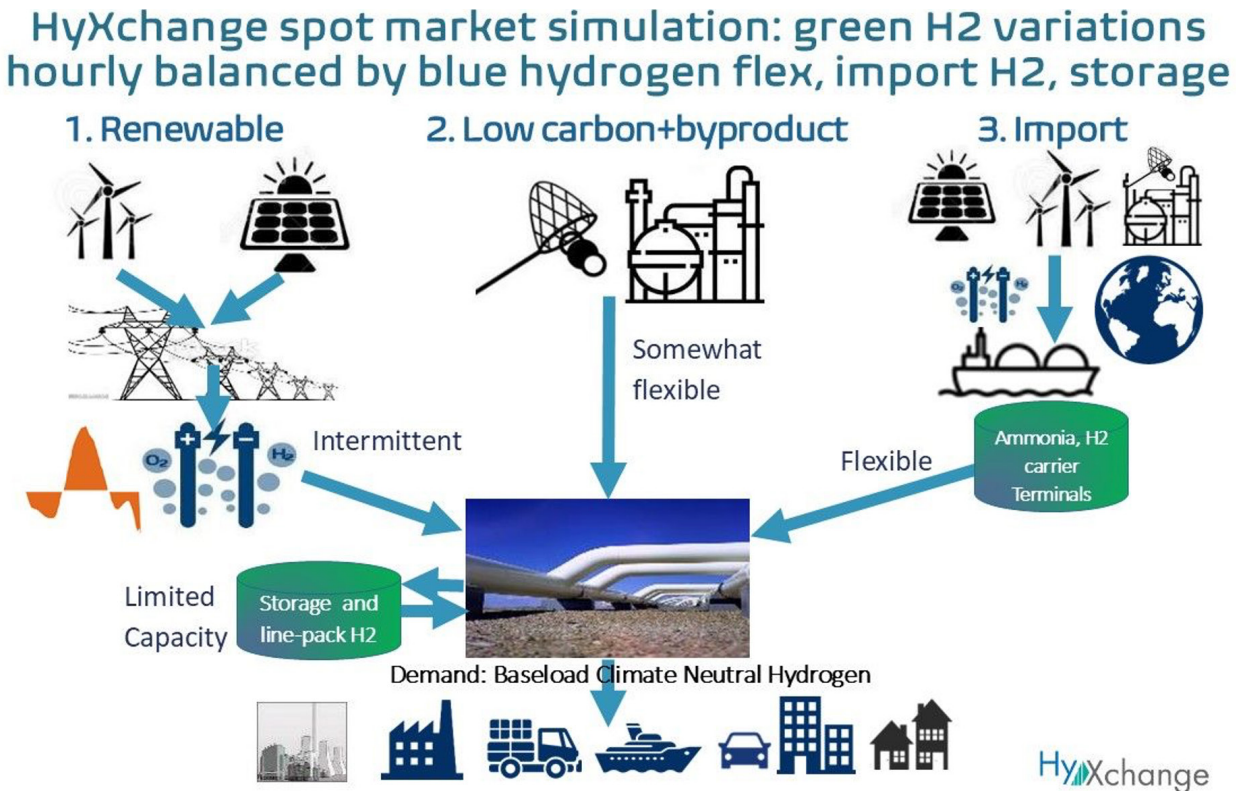


inputs	activities	outputs	outcomes	impact
Acceleration by developing a measurement method/ protocol and by providing input for future permitting procedures and climate policy. **Reducing costs** by possible standards for permitting procedures. **Innovative ecosystem** by initiating collaboration with stakeholders.	Insight in H2 leakages: determination emission factors and quantification of leakages. Basis for an innovative measurement methodology, including a measurement protocol.	Key insights for each involved measurement location. Overall report with anonymized research findings.	Initiating collaboration with stakeholders. Mobile and stationary measurements of H2 leakage. Measurement nearby production areas (from public road and on-site).	TNO knowledge and time. Mobile measurement van equipped with a H2 measurement instrument from the US and other relevant equipment (meteorological a.o.).

HyXchange

Setting up a trading platform

Start	Q2 2025
Subsidy	€ 220.000
Private contribution	€ 140.000
Leadership	Bert den Ouden en Joachim Schellekens
Final results	Q1 2026



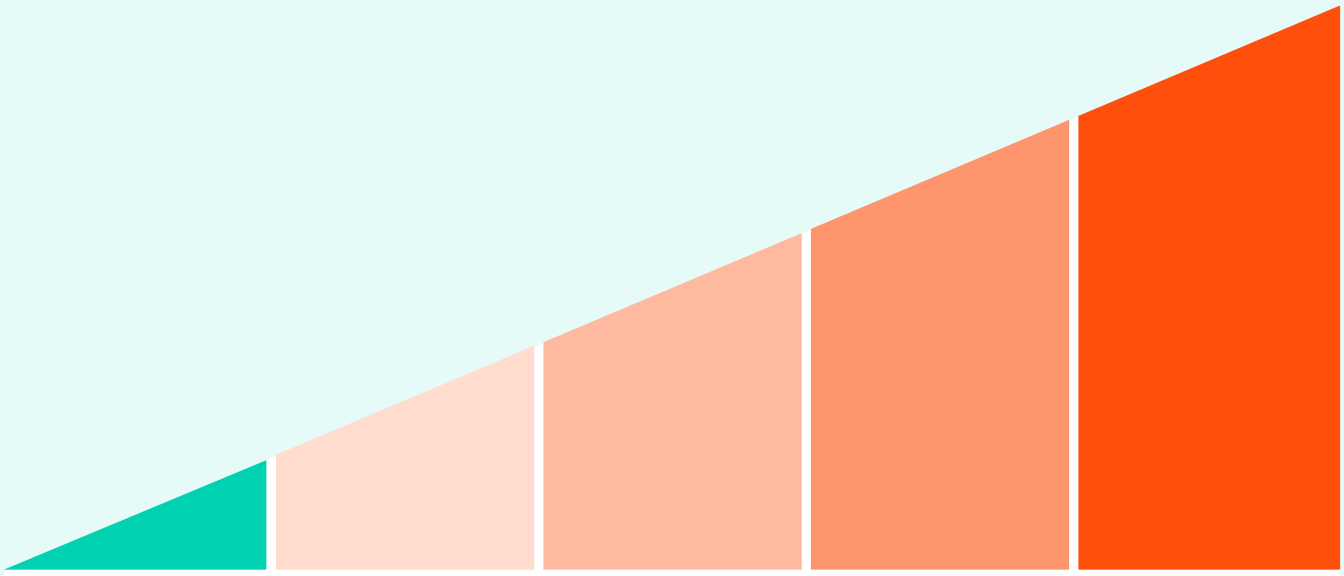
Sub-projects

1. **Report EU-certification methods** with mass balance approach
2. **Automation price indices** for H2 and wind-PPA's extension
3. **Hydrogen market simulation** for 2030, 2035 and 2040; including book-and-claim certificate trade
4. **Preparation of auction in certificates** with the book & claim method

These sub-projects are crucial for developing a trading platform for hydrogen as HyXchange envisons it. Each sub-project contributes to the solution of specific market design – and implementation issues.

GroenvermogenNL ambitions

Acceleration	☑ ☑
Scaling up	☑
Reducing costs	☑
Innovative ecosystem	
New talents	



inputs	activities	outputs	outcomes	impact
Acceleration by realizing a trading platform thereby stimulating the market. **Scaling up** because of potential growth in matching supply and demand. **Reducing costs** by deminishing risks by valorized certificates.	Insight in basic functioning of a trading platform on the short term (when the H2-grid is not yet completed) and the longer term (when H2-supply/demand has increased volume and usage).	Mass balance system valorization Automating HYCLICX Trade simulation throughout NL as a whole, both physical and administrative Tendering with book & claim method.	Research, simulations and tender.	Budget and time from members of Steering Group (Gasunie, Dutch harbours, HyXchange, EBN, TNO, Hinicio, Berenschot, E-bridge, ministry KGG).

Ideation Lab – 4TU

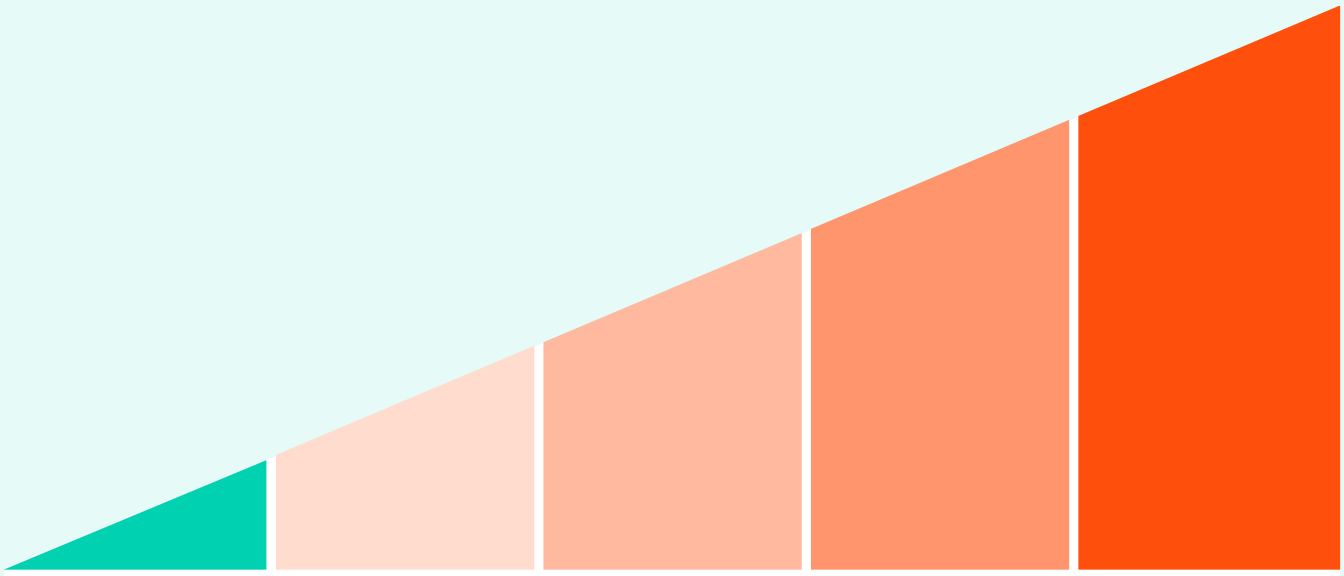
First steps towards startups

Start	Phase 1 2023; phase 2 2025
Subsidy	€ 693.000
Private contribution	€ 700.000 (universities)
Leadership	Gerard Smeden (TU Delft)
Final results	Several years until 2028

TU Delft, TU Eindhoven, Wageningen University of Research, Universiteit Twente, Founded (regio Friesland, Groningen en Drenthe), Radboud Universiteit, Universiteit Utrecht, Vrije Universiteit Amsterdam, Hogeschool van Amsterdam, Maastricht University, Tilburg University, Saxion Hogeschool.

GroenvermogenNL ambitions

Acceleration	☑
Scaling up	
Reducing costs	
Innovative ecosystem	☑
New talents	☑



inputs	activities	outputs	outcomes	impact
Acceleration helping form new startups. **Innovatiev ecosystem** possible new Dutch entrants in the ecosystem. **New talents** students valorizing academic research.	Students get to know what it means to set up a company. Students helped forming a start up.	Training 100+ students. 20+ new startups. 45+ valorized topics.	Training courses Individual support Coordinated approach with 12 universities (some of applied sciences).	Subsidy Connection with supporting organizations from universities (like YES Delft). Trainers and project help.

Fluidwell

Start	2025
Subsidy	
Private contribution	
Project Coordinator	Sjoerd Van Acht
Expected results	2027

Project partners

Description of the project:
Fluidwell is leveraging its core to develop modular electrolyser systems of 100–500 kW per unit. Building on its operational 120 kW PEM prototype, the company aims to produce 50 systems per year from 2024–2027 and scale up to 500 units annually in phase two. By focusing on modularity, local manufacturing in Veghel, and stack-agnostic flexibility, Fluidwell aims to reach the market of small-medium scale local H2 production.

Impact:

Acceleration	
Scaling up	☑
Reducing costs	☑
Innovative ecosystem	
New talents	

- **Scaling up:** Targets scale-up from 50 to 500 units/year through standardisation and series production.
- **Reducing costs:** By scaling up production capacities in the Netherlands and standardising components.

Hoofdstuk 5

Human capital agenda

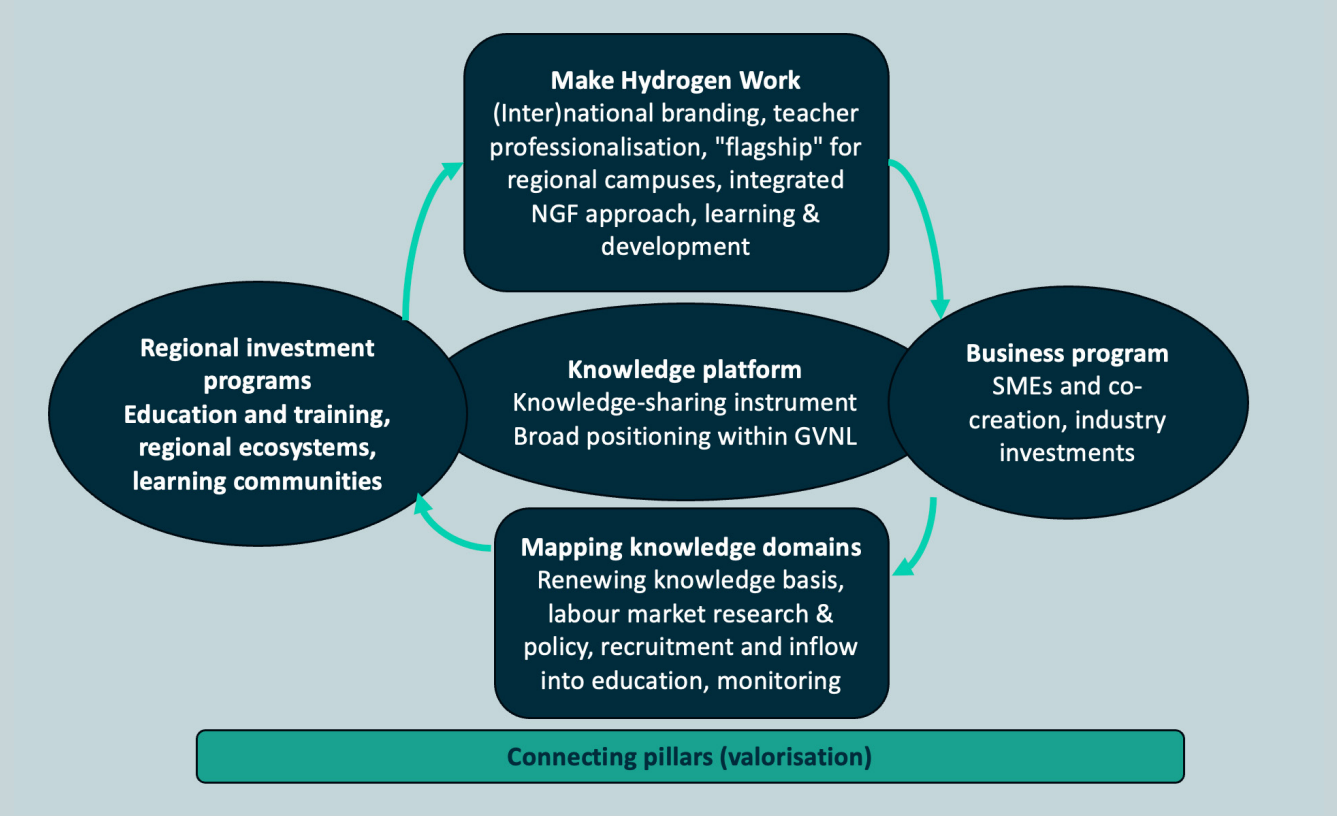
GroenvermogenNL HCA
Overview HCA

General information

Human capital agenda:

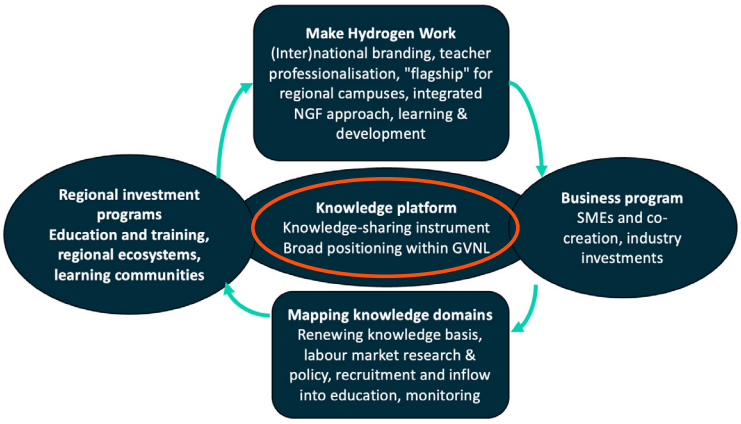
1. Mapping knowledge domains
2. Regional investment programs
3. Knowledge platforms
4. National education and training infrastructure
5. Innovation and training incentives for industry

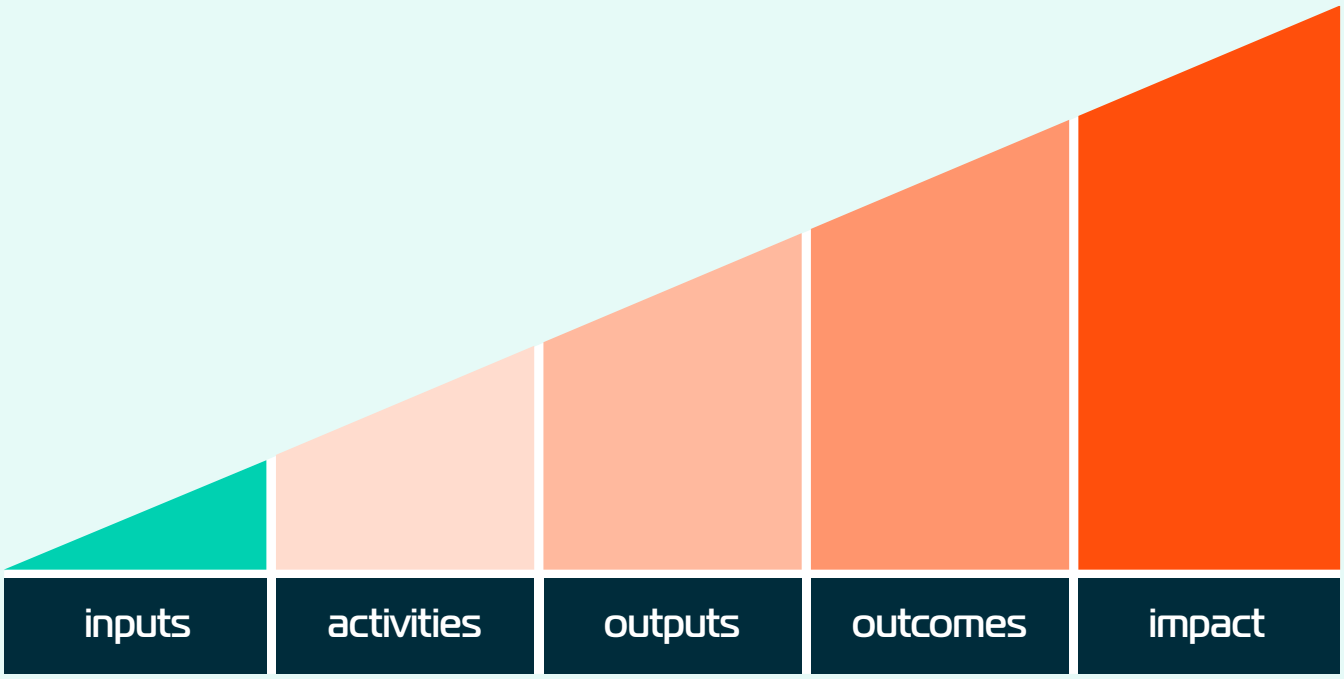
Connecting pillars R&D-P&D-HCA



Knowledge platform

Acceleration	☑
Scaling up	
Reducing costs	
Innovative ecosystem	☑
New talents	☑





inputs	activities	outputs	outcomes	impact
Acceleration by sharing validated knowledge. Innovative ecosystem by connecting key players throughout the value chain. **New talents** by offering the basis for accelerating learning by students, teachers, professionals, and researchers.	An (inter)national community of learners, researchers, and innovators to facilitate large scale knowledge sharing and application.	A smart and digital knowledge tool with validated data and information on green hydrogen and methods. for learning.	Building digital tools, content (R&D, demonstrator, pilots), community building, combining supply and demand for knowledge, integrating Make Hydrogen Work.	Working with SURF and NPuls; connecting with regional learning communities, synergizing pillars of GVNL & subsidies from HCA-GVNL.

Fase 1 Prototype (2022-2024):

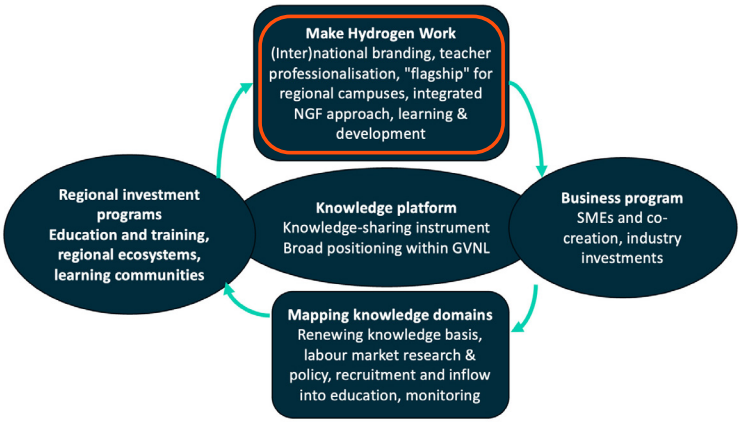
• Door consortium o.l.v Hanze	• **Resultaat**: prototype, organisatieplan en programma van eisen.	• **Investering:** €600.000

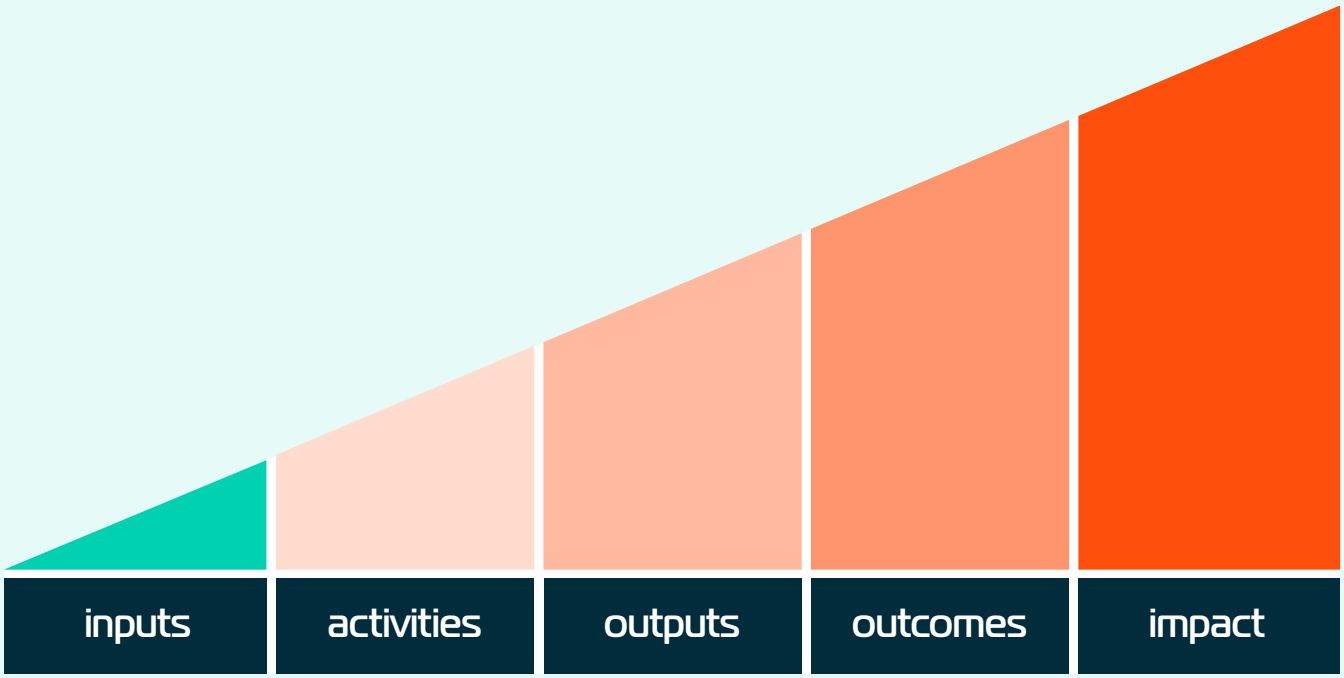
Fase 2 Proof of Concept (2025-2026):

• Start met intentieverklaring, doel is praktijkwerkbaarheid aantonen met integratie van componenten en testen met echte data/ gebruiksdoelen	• Inrichting programma organisatie voor ontwikkeling en testen van digitale tools. Samenstelling stuurgroep Npuls, SURF en GVNL.	• Investering van €800.000 vanuit Npuls (2025/2026)	• **Vooruitblik:** In Q1 2026 opstellen van een meerjarig en gezamenlijk opschalings- en doorontwikkelingsplan 2026-2031

Make Hydrogen Work

Acceleration	☑
Scaling up	☑
Reducing costs	
Innovative ecosystem	☑
New talents	☑





Acceleration by enlarging the potential workforce with personalised training.
Scaling up by connecting people with vacancies.
Innovative ecosystem by connecting people throughout the value chain.
New talents through a skills-oriented approach.

More people able to fulfil hydrogen vacancies than originally expected from available backgrounds.

Regional matching of work demand and supply combined with personalised training schemes.

Developing methods for matching, skills-enhancement connected via regional approaches.

Matchmaking sessions, in-kind contributions in the regions, coordination and method sharing.

Toolings for Life Long Learning for professionals and corporations

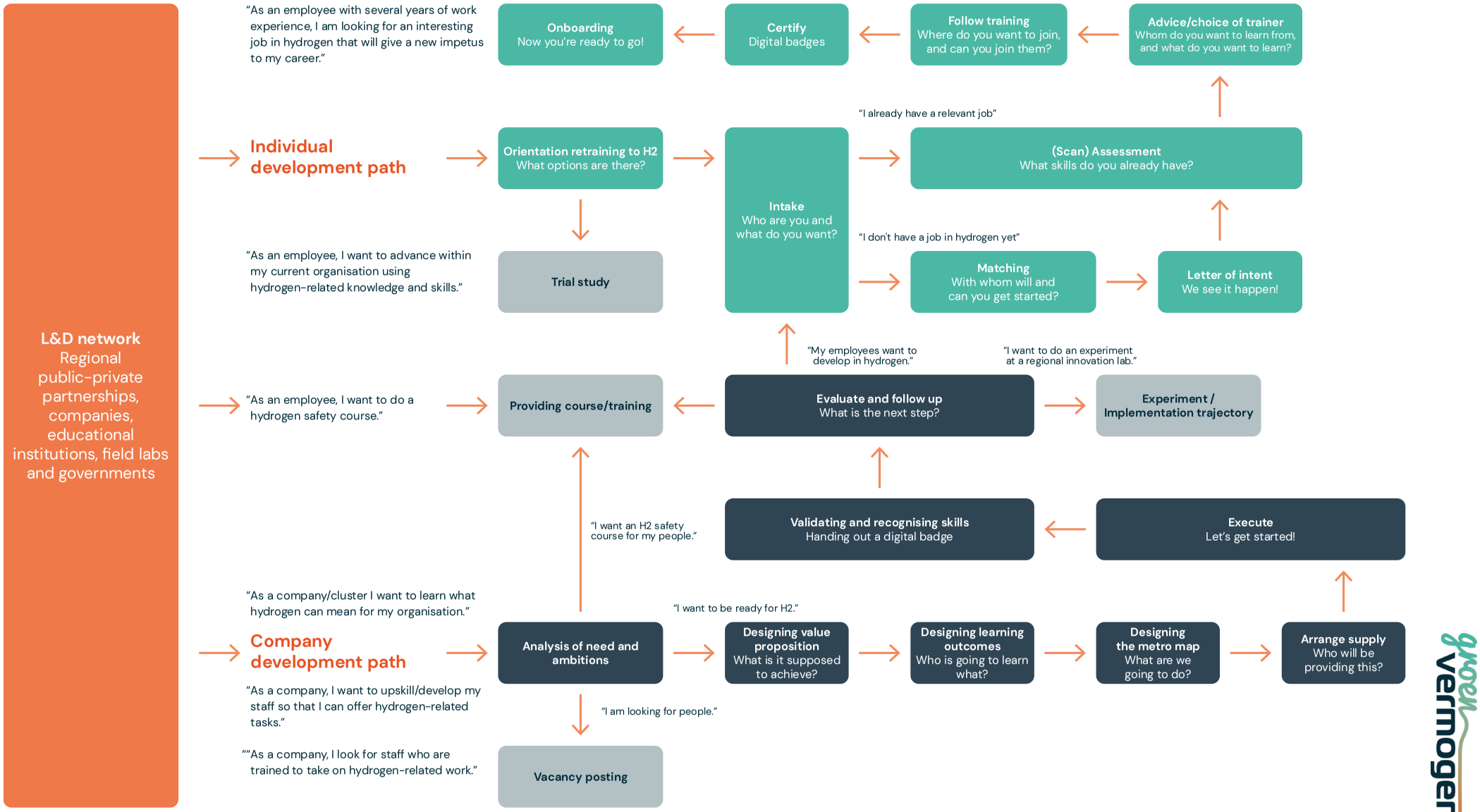
• Collaboration with European Centres for Vocational Excellence	• Development of Learning & Development networks around green hydrogen	• **Early January 2025:** first prototype

Next steps:

• After September 1st 2025, regions will start working on personal use cases (i.e. safety in working with hydrogen)	• Implementation of the action plan for the coordination and organisation of MHW

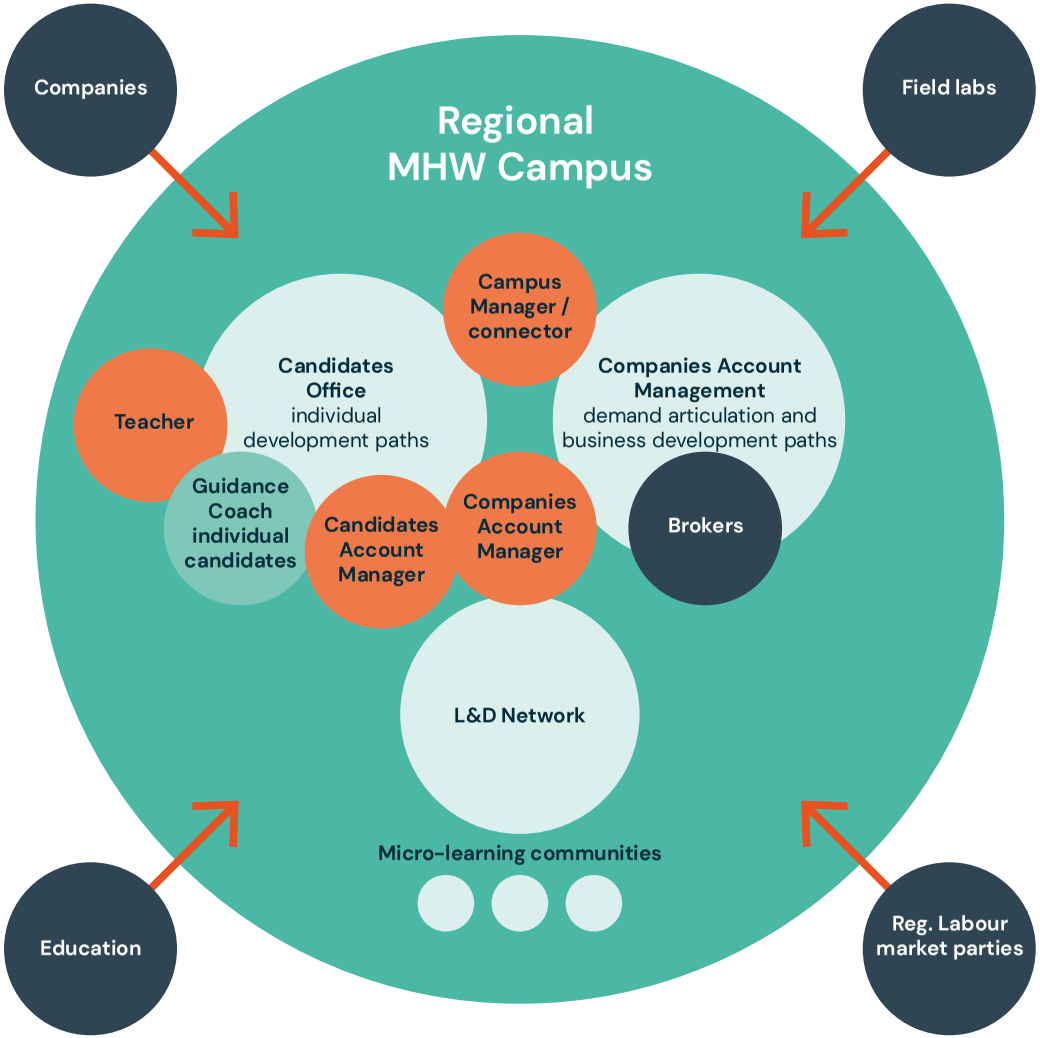
Make Hydrogen Work method

Implementation in regional campuses



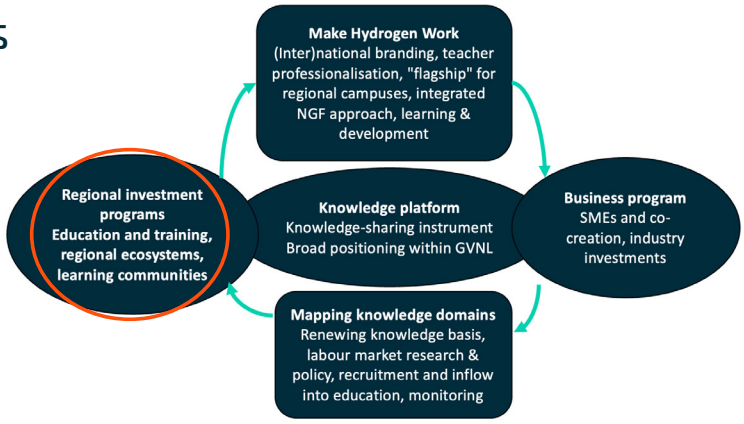
Campus organisation/roles

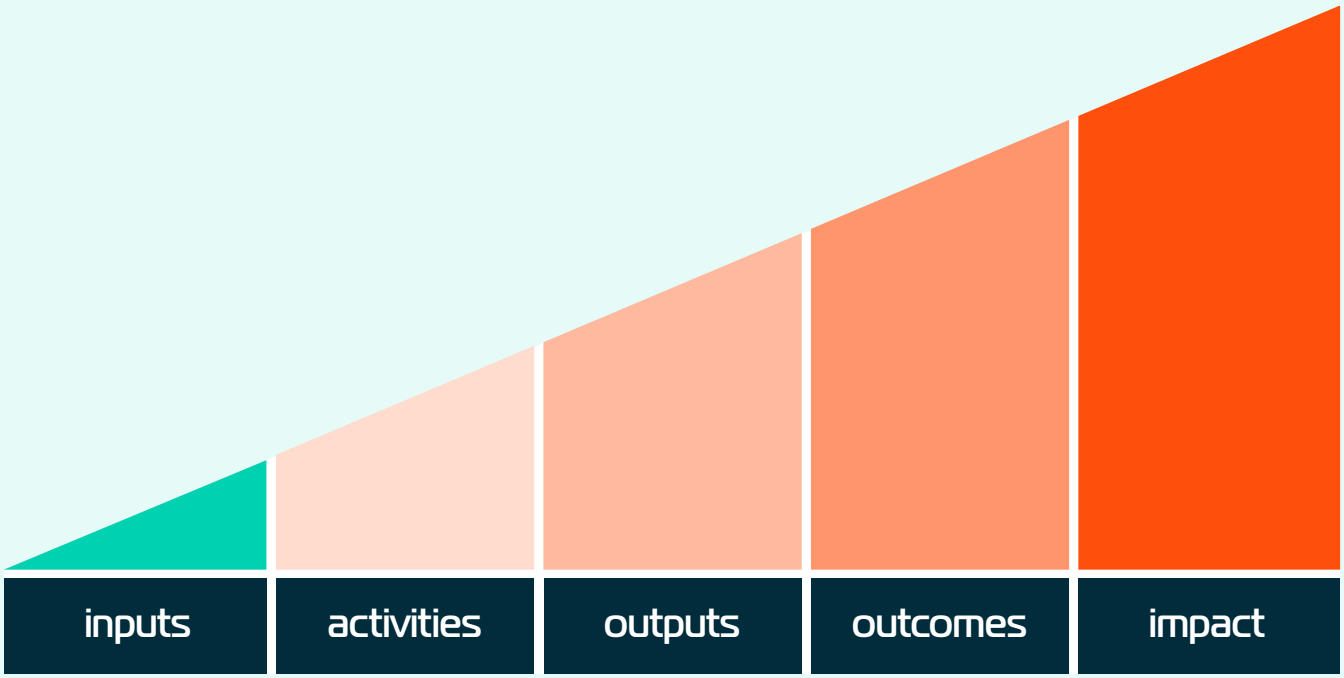
Who is needed?



Regional investment programs

Acceleration	☑
Scaling up	☑
Reducing costs	
Innovative ecosystem	☑
New talents	☑





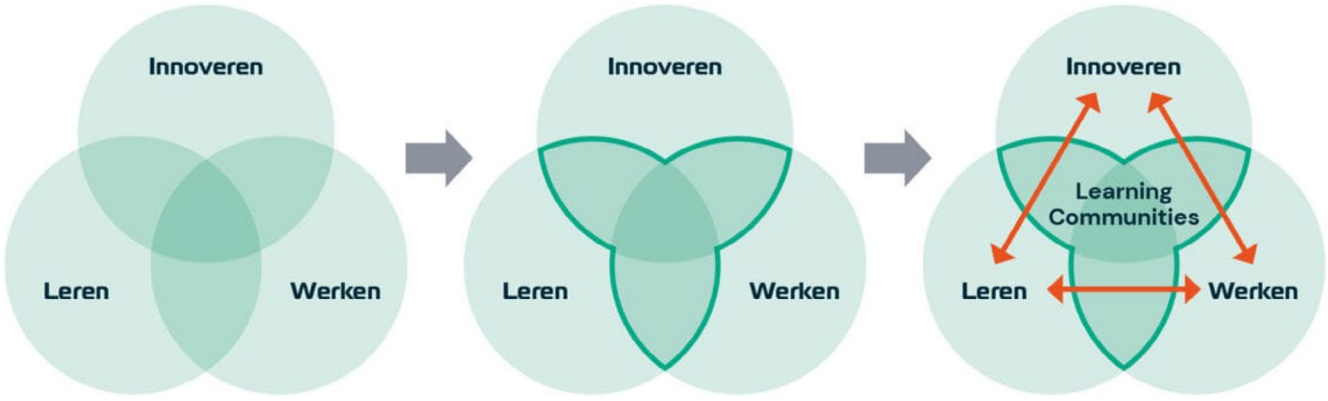
inputs	activities	outputs	outcomes	impact
Acceleration by cooperation between knowledge, companies & education. **Scaling up** by performing on roadmaps per region. **Innovative ecolsystem** by bringing key players of the HCA together. **New talents** by implementing actions from the roadmaps.	Vision on necessary skills and tools to realize the required skilled worksforce.	Roadmaps from 7 regional learning communities, where knowledge centers, companies and educational organizations work together to define the necessary skills for the near future.	Research on educational tools, community building, and connecting with knowledge from other programs.	GVNL-subsidy, in-kind contribution of over 100 regional organisations (micro-, macro and meso learning communities).

Phase 1 2024-2026:

- 7 Bridging grants (7 regional roadmaps, liasons, and preparatory activities for Learning Communities
- **2025:** 7 applications for the Call "Learning Communities as rivers of the green hydrogen economy" (1 deemend ineligible)
- Applications show strong connection with the Knowledge Platform and Make Hydrogen Work

Next steps:

- Consortia to start in Q1 2026 (pending positive NOW decision)



Innoveren, werken en leren dicht tegen elkaar aan organiseren

Investeren op de raakvlakken en de overgangsgebieden

Realiseren van Learning Communities voor waterstof

groen vermogen nl