HEAVENN

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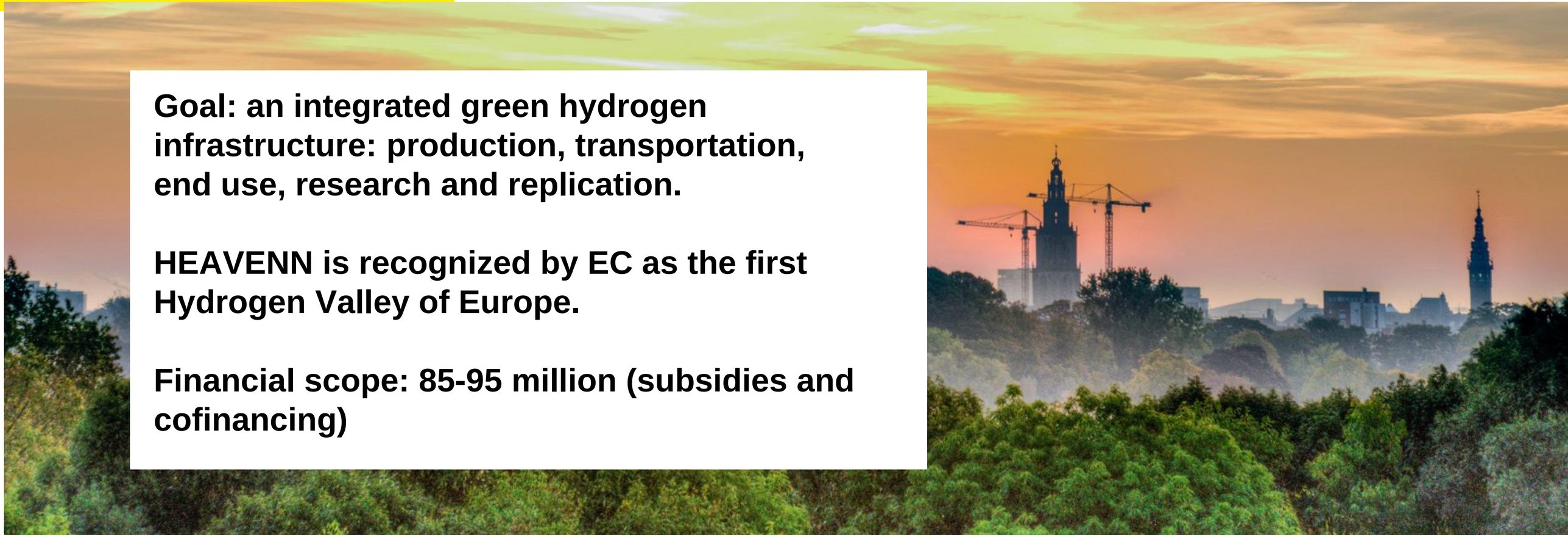
  - Kees Boer (Municipality of Hoogeveen)
  - Martine van Gemert (Municipality of Groningen)
    - Success factors and challenges

HEAVENN: Hydrogen Energy Applications for Valley Environments in the Northern Netherlands



Goal: an integrated green hydrogen infrastructure: production, transportation, end use, research and replication.

HEAVENN is recognized by EC as the first Hydrogen Valley of Europe.

Financial scope: 85-95 million (subsidies and cofinancing)

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Partners in HEAVENN

Supported by

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Supported by

Clean Hydrogen Partnership

Co-funded by the European Union

provincie Drenthe

provincie groningen

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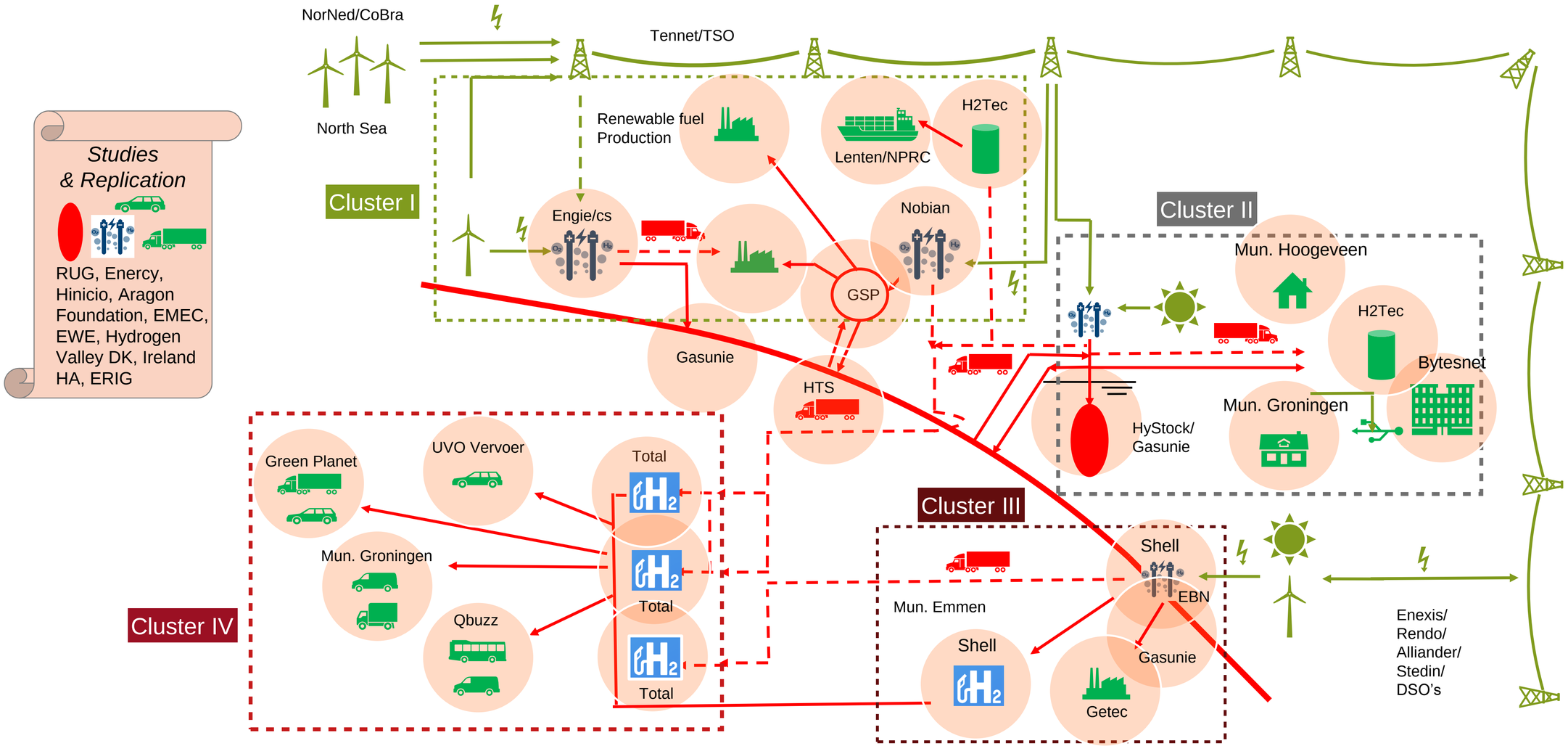
Studies
& Replication
RUG, Enercy, Hinicio, Aragon Foundation, EMEC, EWE, Hydrogen Valley DK, Ireland HA, ERIG
NorNed/CoBra
North Sea
Tennet/TSO
Renewable fuel Production
Lenten/NPRC
H2Tec
Cluster I
Engie/cs
Nobian
GSP
Gasunie
HTS
Cluster II
Mun. Hoogeveen
H2Tec
Bytesnet
Mun. Groningen
HyStock/ Gasunie
Cluster III
Shell
EBN
Mun. Emmen
Shell
Gasunie
Getec
Enexis/ Rendo/ Alliander/ Stedin/ DSO's
Cluster IV
Green Planet
UVO Vervoer
Total
Mun. Groningen
Total
Qbuzz
Total

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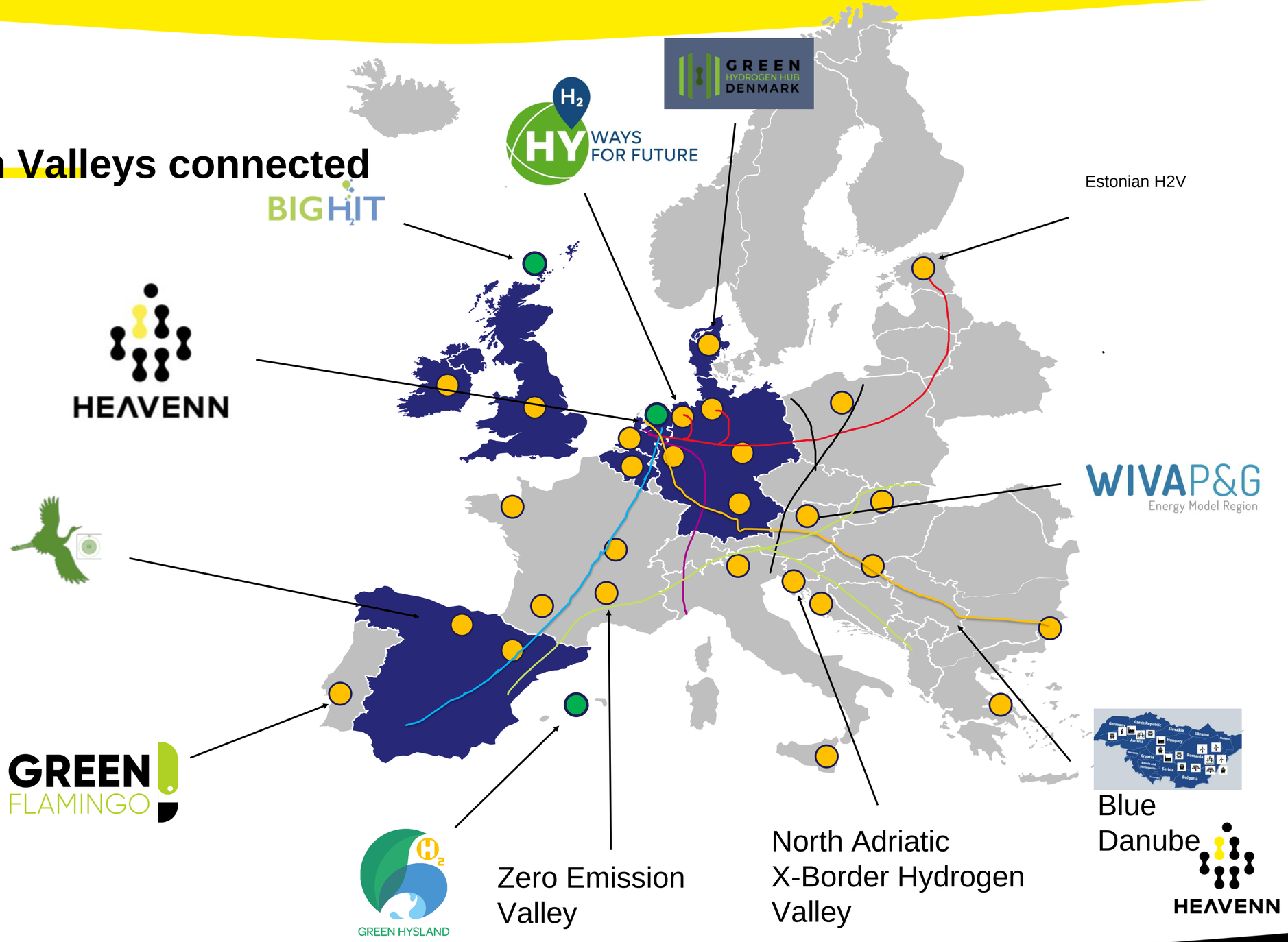
Hydrogen Valleys connected



Hydrogen value chain and logistics

Roadmap development

Dr. Evrim Ursavas
Associate Professor of Energy and Logistics
Faculty of Economics and Business

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Who are we?

- Leading a research team on **Supply chain Network design and value chain optimization problems** surrounding the path towards zero emissions.

- The transition to a low-carbon society requires new research, **business and economic models** and this is what we do with my team here.

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Developing the supply chain

- The development of hydrogen efficient supply chains is crucial to the economy
- an **affordable, reliable and sustainable energy supply is a key factor** that may influence the decisions of companies

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There are challenges with getting this right

- Interconnecting the energy-using sectors will require better synchronization of supply and demand for renewable energy production, hydrogen production, storage, distribution and multiple end-uses.
- Economic feasibility of different settings and scenarios for hydrogen offtake should be studied thoroughly considering the interactions with the other markets (e.g. electricity).
- A set of measures and policies must be carefully assessed to ensure that the transition towards hydrogen does not weaken the economic position of the Netherlands in the long term.

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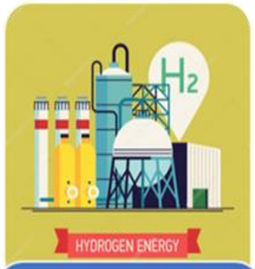
Research on how to make this work!

Overarching landscape impacts of H2

- Optimal H2 value chain design ensuring the seamless integration of different businesses and stakeholders from the production of renewable energy, production of H2, distribution , storage and end use by the industry, mobility and the built environment.
- Development of the roadmap to 2050 in view of uncertainties, limitations, supply and demand at each time phase.
- Upscaling of H2 from local to the national level considering interactions with neighboring countries.



H2 production

- What are the optimal policies and strategies for the production of H2 considering interactions with different power markets?
- How can the production of H2 be optimized bearing in mind challenges such as intermittency and uncertainty in the renewable energy production?
- What would be the stepwise optimal positioning and capacity deployment of production plants for the supply of H2 from local to national level under different growth scenarios?
- Strategic and operational economic assessments for possible configurations for the production of H2 at offshore platforms

H2 storage

- What would be the possible storage type and configuration for each end use considering demand, proximity to the end use as well as the infrastructural and technical limitations and challenges at location
- What should be the optimal balance between decentralized vs centralized storage units?
- Development of optimal inventory policies for the replenishment of storage units.
- Economic assessment of storage in salt caverns, depleted gas fields (onshore/offshore) or at storage tanks
- How can storage be utilized to overcome intermittency challenges and to balance supply and demand?

H2 distribution

- Evaluation and economic assessment for distribution via pipelines and trucks
- What is the optimal design of a pipeline backbone infrastructure considering the retrofitting of current pipelines for H2 use and the deployment of new pipelines?
- Analysis of the current technical and economical challenges such as hydrogen embrittlement or financial limitations for the backbone development
- Assessment of different policies and developments to overcome the challenges and speed up the uptake of hydrogen

H2 Utilization

- Identification of potential end users of hydrogen by industry as feedstock and as heat
- Optimal configuration of the infrastructure and the hydrogen refueling stations for the use of H2 in mobility by heavy trucks, railways and inland waterways
- Assessment of economic feasibility of H2 use by airport land operations and future air transportation
- Configurations and assessment of H2 use by the built environment

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Research team working on:

- Economic conditions for the offtake of hydrogen per sector in the value chain;
- Techno-economic analysis of different hydrogen production technologies;
- Economic interactions of hydrogen with the electricity market;
- Sectoral integration and the development of new business models for the new hydrogen economy;
- Optimal production, distribution and storage policies for the hydrogen value chain;

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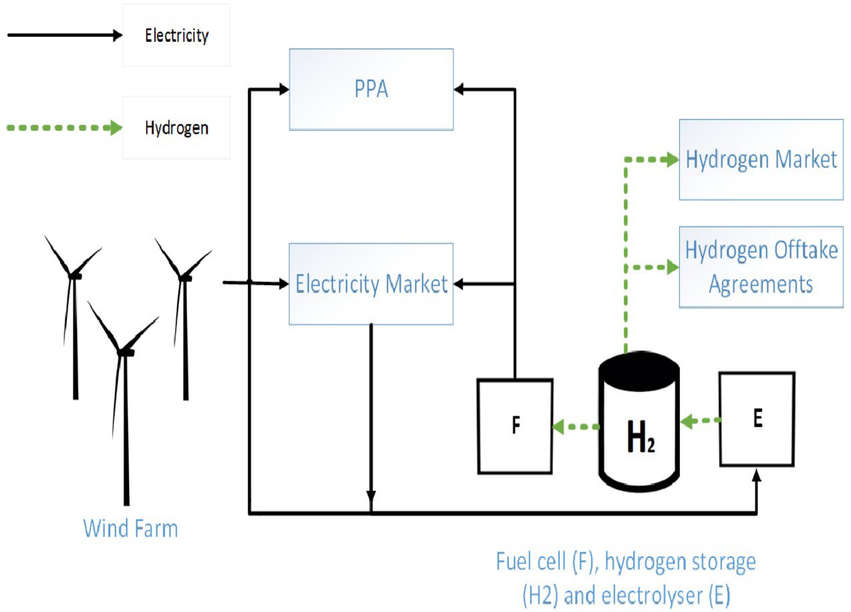
Research team working on:

- Business and economic models to analyze interactions with different stakeholders, price mechanisms and markets;
- Development of mechanisms to deal with the uncertainty in the production of renewable energy and the variations in demand;
- Assessment of different policy measures to ensure economic feasibility of hydrogen for end users;
- Roadmap development

A Green Hydrogen Energy System – Optimal control strategies for integrated hydrogen storage and power generation with wind energy

- Markov Decision Process
- Optimal policies for day-to-day decisions: how much energy to store as hydrogen, to buy or sell from the electricity market and how much hydrogen to sell.



Emphasize practical settings

- Power Purchase Agreements (PPAs)
- Varying electricity prices
- Different distribution channels
- Green hydrogen offtake agreements
- Hydrogen market uncertainties

•Development of an hydrogen market and the flexibility to sell hydrogen is important.
•Hydrogen offtake agreements can be the motor of a transition towards large-scale green hydrogen production.
•PPA agreements settings such as the timing of and the target delivery amount should be carefully decided. For example, spread out during periods rather than bulk selling at a specified due date.

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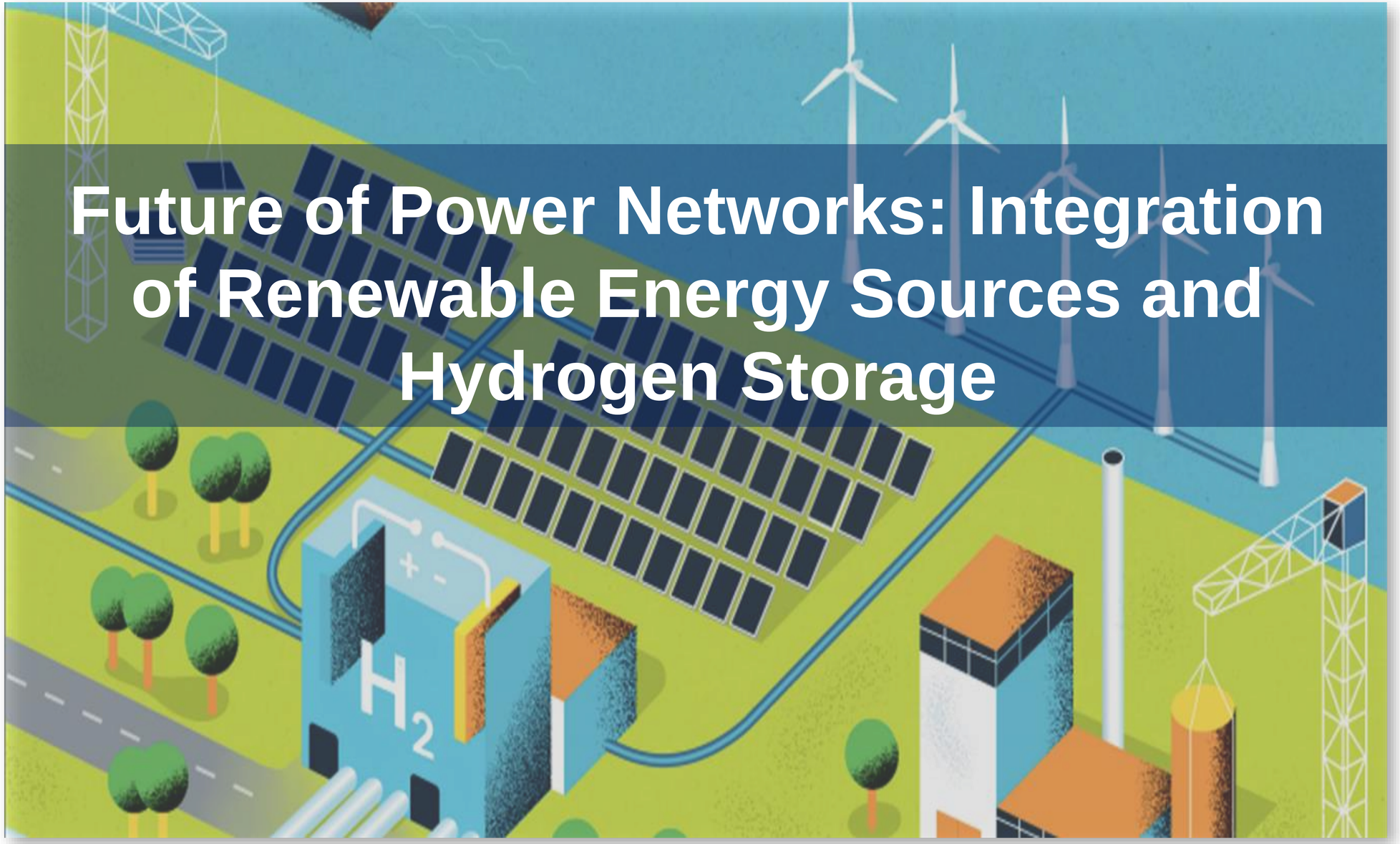
Future of Power Networks: Integration of Renewable Energy Sources and Hydrogen Storage



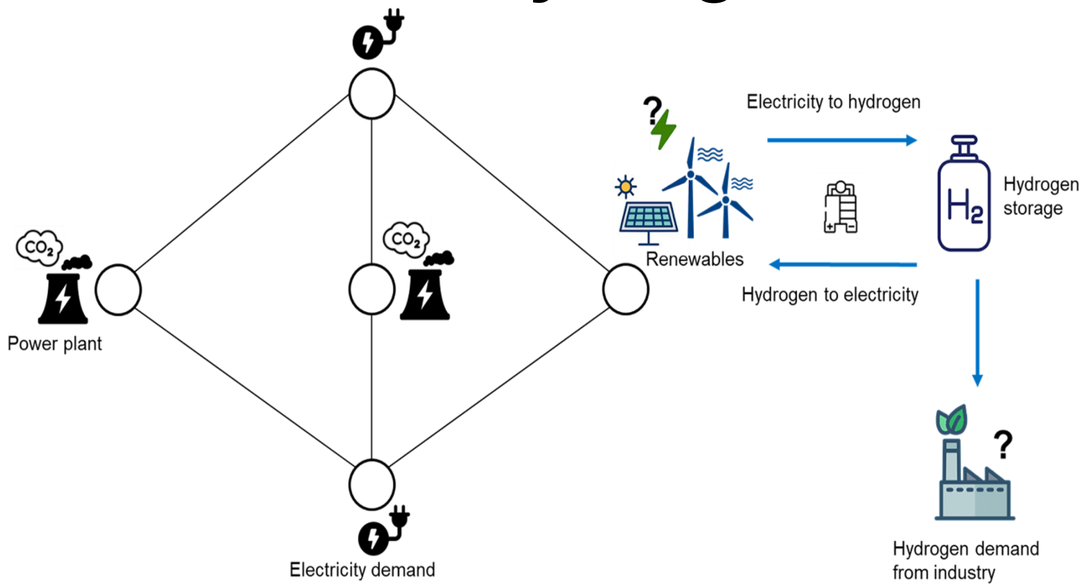
STRATEGIC LEVEL QUESTIONS

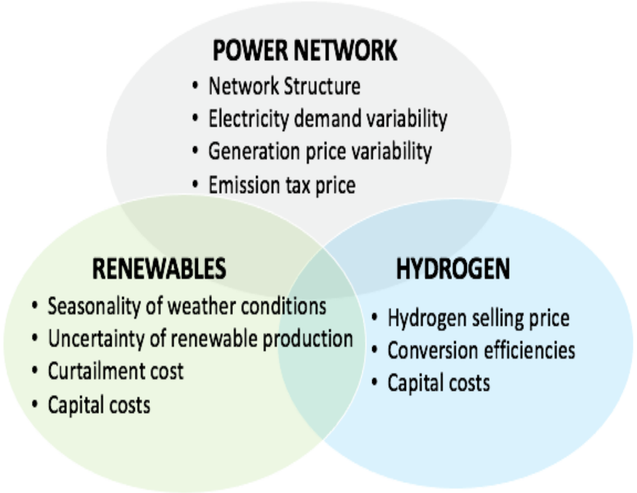
- How should we allocate the investment budget among renewables and hydrogen storage?
- Which locations and sizes are the best for renewables and hydrogen storage installments?
- Can the investment budget be recovered by reducing operational cost?

BASED ON OPERATIONAL LEVEL ANALYSIS

- Daily planning of the network operations to provide a reliable and economically viable power system

Future of Power Networks: Integration of Renewable Energy Sources and Hydrogen Storage





Strategic and operational level insights

- **Budget allocation**
- **Renewable and storage locations**
- **Centralized vs decentralized strategies**
- **Energy conversion schedules**
- **Hydrogen selling decisions**

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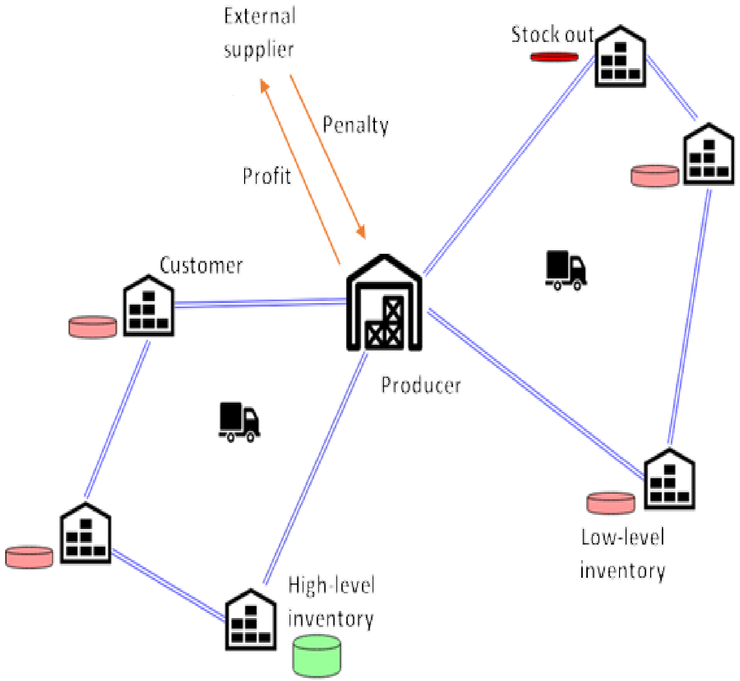
Optimal distribution policies of hydrogen Dynamic production and static distribution of green hydrogen: A combined MIP and MDP approach

“How to provide efficient routing and storage policies for the current green hydrogen economy under uncertainty, while achieving a high service-level?”

- **Inventory Routing Problem**
- **New model and associated solution method**
- **A robust technique for different parameter settings**



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Optimal distribution policies of hydrogen Dynamic production and static distribution of green hydrogen: A combined MIP and MDP approach

To provide insights we focus on

-How to group customers

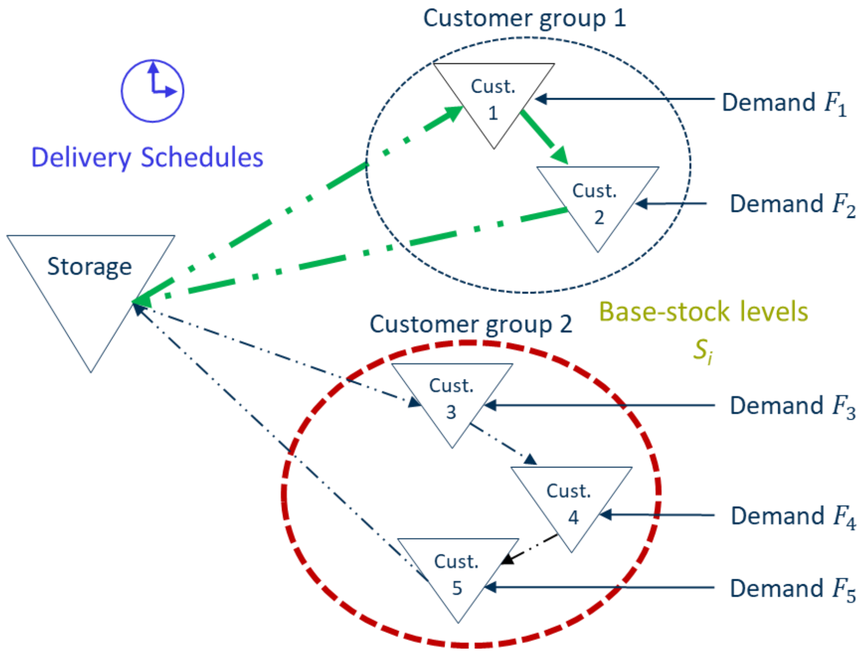
-Which route is the best to replenish for a group

-How often to visit for a group

-What should be the targeted stock level on each customer location

-How to control daily deviation in production/consumption via external suppliers

by efficient solutions that minimizes unwanted occurrences, such as stock out.



We base our analysis at two hydrogen production locations in the Netherlands: Emmen and Eemshaven

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Thank you!

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This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 875090. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe Research.

THE ENGINE OF THE HOME OF THE FUTERE

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The status of the Hydrogen District Hoogeveen

Wind Meets Gas, Groningen

October 5th, 2022

Kees Boer, municipality of Hoogeveen

GREEN HYDROGEN, THE ENGINE OF THE HOME OF THE FUTERE

Hoogeveen wants to show that green hydrogen can make an important contribution to make a part of the Dutch housing stock natural gas-free, with:

- reuse of the existing natural gas network
- a new hydrogen central heating boiler.

Hydrogen District Hoogeveen

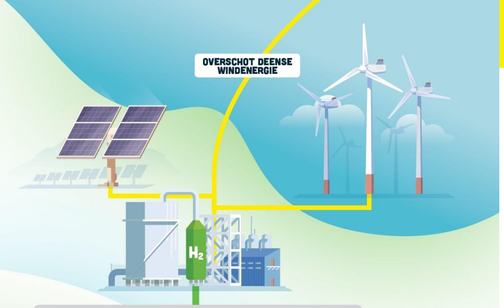
1. Realizing the hydrogen network
2. Connecting 100 new-build homes in Nijstad-Oost
3. Conversion of 427 homes in the existing Erflanden district from natural gas to hydrogen, by reusing the existing natural gas network and replace the natural gas boilers with hydrogen boilers.

Waterstofwijk Hoogeveen
Een blauwdruk voor waterstoftoepassing
Hoogspanning
Kattouw
Schutlanden West
Schutlanden Oost
Gasleidingen
Nijstad Oost
RWZI
Erflanden
NAM locatie Ten Arlo
Recreatieplas
Gasleidingen
Bouw mee aan de waterstofketen van Hoogeveen

System and conversion phasing

HYDROGEN VALLEY

WATERSTOFHOOGEVEEN



PRODUCTIE GROENE WATERSTOF (H_2)

WATERSTOF TINY HOUSE

DOC33
Duurzaam Ontwikkel Centrum

H_2 BACKBONE

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H_2 AANSLUITING DUITSLAND

WATERSTOF HOOGEVEEN

NIJSTAD-OOST
Aansluiten nieuwe woningen

ERFLANDEN
Omzetten bestaande woningen

Hergebruik bestaand aardgasnetwerk

H_2 AANSLUITING INDUSTRIE

FASE 1
Aanvoer in tubetrailers

FASE 2
Electrolyzer bij Rioolwaterzuivering Echten

FASE 3
Aansluiten op H_2 Backbone

H_2 AANSLUITING EMMEN

H_2 AANSLUITING MEPPEL

Clean Hydrogen Partnership
Co-funded by the European Union

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 875090. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe Research.

Interreg North Sea Region Stronghouse
European Regional Development Fund
EUROPEAN UNION

WATERSTOF HOOGEVEEN

WATERSTOF WIJK
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System phasing

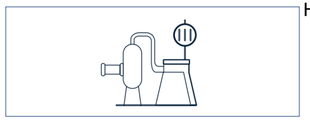
1

Supply(back-up)

Storage

Hydrogen

Unloading station



Hydrogen

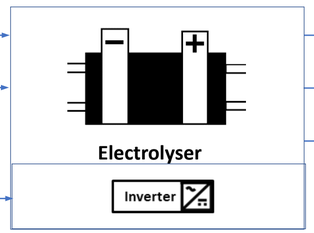
2

Production

Demi-water

kWh in DC

kWh in AC



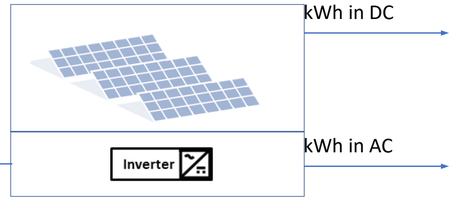
Hydrogen

O2

Warmte

kWh in AC

Solar farm



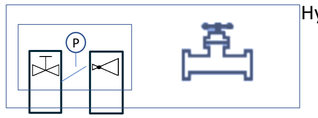
kWh in DC

kWh in AC

3

Main Hydrogen pipeline

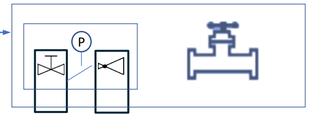
Pressure reduction, odorization



Hydrogen

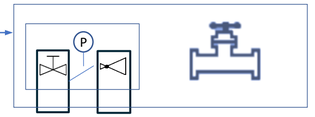
Distribution Network Nijstad

Hydrogen



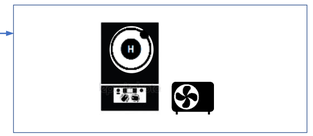
Distribution Network Erflanden

Hydrogen



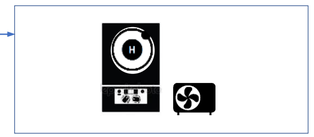
Houses Nijstad

Hydrogen



Houses Erflanden

Hydrogen



Phasing the conversion

Fase 1: Nijstad-oost
100 new-build homes
202023

Fase 2: Erflanden
6 existing homes
2023

Fase 3: Erflanden
95 existing homes
2024

Fase 4: Erflanden
193 existing homes
2025

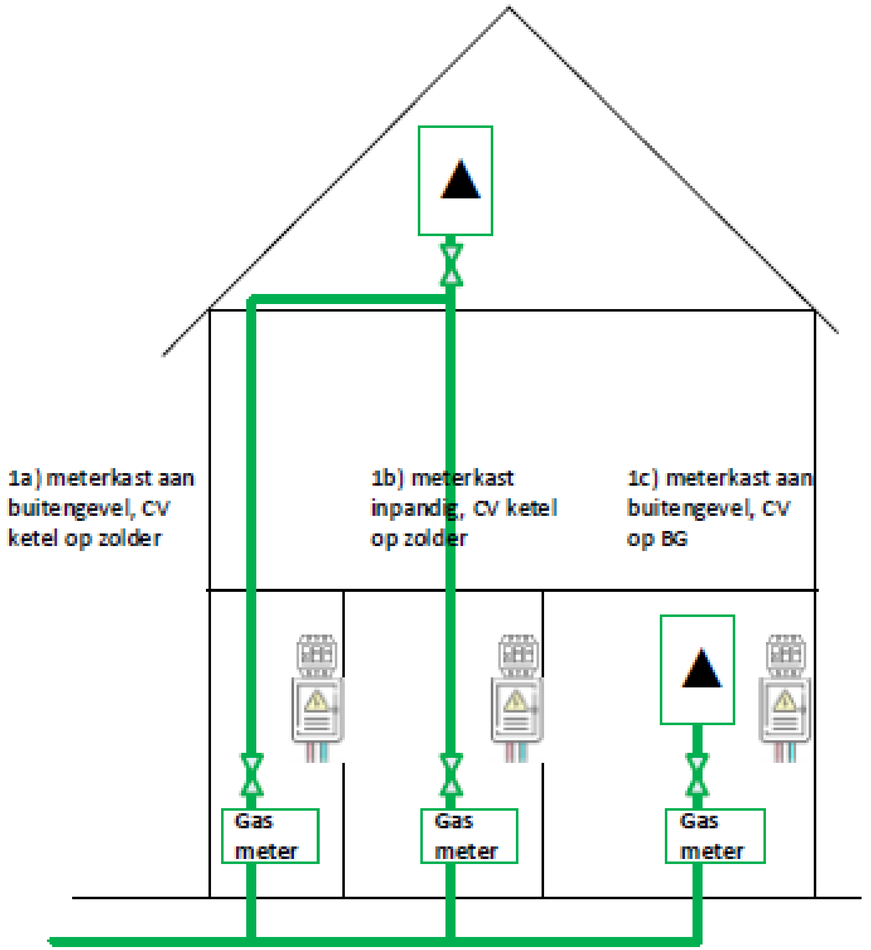
Fase 5: Erflanden
303 existing homes
2026

Fase 6: Erflanden
418 existing homes
2027

Fase 7: Erflanden
> 420 existing homes
> 2028

Expected activities in the home

- replace boiler
- replace gas meter and house pressure regulator
- pressure testing
- new H2 sensors
- replace gas appliances
- home adjustments e.g. in the kitchen
- maintenance and management



Progress 2022

Progress and challenges

- technical design distribution network is ready
- field test certificate hydrogen heating boilers REMEHA is ready (low Nox!).
- zoning plan for the hydrogen unloading station decision city council on October 6.
- sustainable energy/energy tax
- energy crisis→talks ministry for extra contribution
- finding a H2 supplier, purchasing and sales→Essent

BOUWEN VAN H_2 TINY HOUSE

+ WATERSTOF WIJK
+ BEDRIJFSLEVEN
+ ALFA-COLLEGE
  ENERGIE EN DUURZAAMHEIDSCENTRUM
= TINY HOUSE

WATERSTOF TINY HOUSE


IN HET WATERSTOF TINY HOUSE
remeha
remeha
Regio Deal
Zuid- en Oost-Drenthe
DE REGIO WAAR HET MOOI
WONEN, WERKEN EN LEVEN IS
Hoogeveen
Alfa-college
Regio Deal
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EN IS MEDE MOGELIJK GEMAAKT DOOR:
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Groene morgen
Hoogeveen
Voor welke
groene
www.groenemorgenhoogeveen.nl
Optie 1
Hybride
Electric & Aardgas of Waterstof
Hoogeveen
TOTALE INVESTERING: TUSSEN DE € 2.500 EN € 3.000
JAARLIJKSE BESPARING: CIRCA € 378
Voor welke groene toekomst kies jij?
Optie 2
Waterstof
Hoogeveen
TOTALE INVESTERING: GEEN
JAARLIJKSE BESPARING: GEEN
Optie 3
All-electric
Hoogeveen
TOTALE INVESTERING: € 10.000 TOT 15.000
JAARLIJKSE BESPARING: CIRCA € 1100
Voor welke groene toekomst kies jij?


WWW:H2PLANET.EU/NL
NK05
IJSJE?
WATER STOF HOOGEVEEN
PRAAT MEE OVER WATERSTOF
MAN
VHG-89-N

Opening Hydrogen testnetwork EnTranCe

RENDO, Cogas en BAM Energie & Water

Test network H2: a learning and safe environment for practical experience with hydrogen in the built environment in the field of safety, management and maintenance.

Progress and challenges

“temporary exception order” from the Netherlands Authority for Consumers and Markets (ACM): Affordable, reliable and safe hydrogen energy system to protect the residents.

Progress and challenges

- site preparation started
- conditional decisions in December
- investment decision in April 2023
- connecting first houses in the summer of 2023

Safety and Transport of Hydrogen

- No legal framework for transport H2 Natural Gas Grid Operator
- Solution for the pilot projects: “temporary exception order” from the Netherlands Authority for Consumers and Markets (ACM).
- Safety H2 chain: Guideline Ministry of Economic Affairs before it is laid down in legislation.
- Supervision in accordance with the Gas Act/Law
- Home security just like with natural gas (building legislation)
- Proof: Installation design and pro forma permit application

Affordability

- Price guarantee for a period of 15 years.
- According to the “Not More Than Usual” principle
- The use of hydrogen may not cost more on average than a comparable situation with a natural gas boiler. Or “all electric” for new houses.
- Same as the energy price of heat networks
- Cost of investment (Hoogeveen pays this)

Contract, duration and end of the pilot

- General terms and conditions for the supply of hydrogen to consumers by the energy supplier.
- Duration of the agreement;
- Notice period for the customer;
- Procedure in case the pilot is stopped;
- Cancellation fee to be paid by the customer.

Guarantee of supply

- Guarantee for sufficient hydrogen in the cold winter period in combination with peak consumption during the day
- A good and reliable design of the hydrogen chain: from tube trailer to the hydrogen boiler in the home
- Agreements between the energy supplier and the hydrogen supplier about guarantee of supply (how much hydrogen is needed based on the season and weather forecast). And check on available amount of hydrogen in storage etc.

Supplier of last resort

- What happens if Energy supplier and/or the hydrogen supplier cannot supply hydrogen.
- Which party provides the backup
- Which party has to pay for this?

Fall Back Protocol

What happens if hydrogen can no longer be supplied for financial, safety or legal reasons?

Procedure, what circumstances, term, etc.

- Which energy alternative is offered (eg green gas/all electric)
- Who will pay for the conversion to the energy alternative.

Liability for conversion and maintenance

- Which party is responsible and liable for the conversion of the indoor installation?

- Which pilot party is responsible and liable for (checking) the safety and maintenance of the indoor installation?

Information obligation from the Civil Code

How are the information obligations under the Civil Code (consumer protection conditions) fulfilled?

Obligations as in the Gas Act

The grid operator's complaints procedure for customers

The supplier's complaints procedure for customers

The description of the reporting center for defects for the customers

A document with energy cost estimates and invoices;

The shutdown policy;

The invoice terms.

Pilot Agreement

- Tasks, roles and responsibilities of the parties involved in the pilot are clearly described for the consumer with all underlying contracts.

Contact Details

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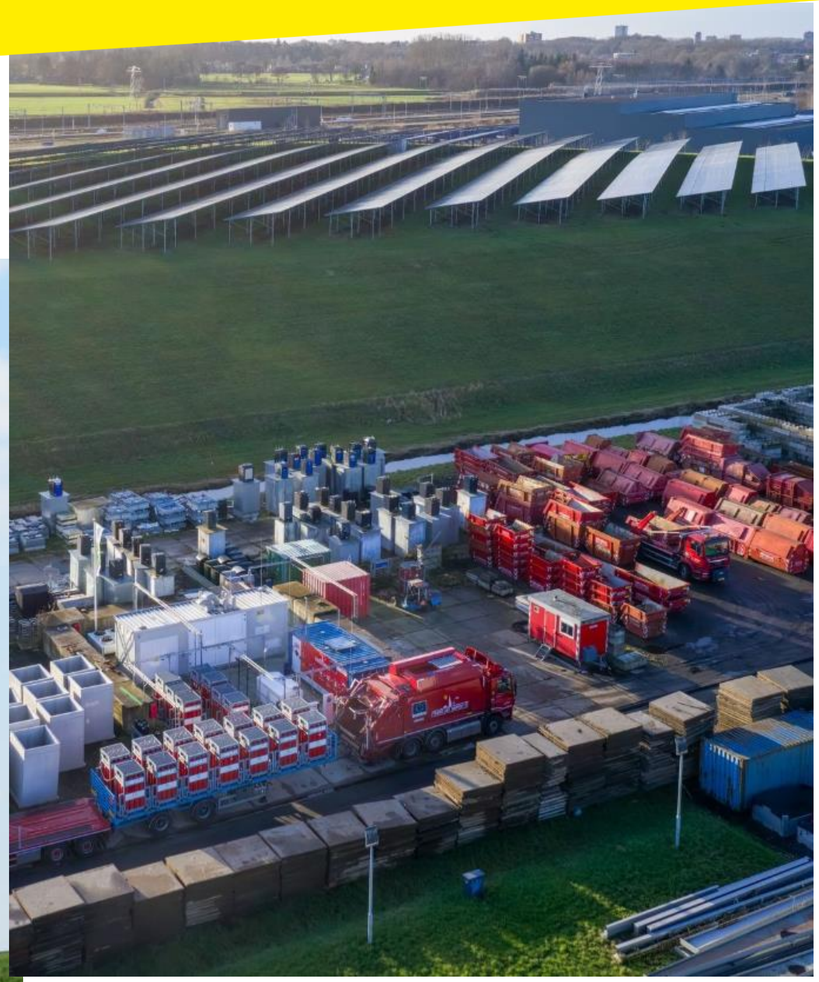
INNOVATION PLANS? DARE TO TAKE THE NEXT STEP WITH US!

Municipality of Groningen

Martine van Gemert

About 20% of the fleet of Groningen runs on H2



Gemeente Groningen

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MILIEUSTRAAT GRONINGEN

Situatie 4, waterstofketel(s) bestaande ketel (deels) als backup

62.376 kWh
11,78 kW

WATERSTOFGENERATOR
P-thermisch: 36,8 kW

747 GJ

WATERSTOFKETEL(S)

Atag Ultra-H2 XL105
Aantal: 1 st.
P-nominaal: 92 kW
D= 0,94
Gasverbr.: 6,01 m3/h
Vollast: 5.297 hr/jr

1.961,5 GJ
55.770 m3

1.119,8 GJ
31.837 m3/jr

1.754 GJ

2.511,9 GJ

BESTAANDE KETEL(S)

841,8 GJ
23.933 m3/jr

P-nominaal: 800 kW
D= 0,9
Gasverbr.: 90,98 m3/h
Vollast: 263 hr/jr

757,6 GJ

- Permitting
- Certification of boiler
- Results not in line

Gemeente Groningen

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Questions and discussion

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More information and follow-up questions

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