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**SHIP>NL**  
**SUSTAINABLE HYDROGEN IMPORT PROGRAM**

## » AGENDA

### SHIP>NL SESSIE VIII 19 OKTOBER 2022

**15:00-15:30** WELKOM EN TOUR DE TABLE

**15:30-16:15** DEEP DIVE: VAREN MET WATERSTOFDRAGERS | RICHARD DE REUS (ANTHONY VEDER)

**16:15-17:00** DISCUSSIE: VOORSTEL GROENVERMOGEN | RENÉ PETERS (TNO)

**17:00** AFSLUITING

# 'HUISREGELS'

- Camera aan, microfoon op 'mute'
- Vragen?
  - Plaats *verduidelijkingsvragen* in de meeting chat; of
  - Steek je hand op
- De moderator zorgt ervoor dat je vraag beantwoord wordt (eventueel achteraf).
- Slides worden na de sessie gedeeld
- We bespreken uiteraard geen marktgevoelige zaken.
- Chatham house rules: De besproken informatie mag gedeeld worden, maar zonder de spreker te onthullen.

# MEERJARIG KENNISPROGRAMMA MET 5 LIJNEN

## In deze sessie:

1 Technisch economisch	2 Beleid	3 Markt	4 Internationaal	5 Omgeving
<ul style="list-style-type: none"><li>Inzicht in importketens productie-conversie-transport-opslag-reconversie-gebruik</li><li>Vraagontwikkeling, scenario's</li><li>Infrastructuur &amp; systeemintegratie: corridors, benutten bestaande infra.</li><li>Technology assessments, R&amp;D</li></ul>	<ul style="list-style-type: none"><li>Impact van 'Fit for 55', REDII, Delegated acts, ETS/CBAM, etc.</li><li>Impact van certificering en CO2 allocatie: emissiefactoren, LCA ketenanalyse, etc.</li><li>Financiering en stimulering (EU &amp; NL): IPCEI, PCI, TEN-E, JTF, EIB, Horizon Europe, MOOI, DEI, MIEK, SDE++, etc</li></ul>	<ul style="list-style-type: none"><li>Marktmodellen: bilaterale contracten, vrije handel, waterstofbeurs</li><li>Internationale handelsstromen: verwachte vraag- en aanbodvolumes en transportstromen</li><li>Importtarieven, trade agreements en handelsbeperkingen, WTO, etc.</li></ul>	<ul style="list-style-type: none"><li>Samenwerking met omringende EU/niet-EU importlanden om corridors te ontwikkelen</li><li>Concurrentie met omringende EU/niet-EU importlanden</li><li>Geopolitieke aspecten: strategische voorraden, afhankelijkheid, politieke stabiliteit van exportlanden</li></ul>	<ul style="list-style-type: none"><li>Ruimtegebruik van ketenelementen</li><li>Veiligheid: brandbaarheid, zorgwekkende stoffen, risicocontouren, etc</li><li>Milieu: stikstof, lekkage</li><li>Maatschappelijke acceptatie</li><li>MVO / samenhang met SDG's in exportlanden</li></ul>

## Synthese

## ACTUALITEITEN | TOUR DE TABLE



# DEEP DIVE: VAREN MET WATERSTOFDRAGERS – KANSEN EN UITDAGINGEN

Richard de Reus | Anthony Veder

# SHIP community



ANTHONY VEDER



19 Oktober

# Content

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ANTHONY VEDER

- Introduction Anthony Veder
- Hydrogen carriers and their physical properties
- LNG shipping vs Hydrogen shipping
- Ammonia shipping
- Usage as a marine fuel
- Projects



# DISCUSSIE: VOORSTEL GROENVERMOGEN

René Peters | TNO & Ed Buddenbaum | Groenvermogen

# › HYDROGEN IMPORT STUDY PROPOSAL

**SHIP.NL**

Groenvermogen  
van de Nederlandse economie



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OCTOBER 2022

# GroenvermogenNL – 838 M€

## Knowledge ecosystem – 227M€ – 8 years

Co-funding – 10-40% – tenders by NWO/RVO

National public-private R&D programme TRL29

1. Making carbon neutral H2	35 M€
2. Transport & storage of H2	27 M€
3. Direct use of H2	26 M€
4. H2 and green e for Cbased chemistry	36 M€
5. H2 & green e for N2 based chemistry	21 M€
6. Green H2 and evoor specialties	20 M€
7. Socio-economic aspects & implementation	12 M€
Human capital	50 M€
	<u>227 M€</u>

## Scaling up – 600 M€ – 4 years

Co-funding – 70% – tenders by RVO

• Small pilots	100 M€
• 4x 100 MW	500 M€
Large scale application value chains	
	<u>600 M€</u>



# Our Program We Connect

Mr. Marjan Oudeman MBA



Prof.dr. ir. Paulien Herder



Drs. Paul de Krom



Sandra de Keijzer  
(will take new position)



Mark Schmets



Board

Secretariat on behalf of Top Sectors

Groenvermogen  
van de Nederlandse economie



Ed Buddenbaum



# Green H<sub>2</sub>: strengths and chances for NL

Ambition GroenvermogenNL

## Vision

The Netherlands has the potential to play an important role in international green H2 developments – for our society and economy

- 
- The map shows the Netherlands with several location pins. A teal box labeled 'NL green H2 potential' is positioned over the western part of the country. The surrounding text lists various strengths and opportunities.
- Large offshore potential
  - Access to salt caverns for large-scale storage
  - Availability of ports for import terminals
  - Strong knowledge base from being a gas hub
  - Export to Antwerp
  - High-tech suppliers
  - Existing gas infrastructure can be re-used
  - Export to Ruhrgebiet
  - Strong industry clusters

1. **Fight climate change** through achieving net-zero in 2050 by reducing greenhouse emissions in non-electrifiable end uses using green hydrogen
2. **Boost earnings power** by become a significant international player in the green hydrogen & chemistry economy, unlocking potential of NL high-tech sector
3. **Retain key industries** within the Netherlands by facilitating their transition to net-zero in a sustainable way using green hydrogen & chemistry
4. **Improve business climate and energy security** by creating national green hydrogen production capacity in parallel with import infrastructure

Vision

# The Netherlands will become a green hydrogen hub

Production

Domestic onshore and offshore production initiatives

- Large-scale central
- Smaller-scale decentral International production for import

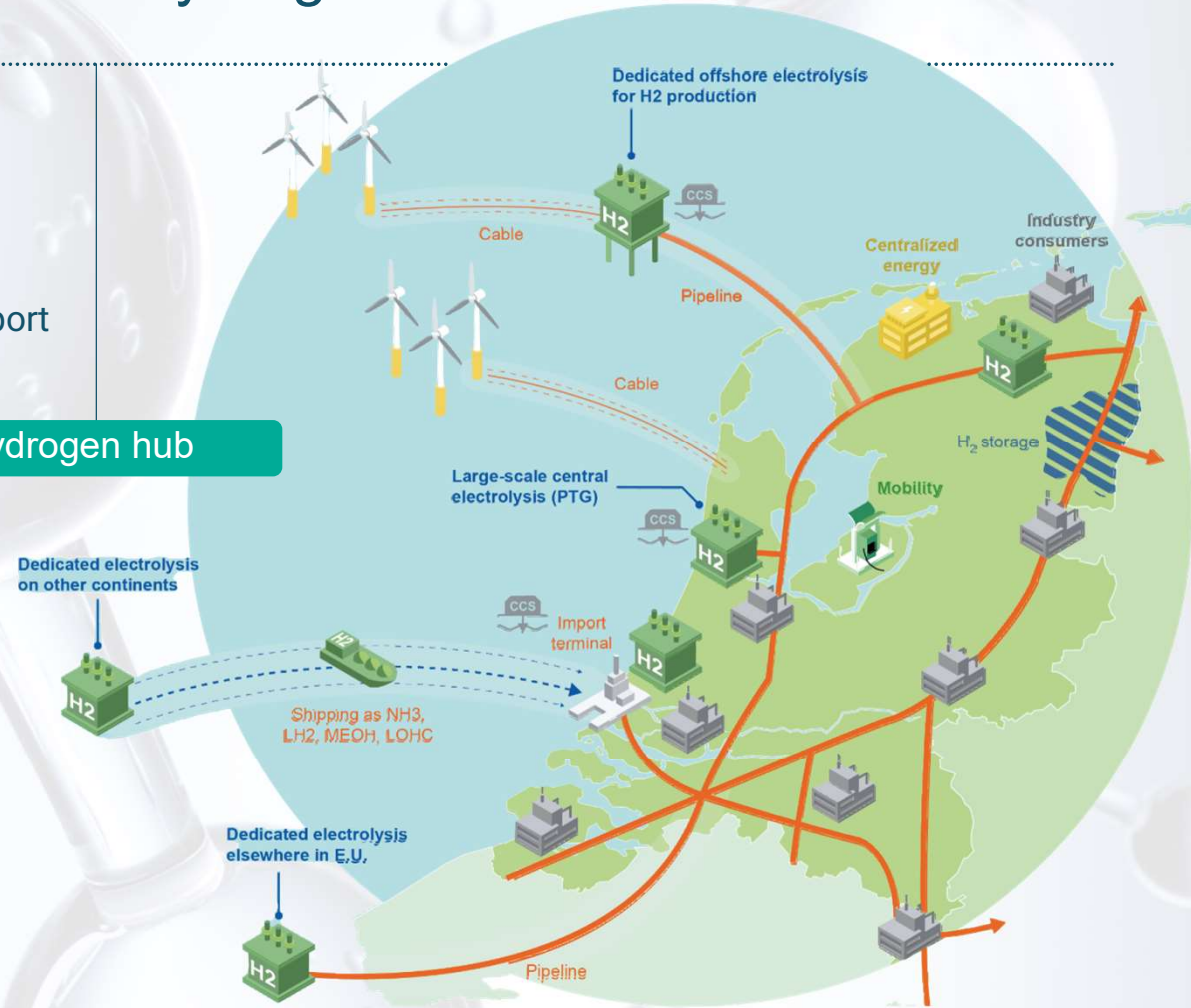
Roundabout

- Hydrogen backbone
- Large-scale storage options
- Port import infrastructure
- International interconnection capacity
- Trading platform

Consumption








- Current and new hydrogen consumers
- Green high quality chemical products
- Sustainable heavy transport

Dutch hydrogen hub



# Accelerate, scale-up, reduce costs, future-proof key industries, create an innovative ecosystem and inspire talent

## Ambition GroenvermogenNL

 <p><b>1</b> <b>5 projects, 2024</b></p>	 <p><b>2</b> <b>&gt;500 MW</b></p>	 <p><b>3</b> <b>2-2.5 EUR/kg</b></p>	 <p><b>4</b> <b>4 key industries<sup>2)</sup></b></p>	 <p><b>5</b> <b>&gt;50 companies</b></p>	 <p><b>6</b> <b>15 k talents</b></p>
<p><b>Accelerate</b> kick-start of projects</p>	<p><b>Scale-up</b> production, transport and use</p>	<p><b>Reduce</b> future H2 cost through innovation</p>	<p><b>Future-proof</b> key industry clusters</p>	<p><b>Create</b> an innovative &amp; high-tech ecosystem</p>	<p><b>Inspire</b> new talent</p>
 <p>Support the initiation of 5 projects before 2024 and invest in already initiated and running H2 projects</p>	<p>Realize &gt;500 MW production/import capacity<sup>1)</sup> directly by 2025 and make a significant contribution to the NL ambition of 3-4 GW in 2030</p>	<p>Contribute to a reduction in costs for green hydrogen to 2.0-2.5 EUR/kg by 2030</p>	<p>Enable the demonstration of large-scale feasibility of transition within four key industries by 2030</p>	<p>Promote the creation of an ecosystem of &gt;50 (new) companies supplying high-tech components to green hydrogen &amp; chemistry value chain by 2030</p>	<p>Facilitate the resourcing of 15 k job vacancies in green hydrogen and green chemistry by 2030</p>
<p><b>i</b> Although there is a filled pipeline, few projects have actually started, the build-out needs to start in order to learn and overcome implementation barriers</p>	<p>Large volumes of green hydrogen are required by 2030, demanding the realization of projects that have large volume targets</p>	<p>Significant green hydrogen cost reductions are required to be competitive with grey hydrogen in the long term</p>	<p>In order to retain key industries with a high economical impact for NL their transition to green hydrogen and green chemistry needs to be secured</p>	<p>The Netherlands has the building blocks to build an innovative high-tech ecosystem of green hydrogen &amp; green chemistry value chain suppliers</p>	<p>To build all elements of the green hydrogen hub, many new skilled labour is required in an already hot labour market</p>



## Four instruments available to realize ambition



### Demo support

Green electrolyzer projects with >100+ MW capacity

- 4 hydrogen production/import facilities



### Pilot support

Projects throughout the value chains of production, transport, storage and industrial use of green hydrogen (carriers).

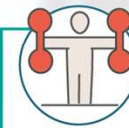
- 3-5 projects in H2 value chain



### R&D

7 work packages:

- Making carbon neutral H2
- Transport & storage
- Direct use of H2
- C-based chemistry
- N-based chemistry
- Speciality chemistry
- Socio-economic aspects & implementation



### Human Capital

National human capital agenda

- Regional learning communities
- Digital platform
- National coordination



## Four instruments available to realize ambition



GroenvermogenNL connects

The four instruments will be deployed jointly to maximize impact

GVNL will build an interconnected portfolio of activities to ensure this joint deployment and execution

# THE CHALLENGE AHEAD ON INDUSTRIAL DECARBONISATION

Fertilizers



HT heat



Electricity



Refineries



Mobility



Steel



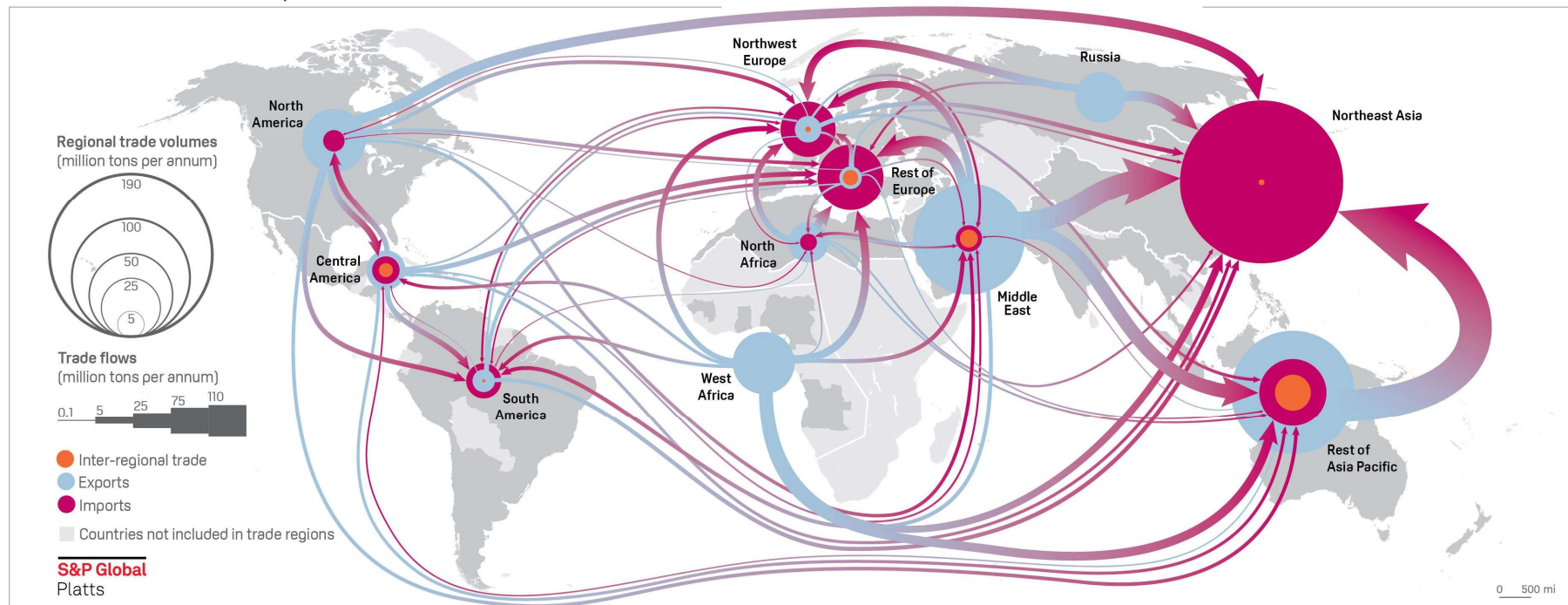
- Sectors have various decarbonisation options, H2 is an important option
- What will NW-Europe import, produce and convert locally or export?
- How will feedstock & energy volumes change over time?
- What role will geo-political strategic autonomy play?



# FUTURE ENERGY IMPORT REQUIREMENTS (HYDROGEN CARRIERS)

- What are plausible hydrogen import routes for the Netherlands?
- Which H2 transport options are most economic for various countries?
- How can we develop the first H2 import projects towards our ports?

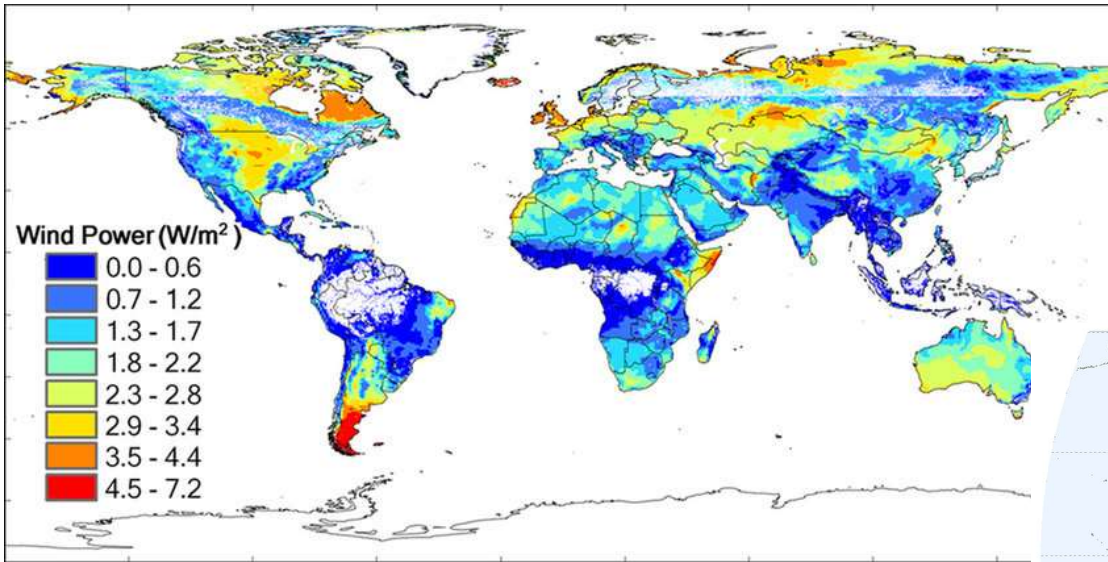
LIQUIFIED NATURAL GAS TRADE FLOW, 2018



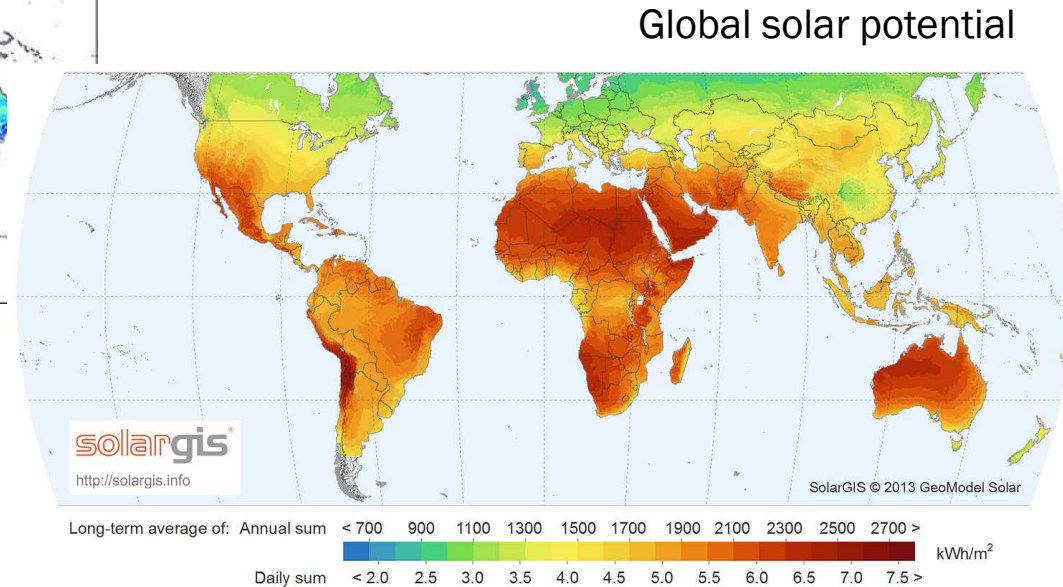
Source: S&P Global Platts

# THE CHALLENGE AHEAD

## BALANCING SUPPLY & DEMAND OF H2 WILL NEED IMPORT



Global wind potential



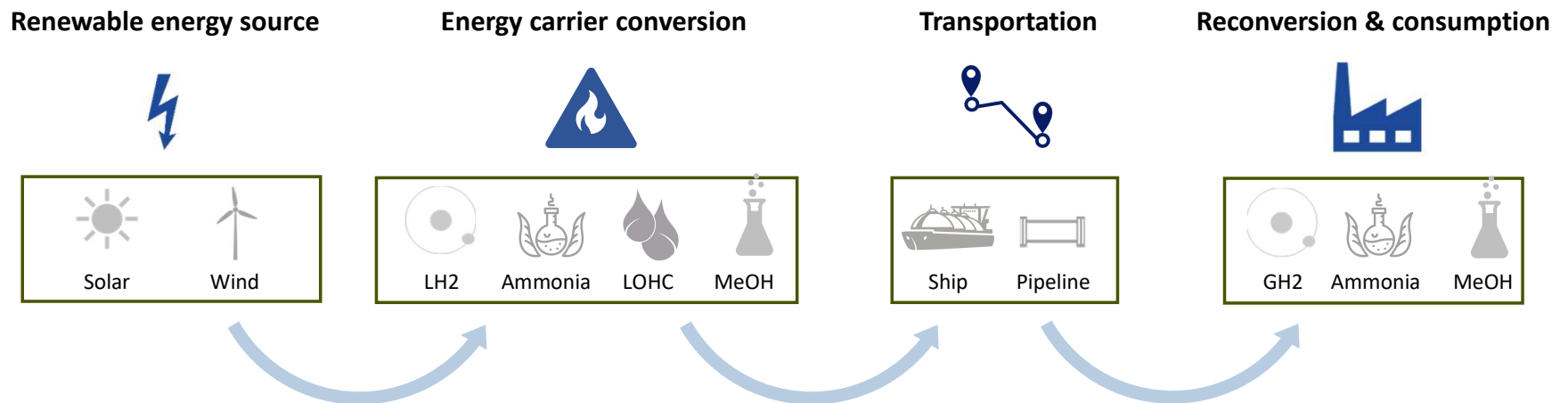
Potential supply regions from green H2 are identified:

- EU: Iceland, Norway, Portugal, Spain..
- MENA: Marokko, Saudi Arabia, Oman, Abu Dhabi...
- South America: Chile, Uruguay, Argentina...
- Africa: Namibia, South Africa....

\*ref: wupperinst.org/fa/redaktion/downloads/projects/INFRA\_NEEDS\_Policy\_Brief.pdf

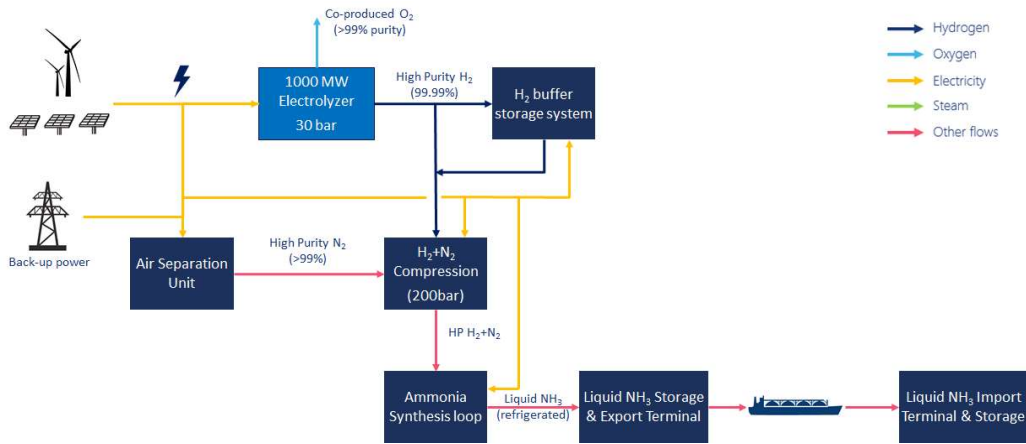
# H2 PRODUCTION AND TRANSPORT CHAIN

## WHAT HAS BEEN DONE: COST MODEL H2 CHAINS\*

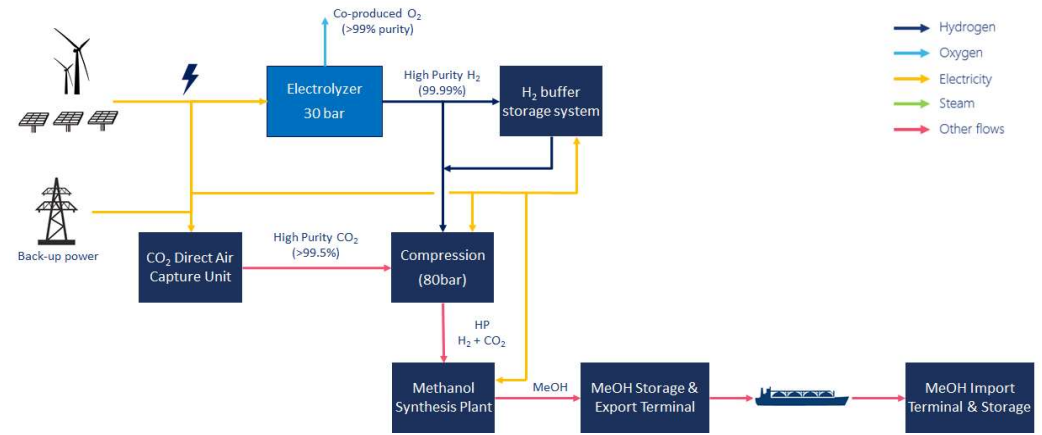


\* Work carried out in the HyDelta program ([www.HyDelta.nl](http://www.HyDelta.nl)) and HyChain (ISPT)

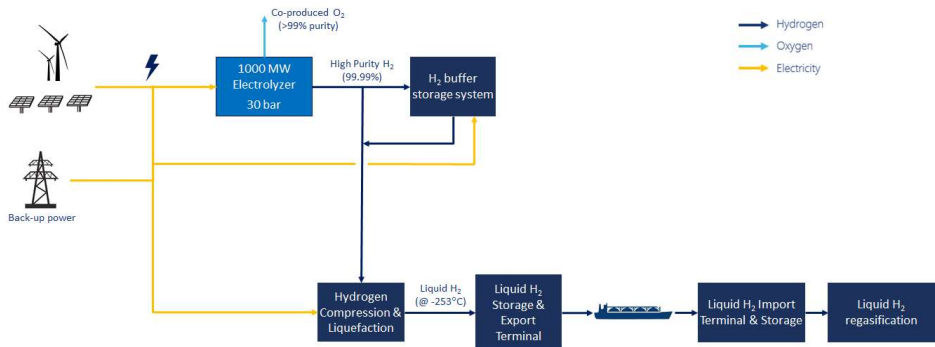
# NH3



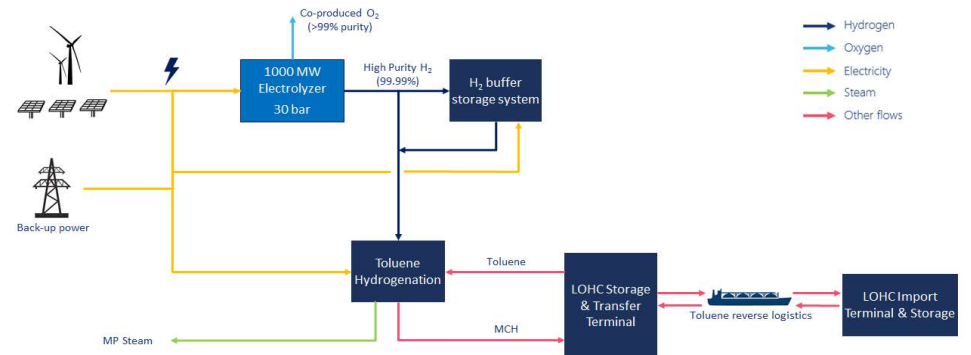
# MEOH



# LH2

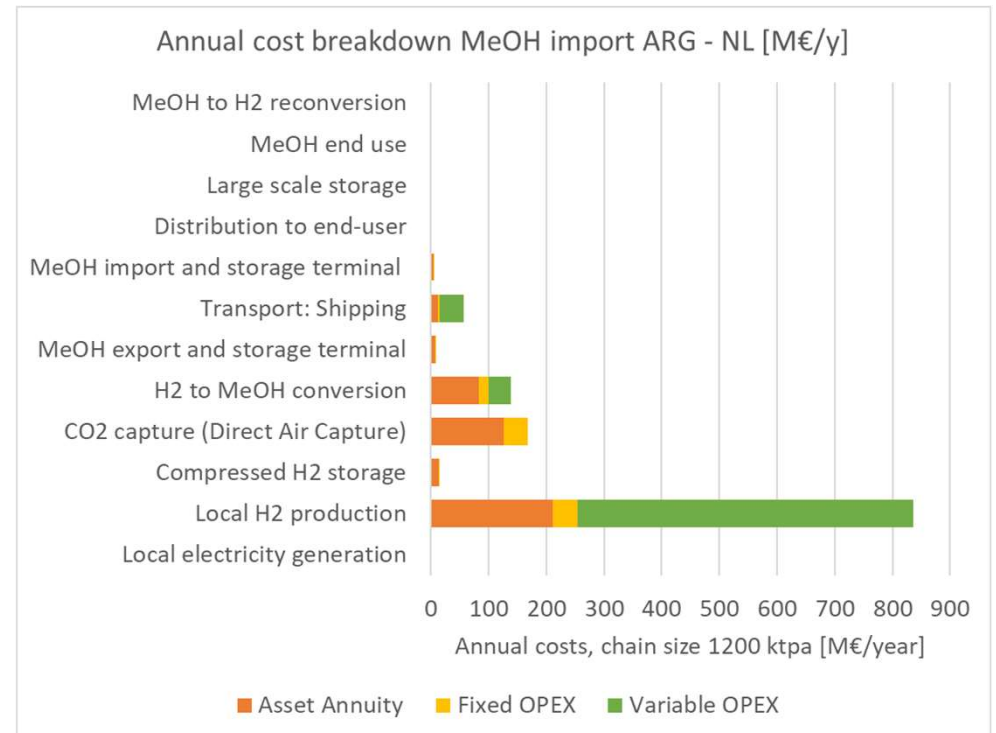
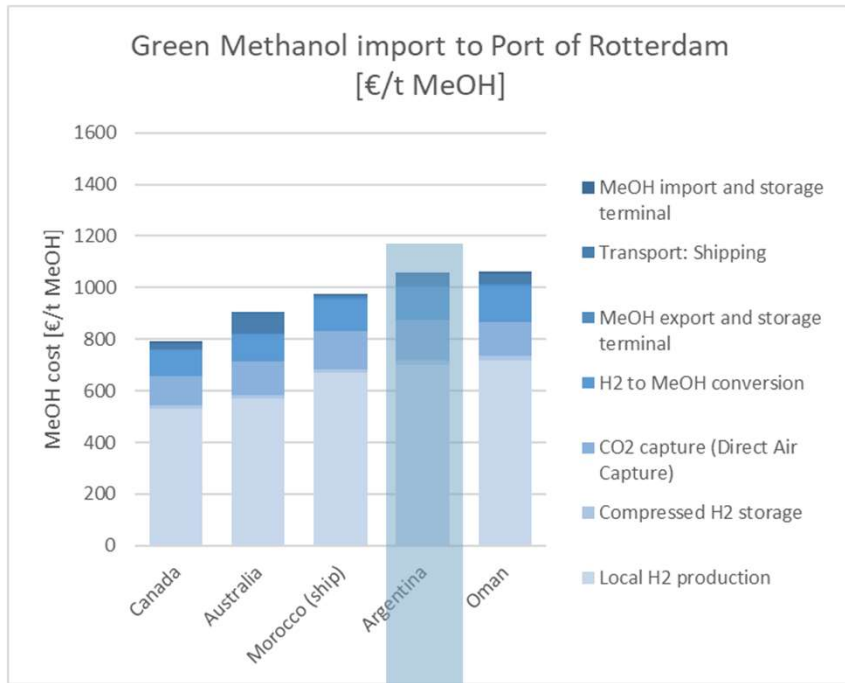


# LOHC



# CURRENT INSIGHTS

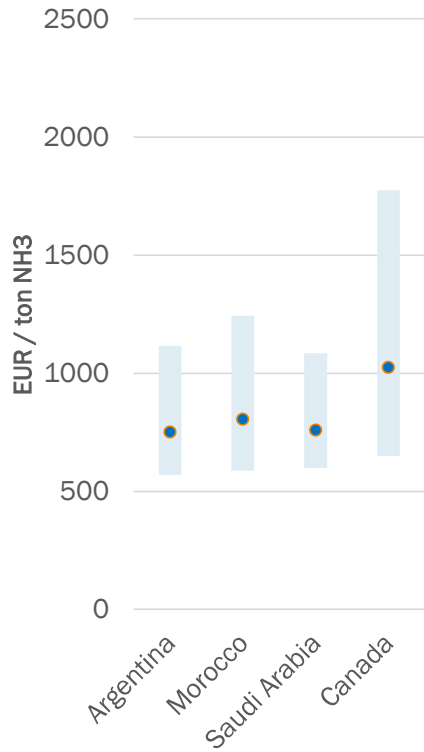
## THE RESULTS



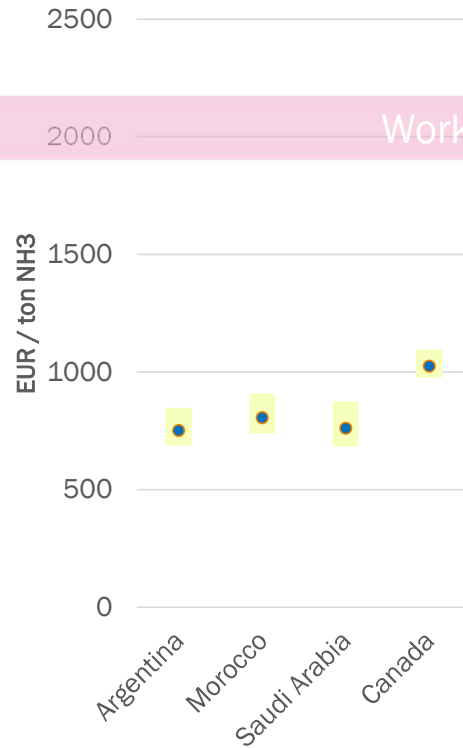


# SENSITIVITY ANALYSIS: NH3 IMPORT

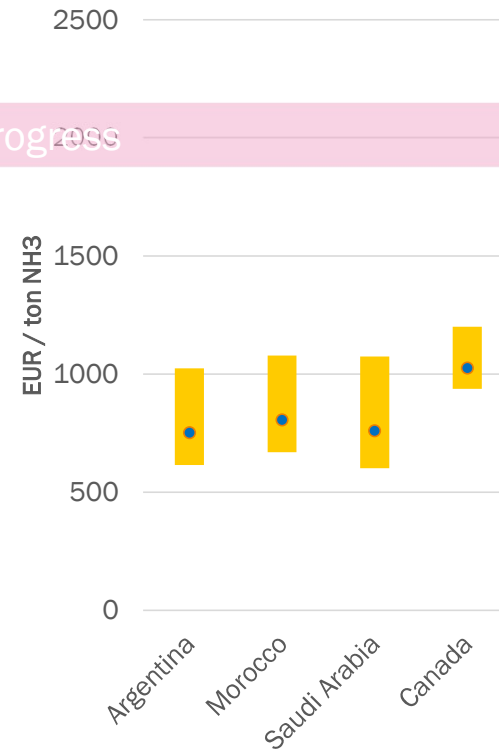
Cost of NH3 import  
Uncertainty ranges for  
**LCoE** (50%, 100%, 150%)



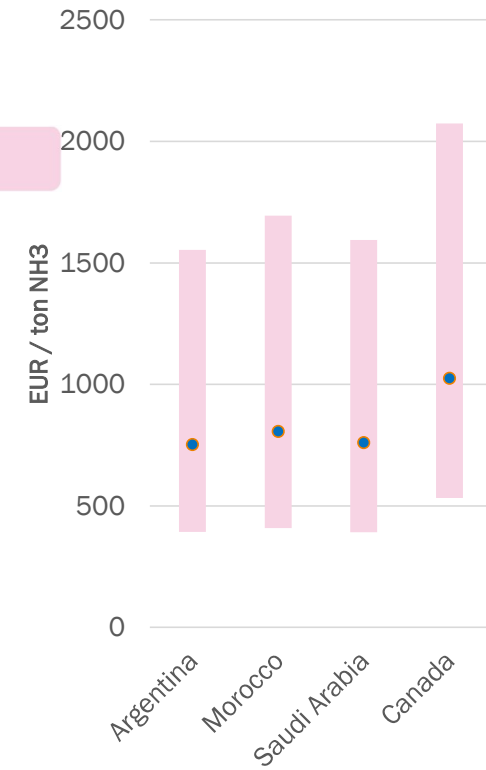
Cost NH3 import  
Uncertainty ranges for **RES  
FLH** (80%, 100%, 120%)



Cost of NH3 import  
Uncertainty ranges for **all  
CAPEX** (50%, 100%, 150%)



Cost of NH3 import  
Combined uncertainty  
ranges **LCoE, RES FLH and  
all CAPEX**



Work in progress

# › WHERE DO WE GO FROM HERE? AN OPEN INVITATION TO COLLABORATE UNDER THE GROWTH FUND

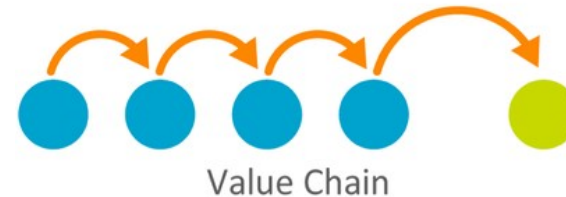
Innovation & implementation program



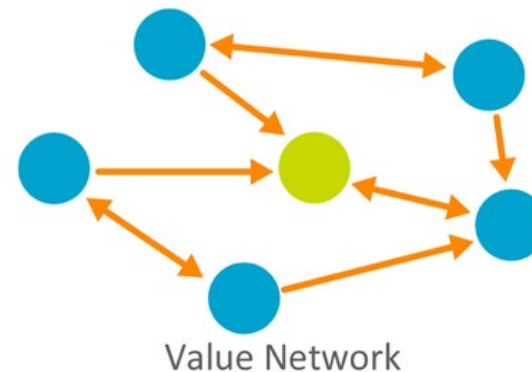
Let's discuss...

- the role that Growth Fund can play to realise some of the potential import value chains for H2 towards our ports
- the potential and innovation needs of chain elements, incl. expected cost developments.
- Not technical aspects, legal, MVO, ESG, political, economic...

Groenvermogen  
van de Nederlandse economie



... Many initiatives under development for initiation of an import value chain for H2 to ports in the Netherlands by various consortia and partners. Need for a joint program....



# WHAT ARE THE QUESTIONS CURRENTLY ON THE TABLE?

## Current insights

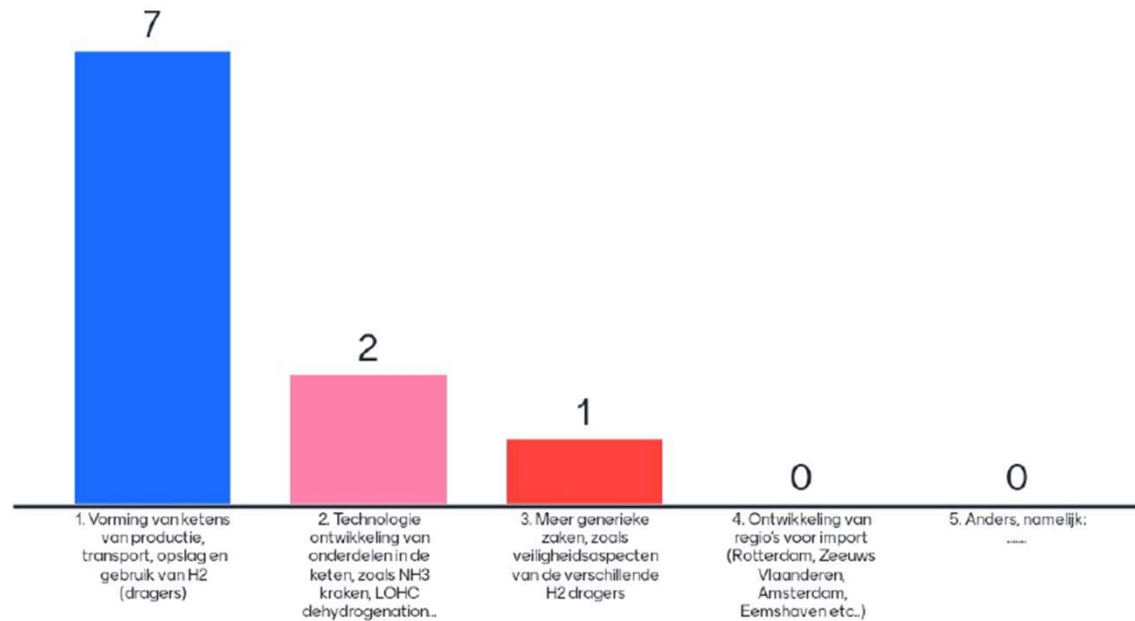
1. What are the **import costs (EUR/kg)** for fuels/chemicals, with single technologies per carrier and production locations globally towards the Netherlands.
2. Which elements are **dominant cost drivers** (%) in the specific import costs per carrier?
3. What is the **cheapest production location (incl. transport)** for LH<sub>2</sub>/NH<sub>3</sub>/MeOH/LOHC out of the selected countries?
4. **How do different chain elements** of an international hydrogen / fuel supply chain **affect the cost** of import to NL?

## Future challenges

- How does importing H<sub>2</sub>/NH<sub>3</sub>/MeOH compare with the locally produced equivalent in NL from renewables?
- What is the cheapest way to import gaseous hydrogen into NL? (add NH<sub>3</sub> and LOHC/MeOH reconversion)
- Which chain has the highest (energy-based) round trip efficiency of the 4 options?
- How much electricity does the supply chain consume per ton/GJ produced?
- What are the safety challenges and environmental footprint?

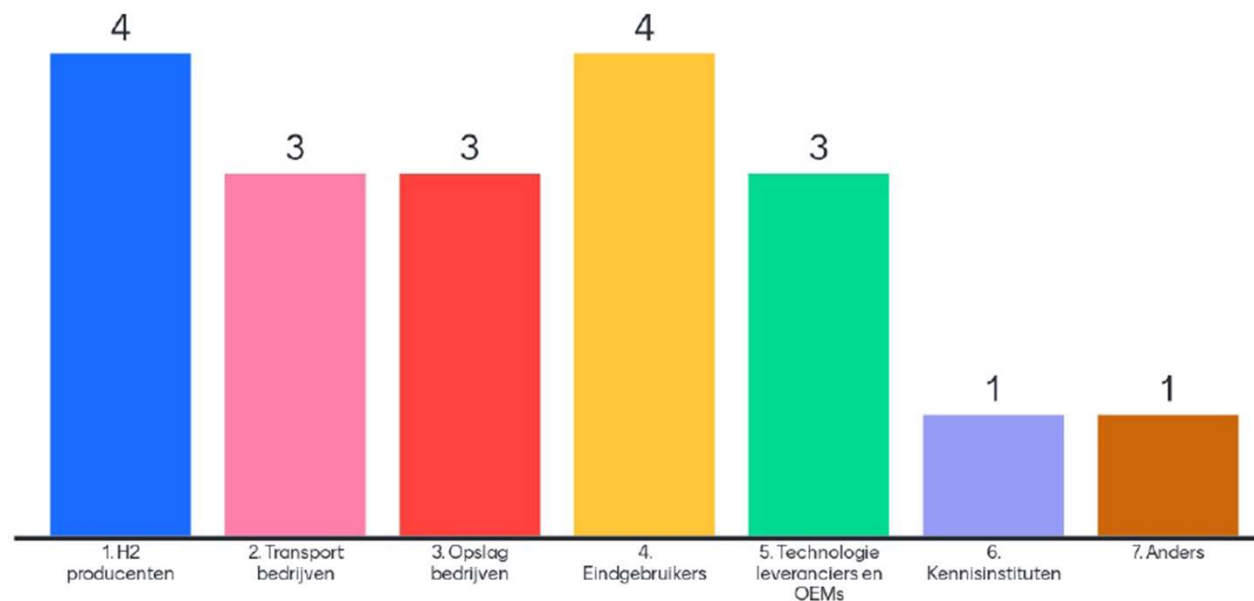
## Een samenwerkingsprogramma op H2 import onder het groeifonds zou zich moeten richten op:

Mentimeter



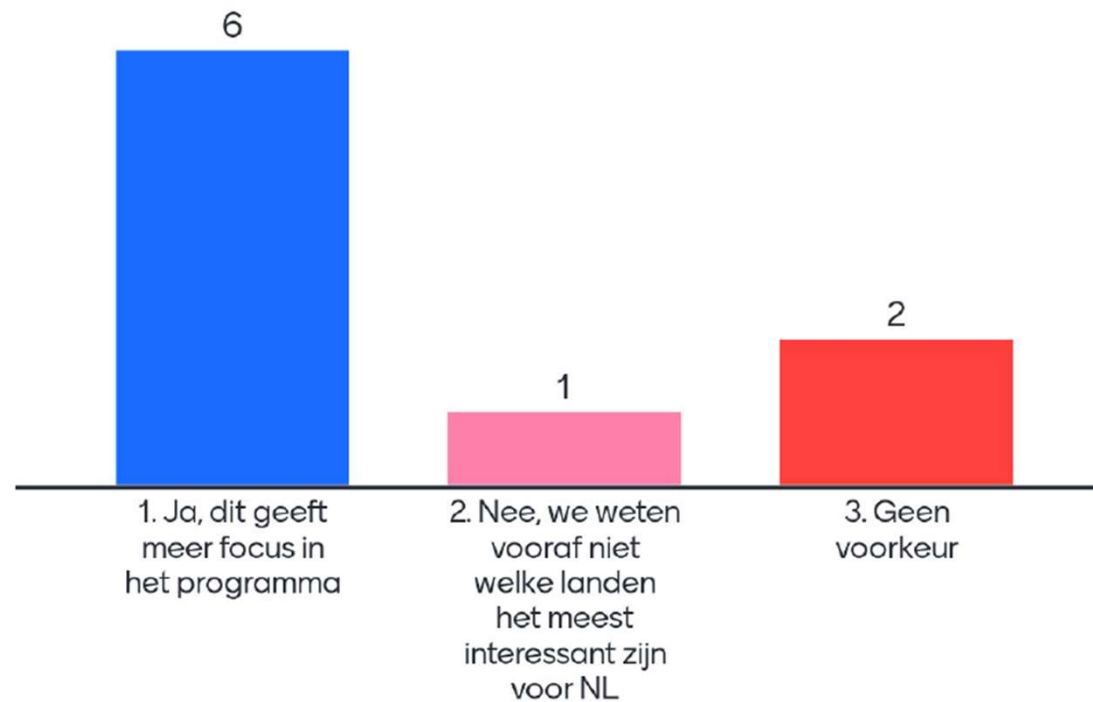
## Een samenwerkingsprogramma is alleen zinvol als de volgende partners deelnemen

Mentimeter



## In het programma zou een keuze moeten worden gemaakt voor een aantal landen

Mentimeter



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# VOLGENDE KENNISSESSIE 16 NOVEMBER

## Face-2-Face

- Ministerie van EZK – Bezuidenhoutseweg 73, Den Haag

14.30 – 15.00	Ontvangst	
15.00 – 15.30	Tour de table	
15.30 – 16.15	Milieu en omgeving: Draagvlak	Axel Pel   DCMR
16.15 – 17.00	Marktontwikkelingen en certificering	Bert den Ouden   HyXchange
17.00 – 18.00	Borrel	



## HARTELIJK DANK VOOR UW AANDACHT

Vragen? Neem gerust contact met mij op:

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+31 6 23 34 65 16