



# Welkom bij DNV

DNV TECHNOLOGY CENTRE GRONINGEN

2 November 2023 – Groningen – The Netherlands

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WHEN TRUST MATTERS





# Welkom in PLVS VLTRA Groningen ([Link](#))





# Welkom bij DNV Technology Centre Groningen





# DNV in brief

## Our purpose

To safeguard life,  
property, and the  
environment

## Our vision

A trusted voice  
to tackle global  
transformations

# A global assurance and risk management company

159  
years

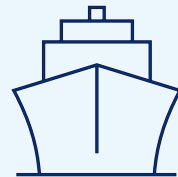
~13,000  
employees

~100,000  
customers

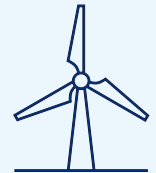
100+  
countries

5%+  
of revenue in R&D

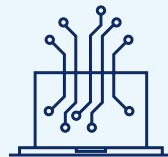
Ship and offshore  
classification and advisory



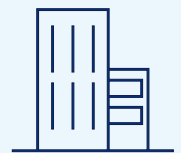
Energy advisory, certification,  
verification, inspection and  
monitoring



Software, cyber security,  
platforms and  
digital solutions



Management system  
certification, supply chain and  
product assurance



# Enabling our customers and their stakeholders to manage risk and complexity with confidence



## Certify, verify and test

against standards, specifications and regulatory requirements



## Qualify and assure

new technologies, systems, data, platforms, supply- and value chains



## Give expert advice

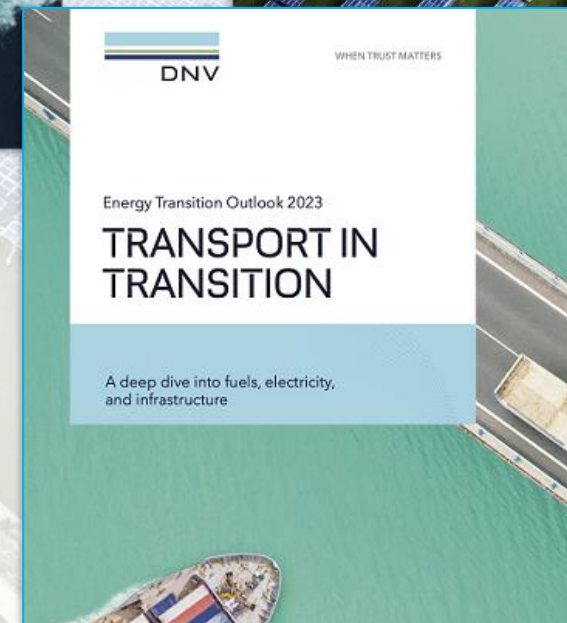
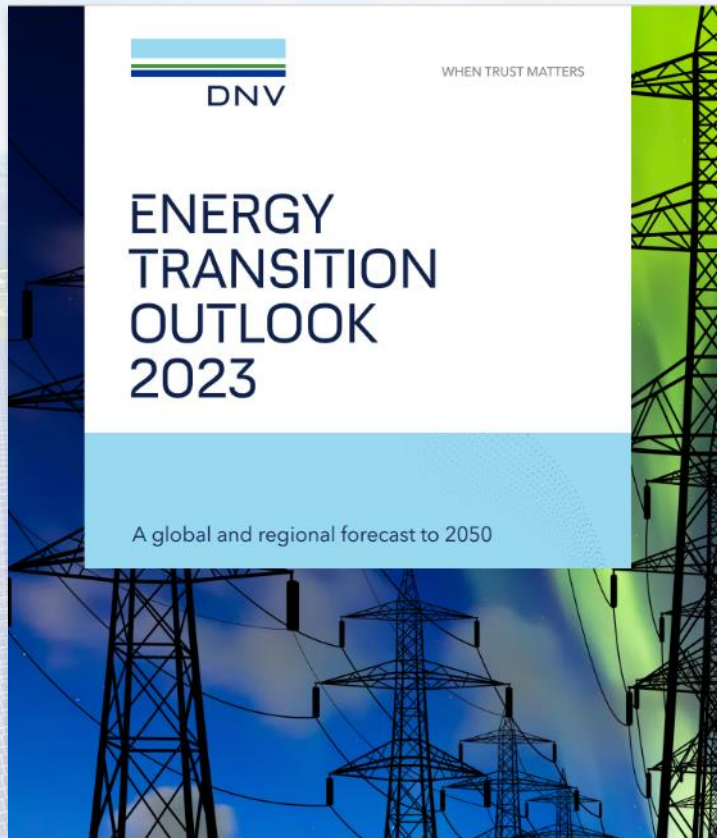
on safety, technology and commercial risk, and operational performance



## Co-create and share

new rules, standards, software and recommended practices

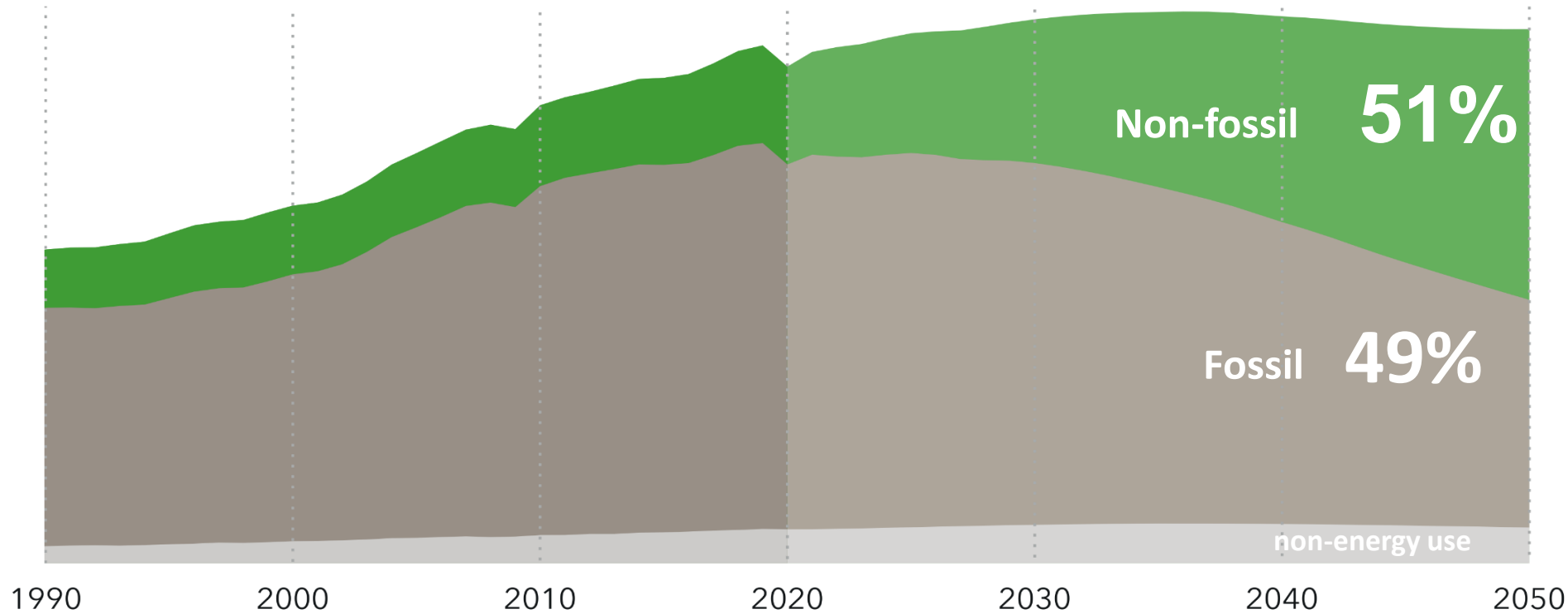






# We predict a significant decarbonization of the world's energy system

World primary energy supply by source

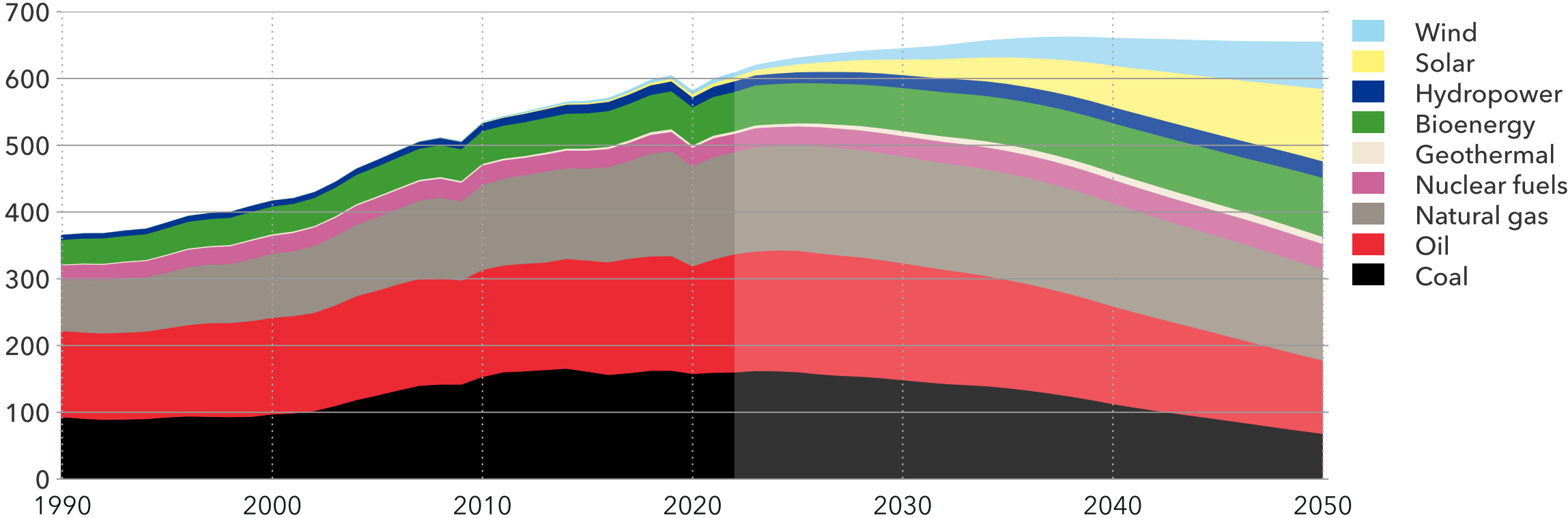


Historical data source: IEA WEB (2022)

# Primary energy supply peaks in 2036

World primary energy supply by source

Units: EJ/yr



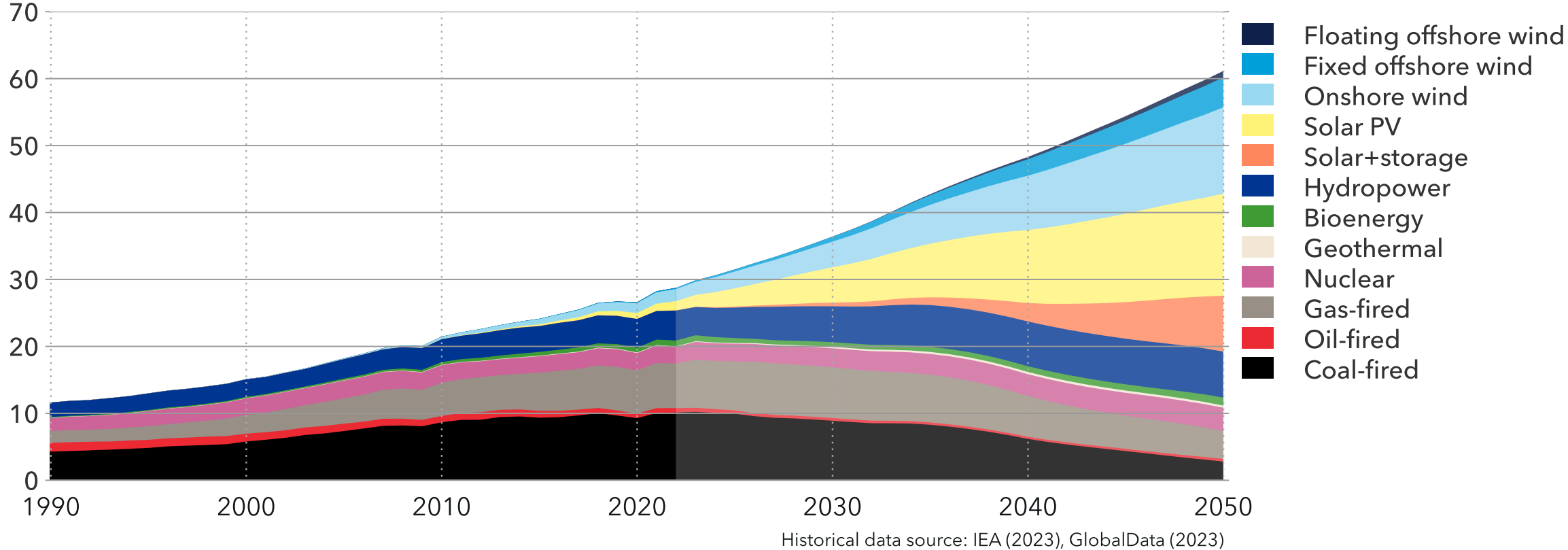
Historical data source: IEA WEB (2023)



# 68% of electricity will come from solar and wind in 2050

## World grid-connected electricity generation by power station type

Units: PWh/yr



# DNV Technology Centres

Oslo (No) - Spadeadam (UK) - Groningen (NL) - Columbus-Ohio (US) - Bergen (No) - Singapore



# DNV Technology Centres

## TRUST

By combining deep industrial expertise with test capabilities, our Technology Centres help our customers to understand and navigate the complexity of decarbonizing with trust.

## ASSURANCE

We provide assurance by qualifying and applying innovative technologies and new ways of working in a safe, cost-effective and sustainable way.





## Firmly established in the energy industry

We understand business drivers and threats as we are deeply rooted in the energy industry



# Collective in-depth and broad knowledge

**We provide expert advice and have test capabilities across the energy landscape, including offshore wind, hydrogen and carbon capture in the areas of:**

Materials  
corrosion

Structural  
integrity

Safety analyses &  
Failure investigation

Metrology  
in energy

Low-carbon fuels  
and technologies

# Ensuring the reliable operation of critical assets and systems

We enable our customers to establish operational limits and assure performance through the lifetime of their assets.





# Inspire and help the energy industry to move forward together

We drive innovation and standardization by bringing industry players together in joint industry programmes to develop new technologies, recommended practices and standards.



# DNV Technology Centre Groningen (NL)

Visit our website: [Link](#)



# DNV Technology Centre Groningen



Fuel Transition

Hydrogen Innovation

Combustion technology

Metrology & Flow technology

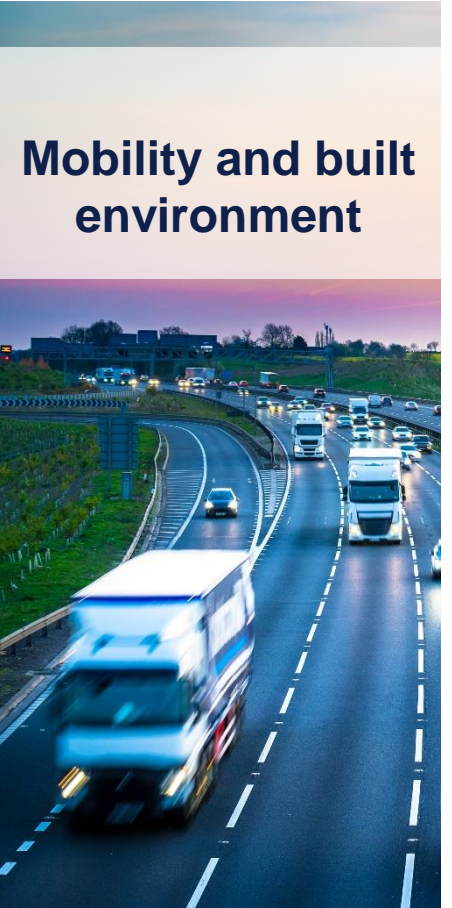
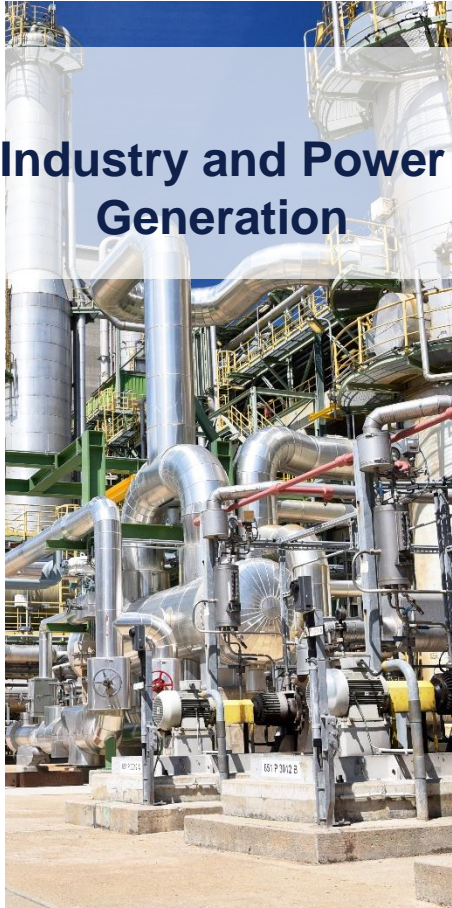
Gas Technology

New Energies

Clean Technology



# Application areas





# Hydrogen project portfolio

## Understand fundamentals



Proofing the safety case for Hydrogen Dispersion experiments for small leaks

## Qualify & Demonstrate



Pilot Rozenburg- Heating homes with locally produced hydrogen

## Mature & Implement

Parameter	Eenheid	
Wobbe-index	MJ/m <sup>3</sup> (n)	18.48-20.35 <sup>A</sup>
Waterstof	mol%	≤ 9
Inerten	mol%	≤ 2 inert N <sub>2</sub> , Ar, He
Koolwaterstoffen	mol%	< 1.5 incl. CH <sub>4</sub>
Koolwaterstofdauwpunt	°C	≤ -2 bij heersende druk
Waterdauwpunt	°C	-8 bij 70 bar(o)
Zuurstof	molppm	≤ 10
Koolstofdioxide	molppm	≤ 20
Totaal S gehalte (incl. H <sub>2</sub> S)	molppm	≤ 3
Halogenen	molppb	≤ 50
Koolmonoxide	molppm	≤ 20
Mierenzuur	molppm	≤ 10
Ammoniak	molppm	≤ 10
Formaldehyde	molppm	≤ 10
Stofdeeltjes (> 5 µm)		Disclaimer <sup>B</sup>
Temperatuur (entry)	°C	5 - 30 <sup>C</sup>
Temperatuur (exit)	°C	5 - 30 <sup>C</sup>

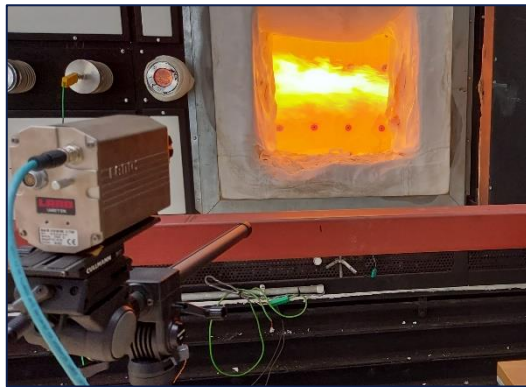
H<sub>2</sub> specification

Hydrogen specification for governments and authorities

## Operational support



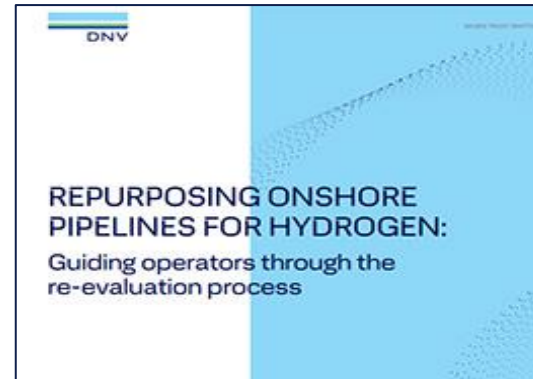
Hydrogen tube trailer – ready for operation test



Industrial Decarbonisation  
Hydrogen for high temperature processes



Hydrogen readiness assessment of flow meters in Joint Industry project



Guidelines and recommended practices



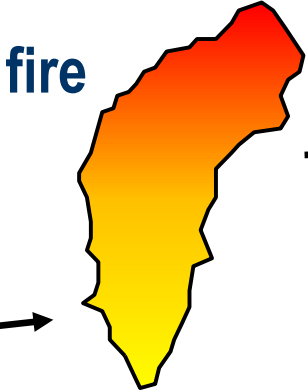
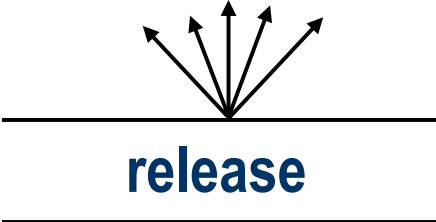
Commissioning hydrogen fuelling stations

# Hydrogen Safety



# Hazards from Flammable Gases

We will concentrate on the items within the red line



Harm to People

structural collapse





# HyStreet: A Distribution and Domestic Gas Research Facility at DNV Spadeadam



Releases from gas distribution network upstream of the meter



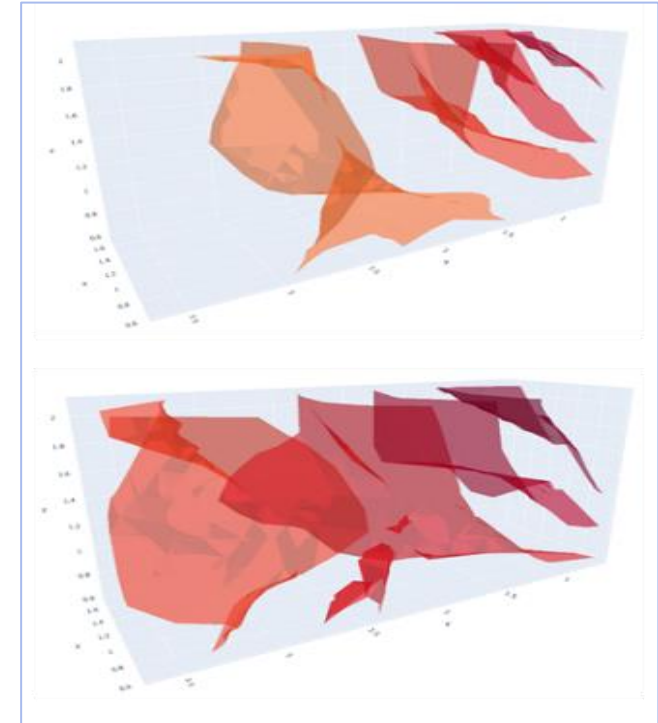
Releases from domestic pipework downstream of the meter



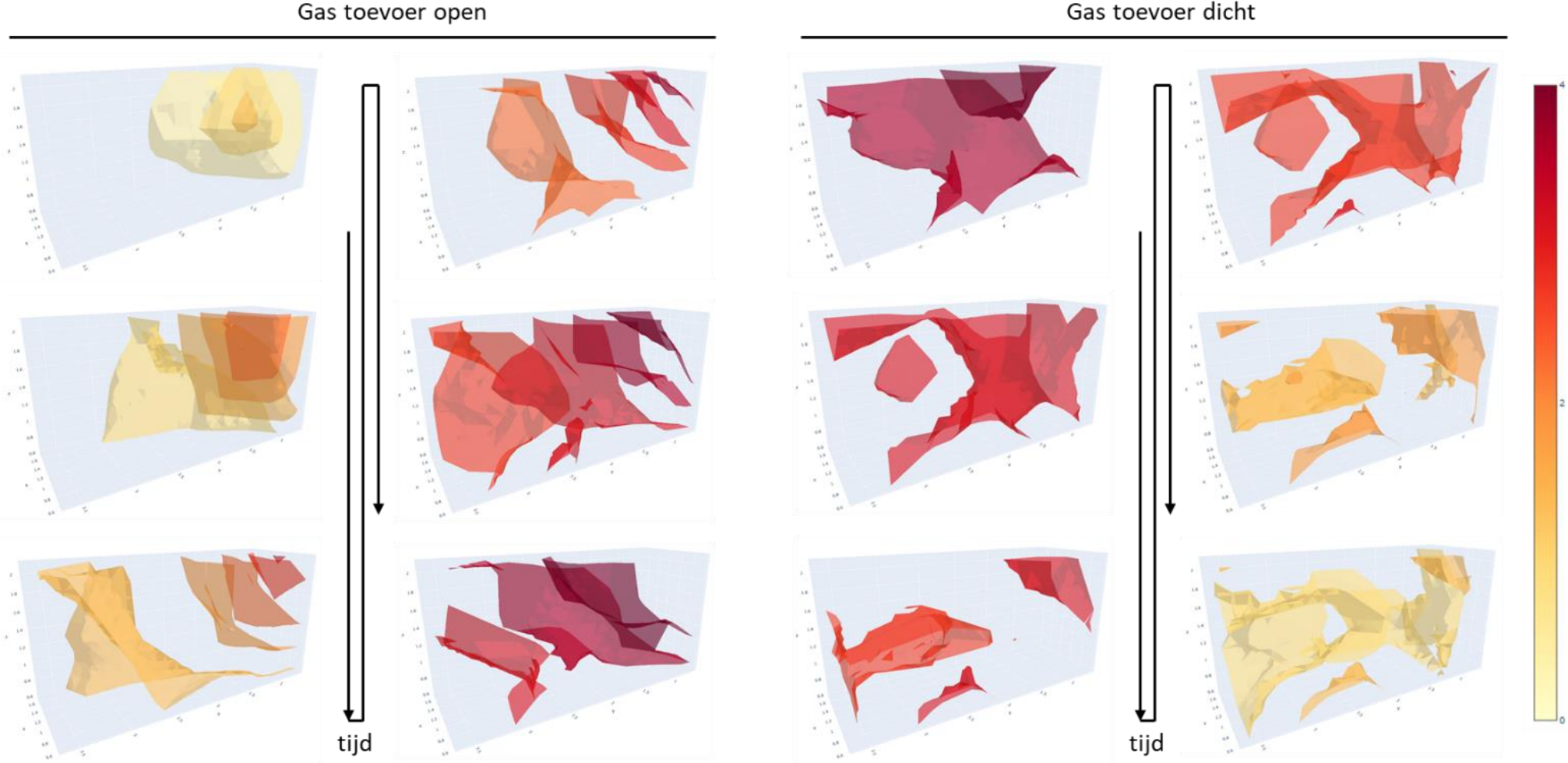
Understanding de safety case for hydrogen

# Dispersion experiments for small hydrogen leaks

(<20 dm<sup>3</sup>/h)



# Gas build-up

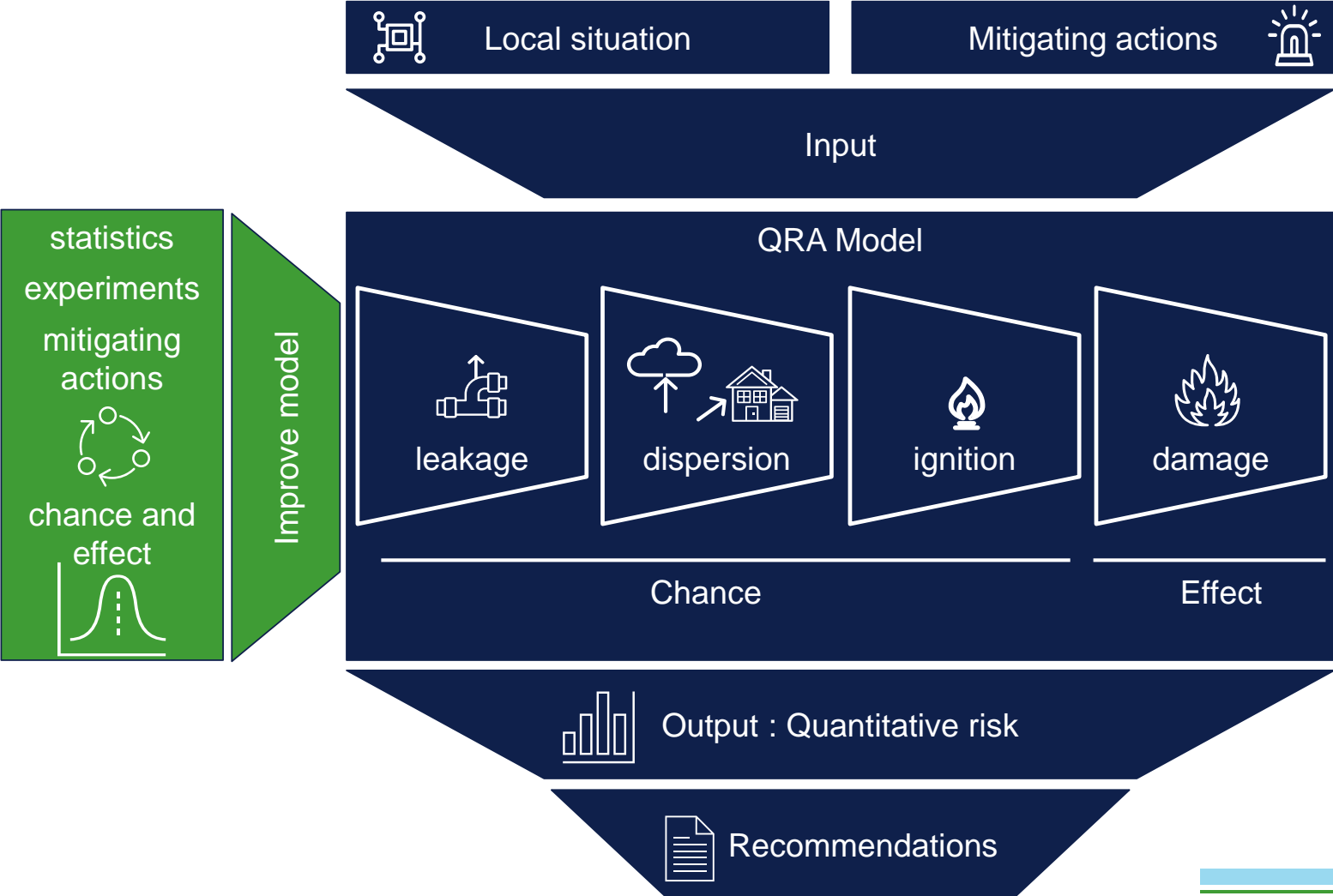




# Quantifying risks helps

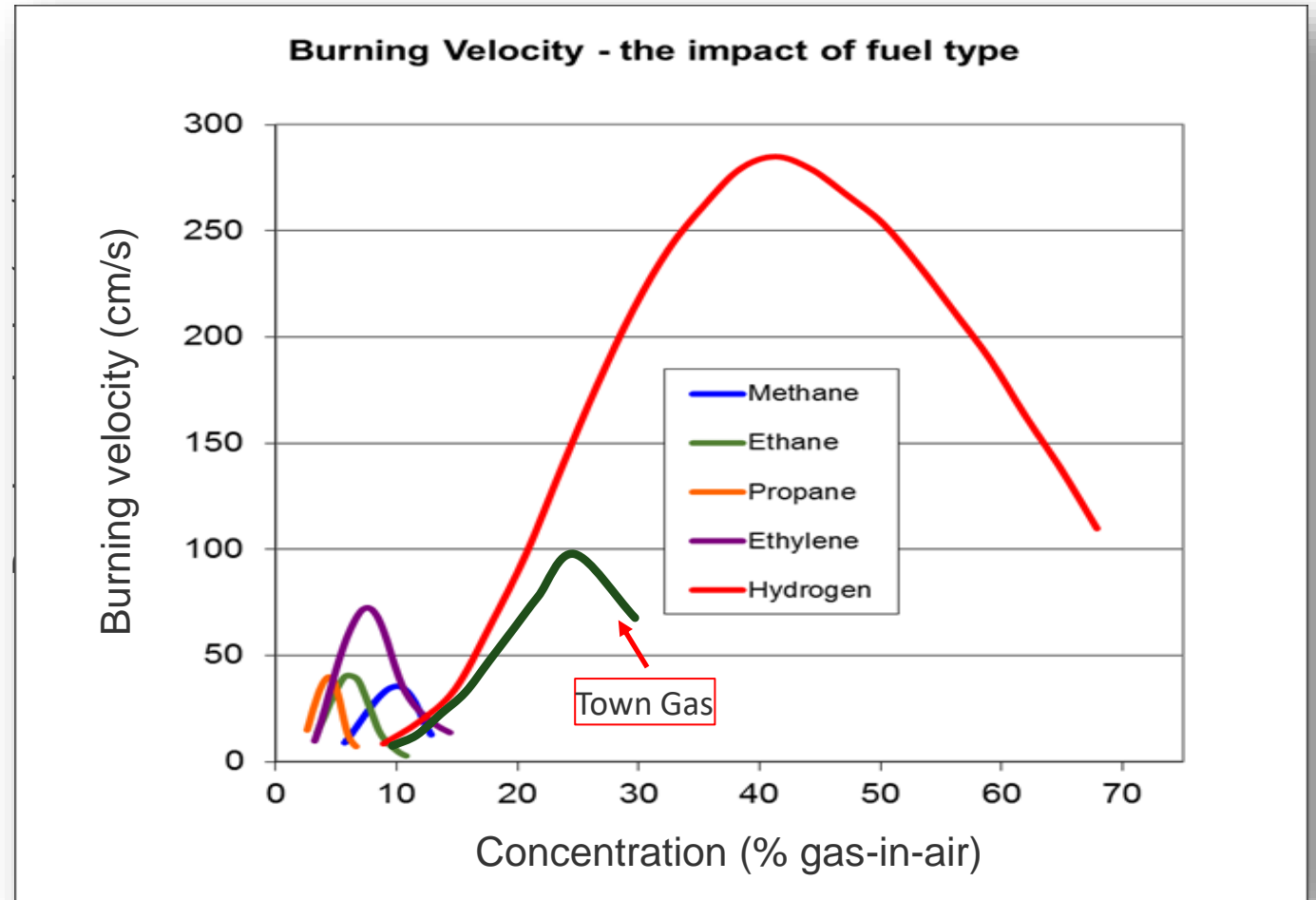
## DNV Quantitative risk model:

Mapping the risks of the behaviour of hydrogen in the event of leaks in homes and in the distribution network and to define mitigation measures based on the risks.



# Burning Velocity Comparison with Hydrogen

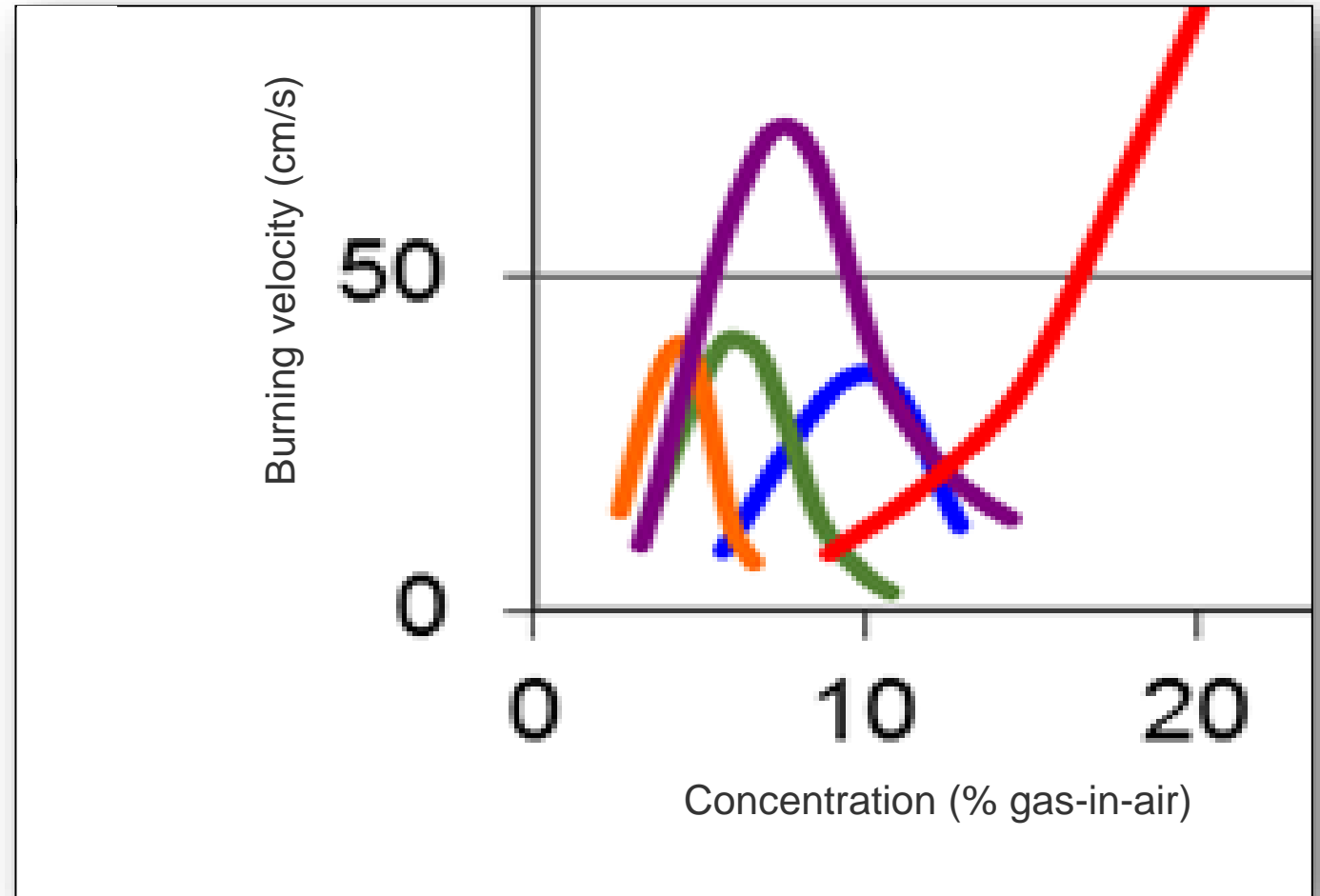
- Hydrogen has a much higher burning velocity than hydrocarbons (& Town Gas)





# Burning Velocity – Actual Concentrations

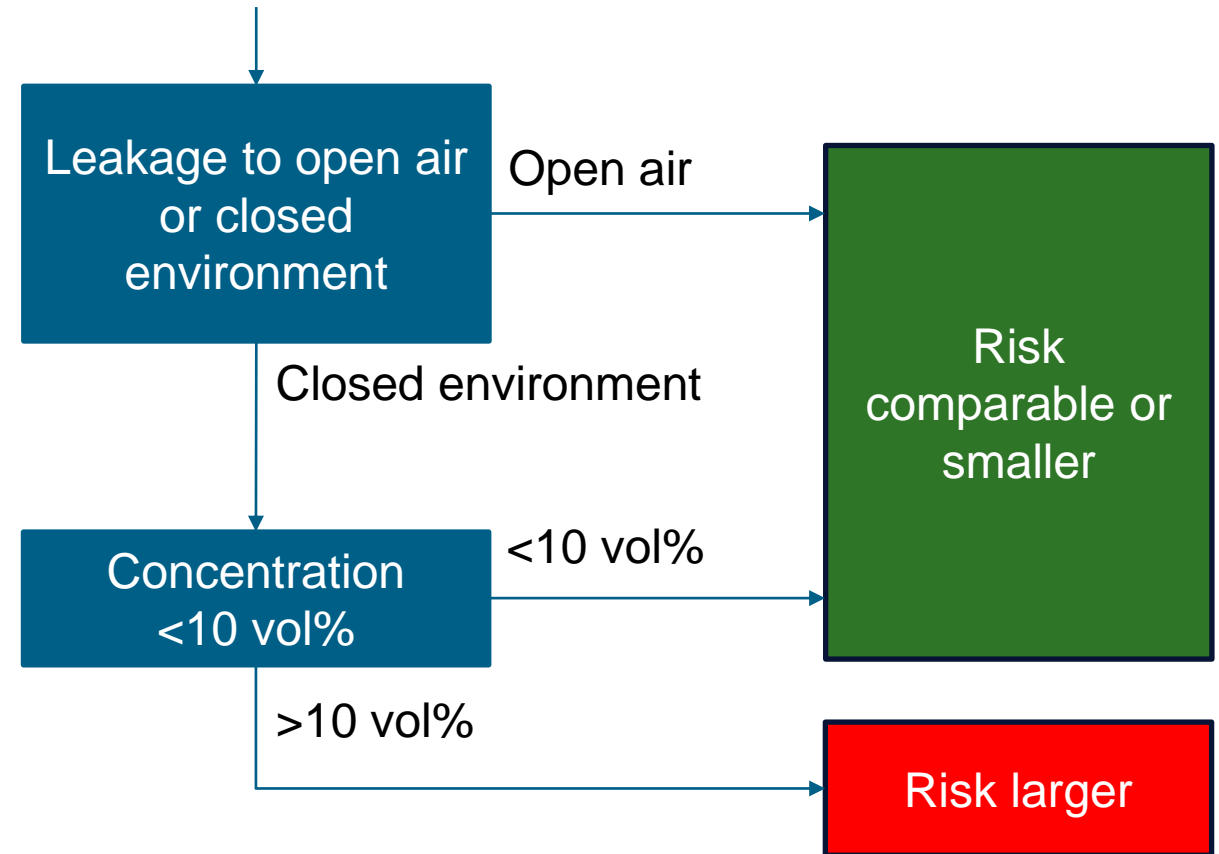
- Hydrogen requires much higher concentrations
- At low concentrations it is no worse than natural gas
- Need to understand gas build-up and explosions to understand safety implications



# Hydrogen versus Natural Gas

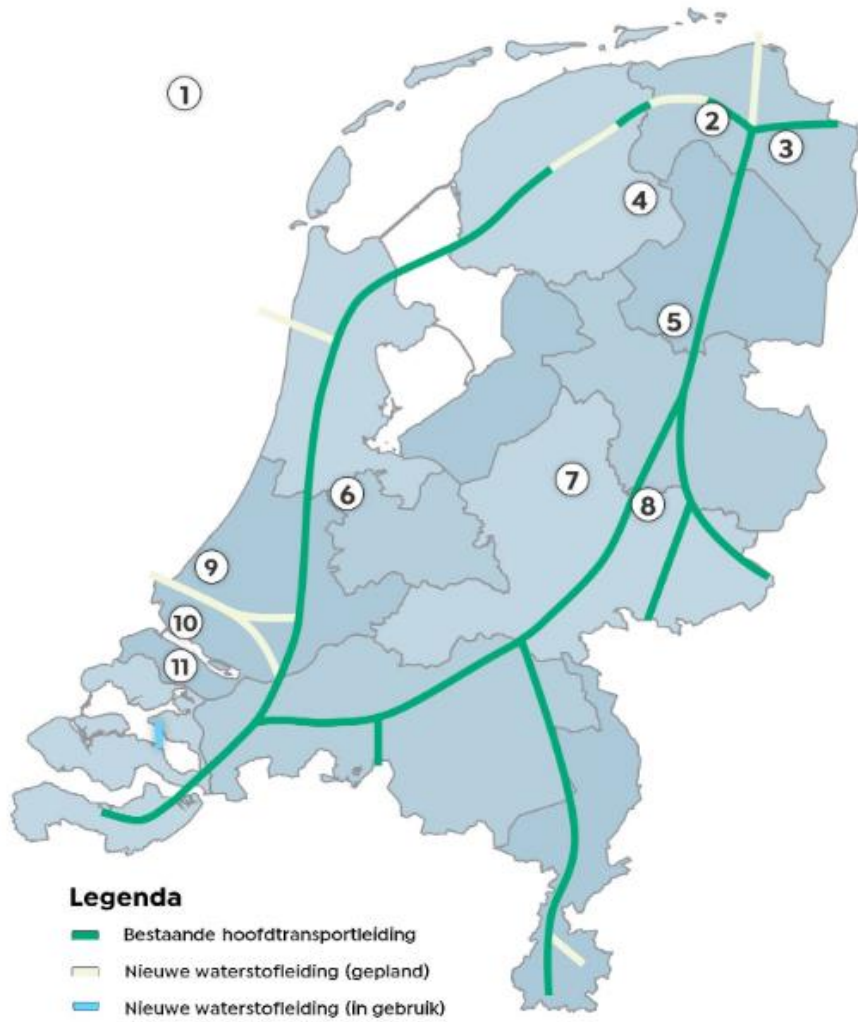
Many risks are comparable. Nevertheless, accumulation of hydrogen results in higher risk

- Number of leakages and outflow are comparable with natural gas
- Leakage to open air is comparable with natural gas:
  - Chance is comparable
  - Effect of fires are smaller or equal
- Accumulation in closed spaces
  - Concentration < 10vol%: risk smaller
  - Concentration > 10 vol%: risk higher
- **Find mitigating actions to lower the risk!**
- **Learn and find evidence**





# Dutch hydrogen pilots for built environment



Source: Netbeheer Nederland

3. Hydrogen village “**Wagenborgen**” – 30-40 existing homes on 100% Hydrogen– opening mid 2023
5. Hydrogen project **Hoogeveen** – 100+ house on Hydrogen – construction started
8. Hydrogen village **Lochem** – 11 homes of nearly 100 years old are switched to 100% hydrogen – opened in December 2022
10. Hydrogen pilot “**Rozenburg**” (STEDIN)– one apartment block on 100% hydrogen – ongoing for 3 years
11. Hydrogen village “**Stad aan ’t Haringvliet**” (STEDIN) – 600 houses – in preparation



# Assuring the quality hydrogen



# Assuring the quality of natural gas, hydrogen, biogas...

## Commissioning H2 fuelling station



## Checking biogas composition



# Satisfactory odorisation is a matter of public safety

What is the proper odorant for hydrogen?

- Natural gas (as well as hydrogen) has no or very little inherent odor.
- Gas must be odorised to give a distinctive and characteristic odor so that leaks are readily detected - (NEN 7244-1)
- Therefore, odorant compounds are added to provide it with the required warning odor.
- Satisfactory odorisation is a matter of public safety - this is valid for hydrogen and natural gas / hydrogen mixtures as well
- A common odorant across Europe is **Tetrahydrothiophene (THT)**, however, THT contains sulphur which will damage fuel cells
- So, we need a new odorant for hydrogen



Natural Gas

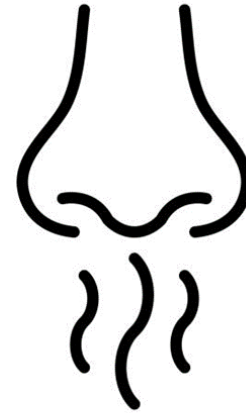
?

Hydrogen



# Hedonic tone – evaluation index for odors

- The offensiveness of an odor perception is often measured in terms of the “hedonic tone”, a category judgment of the relative like (pleasantness) or dislike (unpleasantness) of the odor.
- Odor perception is expressed in a scale ranging from -4 (extremely unpleasant) to + 4 (extremely pleasant), being 0 an odor that is not perceived neither as pleasant nor unpleasant.



Odor	Hedonic tone
Strawberry	2.93
Apple	2.61
Hay	1.30
Grain	0.63
Mushroom	0.52
Iso-valeric acid	-1.57
Butyric acid	-1.77
Mercaptans	-2.30
Ammonia	-2.47
Rotten fruit	-2.76
Urine	-3.34
Manure	-3.36
Dead animal	-3.75



# A good odor....

- must have a **unique odor** so that confusion with any other substance is prevented;
- should be **easily perceived** by a person with an average olfactory (sense of smell);
- the perception of the smell is **alarming**- also at low concentrations (1% in air)
- the smell should **not change when diluted**;
- must remain **stable** in the gas system and not react with natural gas / hydrogen;
- must **not be harmful** to components in the gas system and/or gas applications;
- may **not lead to undesirable emissions** - may not leave residual products behind after use of the gas,
- may **not be toxic** for humans;
- should have a vapour pressure that high that keeps the odorant under all conditions is in the **gaseous phase**;
- must be **available** and **affordable**.

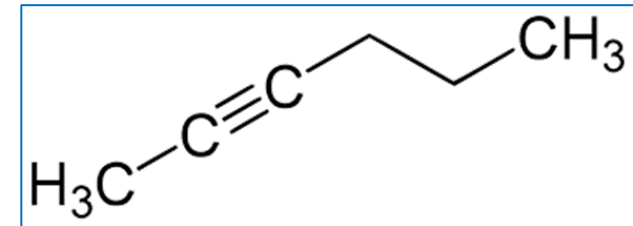


# Hydrogen odorant selection

## Long list

- Tetrahydrothiophene (THT)
- Spotleak ® 1001 (THT)
- Gasoder ® (S-Free)
- Dimethyl sulfide (DMS)
- Tert-butyl mercaptan (TBM)
- 5-ethylidene-2-norbornene;
- methyl tert-butyl ether;
- 2-hexyne
- 2,3-butanedione
- Ethyl sugar lactone
- Ethyl isobutyrate
- 5-ethylidene-2-norbornene
- Cyclohexane
- Methyl tert-butyl ether
- Tri-methylamine
- 1-pentyne
- Ethyl isocyanide (enamine or isocyano ethane)
- n-Butyl isocyanide
- Methyl methacrylate
- DES (DiEthylStilbestrol)
- 1-Butyne
- 5-Ethyl-3-hydroxy-4-methyl-2 (5h)furanone
- Mix of selenides
- Mix aldehyde, acrylates and selenide
- Cyclo-octyne
- Acetylene
- ....
- .....

**We have a first candidate**



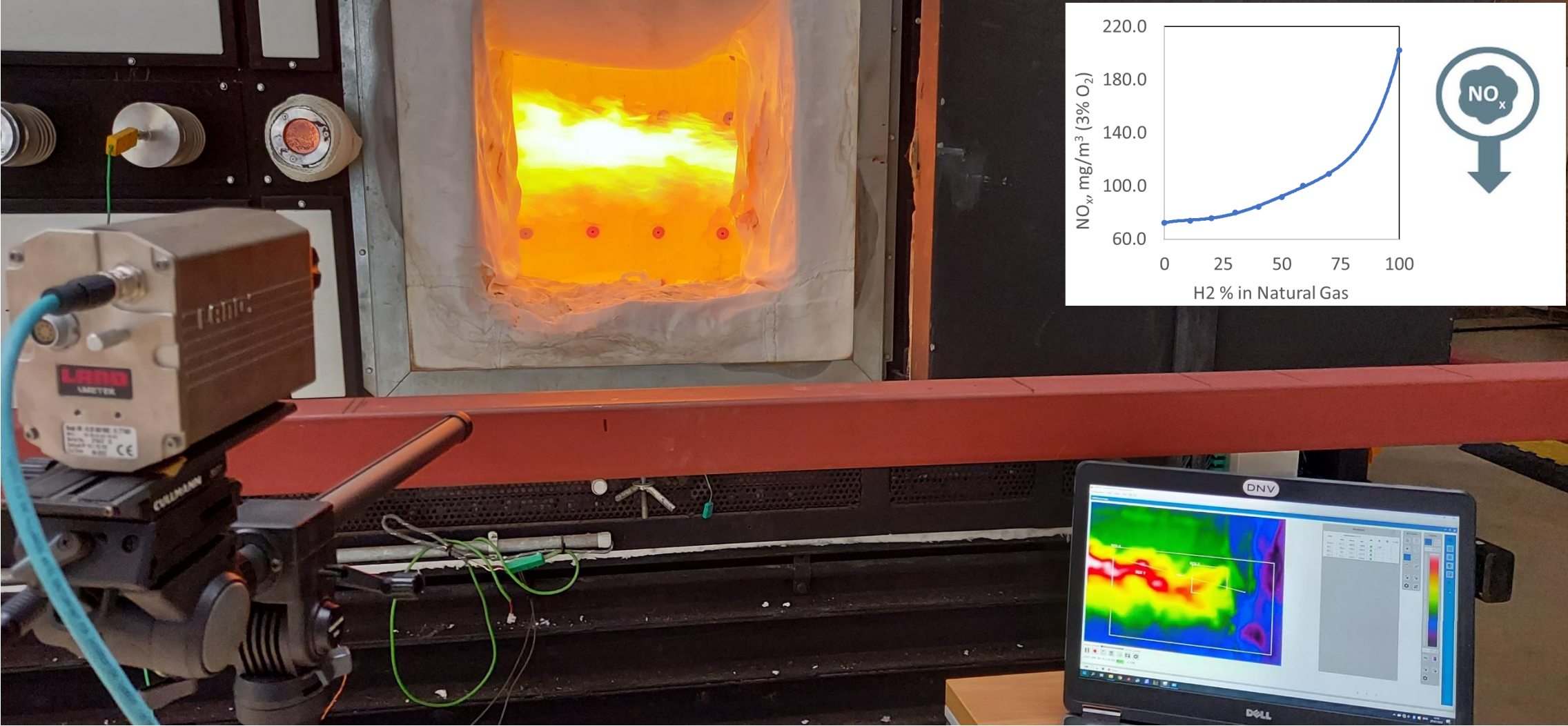
**2-hexyne – (C<sub>6</sub>H<sub>10</sub>)**



# Industrial decarbonisation

# Facilitating the introduction of hydrogen for the industry

Decarbonize industrial production processes (steel, ceramics, glass, food)





# Key steps to successfully implement industrial decarbonization solutions

1

## Evaluation of options

- Detailed, prioritized techno-economic overview of the solutions
- In depth techno-economic-environmental feasibility study
- Develop business cases and Project Development Plan
- Stakeholder mapping
- Technology assessment (BAT scan)
- System impact analyses

*Explore*

2

## Concept development

- Functional Specification / Conceptual design
- Inventory of local laws, regulation and permitting
- Define objective of pilot
- Safety & risk analysis studies (TRA / HAZOP / RIE / contour calculation)

*Prepare*

3

## Design & Build

- Engineering concept design (P&ID)
- Safety Studies
- Permitting process
- Bill of Material (BOM) & purchasing support
- Design documentation (QRA, PED, EVD, ATEX)
- Commissioning (FAT, SAT)

*Realize*

4

## Operate and Monitor

- Monitoring performance
- Analysis and discussion of the data
- Organize dissemination activities (PR) / share key results
- Safety aspects evaluation
- Publish the results
- Define next steps

*Learn*



WHEN TRUST MATTERS

# Thanks for you attention

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