RYSTAD ENERGY

THE EUROPEAN HYDROGEN MARKET

KEY PROJECTS AND TRENDS

JONNY SCAFIDI, HYDROGEN ANALYST

MAY 2022

Norwegian Energy Partners

Hydrogen & CCS Webinar – Europe

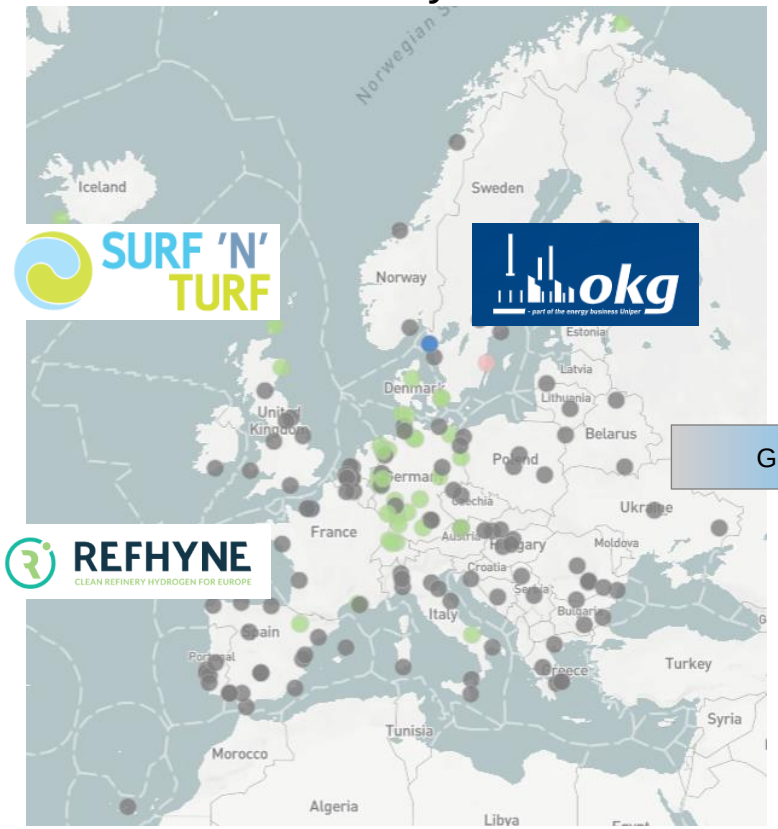
Agenda

1) Current and future state of play in Europe
2) Production, targets, and imports
3) The effects of Russia’s invasion of Ukraine
4) Costs

Setting the scene: European hydrogen projects

Today vs 2040

Today



Small individual projects

Grey to green via blue

2040

Large clusters

Source: Rystad Energy HydrogenCube

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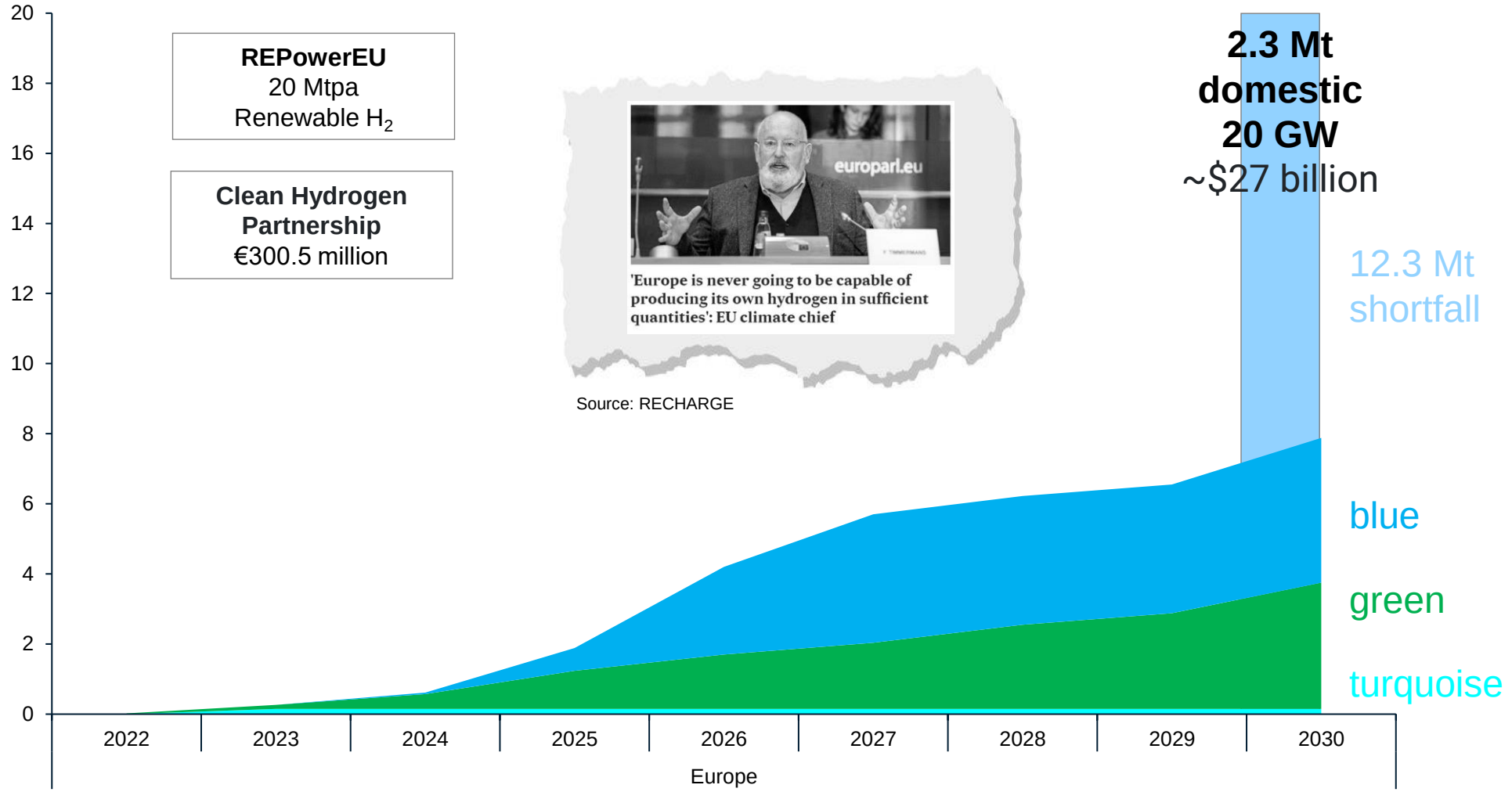
EU hydrogen pipeline needs to ramp up fast to meet targets

Planned production capacity (Mtpa H_2)



Source: Rystad Energy HydrogenCube

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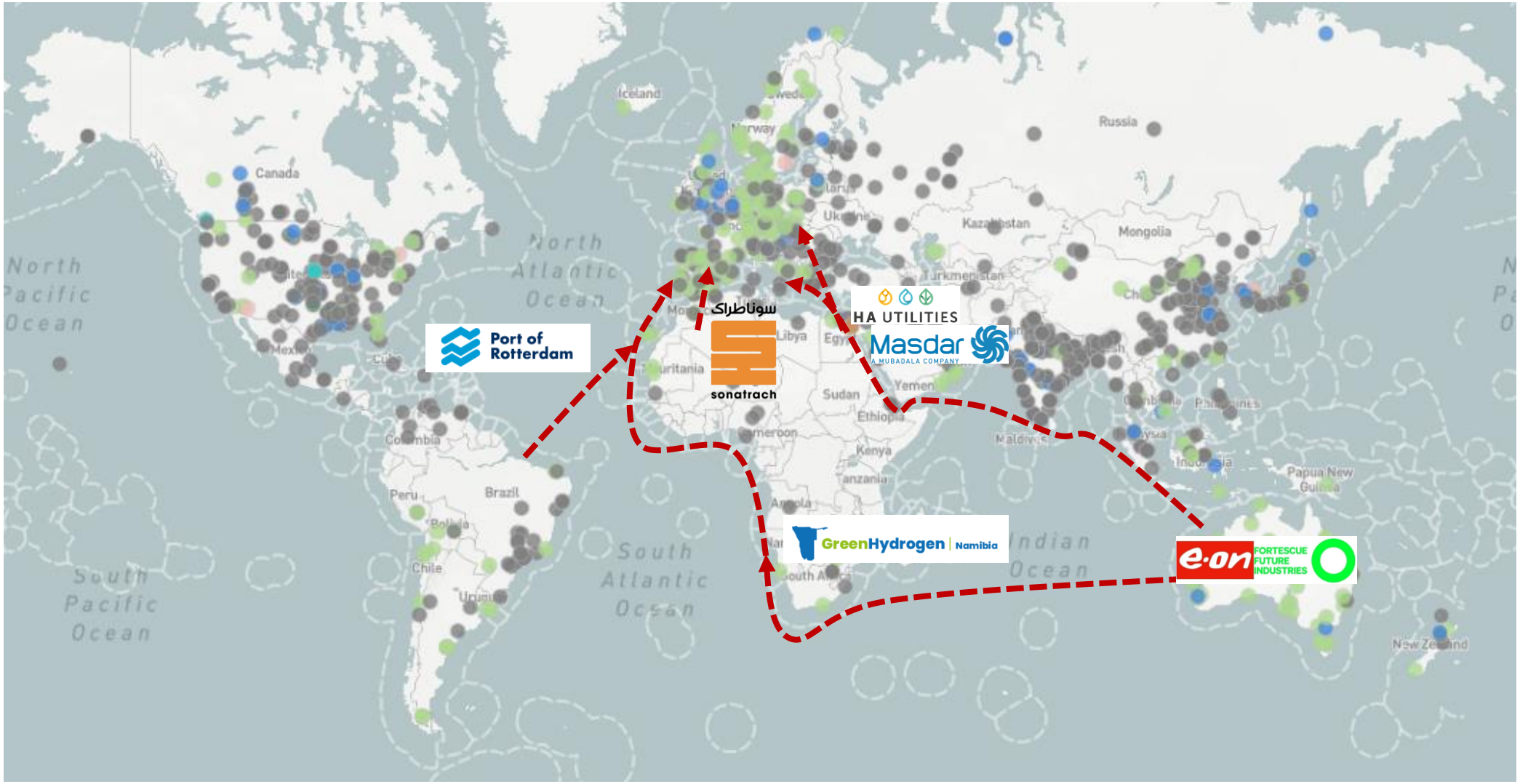
Africa set to become major exporter of renewable hydrogen to Europe

Potential for imports from further afield



Source: Rystad Energy HydrogenCube

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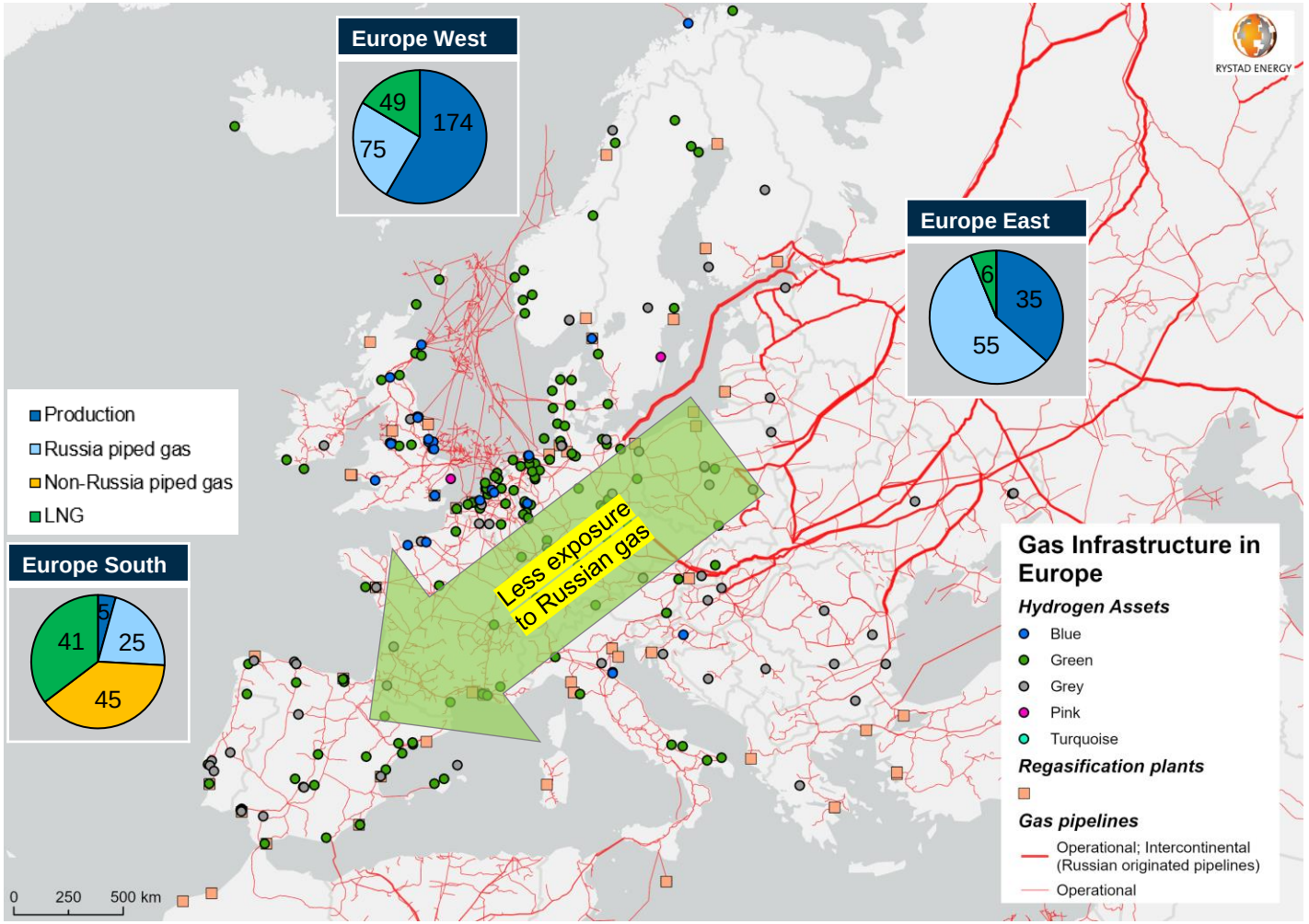
Regional natural gas supply by source (2021) and European hydrogen projects

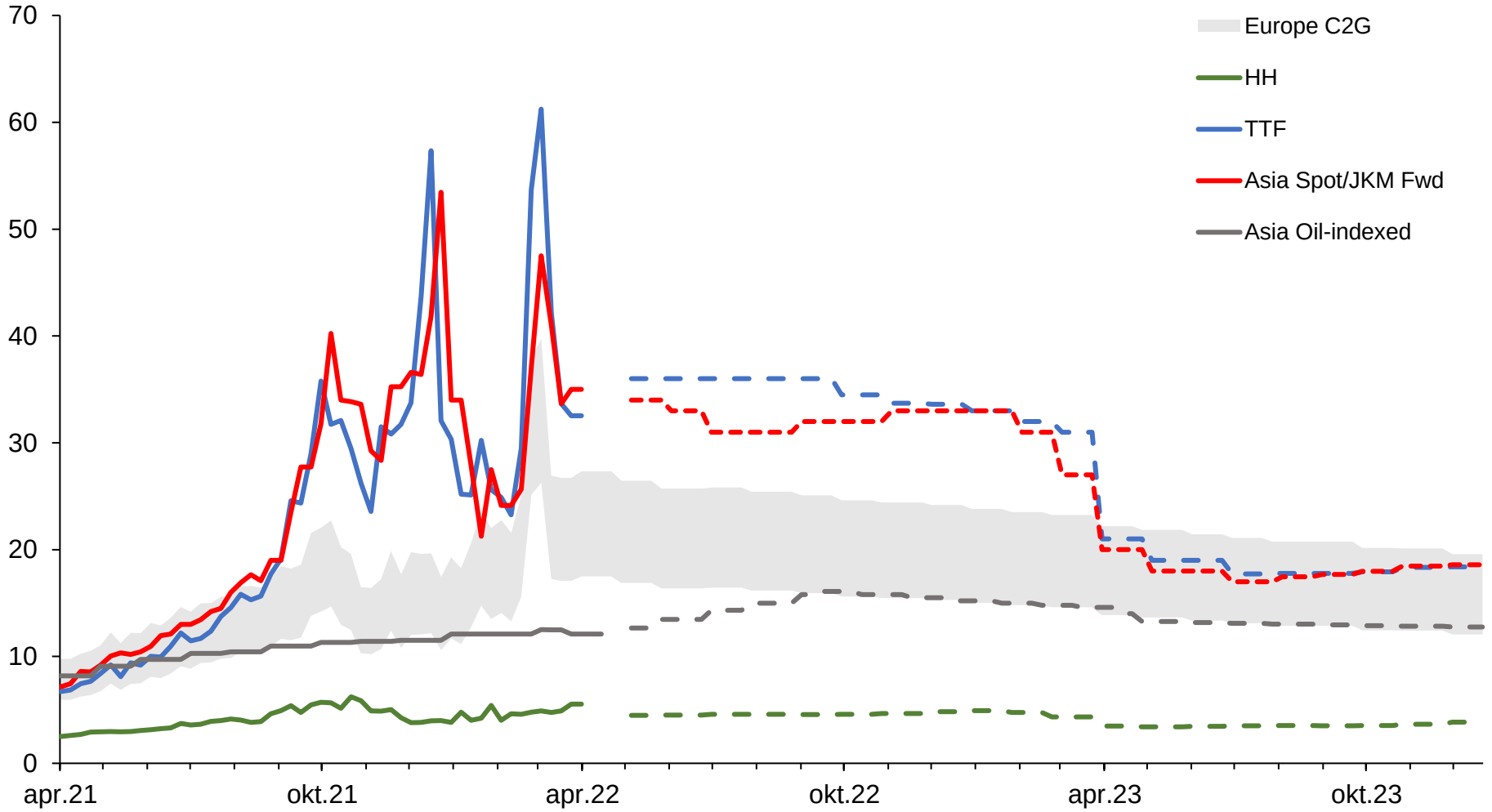
Billion cubic meters



Source: Rystad Energy HydrogenCube, Rystad Energy GasMarketCube

European prices spike as the Russian invasion of Ukraine heightens risk of supply disruptions

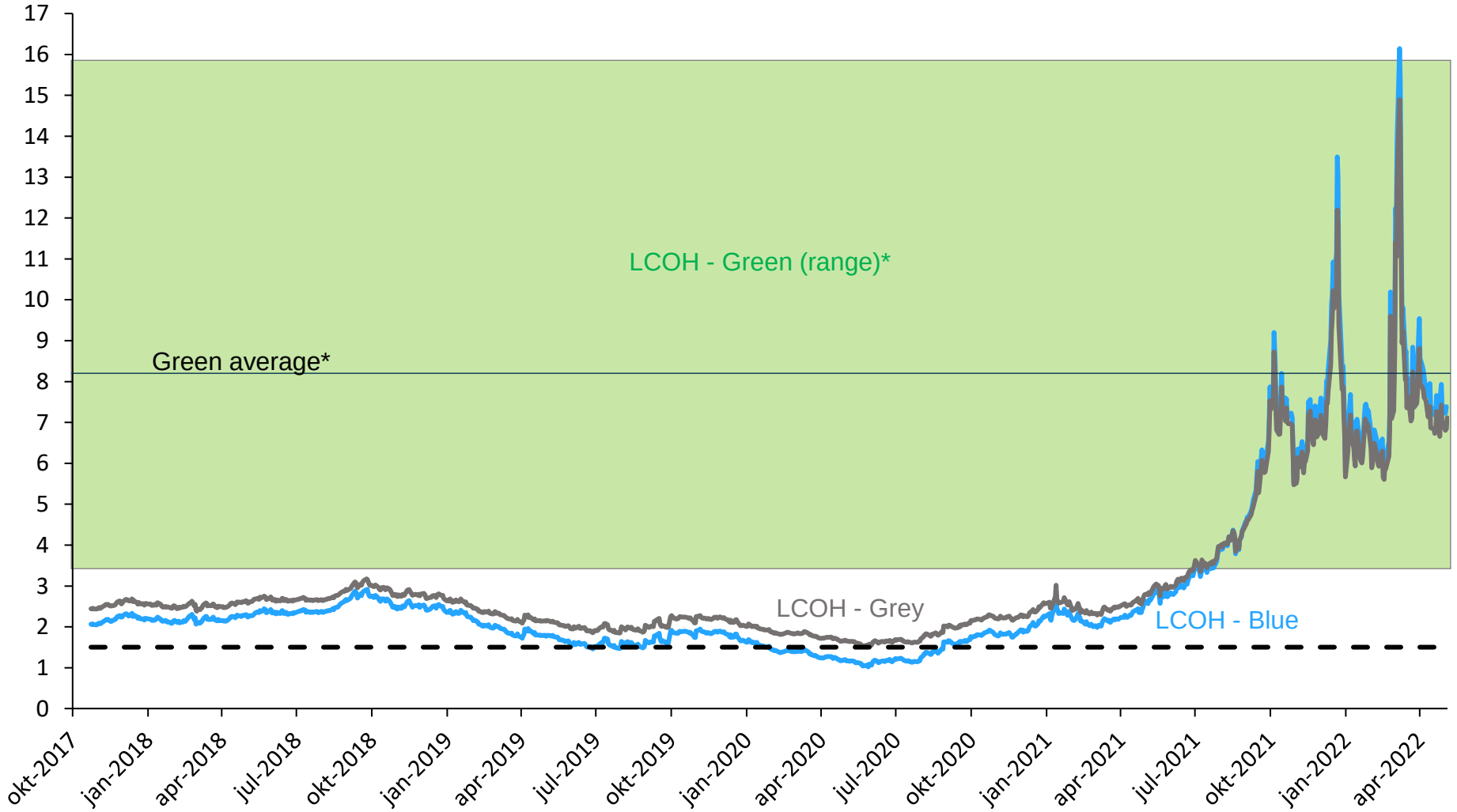
International natural gas prices* (historical and forward curves) USD per MMBtu



Source: Rystad Energy Research and Analysis, Refinitiv

Levelized cost of hydrogen in Europe - spot

USD/kg hydrogen



*Green average and range based on European renewables PPA from 2020 onwards
Source: Rystad Energy HydrogenCube, RenewablesCube

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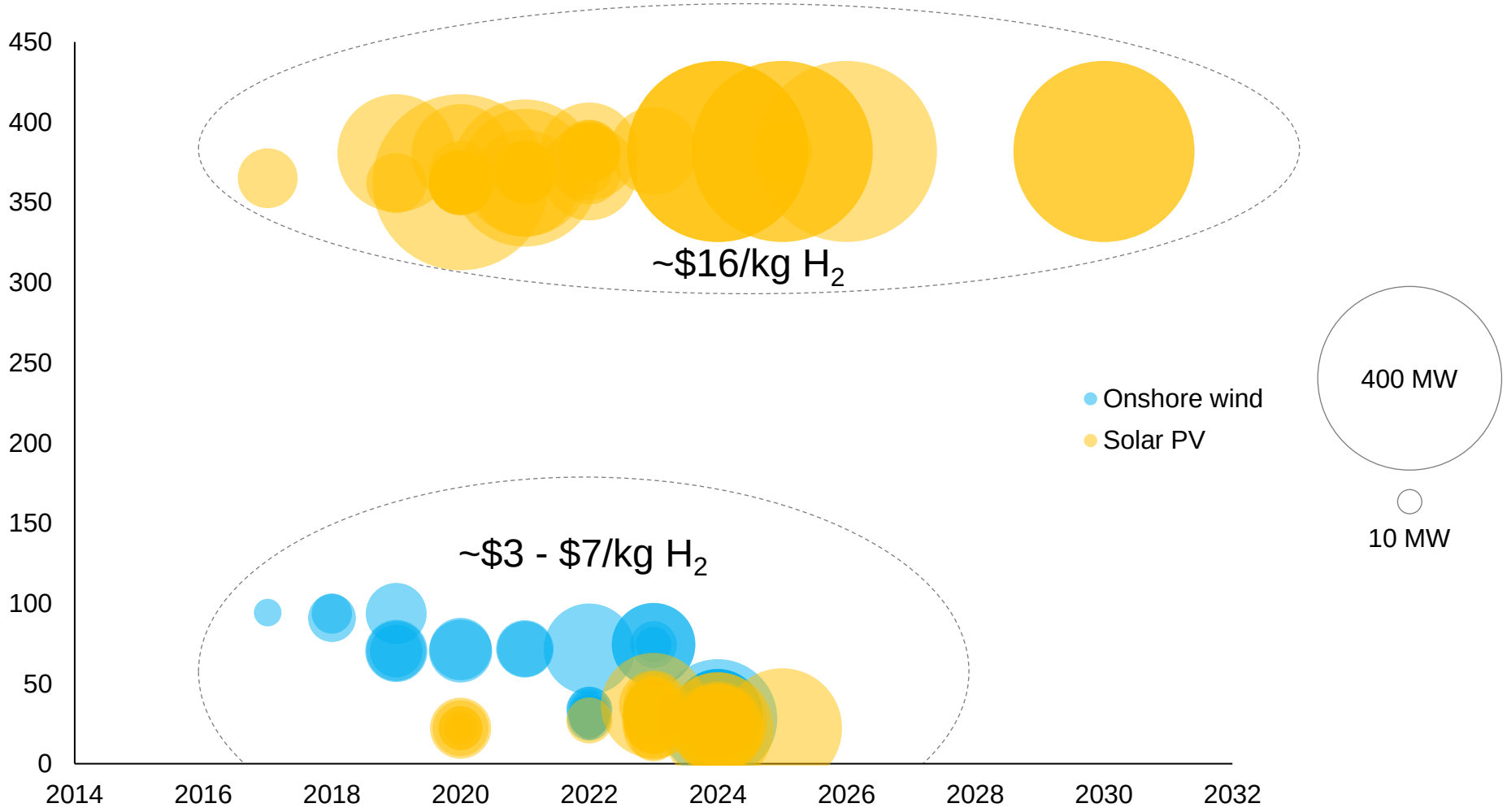
Renewable PPA tariffs in the Iberian Peninsula

USD/MWh



Source: Rystad Energy RenewablesCube

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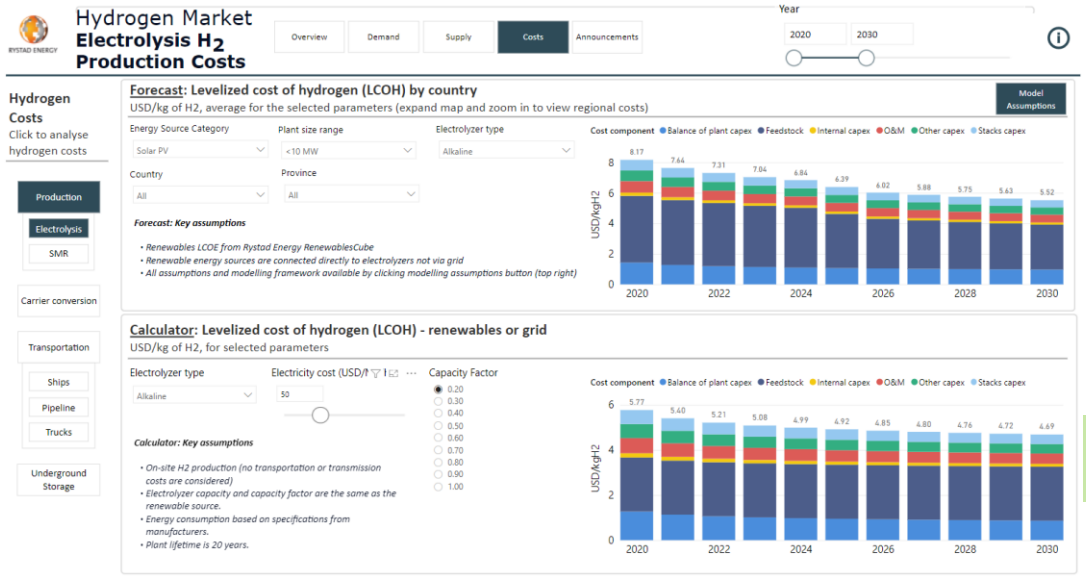
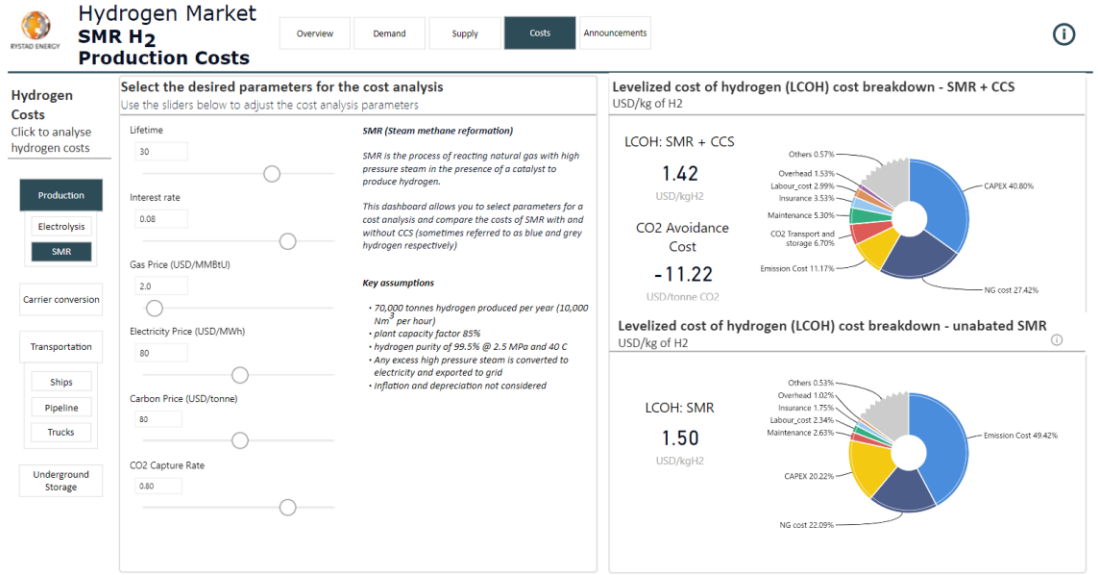
Rystad Energy Hydrogen Market levelized cost calculators



- Electrolysis LCOH to 2050
- By Country and Province based on real PPA data
- Estimator with user inputs
- Different electrolyser types

- SMR +/- CCS LCOH
- Estimator with six key user inputs
- Includes gas, electricity and carbon prices
- Gives CO_2 avoidance costs



Source: Rystad Energy HydrogenCube

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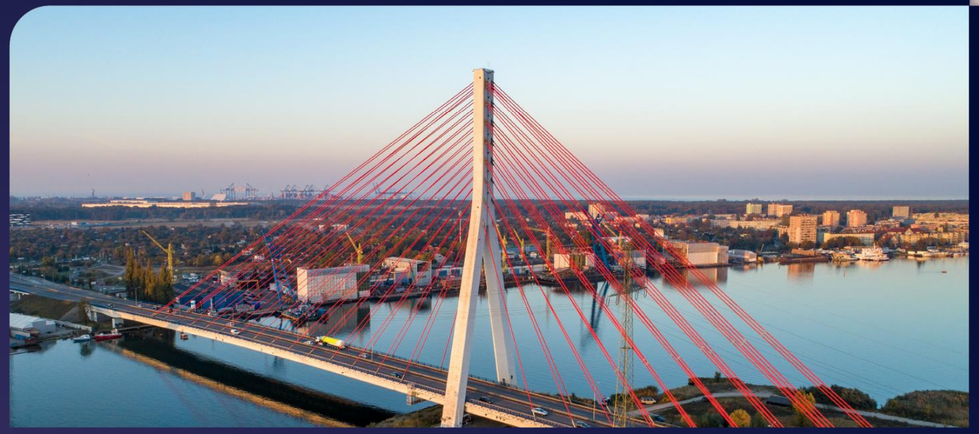
ORLEN Group Hydrogen Strategy 2030

Dominika Niewierska
New Business Streams Development Unit Manager, PKN Orlen S.A.

May 2022



Our aspirations

The ORLEN Group Strategy 2030 seeks to build a sustainable portfolio of businesses. Hydrogen is part of the plan to invest in the future

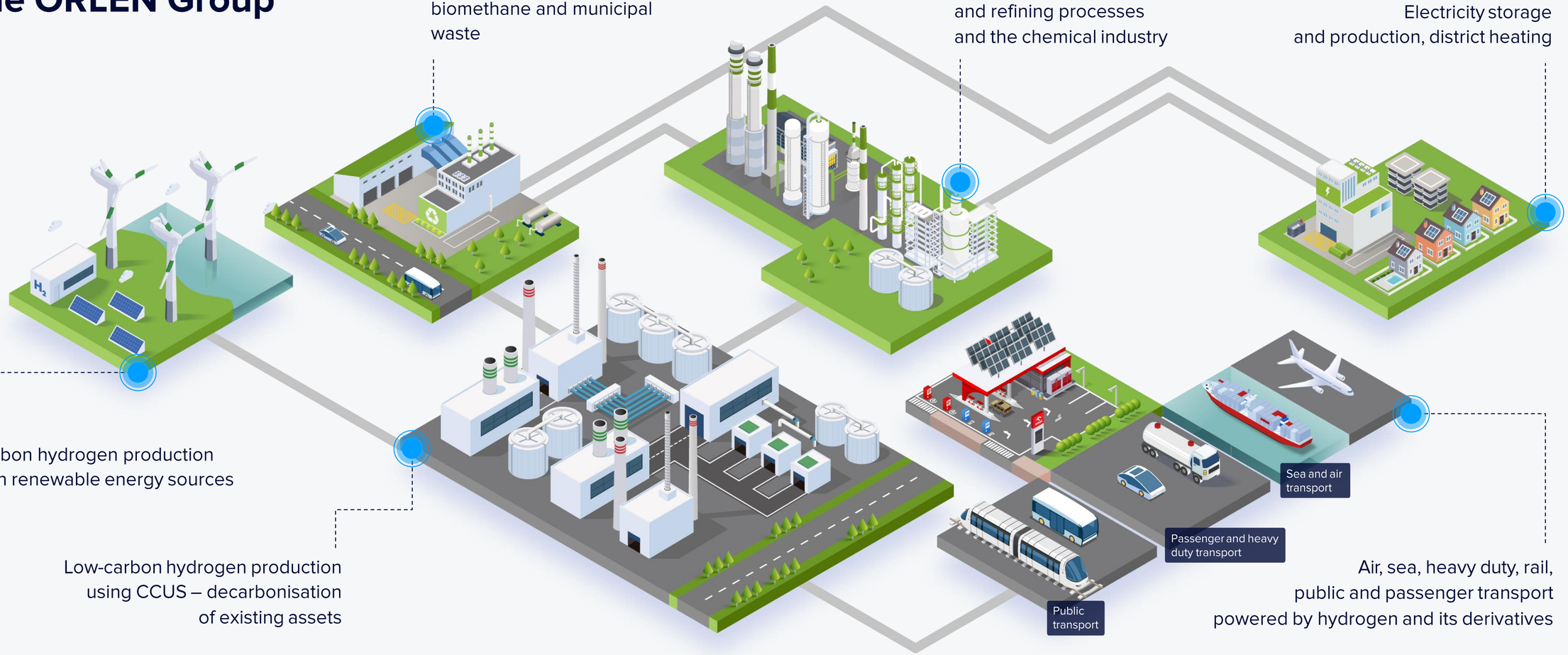
Business logic of the ORLEN Strategy 2030	Key business segments and areas				Share in total investment
 **Maximising performance**	Upstream		Fuel retail		~35-45%
	Refining		Energy/gas distribution		
 **Strategic development**	Petrochemicals		Renewable power		~45-55%
	Gas-fired power		Non-fuel retail		
 **Investing in the future**	New mobility		Recycling		~5-10%
	Hydrogen		R&D&I and digital transformation		

Vision for the production and use of hydrogen at the ORLEN Group

Production of hydrogen from biomethane and municipal waste

Hydrogen for petrochemical and refining processes and the chemical industry

Electricity storage and production, district heating



Zero-carbon hydrogen production based on renewable energy sources

Low-carbon hydrogen production using CCUS – decarbonisation of existing assets

Air, sea, heavy duty, rail, public and passenger transport powered by hydrogen and its derivatives

Hydrogen strategy aims to establish the ORLEN Group as a leader of the hydrogen market in Central Europe

Key indicators for the ORLEN Group in 2030

540 MW

of new low- and zero-carbon hydrogen capacity, including from water electrolysis powered by renewables and municipal waste. With the ambition to achieve 1 GW in the long term 2030+

~50%

of hydrogen produced by the ORLEN Group to be low- or zero-carbon, with an ambition of ~80% in the long term 2030+

1.6

m tonnes

tonnes less of CO_2 emissions from hydrogen production in 2030, with up to 3m tonnes less in the long term 2030+

19

kt H_2 / year

per year of automotive grade hydrogen

>100

hydrogen refuelling stations with necessary logistics infrastructure in Poland, the Czech Republic and Slovakia

Hydrogen potential

Energy transition is reshaping our external environment

Technology advances

- Growing cost-efectiveness of renewables
- Low-carbon transport and industrial sector decarbonisation
- Circular economy with a focus on recycling technologies

Regulations

- Ambitious reduction targets for greenhouse gas emissions
- New Green Deal, Fit for 55 package
- Ongoing regulatory support

Environmental concerns

- Evolving expectations from providers of goods and services
- Proactive and increasingly conscious consumers

Strategies and roadmaps are vital in areas requiring long-term planning

Ambitious reduction targets for greenhouse gas emissions

New Green Deal, Fit for 55 package

Ongoing regulatory support

Ambitious goals for developing a hydrogen economy, supported by public and private funding, are included in both the EU Hydrogen Strategy and Poland Hydrogen Strategy*.

40 GW capacity

Strategies and roadmaps are vital in areas requiring long-term planning in electrolysers powered by renewables that can produce up to 10m tonnes of green hydrogen in the EU.

A major factor is a demand-side policy creating new sales markets, particularly in industry and transport.

2 GW capacity

in facilities producing hydrogen and its derivatives from low-carbon sources, processes and technologies, including electrolysis units.

The primary goal is to create and advance a competitive hydrogen industry to achieve climate neutrality.

* Poland Hydrogen Strategy 2030 with an Outlook to 2040.

Hydrogen is now considered a key element of the energy transition

It is a key pillar of decarbonisation

Allows to reduce CO_2 emissions from industry, transport, energy generation and district heating

Stands out from other fuels

Emits no CO_2 or other environmentally harmful compounds

It provides flexibility in the operation of the power grid

Hydrogen production will help stabilise the operation of renewable energy sources, allowing for their maximum utilisation at times of o -peak electricity demand

It is ubiquitous

Hydrogen is the most abundant element

Can be stored in the form of derivative products

Can be used as a feedstock to produce synthetic fuels and ammonia

It has a high energy density

Hydrogen has a much higher energy density per unit mass compared with other fuels (nearly three times the energy content of gasoline)

Our strategy

Hydrogen economy: our strategy

	Area	Aspirations	2022 - 2025	2025 - 2030	2030 +
1	**Mobility**	a transition leader in Central Europe	Hydrogen refuelling stations + Public transport and rail	Heavy-duty transport	
				Air transport	Sea transport
2	**Refining and petrochemicals**	a key enabler of decarbonisation	CCUS (including synthetic fuels)		
				Zero- and low-carbon hydrogen production in new facilities	
3	**Industry and energy**	a major supplier and customer within the European Hydrogen Backbone			District heating and energy generation + European Hydrogen Backbone
4	**Research and development**	a partner of choice for building a hydrogen economy in Central Europe	Open dialogue with regulators		
			Dedicated R&D unit		

1 **Mobility** – hydrogen as a fuel for public and rail transport, and in the long term – also for heavy-duty, air and sea transport

Aspirations:
Leader in advancing hydrogen mobility in Central Europe, actively supporting decarbonisation of transport.

- Market development starting with city buses and railway, through long-haul heavy-duty and passenger transport, to synthetic fuels for air and sea transport.
- Network of publicly accessible hydrogen refuelling stations.
- Leveraging existing assets and building new capacities to produce automotive grade hydrogen for transport.

2 **Refining and petrochemicals** – hydrogen as an enabler of decarbonisation. Balanced investment portfolio addressing the needs of existing assets and regulatory challenges

Aspirations:
The hydrogen strategy is both an extension of the ORLEN Group's ambitious decarbonisation plan and a response to the rapidly changing market and regulatory environment.

Implementation of numerous projects addressing key challenges facing the ORLEN Group until 2030:

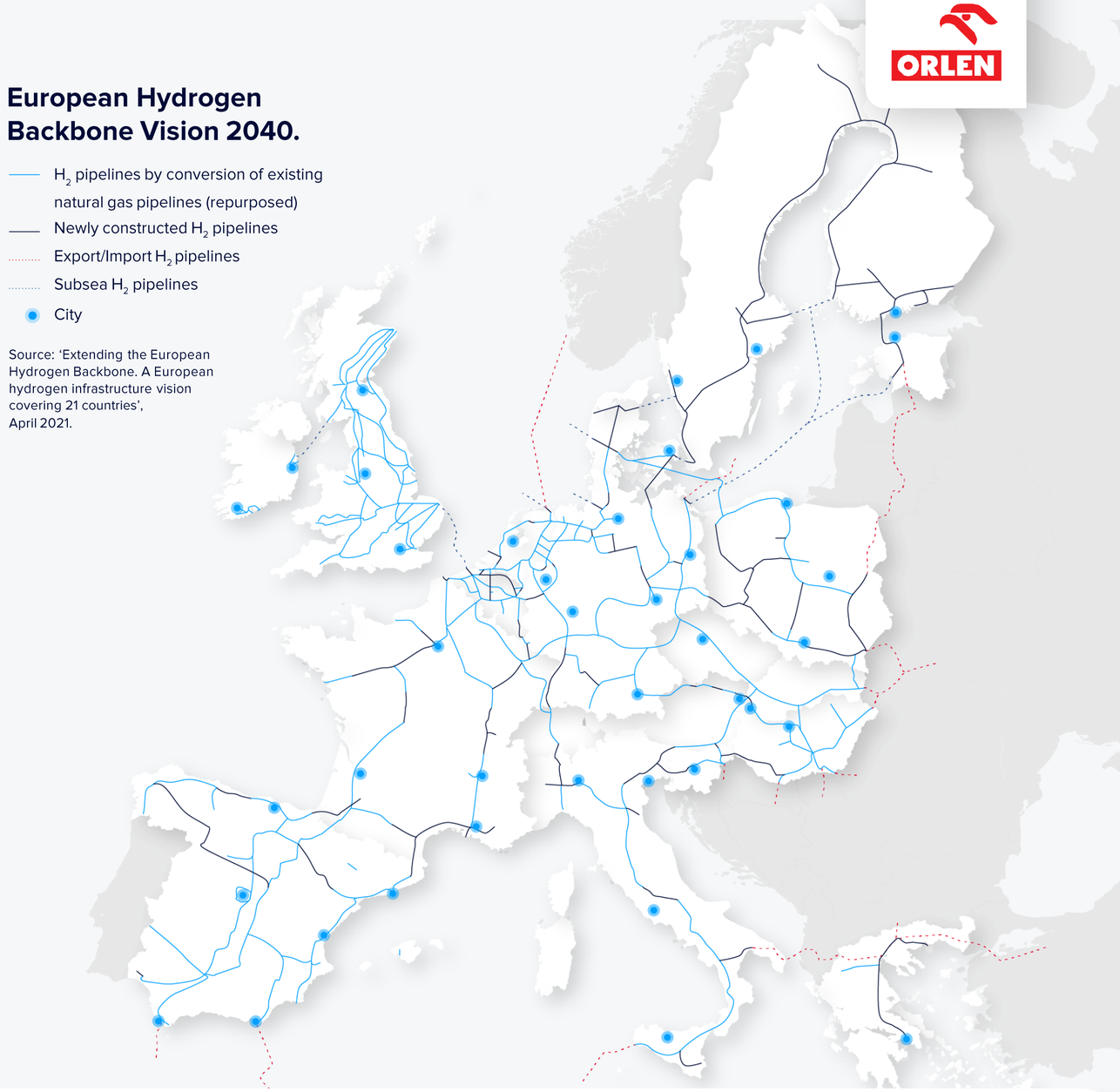
- Reduction of CO_2 emissions from existing hydrogen production facilities of the ORLEN Group using low-carbon technologies – carbon capture, utilisation and/or storage (CCUS).
- Development of new generation sources based on electrolysis units and renewables.
- Implementation of municipal waste to hydrogen technology.

3 Industry and energy generation
– promising areas of focus depending on the scale of development and availability of zero-carbon electricity sources

Aspirations:
Building a significant position as a supplier and customer to the European Hydrogen Backbone

- Industry and export: after 2030 surplus zero- and low-carbon hydrogen could be directed to meet the needs of other industries at home and abroad (e.g. within the framework of the European Hydrogen Backbone).
- District heating and power generation as promising applications of low- and zero-carbon hydrogen.
- Grid stabilisation: large-scale utilisation of hydrogen and/or ammonia for energy storage will be possible after 2030 with wind farms in the Baltic Sea when there is a significant periodic surplus of renewable electricity in the grid.
- New CCGT units planned within the ORLEN Group will be able to co-fire hydrogen.

European Hydrogen Backbone Vision 2040.



Source: 'Extending the European Hydrogen Backbone. A European hydrogen infrastructure vision covering 21 countries', April 2021.

4 **Research and development** – a partner of choice for building a hydrogen economy in Central Europe, focused on innovation and in-house capabilities development

Aspirations:
Advancement of research and development activities actively supporting the potential of the ORLEN Group

- Forging and promoting hydrogen partnerships and the hydrogen ecosystem.
- Building in-house capabilities across the hydrogen value chain.
- Setting up a dedicated hydrogen laboratory at the Research and Development Centre in Płock by 2025 to perform tests and conduct research in test facilities on hydrogen production, quality, purification, storage and transport.
- Taking a leading role in the Mazovian Hydrogen Valley, whose main aim is to implement R&D projects that help drive progress in hydrogen technology.

At the ORLEN Group in 2030

Hydrogen hubs will help supply key sales markets, and hydrogen refuelling stations enable transport on major routes and in major cities

Hydrogen production sources:

- Existing sources at plants
- O shore electrolyser powered by renewables
- Onshore electrolyser powered by renewables
- Conversion of municipal waste into hydrogen

Hydrogen strategy relies on capabilities of the ORLEN Group companies

Energy sources

Energa

Leader in developing onshore renewable energy segment for zero-carbon hydrogen production

ORLEN + Baltic Power

Key player in o shore wind development in the Baltic Sea

ORLEN + ORLEN Południe

Largest operator of agricultural biogas plants in Poland

Production

Anwil

Central Europe's first producer of fertilizers based on low- and zero-carbon hydrogen

ORLEN

Central Europe's first refinery relying on low- and zero-carbon hydrogen

ORLEN + ORLEN Eko

European leader in developing municipal waste conversion technologies

ORLEN Unipetrol

Central Europe's first large-scale CCU plant operator

Distribution

ORLEN

Enabler of the Polish hydrogen mobility market. Operator of the largest network of hydrogen refuelling stations and a partner of choice for local governments and companies

ORLEN Unipetrol

Key player in the Czech and Slovak hydrogen mobility market

Capital expenditure

Planned capital expenditure

PLN 7.4bn with an ambition to increase spending in the long term

Key goals:

- Focus on cost-eficient decarbonisation of existing hydrogen production assets.
- Build new low- and zero-carbon hydrogen production assets.
- Expand hydrogen refuelling and supply logistics networks.
- Address the challenges of green transformation.
- Use non-repayable funding eficiently.

Majority of key capital projects are scheduled to come online before 2025. Being innovative, comprehensive and cross-border in nature, each project has applied for non-repayable funding to finance 40%–80% of the costs.

* Including: hydrogen production infrastructure; incl. RES-powered electrolysers, hydrogen production installations using municipal waste, distribution and storage infrastructure for produced hydrogen and the network of FCV charging ponits


ORLEN
Powering the future.
Sustainably.

List of abbreviations, acronyms and units used in the Hydrogen Strategy

Units	Glossary of abbreviations
R&D	Research and development
CAPEX	Capital expenditure
CCGT	Combined Cycle Gas Turbine plants
CCU	Carbon Capture, Utilisation
CCUS	Carbon Capture, Utilisation and Storage
CO_2	Carbon dioxide
Fit for 55	an EU legislation package aiming to reduce greenhouse gas emissions by 55% compared with 1990 levels
GW	Gigawatt
H_2	Hydrogen
kt H_2	Kilotonne of hydrogen
MW	Megawatt
RES	Renewable energy sources
UE	European Union

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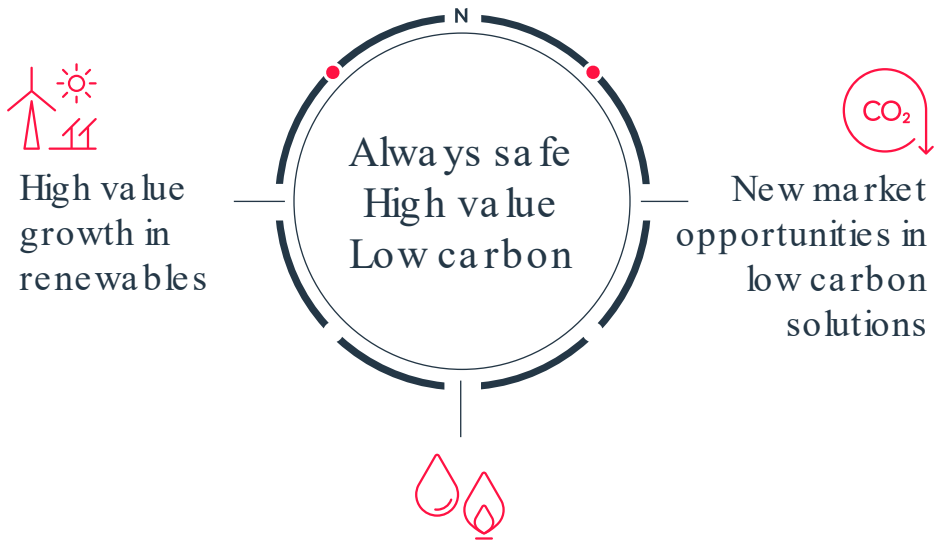
Equinor’s Low Carbon Activities

A leading company
in the energy transition

ACCELERATING OUR TRANSITION



OUR AMBITIONS

Zero harm

30 USD PER BBL

Portfolio cash flow positive at 30 USD per barrel until 2026

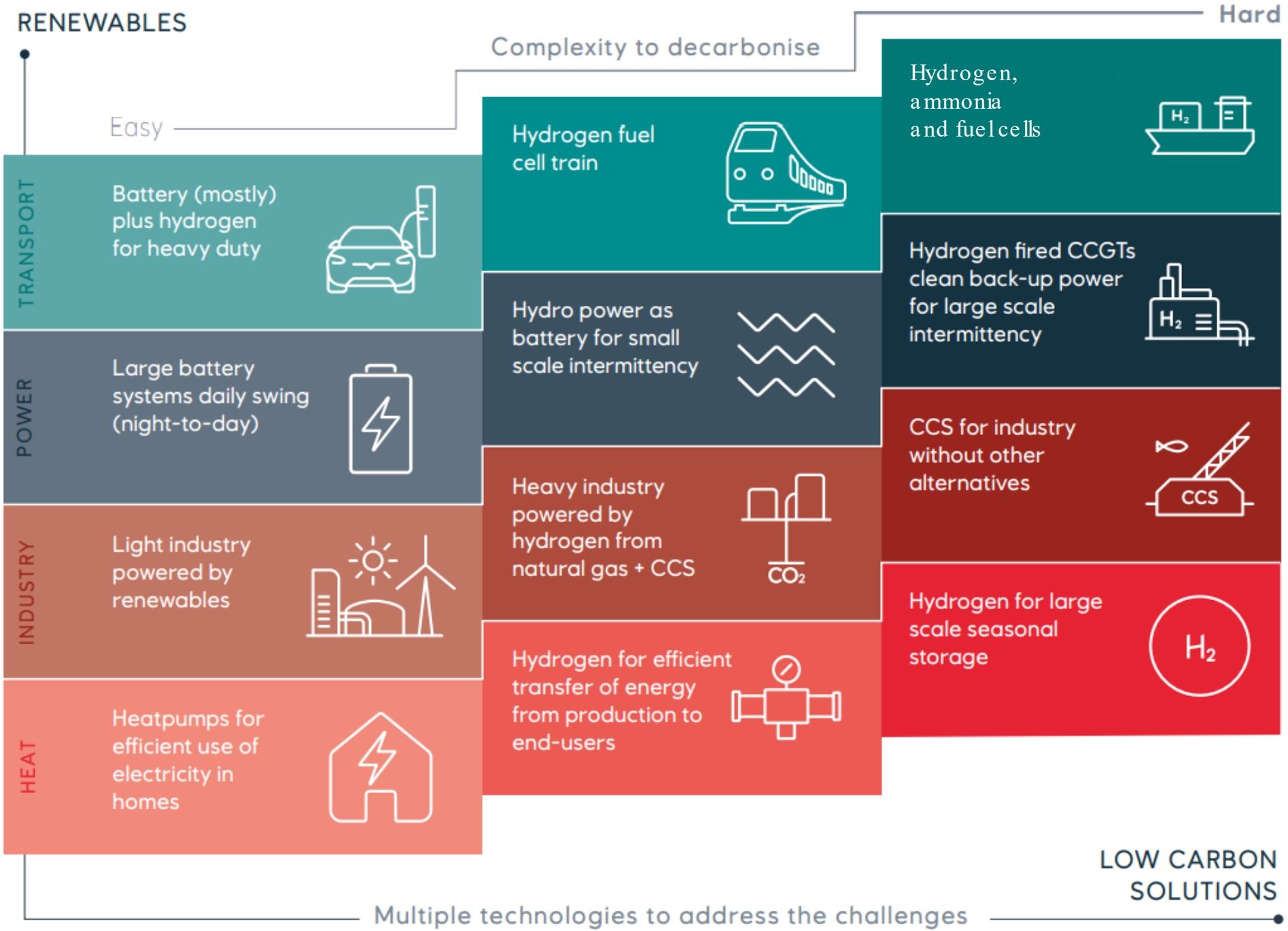
40 %

Reduce net carbon intensity by 2035
Net zero by 2050

>50 %

Of gross investments to renewables and low carbon solutions by 2030

Decarbonising energy systems



Carbon Capture &Storage | 3 roles

Emissions from our own operations

Being industry leading in carbon efficiency

Decarbonise O&G products

Enables **blue** hydrogen production

Stand alone business

CCS as a service to industries

New market opportunities in low carbon solutions

15-30 MILLION TONNES PER ANNUM

CO_2 transport and storage capacity by 2035
Equinor share

>25%

CO_2 transport and storage market share in Europe by 2035

3-5 MAJOR INDUSTRIAL CLUSTERS

Clean hydrogen projects by 2035

>10%

Clean hydrogen market share in Europe by 2035

Low carbon solutions project funnel

Project name	Project type	Country	Decarbonisation segments			
			HEAT	INDUSTRY	POWER	TRANSPORT
Northern Lights (NL)	CO_2 Infrastructure	NO		●		
East Coast Cluster (NEP)	CO_2 Infrastructure	UK	●	●	●	●
H2H Saltend	Blue hydrogen	UK	●	●	●	●
Aldborough hydrogen storage	Hydrogen storage	UK	●	●	●	●
Net Zero Teesside (NZT)	Power+CCS	UK			●	
Keadby 3	Power+CCS	UK			●	
Peterhead	Power+CCS	UK			●	
Keadby Hydrogen Power Station	Hydrogen to power	UK			●	
H21	Hydrogen fuel switch	UK	●	●		
H2M Magnum	Blue hydrogen	NL			●	
H2morrow Steel	Blue hydrogen	DE		●		
H2BE	Blue hydrogen	BE		●		
NorthH2	Green hydrogen	NL, BE, DE		●		●
Clean Hydrogen to Europe	Blue hydrogen	NO	●	●	●	●
Barents Blue	Blue ammonia	NO		●		●
US Tristate	CCS+Power+H_2	US		●	●	●

Further developing the North Sea

An industrial plan for a European energy center

- Contribute to combat climate change
- Ensure value creation through the energy transition
- Build further on a solid foundation
- The opportunity is now!

3,9
Million boe/d
Oil and gas production

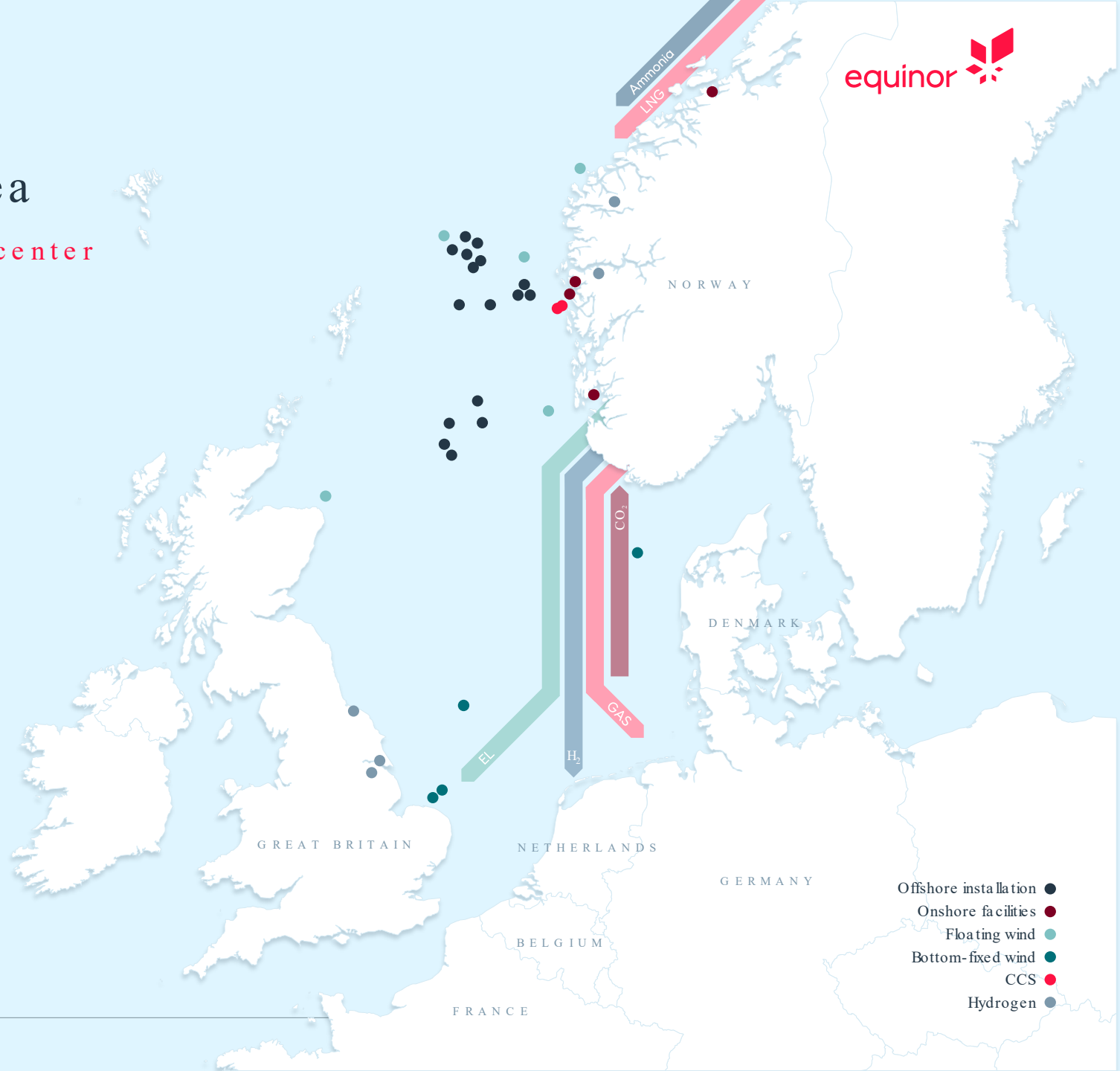
50-100
kboe/d
Export of LNG

6,5
GW
Bottom-fixed wind

3,5
GW
Floating wind

40
Million ton/year
CCS storage capacity

2 → 10
GW
Hydrogen



A leading company in the energy transition

Vaibhava Singh | Business Developer | Low carbon solutions

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SINTEF leading a new research centre on hydrogen and ammonia

HYDROGENi

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Chief Scientist, SINTEF Energy
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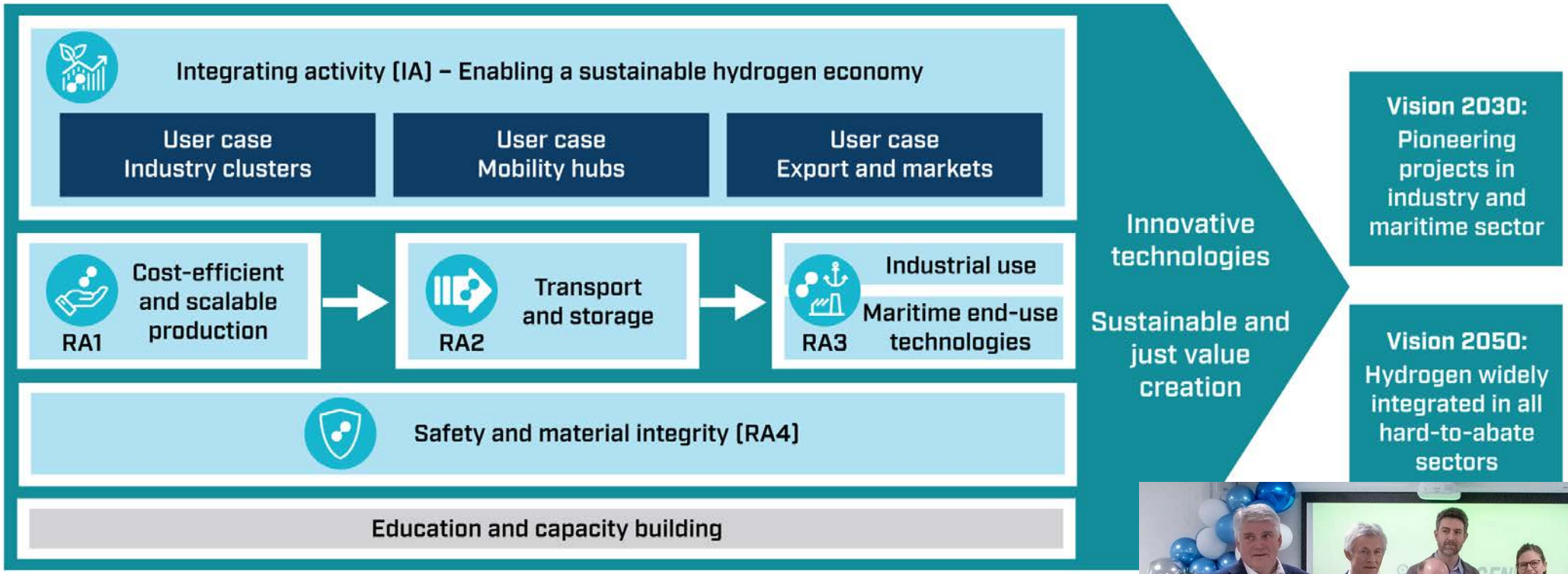
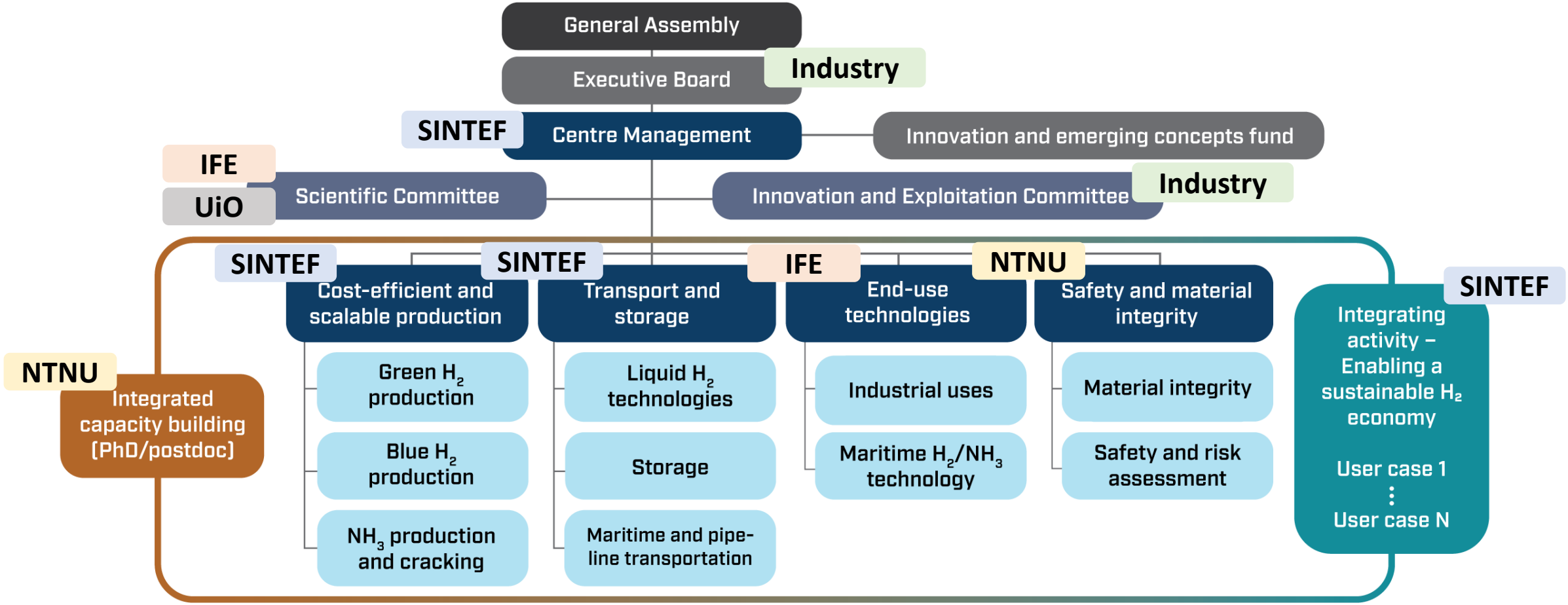
FME HYDROGENi – Hydrogen for net zero by 2050



March 11th 2022 – Funding announcement

Centre organization



HYDROGENi Targets

Accelerate a hydrogen-based energy and technology export industry for Norway, reducing emissions while boosting industry competence and creating new green jobs.

- Enable cost-effective and large-scale H2 and NH3 production technologies
- Enable H2 storage and transport for emerging large-scale and high-energy demand applications
- Enable end use of clean H2 and NH3 in hard-to-abate sectors, including industry and maritime transport
- Develop new knowledge on critical aspects of safety, material integrity and standards
- Stimulate innovation, industrial establishment and uptake of new technology and solutions through industry-driven user cases
- Build capacity for the hydrogen economy

FME HYDROGENi – strong partnership

The Research Council of Norway

ABB
Air Liquide
AKER CARBON CAPTURE
AKER CLEAN HYDROGEN
AkerSolutions
altera INFRASTRUCTURE
Bergen Tankers as
BOSCH
CASALE
CoorsTek
Corvus Energy
DNV
ENERGI I NORD
equinor
Ferrolegeringsindustriens Forskningsforening
TiZir
GASNOR
GASSCO
GEXCON
Green Industry Cluster NORWAY
Hydro
HAV hydrogen
H2
HYEX SAFETY
HYDROGEN Mem-Tech AS
Clean hydrogen and carbon capture
HYON
hystar
ICT
IFE Institutt for energiteknikk
JOTUN
KONGSBERG
maritime cleantech
Mo Industripark as
nel
NORDKRAFT
Norwegian Hydrogen
NTNU
Panametrics a Baker Hughes business
PERMASCAND
REINERTSEN NEW ENERGY
SAFETEC
SICK Sensor Intelligence.
SIEMENS
SINTEF
Statkraft
TechnipFMC
TECO 2030
Troms Kraft
TrønderEnergi
UiO : University of Oslo
UiT The Arctic University of Norway
USN University of South-Eastern Norway
vallourec
vår energi
Wilhelmsen
wintershall dea
YARA
ZEG Power

FME H2i

Supporting partners: inovyn An INEOS company, Statnett, SUSTAINABLE ENERGY, NORWEGIAN CATAPULT CENTRE

HYDROGENi

Norwegian research and innovation centre for hydrogen and ammonia

WHEN TRUST MATTERS

Hydrogen production from offshore wind

Opportunities and developments

Hydrogen & CCS Webinar Norwep – Europe

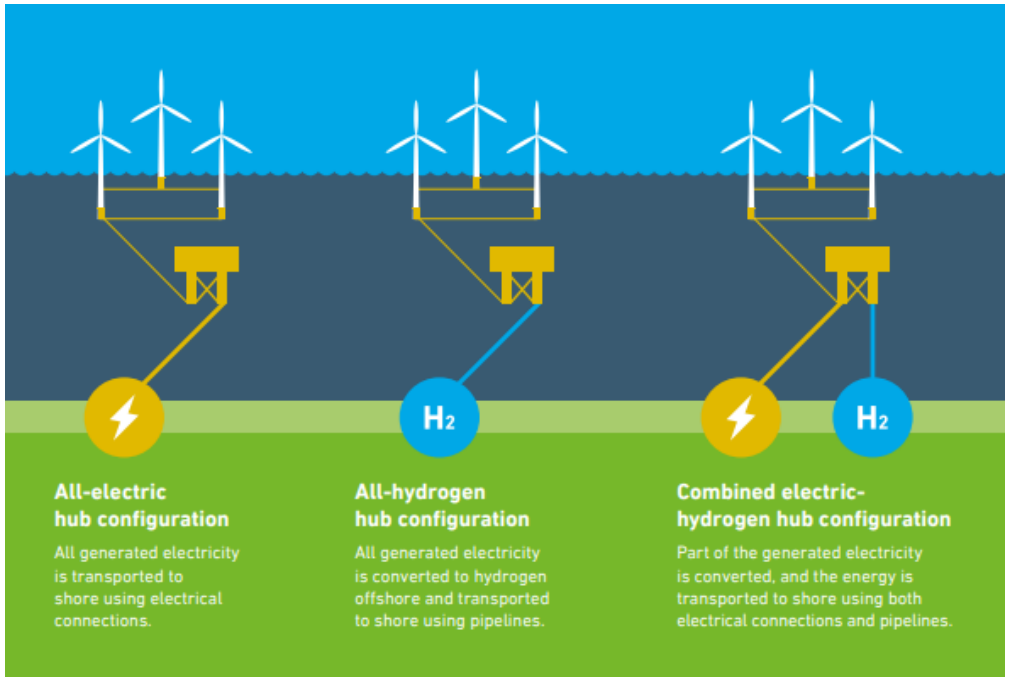
Magnus Killingland
Segment lead H2&CCS, North Europe
E-mail: magnus.killingland@dnv.com

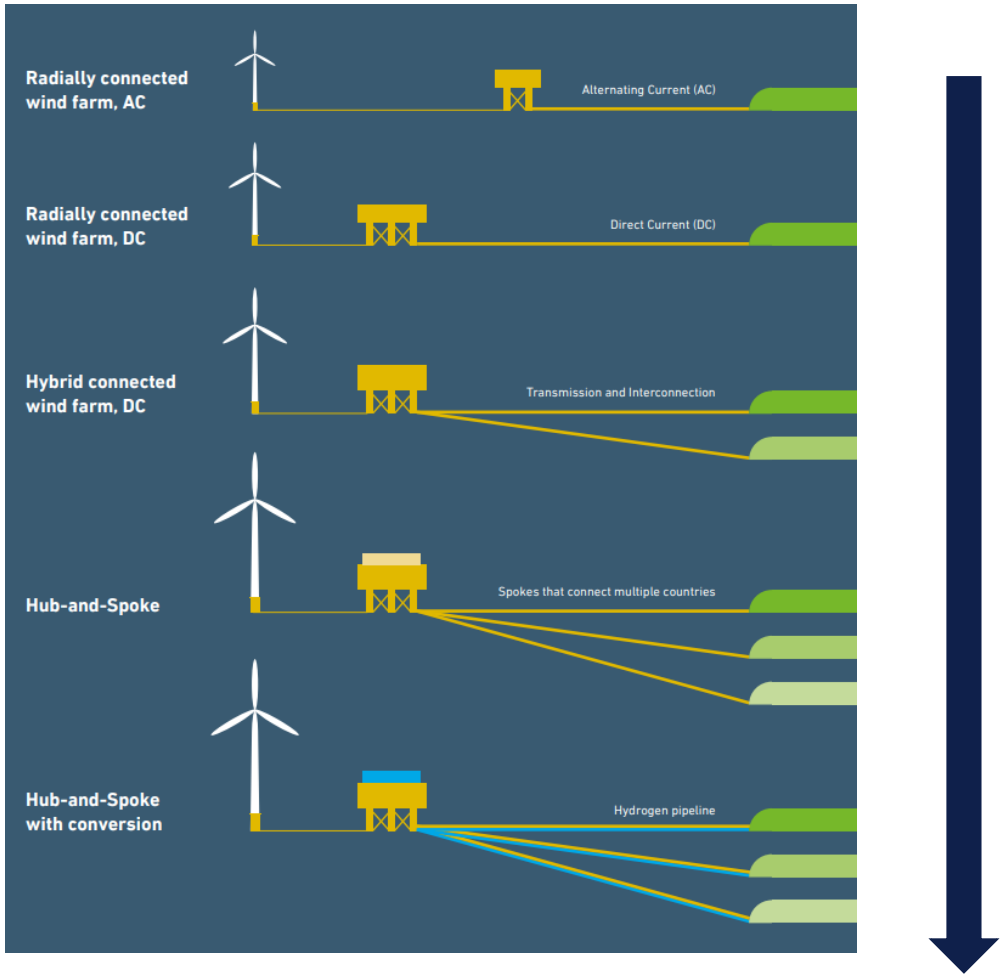
May 11, 2022

Safety Moment

Concentrations of H2 below 15%,
could be comparable to natural gas

Offshore wind will develop with PtX





- Hub-and-spoke is a next step in the evolution of offshore wind connections
- The evolution is ongoing:
  - From near-shore radial alternating current (AC) connections to far offshore direct current (DC) connections.
  - The hub-and-spoke concept is another step in this evolution, adding interconnection and potentially electricity conversion.
- DNV derisks and calculates LCOE/H for all scenarios and value chains, also with hybrid merchant interconnectors and hubs

Off-grid (gas grid)

Shipped to shore, secondary ship

Hydrogen carrier for global commodity trade

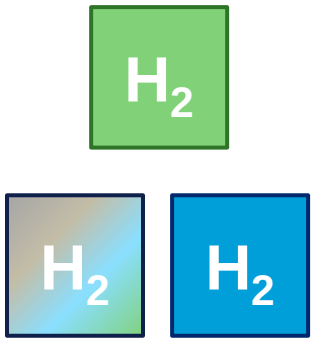
Offshore PtX – what, why and where

What

0.45-6 / 3 / 4.9

USA / EU / China

$kgCO_2/kgH_2$



Why PtX

>1-2 GW
wind power

Bottom fixed
>100-200 km
offshore

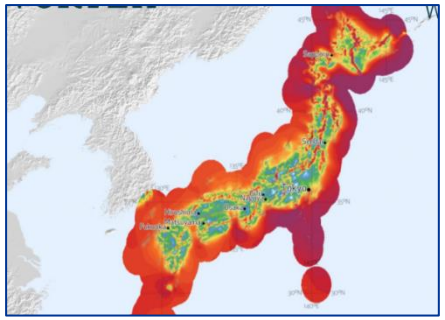
Floating
>400 km
offshore

Molecules vs. electrons
Pipelines or ships most cost-efficient energy transport option

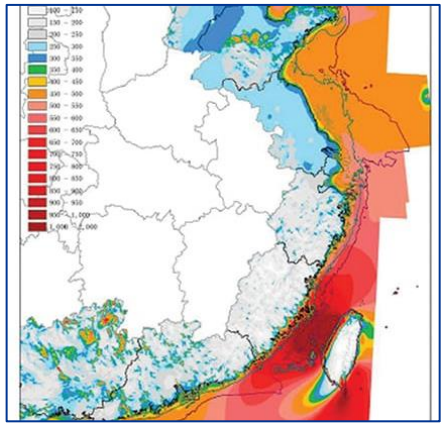
Where

A North Sea vision

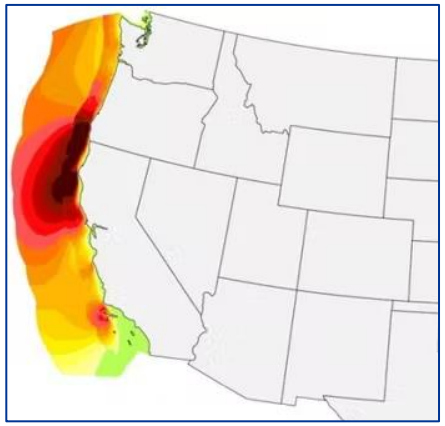
Japan or islands



China



California



Working hypothesis
Cost efficiency OW PtX

Wind PtX…

…with excellent wind conditions and

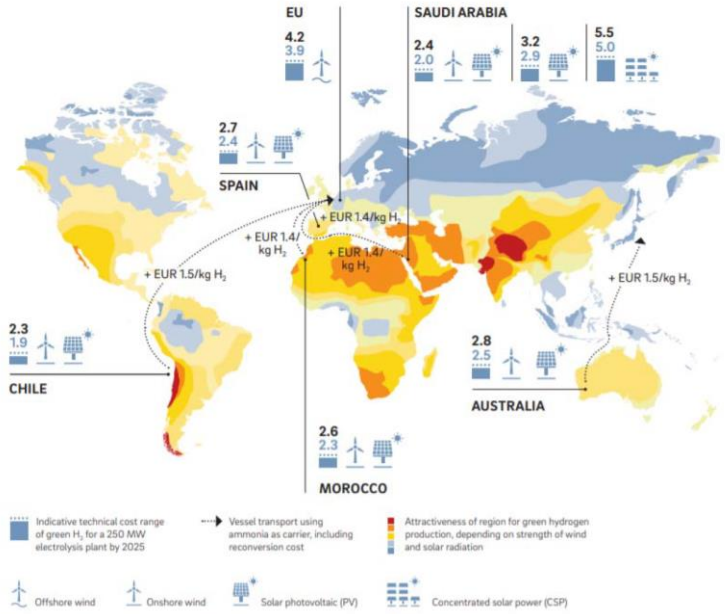
…a wind power area and turbines, designed for hydrogen production, and not power production

…with direct bunkering and/or ship transport to hubs

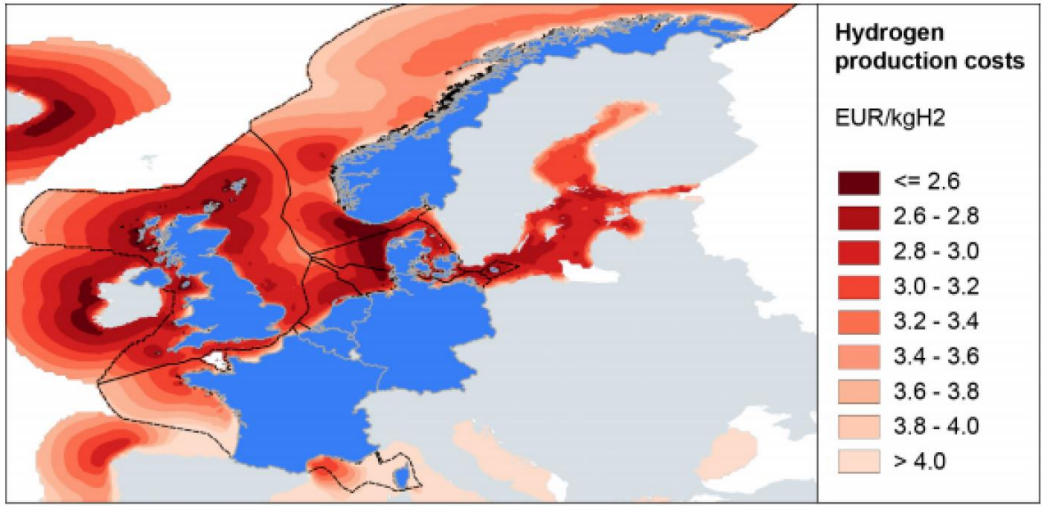
…has a better LCOH than for an energy island or hub near shore!

Expected Green Hydrogen Cost onshore:

But what about offshore?



2030 estimates



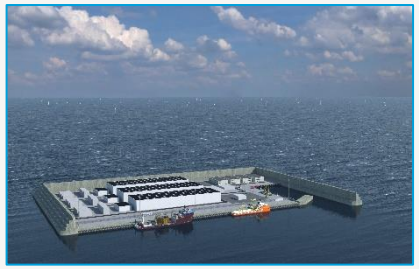
Offshore renewable green hydrogen production

– Power and or gas grid connected, or off-grid?

Centralized | **De-centralized**

Bottom fixed

Energy island



Platform / Hub

Attached

Integrated

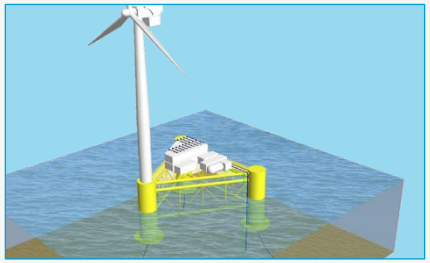
Gas grid connected

Floating

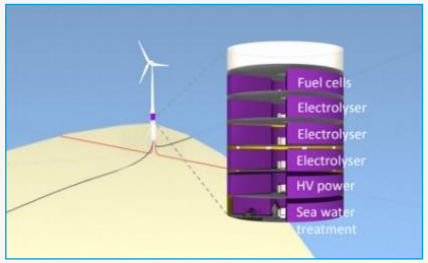
FPSO

Platform / Hub

Attached



Integrated



Off gas grid

Shipped to shore, secondary ship

Hydrogen carrier for global commodity trade

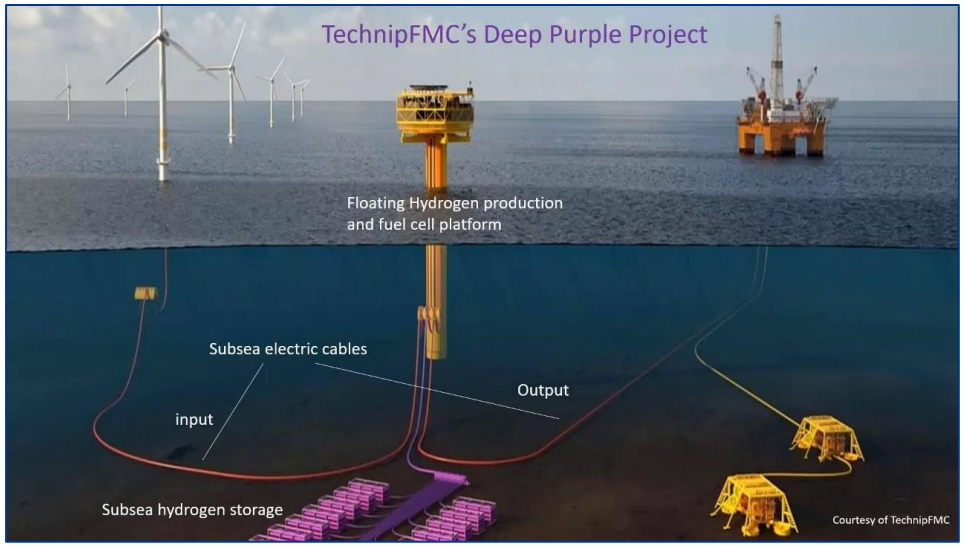
Off gas grid

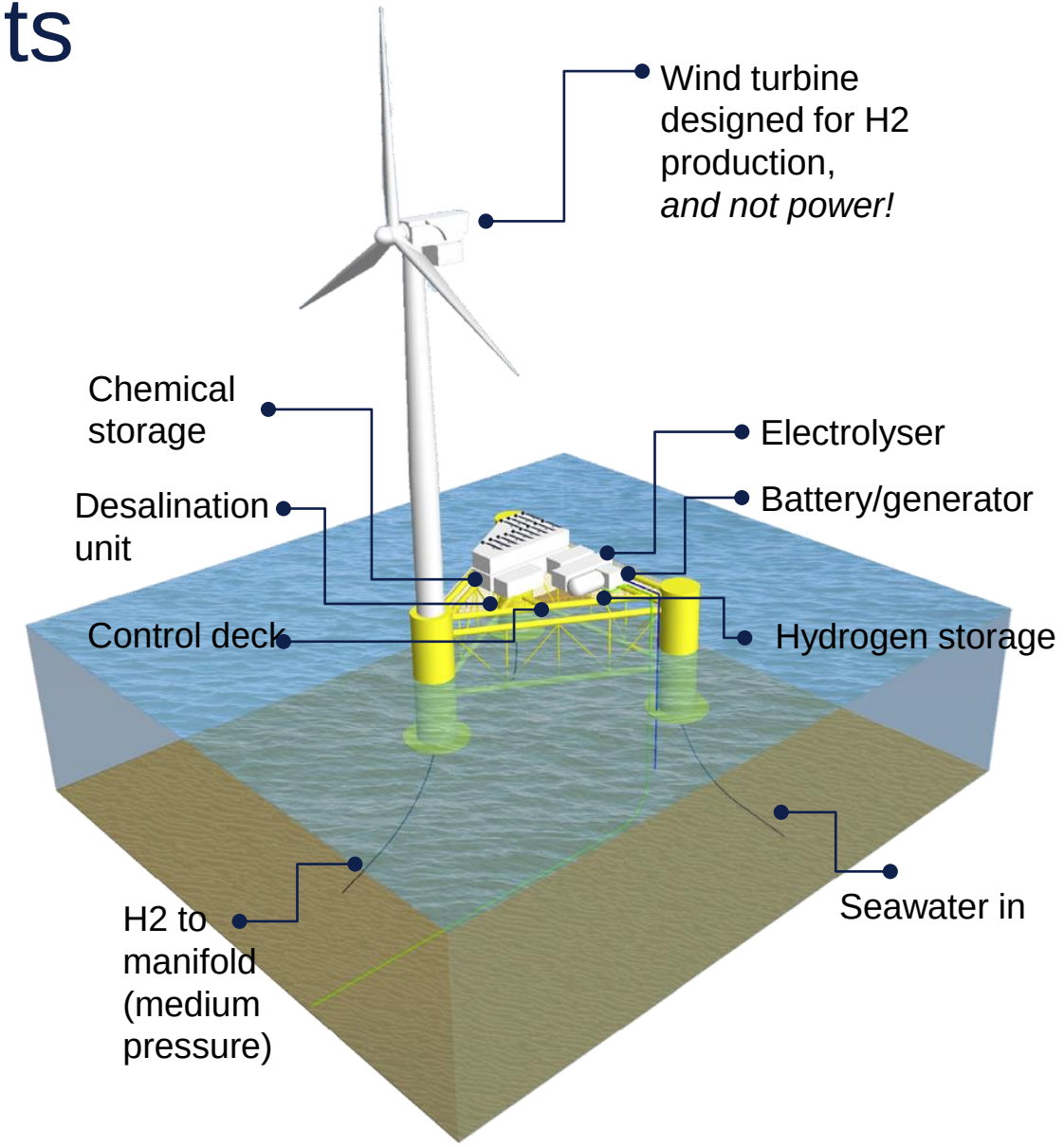
Direct use bunkering, with medium scale storage

DNV © WEDNESDAY, MAY 11, 2022

Emerging floating PtX concepts

- Concept designs for production of large-scale renewable ‘green’ hydrogen from offshore floating wind
- Deep Purple has several concepts:





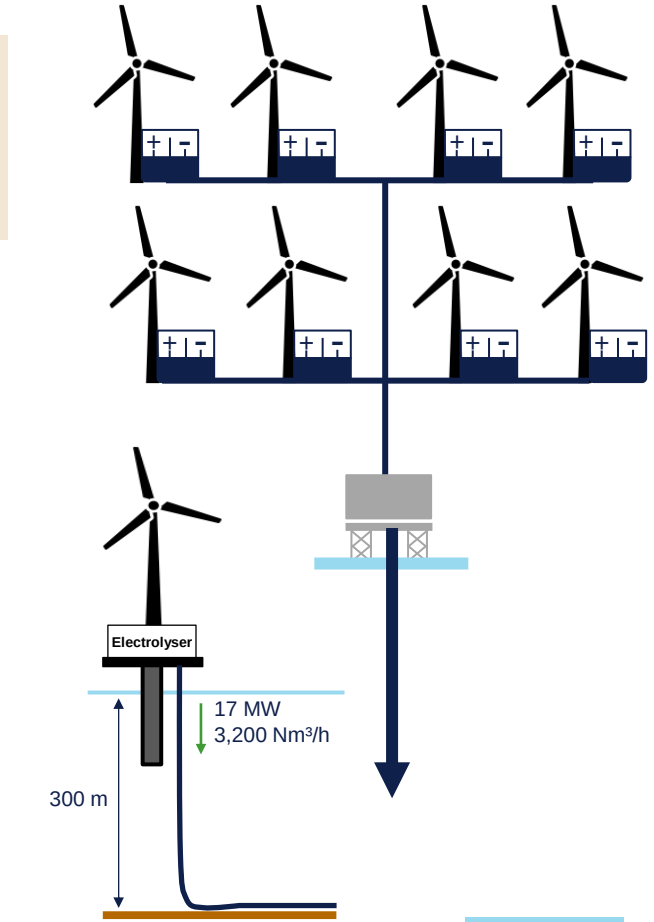
Decentral offshore H2 production
The DNV (composite) pipeline competency can contribute

A 2-3 GW windfarm with electrolysers integrated in the turbine.

- 17 MW turbine producing 3,200 Nm³/h
- Water depth of 45 m (floating alternative is 300 m)
- Radically new lay-out design compared to steel pipelines with no Daisy-Chaining

Pipeline Infrastructure can be up to 15% of CAPEX.

Decentral Hydrogen production



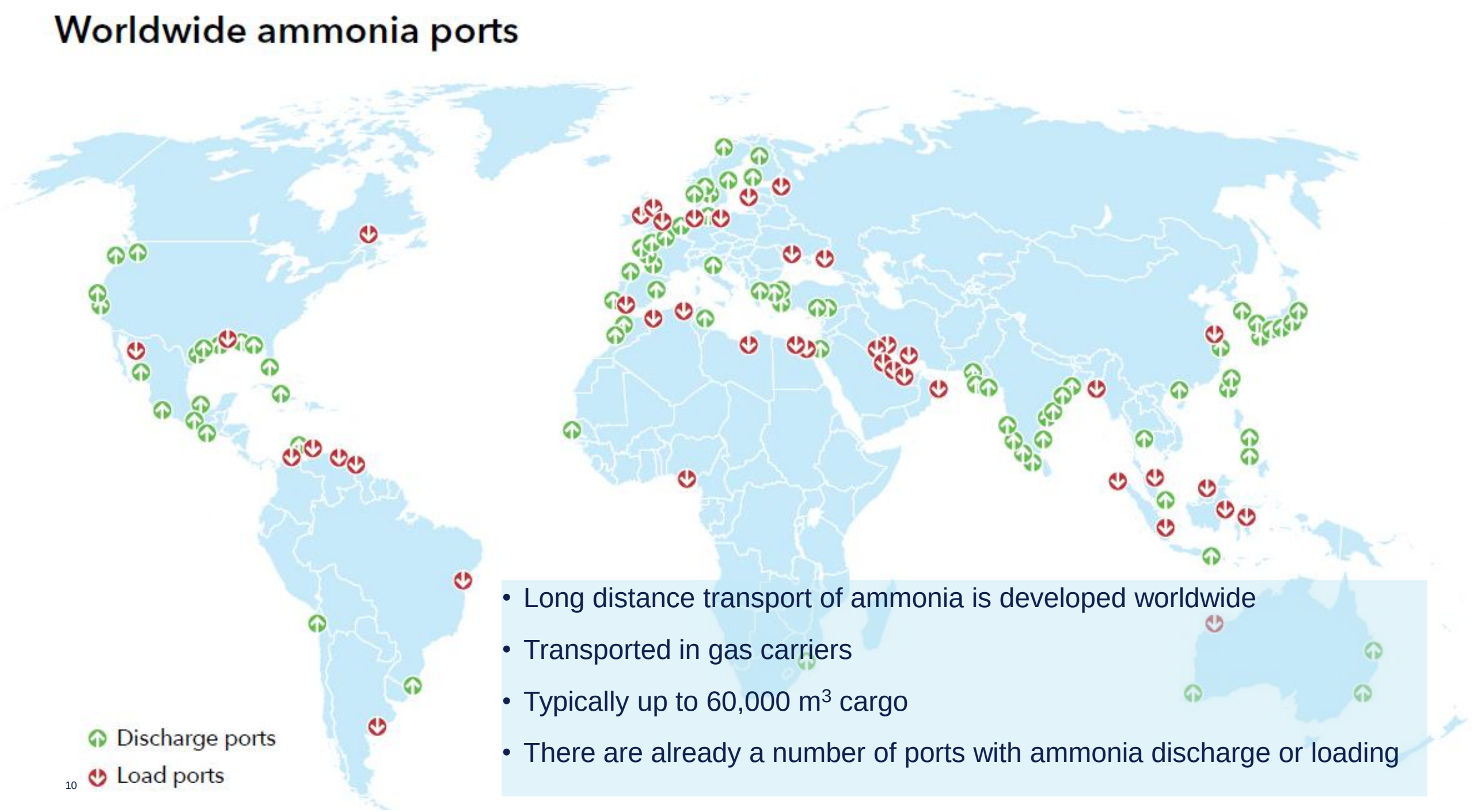
Floating concept

Infrastructure Overview (NH3)

In general, large-scale terminals already exist for hydrogen carriers such as LOHC, ammonia and methanol and this existing infrastructure could therefore be readily reused for the decarbonized alternatives. Large-scale storage of LOHCs can be done in internal floating roof tanks, such as the ones used for hydrocarbon fuels.

Existing infrastructure for ammonia. Source: DNV, Alternative Fuels Insight (AFI), status 5 January 2022.

Worldwide ammonia ports



- Long distance transport of ammonia is developed worldwide
- Transported in gas carriers
- Typically up to 60,000 m^3 cargo
- There are already a number of ports with ammonia discharge or loading

DNV Perspective offshore wind PtX

Hydrogen import/export from low-cost vRES

Off-grid with superior wind and solar to ammonia/hydrogen as global commodity

Symbiosis renewable and (ultra) low-carbon

Green part of grey and blue value chains

Safety

Gaps and standardization

Gas grid vs. shipping

Grid and offtake strategies for avoided costs, or shipping globally

“Price *and* Emissions Competition”

Emission levels defines ticket to trade, *and* the green finance terms with support mechanisms

Thank you for your attention!

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Energy Systems Northern Europe
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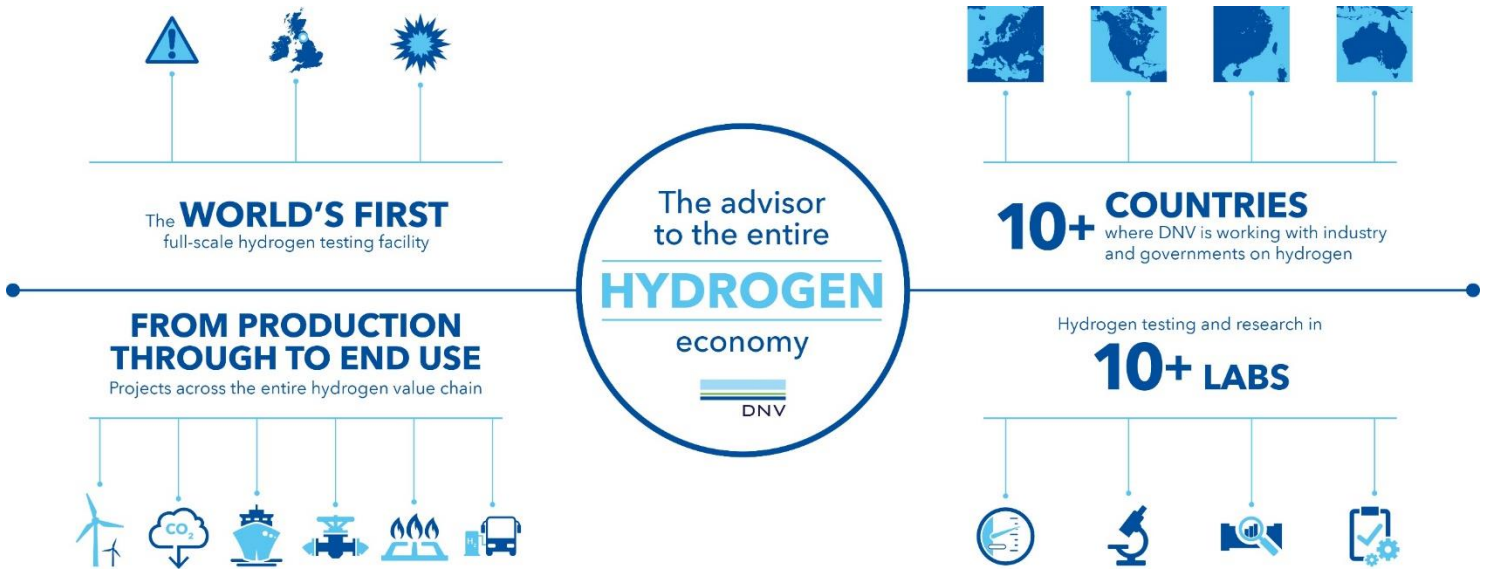
Phone: +47 99 60 26 90



Eksfin NO
EXPORT FINANCE NORWAY

Eksfin – Financing opportunities for Norwegian export and international growth

Hydrogen & CCS Webinar – Europe, 11 May

Arild Bakås

The state-owned Norwegian Export Credit Agency

We provide government-backed loans and guarantees to promote export

- Eksfin's guarantees come with an AAA rating, which is very attractive to most banks
- Eksfin can offer long-term loans or guarantees with long maturities and attractive terms
- Long-term financing can be crucial for winning contracts

STORTINGET

Norwegian Ministry of Trade, Industry and Fisheries

Eksfin NO
EXPORT FINANCE NORWAY

How Eksfin helps Norway's renewable energy industry

We collaborate across all industries

Entire export value chain

- Financing solutions are available to exporters, foreign buyers, project developers, EPC suppliers, Norwegian power companies, and other buyers in the energy industry
- Long-term financing to buyers of Norwegian capital goods and services in all parts of the renewable energy sector
  - Can be in form of contracts with a well-established foreign buyer, or partial deliveries to a project
- Full financing packages with long-term financing and/or risk-mitigation guarantees
  - These can include CO2 capture and sequestering, hydrogen, ammonia, etc.
- Fixed interest rate options and long maturities make export financing an attractive element in financing solutions for renewable energy projects

Eligibility for guarantee

- At least 30% Norwegian content in export contracts
- If Norwegian content < 30%, Eksfin may consider Norwegian value creation based on other criteria, like R&D contribution(s) and Norwegian technology/patent(s)

CAPEX investments in Norway

When you want to expand your production facilities

You are either an existing company wanting to expand your facilities, or you are a new company wanting to set up a new production facility

- The guarantees can cover investment in fixed assets (in Norway)
- Debtor can either be an operating company or an SPV
- Cover is also available to subcontractors to Norwegian exporters who can demonstrate substantial indirect export revenues
- Projects at any size
- Tenor up to 8.5 years, or up to 18 years for renewables

Eligibility for guarantee

- At least 50% of revenues are derived from export
  - Either directly or indirectly
- Eksfin's risk must be shared with a commercial bank
- The commercial bank provides the financing

Export / buyer financing

Gives your foreign customers financing so that they can pay you

You are a Norwegian exporter providing export for capital goods or services

- International buyers of Norwegian capital goods and services
- You are a Norwegian company exporting capital goods or services
  - Your delivery can also be part of a larger contract
- Offers your client access to reasonable and long-term financing conditions
- In addition to purchase-based financing, Eksfin offers financing for capital goods produced by a Norwegian exporter for leasing to clients overseas

Eligibility for guarantee

- At least 30% Norwegian content or Norwegian interest in the export contract
- Underlying export transaction
- Eligible for loans with a repayment term > 2 years
- Application to Eksfin prior to contract signature

We cooperate with banks and financial institutions all over the world

Expanded opportunities for Norwegian businesses and banks

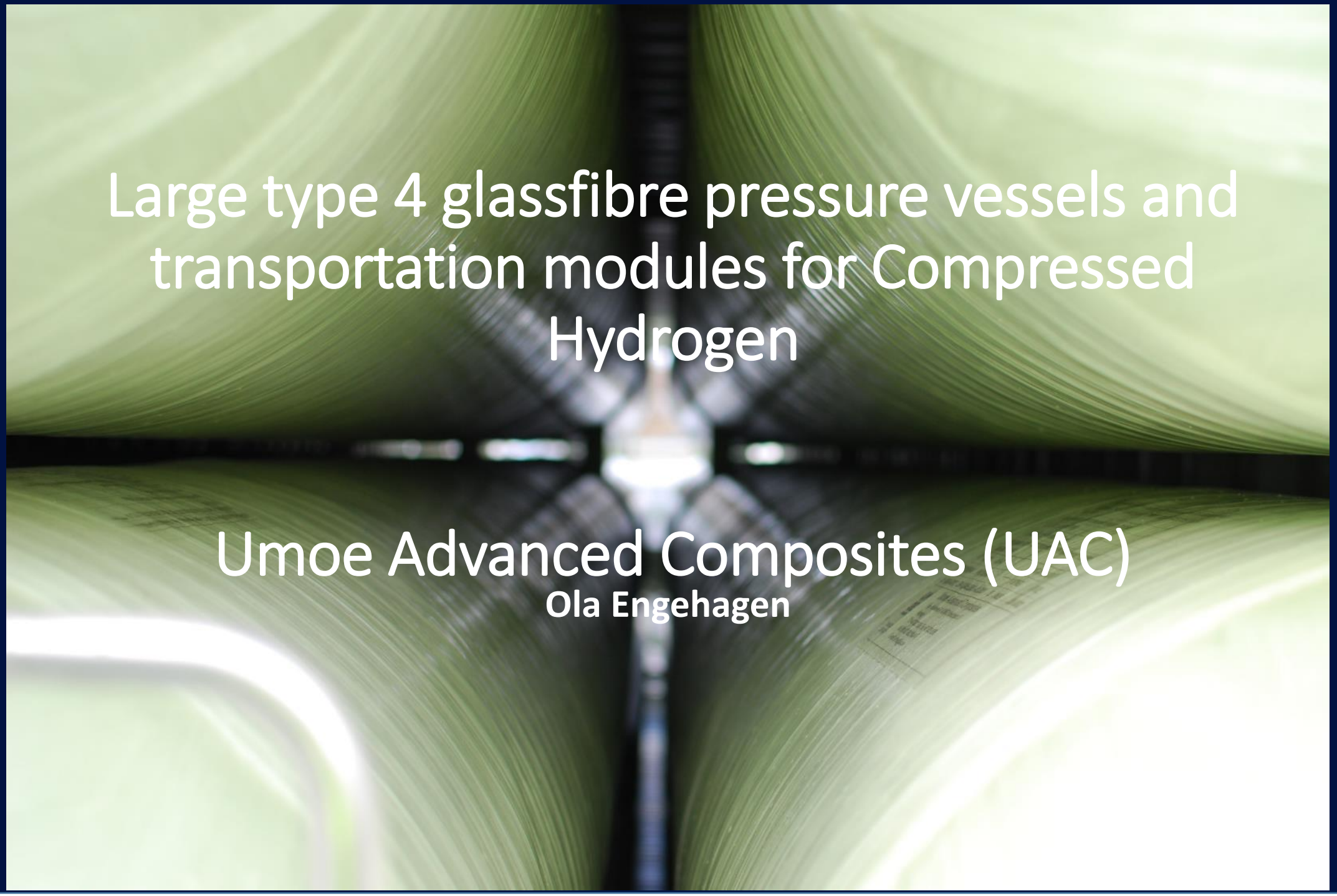
- Eksfin frames its guarantees and/or loans to match customer needs
- Banks normally act as the arranger and agent for a loan/guarantee
- Eksfin's network of banks adds value for exporters and purchasers

09.05.2022

ARILD BAKÅS
SVP, Senior Client Executive
Renewable Energy and Industry, Large Corporates
+47 416 458 83 | aba@eksfin.no

Thank you

Eksfin NO
EXPORT FINANCE NORWAY



Large type 4 glassfibre pressure vessels and transportation modules for Compressed Hydrogen

Umoe Advanced Composites (UAC)

Ola Engehagen

UAC | At a glance

Company description

- UAC is the leading global supplier of type 4 glass fibre pressure vessels and transportation & storage modules for Hydrogen
- UAC's product portfolio are tested under extreme conditions and witnessed by an independent 3rd party certification provider
- Customized solutions from UAC optimize the balance between Capex and Opex, and enables low Cost of Ownership

Key facts and figures

2007
Founded

35+
Employees

Kristiansand, Norway
Headquarter

EUR ~15m
Revenue 2021

Customer value proposition

- Lower CAPEX and OPEX
- Lightweight material
- 25+ years lifetime
- Ultimate safety

Fit For Purpose

- Distribution

- Static/Stationary Storage

- Fuel tanks for coastal ships and cargotrains

UAC | History

- **2008:** UAC started world wide deliveries of first light weight composite T4 cylinders made of glass fiber (230 and 330 bar applications) into the international offshore oil&gas sector. Installed on more than 80% of ultra-and deep water drilling rigs since 2008 (3000 Cyl.).

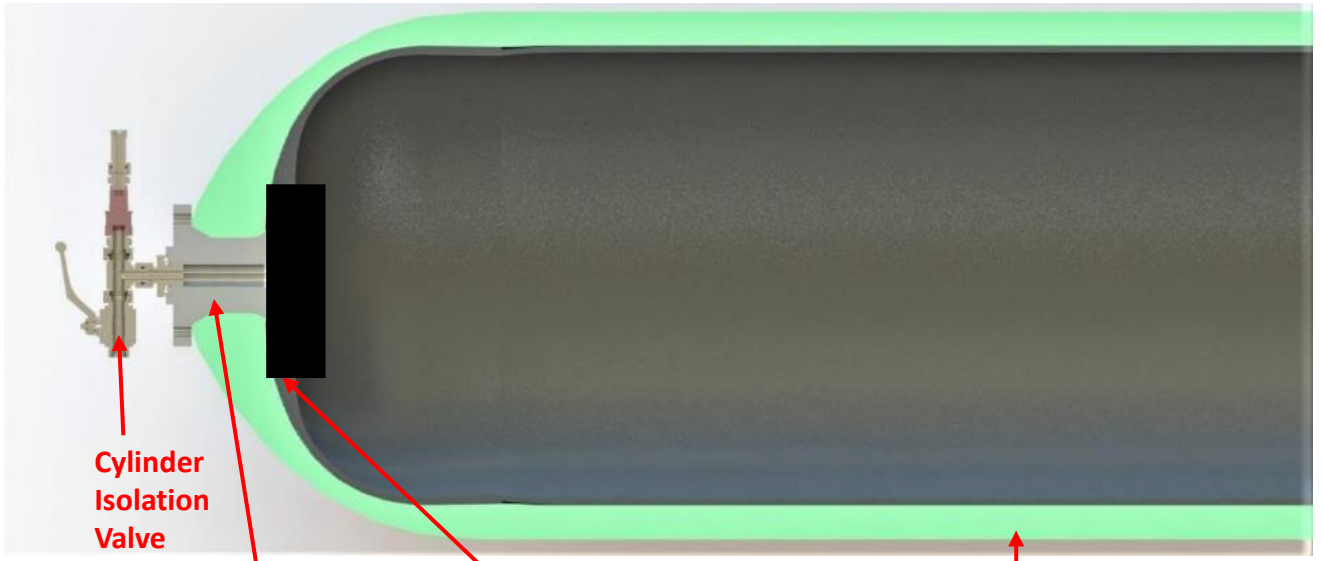
- **2016:** UAC started deliveries of light weight composite T4 cylinders made of fibre glass (250, 300 and later on 350 bar applications) and system solutions for ADR transportation and storage of Hydrogen, Biogas and CNG.

- **2020:** UAC started development of T4 cylinder for 425/450 bar ADR/TPED/RID application and commercial deliveries are done from 2nd quarter 2022

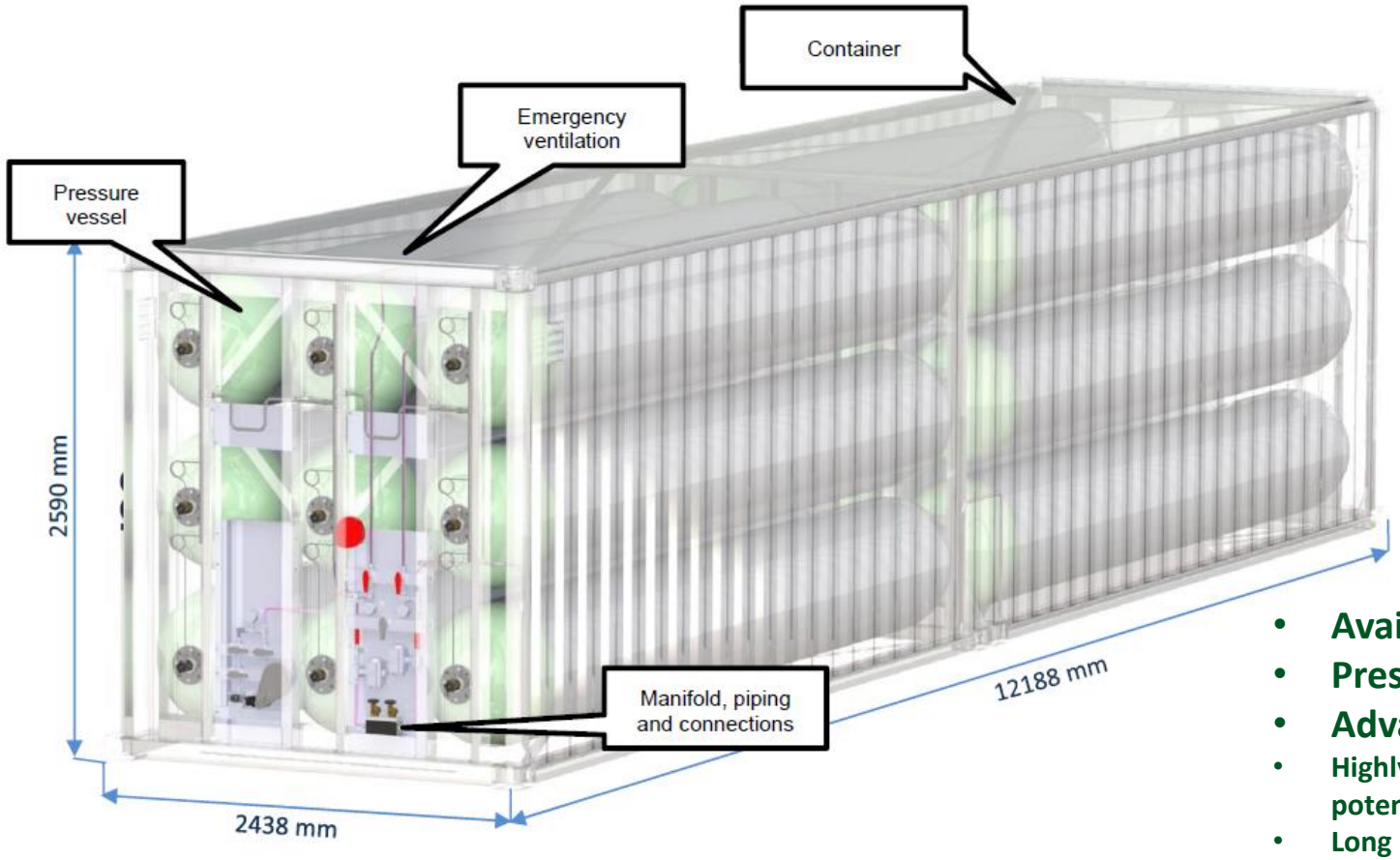
UAC | The pressure vessels – T4

UAC Type IV pressure vessel in high strength fibre glass and epoxy resin materials are delivered with plastic liner, stainless steel leak proff endbosses and customized manifold configurations

- Composite materials have lightweight, very robust, non-toxic and non-corrosive properties, eliminationg risk of oxidation
- Pressure vessles have wide temperature tolerances (-40/+65 C) and excellent fatigue properties, durable liftetime (+20 years)



UAC | The gas containment system - highly favourable Cost of Ownership



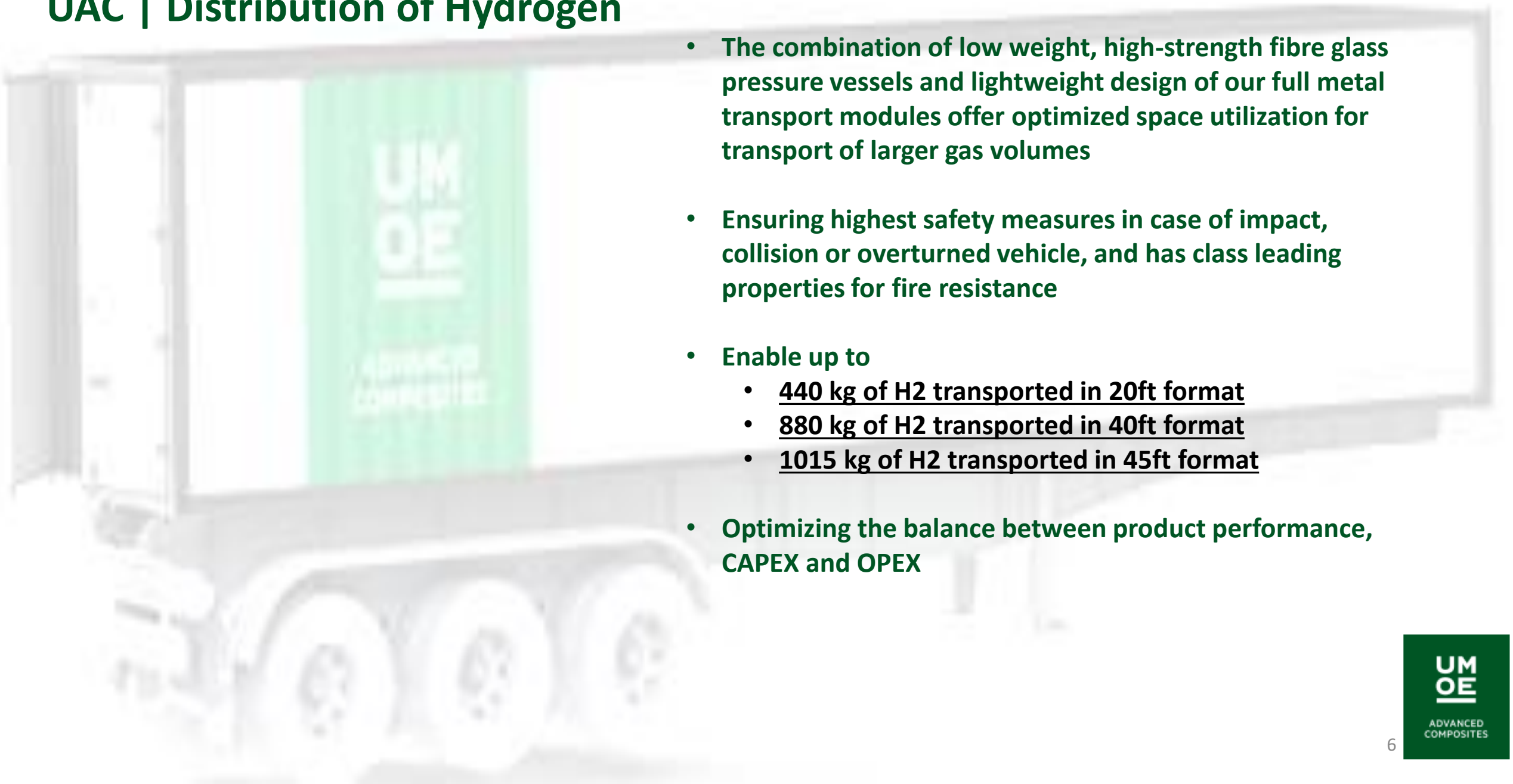
Picture 1

(General picture, type of manifold and equipment may vary)

- **Available in 20ft, 40ft, 45ft configurations**
- **Pressure range: 250, 300, 350 bar. 450 bar from 2022**
- **Advantages:**
- **Highly customized manifold solutions with design focused on minimizing potential leak points**
- **Long Lifetime - 25+ years design life**
- **No corrosion and No galvanic corrosion**
- **Class leading Safety properties**
- **Ultimate fire and impact resistance**

- **All products supplied to the market are issued with regulatory required certificates, ADR-PED/TPED/RID**

UAC | Distribution of Hydrogen



- The combination of low weight, high-strength fibre glass pressure vessels and lightweight design of our full metal transport modules offer optimized space utilization for transport of larger gas volumes

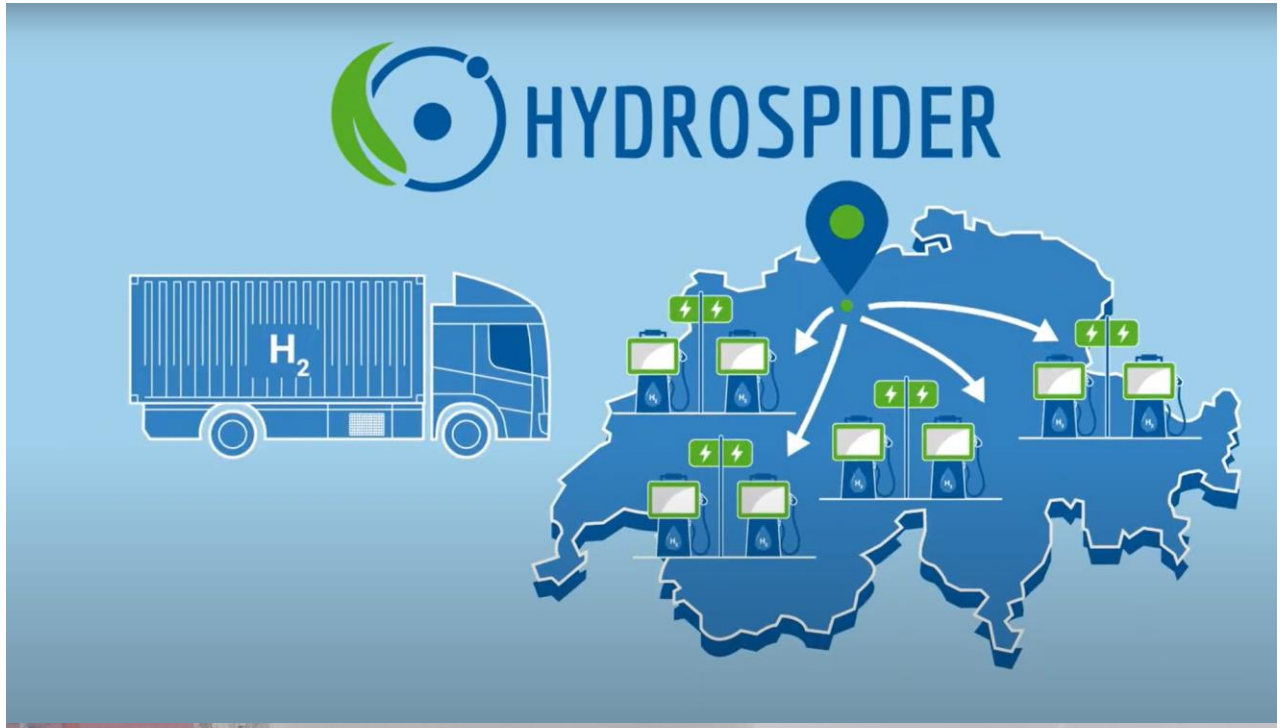
- Ensuring highest safety measures in case of impact, collision or overturned vehicle, and has class leading properties for fire resistance

- Enable up to
  - 440 kg of H2 transported in 20ft format
  - 880 kg of H2 transported in 40ft format
  - 1015 kg of H2 transported in 45ft format

- Optimizing the balance between product performance, CAPEX and OPEX

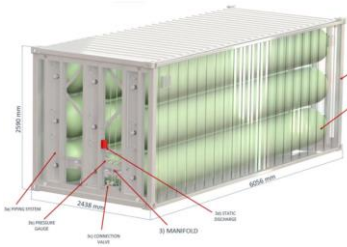
UAC | Distribution of Hydrogen – reference project

THE ECO SYSTEM FOR HYDROGEN IN SWITZERLAND



Ambitions within 2026:

- **1600 Hyundai Fuel Cell Electric trucks within 2025**
- **~100 Hydrogen Refueling Stations**
- **~100 MW electrolyser capacity**
- **~200 20ft H2 container modules for transport**



Status Q2 2022

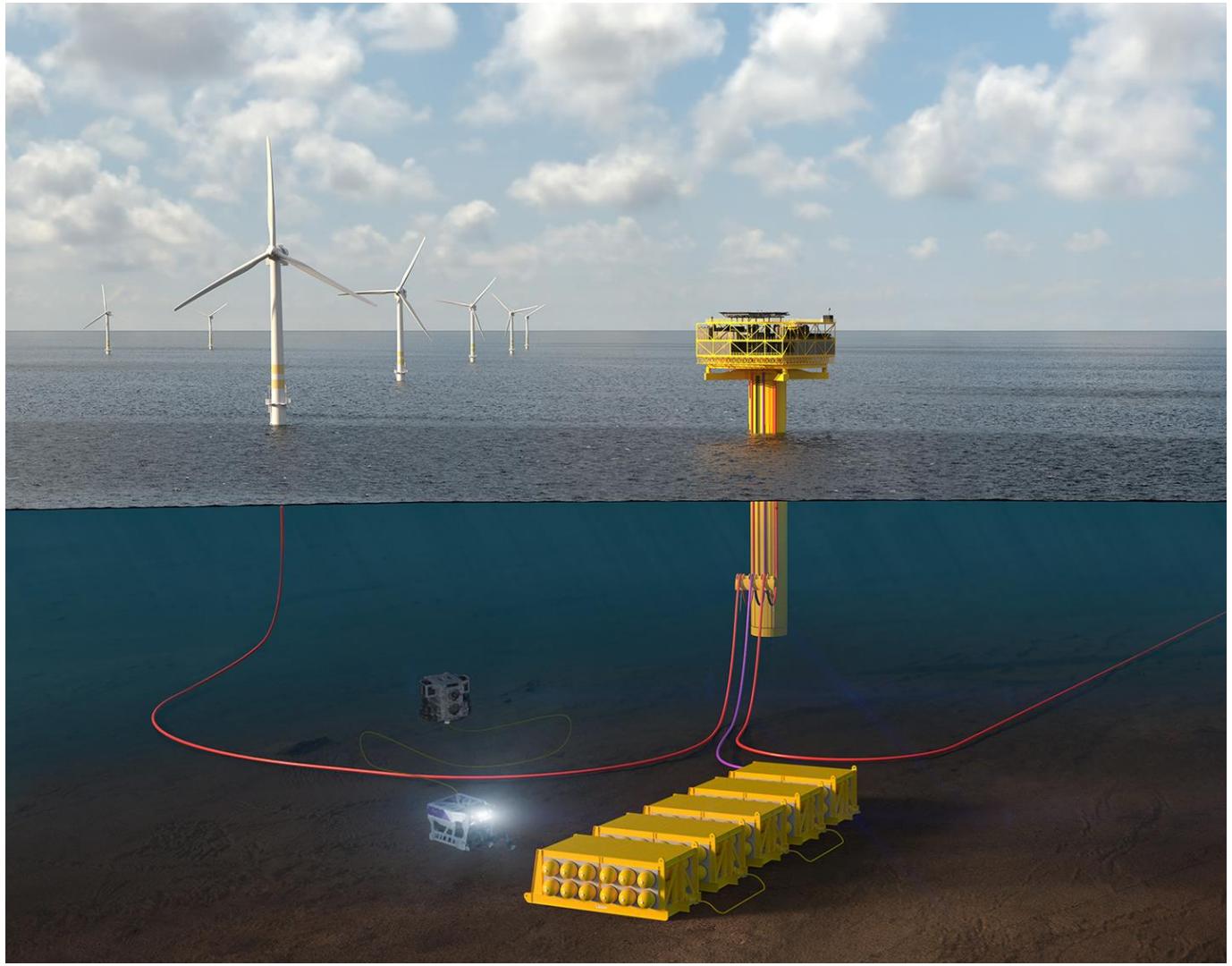
- **~50 Hyundai FCEV trucks in service**
- **10 HRS fuelling ~7-8 t of H2 every week**
- **3 MW electrolyser capacity**
- **24 H2 containers modules delivered from UAC**
- **Performed more than 1500 container swaps at HRS/electrolyser with connection/de-connection inlet/outlet**

UAC | Static/Stationary Storage of Hydrogen

- Optimizing footprint whether it is delivered as single vessels to be stacked in different configurations, or in plug and play ready containers
- Highly competitive CAPEX compared to type 1 cylinders, as well as lower installation costs, and extended lifetime
- Composite materials have lightweight, very robust, non-toxic and non-corrosive properties, eliminating risk of galvanic oxidation

UAC | Static/Stationary Storage of Hydrogen – reference development project

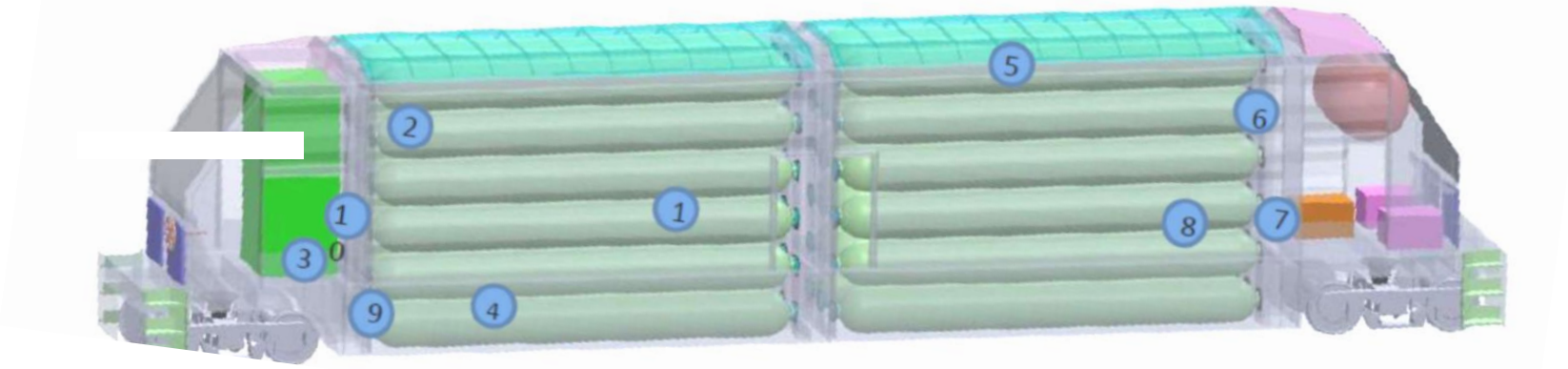
Deep Purple – Industry Consortium – Subsea Storage of Hydrogen



- Development project with several industrial participants, led by TechnipFMC in Norway
- UAC is a project member., responsibility is to develop large size pressure vessel – 40.000L – for 350 bar hydrogen for subsea installation (down to 300m waterdepth)

UAC | Fuel tanks for regional ships and railway

Hydrogen fuelled ships – starting to come true



THANK YOU FOR LISTENING!

Ola Engehagen
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Hydrogen and CCS introduces new transportation needs – green shipping solutions for the new stuff

Topeka

Steinar Madsen
11.05 - 2022

Wilhelmsen Group company

Maritime Experience & Capacity

Wilhelmsen Group

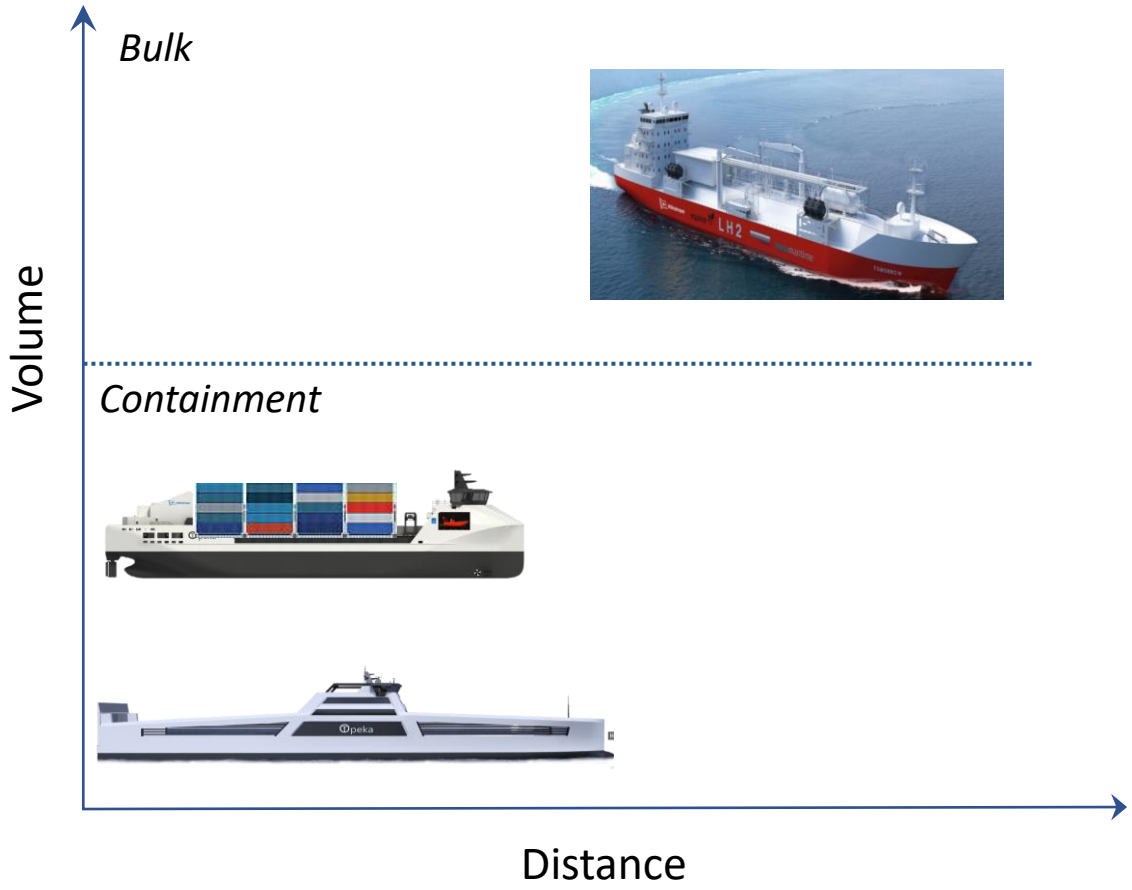
2 200 locations	**125** countries	**21 000** employees
50% of the world's merchant fleet as customers	**75 000** port calls handled by our port agents per year	**210 000** product deliveries per year. One every three minutes 24/7/365
9 200 seafarers	**2 700 000** square metres of offshore base storage capacity	**250** ships under management

GREEN INDUSTRY –

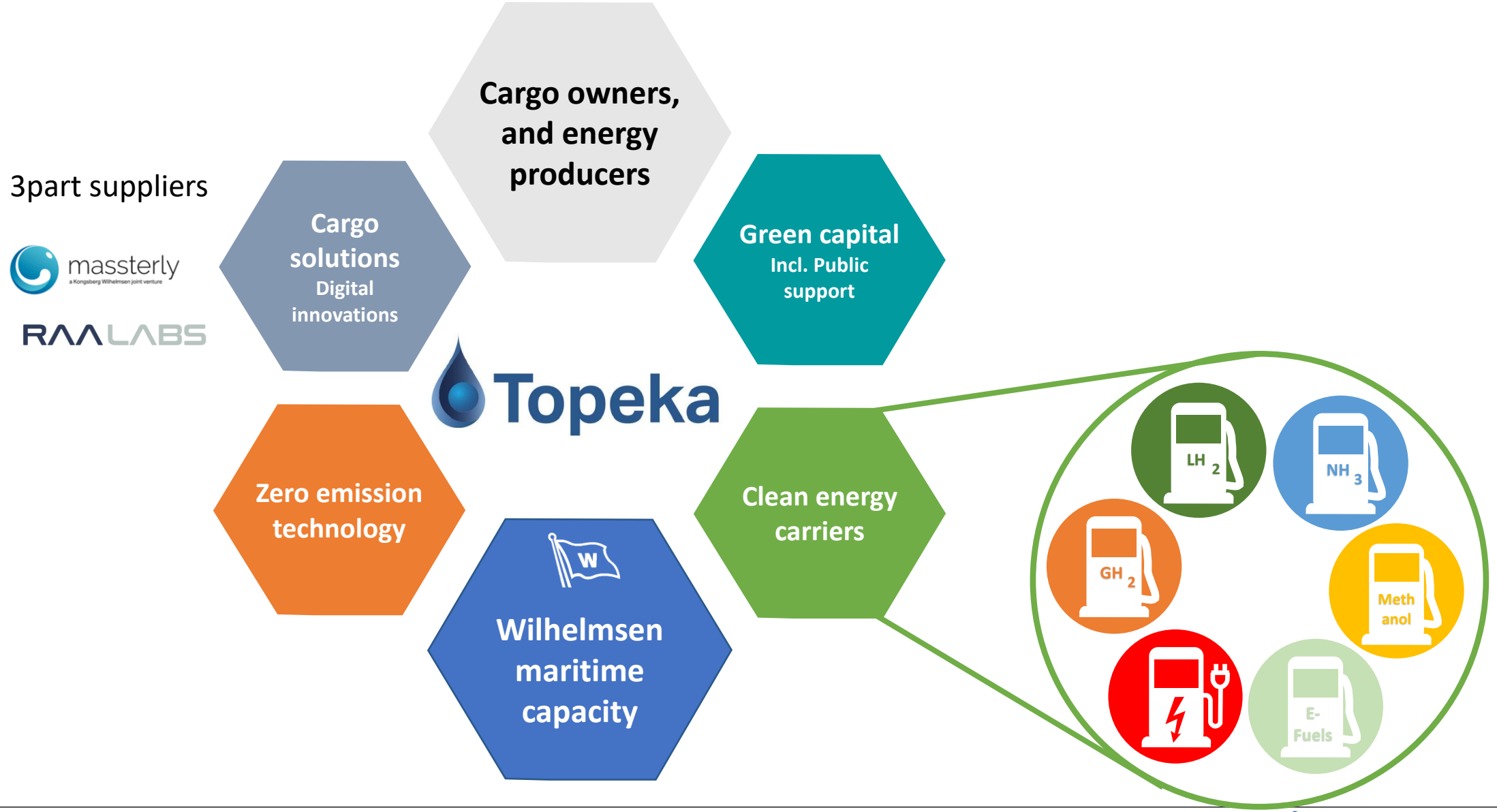
IS ONLY GREEN WITH GREEN LOGISTICS

Transporting the new stuff

Zero-emission solutions



Topeka supports decarbonization of supply chains

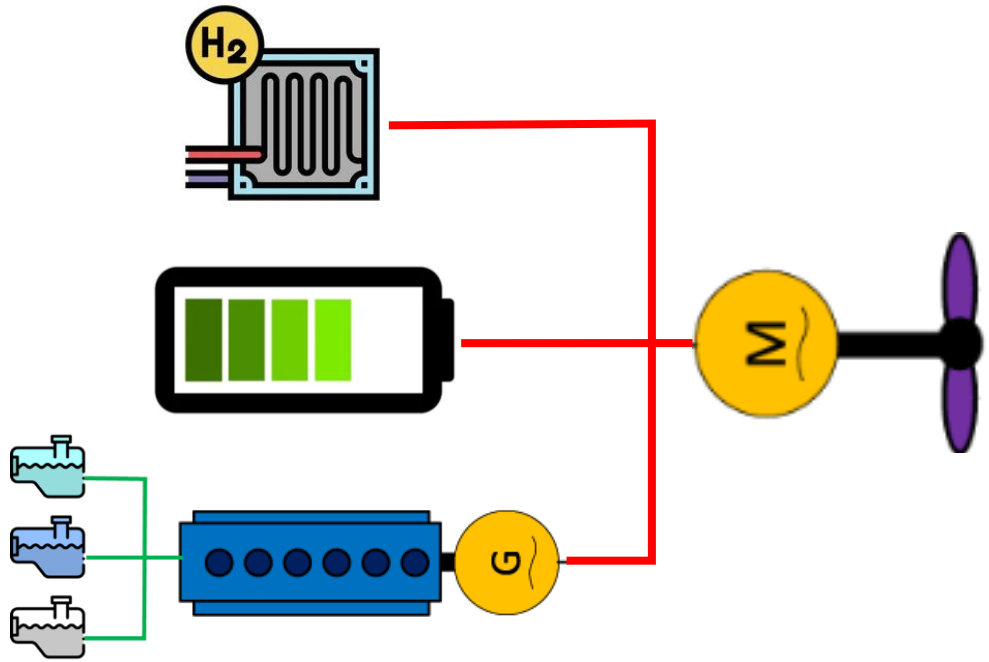


Fuel flexibility

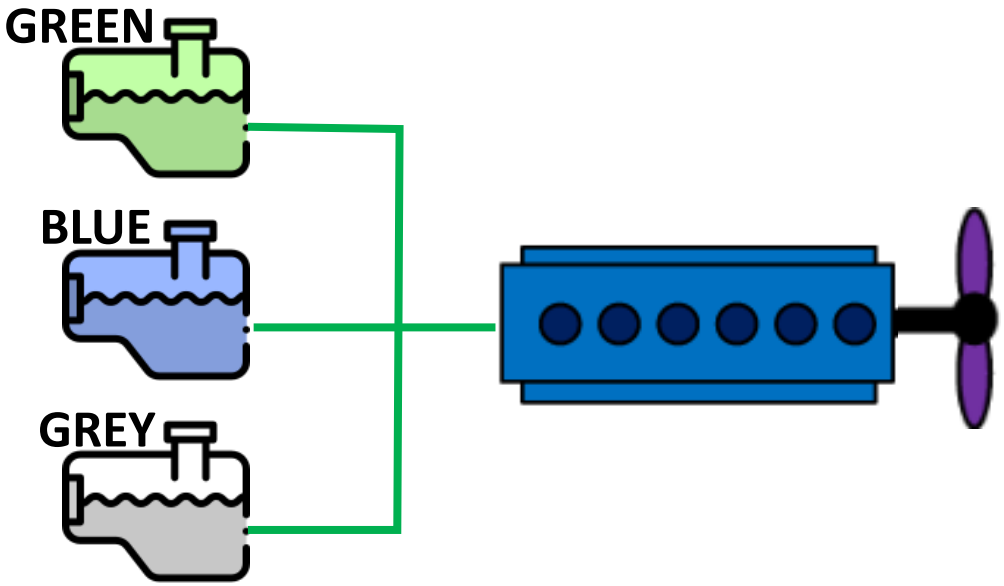
Built-in zero emission capabilities

Gradually change to 100% emission free operations when clean fuels supplies become accessible, reliable and economically viable

Electric powertrain – hybrid solutions



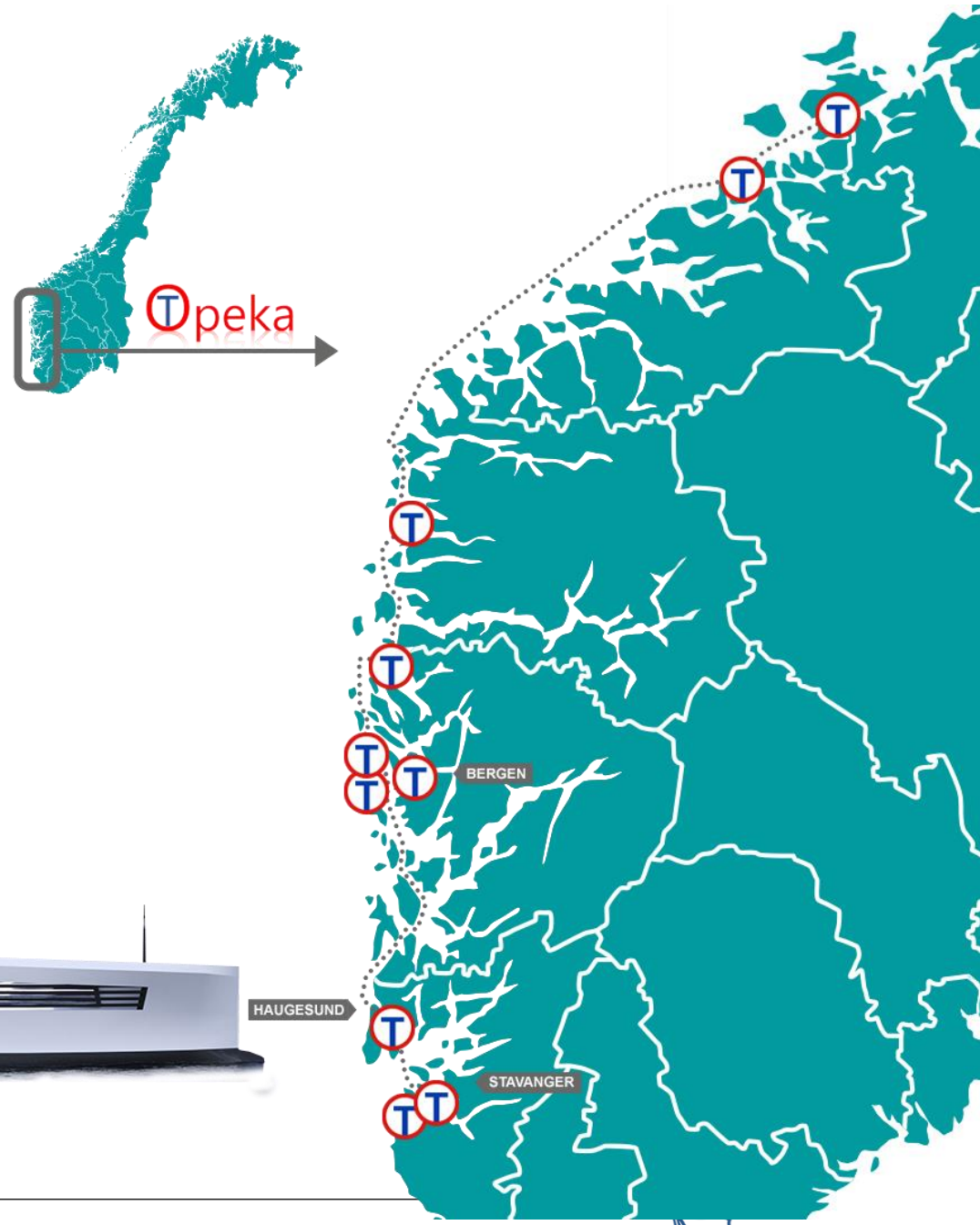
Direct driven – dual fuel



Topeka base-base

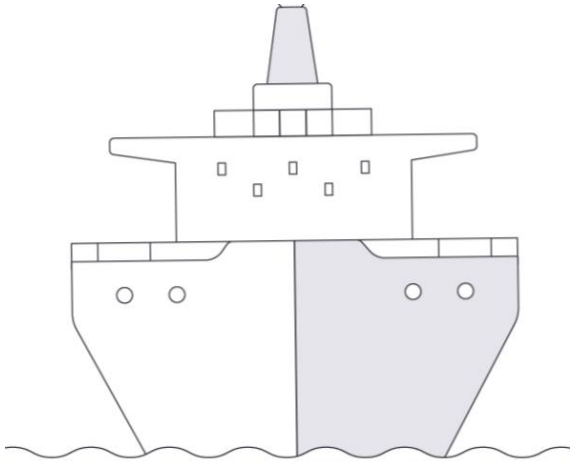
Zero emission seaborn transport:

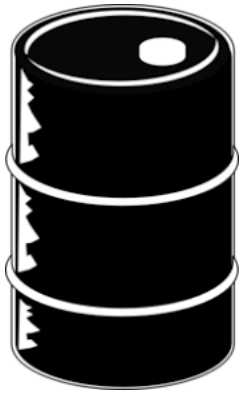
- Oil and gas industry – supply bases
- General cargo - public ports
- Hydrogen distribution - hydrogen hubs



Shipping in figures

End user potential





6 000 000
oil barrels pr day

Global shipping fleet
Number of commercial vessels in operation

100.000

Fleet fuel consumption
Amount of fuel burned per year

300M
tons

GHG emissions
Shipping's share of global emissions

3%

Source: Mærsk Mc-Kinney Møller Center for zero emission Shipping

Energy transitions

Starts with smaller vessels – shorter distance

LNG

2000

2004

2014

2020

Battery Electric

2015

2022 - 80 battery electric ferries

Hydrogen/Ammonia/Methanol

2021

2024?

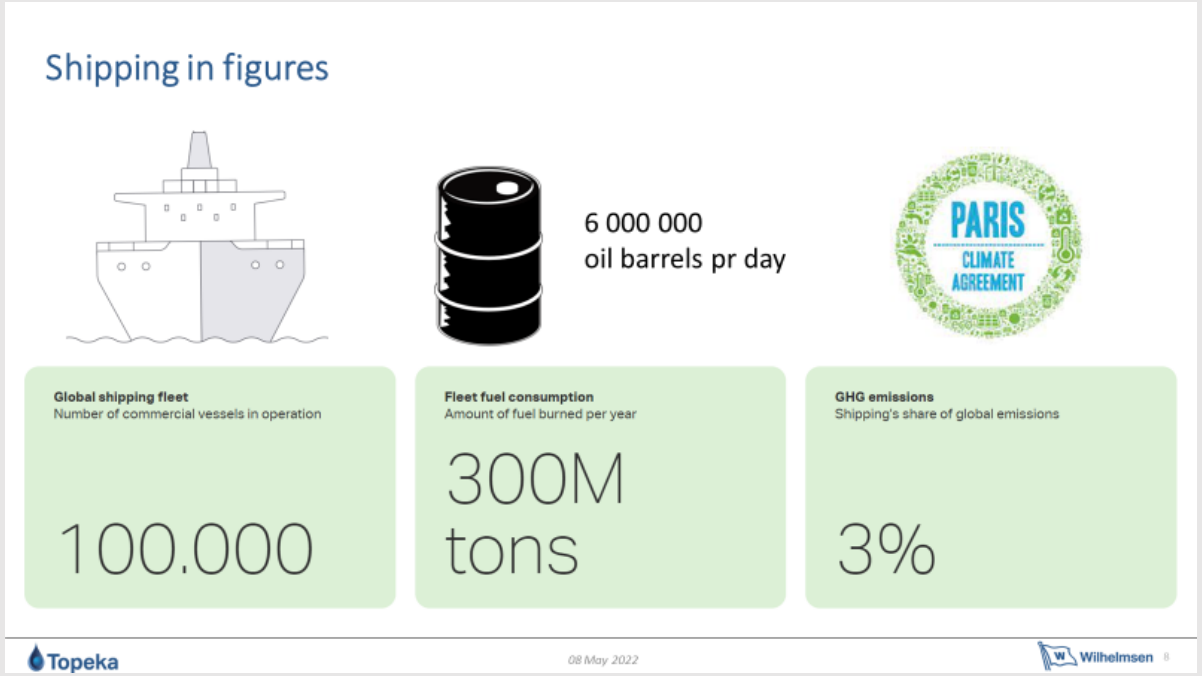
Green shipping

Transport solution and market maker

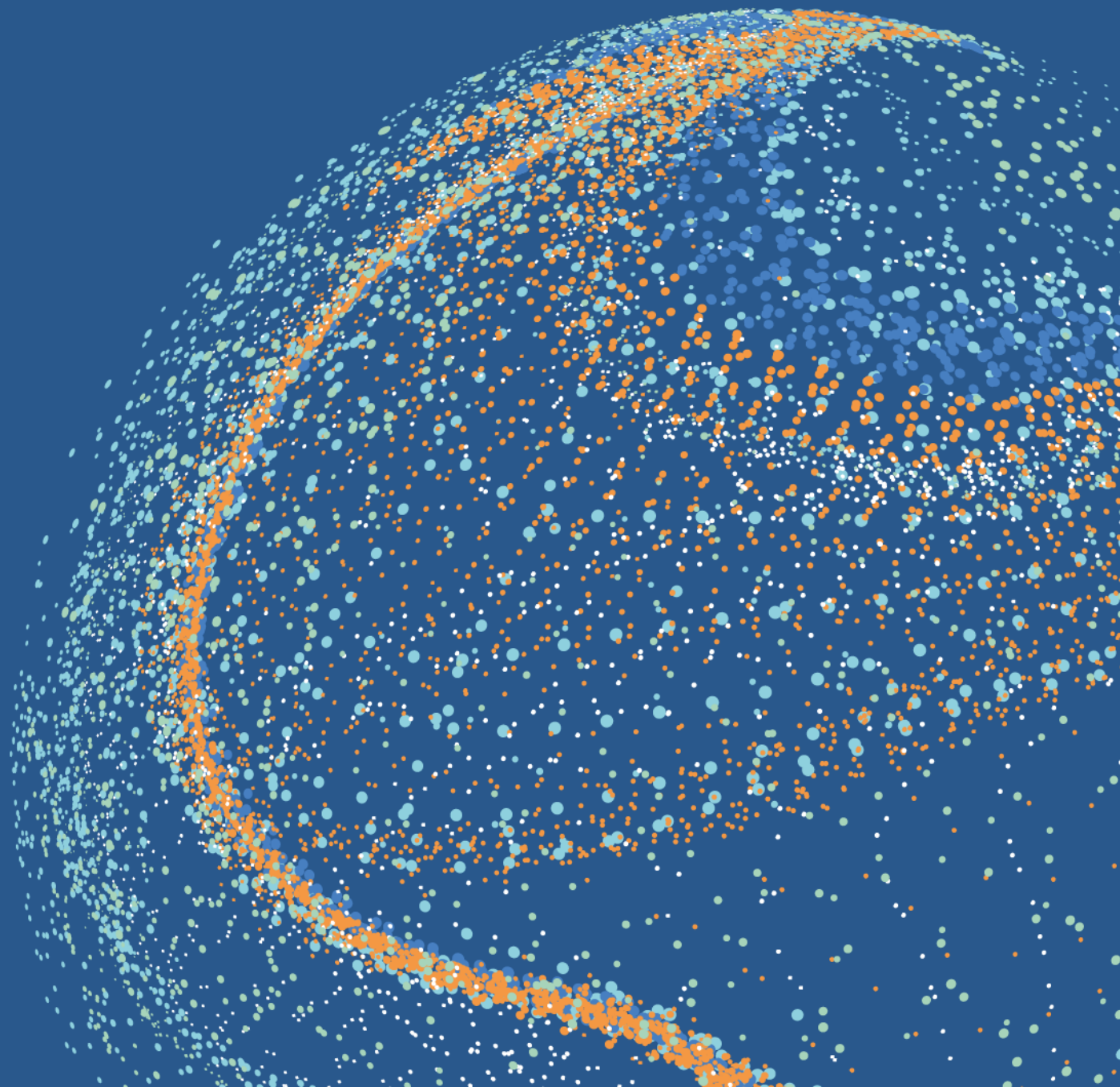
- Shipping, frontrunner for new energy carriers
  - History for energy transitions
  - Ship - large tailor-made applications
  - Possibilities for dual fuel solutions
  - Large volumes/bunker facilities
- Safe and sustainable logistic, license to operate for new industries

GREEN INDUSTRY

IS ONLY GREEN WITH GREEN LOGISTICS



Wilhelmsen



Gas Technologies

Moss technology for the transportation of green liquefied gas

mossmaritime

Tor Skogan, Vice president gas

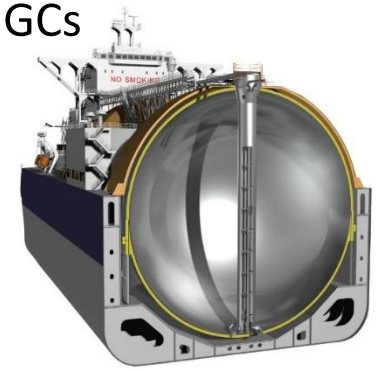
mossmaritime

Company facts

- Engineering company within the maritime energy sector
- Office: Oslo, Norway - 65 employees
- Owned by Saipem since 2001
- Business focus: Design & engineering for LNG ships, LNG floating terminals and floating renewable solutions incl. LCO2 and LH2
- Clients: Shipyards, shipowners, energy companies, EPC contractors

LNG carriers

- Moss is the originator & owner of technology for Moss LNG carriers with the famous spherical LNG tanks
- From 1973 until today 145 Moss LNG carriers have been built world-wide, including many for Autralian LNG exports
- Moss LNG tanks = superior robustness & reliability
- Moss has in particular competence related to cargo tanks and cargo handling aspects of LNGCs



mossmaritime

Floating LNG terminals (FSRU, FLNG, FSU)

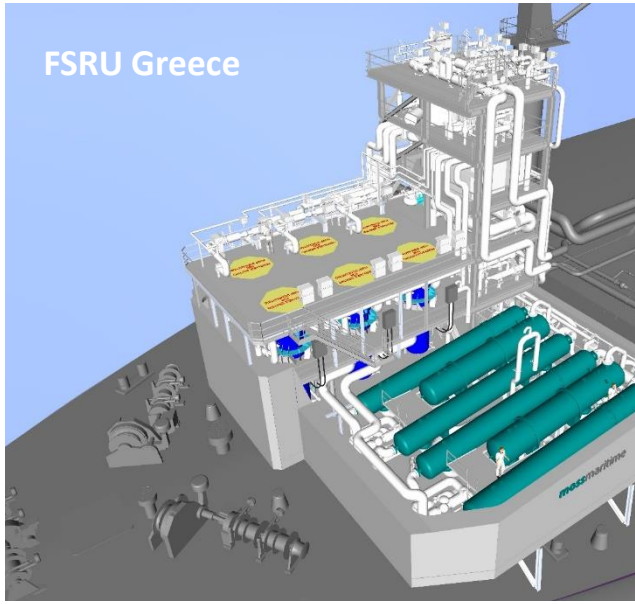
- Moss Maritime is a pioneer for design & engineering of floating LNG terminals (FSRUs, FSUs and FLNGs)
- Moss provides a wide range of multi-discipline engineering services to shipowners, shipyards and charterers (concept → basic/FEED → detail eng.)
- All engineering disciplines covered (process/cargo handling, piping, EIT, structures, naval, safety).
- Plenty of experience related to conversions → Moss has engineered the conversion of 10 x LNG carriers into floating LNG terminals


FSU Malta


FSRU El Salvador


Brazil FSRU


FSRU Indonesia


FSRU Greece

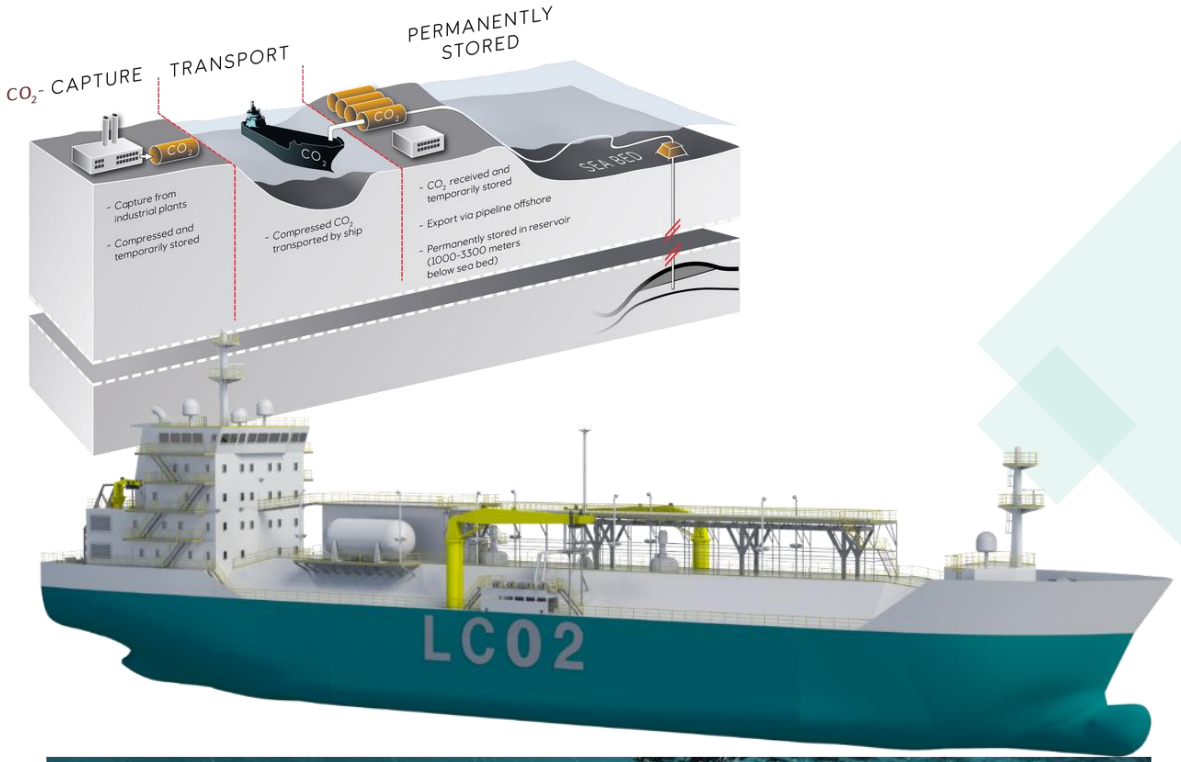

FLNG Cameroon


FSRU Toscana

mossmaritime

CO2 ship transport & injection

- Moss LNG experience → Moss LCO_2 design
- 2019: Moss engaged by Northern Lights project (Equinor, Total & Shell) for basic design of cargo handling system for 7500m^3 medium pressure LCO2 ships. Work scope:
  - Process definitions of cargo system including operational procedures
  - Layout & piping basic design
  - Equipment definitions & budgetary pricing
- 2020-2022: Moss engaged by Altera Infrastructure and Høegh LNG, in developing technology for ship transport & offshore injection of LCO2 (low pressure). Moss responsible for all aspects of technology and systems for LCO2 handling
- 2021-2022: Moss engaged by the CETO JIP (Equinor, Shell, Total and Gassco) for development of 30.000 m3 medium pressure LCO2 carrier.



mossmaritime

Hydrogen bunkering & ship transport

- In 2018 Moss developed an LH_2 carrier with bunkering capability
- Collaboration with Equinor, Viking Cruises, DNV and ship operator Wilhelmsen)
- Focus on cargo handling aspects
- Suitable for short/medium distance transport and providing LH2 fuel to other ships

Artist impression of Moss bunker vessel for LH2

mossmaritime

Long distance hydrogen ship transport

- Large ships for LH2 transport will be required for long distance transport
- Technology does not yet exist for large LH2 ship tanks @ low pressure → technology development is required
- Key challenge is related to insulation (LH2 has very low heat of evaporation) → vacuum plus special insulation materials are required
- Low pressure tanks → boil-off is utilized as fuel in propulsion system
- Moss is leading a concept study supported by SINTEF. Financing by Research Council of Norway and three (3) energy majors.
- Completion in 2023

Moss LNG carrier

Artist impression of Moss large LH2 carrier

mossmaritime

Why choose to engage Moss for your project

- Decades of recognized experience from design of ships & floating terminals for liquefied gases/LNG
- Multidiscipline team
- Renewable focus (LH2, LCO2)

www.mossww.com

mossmaritime@mossww.com

tor.skogan@mossww.com

Green hydrogen approaching fossil parity – game-changer across applications and markets

Thorsten Herbert
Director Market Development and Public Affairs

Forward-looking information

This Presentation includes and is based, inter alia, on forward-looking information and statements relating to the business, financial performance and results of Nel ASA and/or industry and markets in which it operates that are subject to risks and uncertainties that could cause actual results to differ materially from the statements expressed or implied in this Presentation by such forward-looking statements. These statements and this Presentation are based on current expectations, estimates and projections about global economic conditions, the economic conditions of the regions and industries that are major markets for Nel ASA and Nel ASA's (including subsidiaries and affiliates) lines of business. These expectations, estimates and projections are generally identifiable by statements containing words such as "expects", "believes", "estimates" , "aims", "anticipates", "intends", "plans", "projects", "targets" or similar expressions. Important factors that could cause actual results to differ materially from those expectations include, among others, economic and market conditions in the geographic areas and industries that are or will be major markets for Nel ASA's businesses, raw material prices, market acceptance of new products and services, changes in governmental regulations, interest rates, fluctuations in currency exchange rates and other factors.

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Agenda

1. Nel in brief
2. Highlights & other developments
3. Execution strategy
4. Summary/Outlook

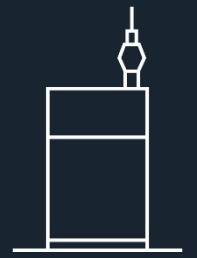
1. Nel in brief

Leading pure play hydrogen technology company with a global footprint

Pure play hydrogen technology company listed on Oslo Stock Exchange (NEL.OSE)

Manufacturing facilities in Norway, Denmark, and U.S., and a global sales network

World's largest electrolyser manufacturer, with >3,500 units delivered in 80+ countries since 1927



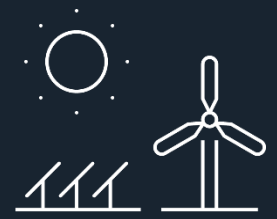
Leading manufacturer of hydrogen fueling stations, with ~120 H2Station™ solutions delivered/in progress to 14 countries

Green hydrogen approaching fossil parity – game-changer across applications and markets

Hydrogen is compressed and cooled in the H2Station™ ready for fueling through the dispenser

Hydrogen fueling is relevant for both light duty vehicles (LDV) and heavy-duty vehicles (HDV)

Electricity production



Hydrogen production

Electrolysers

nel

H2Station™

nel

Fuel Cell Electric Vehicle

Industrial applications

Power-to-X

Electricity is generated from wind or solar

Electricity is used to split water (H_2O) into hydrogen and oxygen

Green hydrogen has a massive potential to decarbonise industries, i.e. ammonia and steel

Hydrogen is expected to become relevant within all forms of industry, energy storage, heating, energy export and new applications

nel

Strong field know-how and manufacturing capacity

PEM electrolysers

Wallingford, USA

Systems delivered: **2,700+**

Production capacity: **>50 MW/year**

History: **23 years**

Alkaline electrolysers

Notodden/Herøya, Norway

Systems delivered: **800+**

Production capacity: **500 MW/year (~2 GW/year)**

History: **90 years**

Hydrogen refueling stations

Herning, Denmark

Stations delivered: **~120**

Production capacity: **300 HRS/year**

History: **16 years**

$1.50/kg

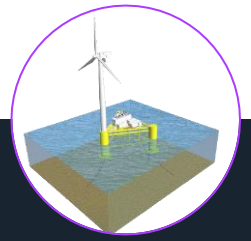
Nel green hydrogen cost target by 2025

Assumptions: Nel analysis based on electricity of $20/MWh, >8% cost of capital, cost of land, civil works, installation, commissioning, building water etc., lifetime 20 years incl. O&M cost, at 30 bar

2. Highlights & other developments

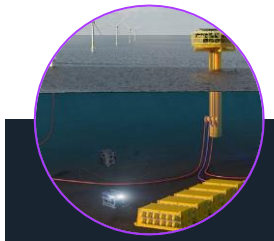
PROJECT EXAMPLES

Nel at the forefront of developing solutions for hydrogen production from offshore wind - a potential next step towards hydrogen production at scale



Dolphyn
Large Scale Offshore Hydrogen Production

- Production of green hydrogen at floating offshore wind installations
- Project has potential to supply energy to heat more than 1.5 million homes
- Assessment underway for application of a PEM electrolyser from Nel
- Other partners are ERM and Doosan Babcock amongst others
- Funding obtained through the UK Government "Hydrogen Supply Programme"



Deep Purple™
Pilot

- Production of green hydrogen offshore combined with subsea storage
- Demonstrate opportunity for stable energy production and supply off-grid, i.e. remote islands, offshore installations
- Consortium is led by Technip FMC and consists of Vattenfall, Repsol, Nel, DNV, SINTEF amongst others
- Funding obtained through Innovation Norway

POSHYDON

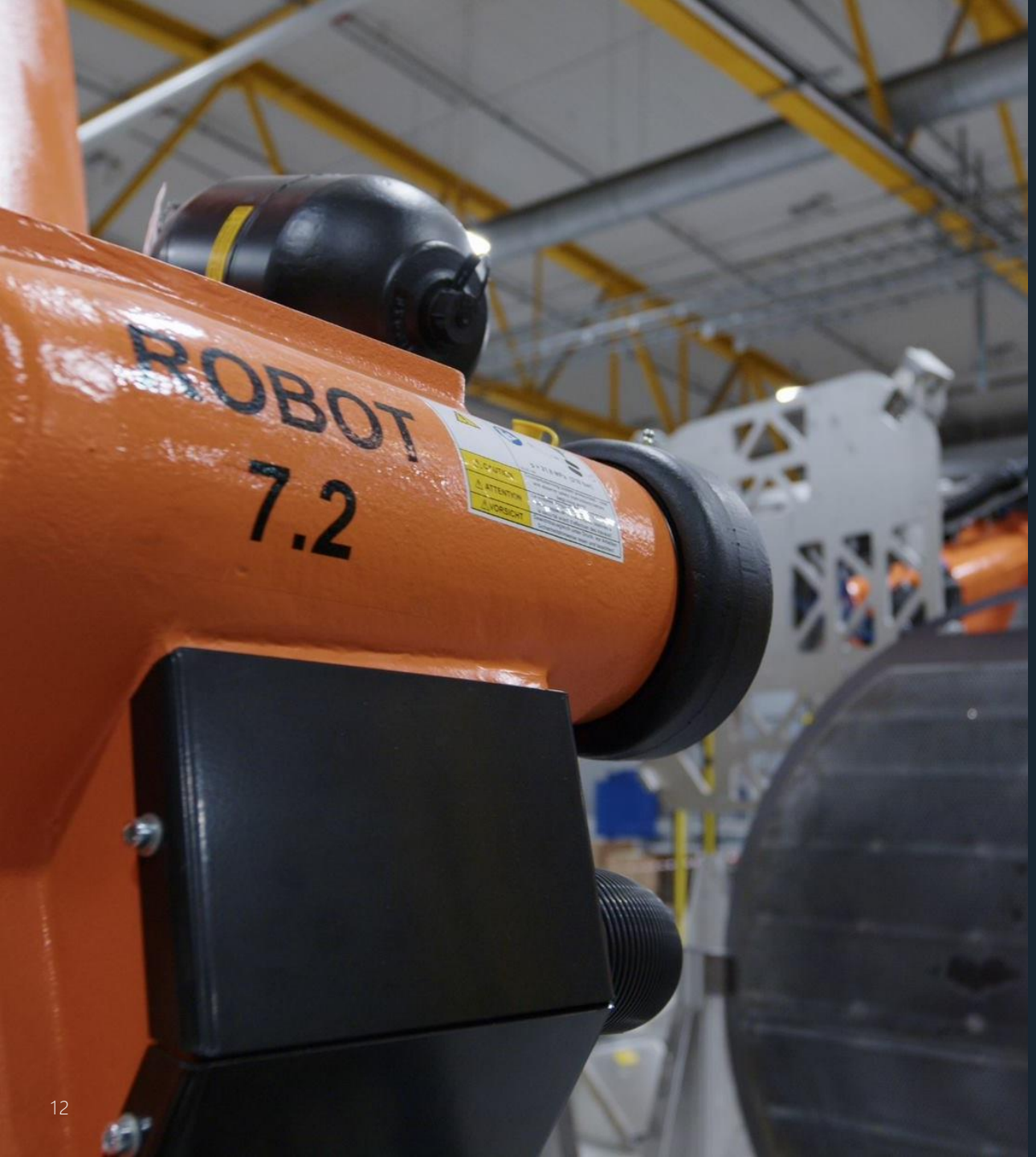
- Production of green hydrogen from demineralized seawater and offshore wind. Mixed with natural gas to be transported to shore via existing gas pipelines
- Nel to provide 1.25MW containerized PEM electrolyser to pilot project
- Consortium partners include TNO, Neptune Energy, Nel, Gasunie, Noordgastransport amongst others
- Funding obtained through Dutch Government DEI+ scheme

HERØYA CAPACITY EXPANSION

Game-changing expansion at Herøya - on time and on budget

- Fully automated and designed according to **lean manufacturing and industry 4.0 principles**
- Industrial scale production of most efficient electrolysers in the market, at a **game-changing cost**
- Large scale production line, name plate capacity of **more than 500 MW**
- Room to expand to **~2 GW** annually
- CO_2 reduction potential in line 1 (pilot) of **1.000,000 tonnes** – with 2 GW, **4-5 million tonnes**
- Production for **Nikola and Everfuel** will commence in Q4

https://nelhydrogen.com/articles/video/nel-hydrogen-heroya-factory-tour/

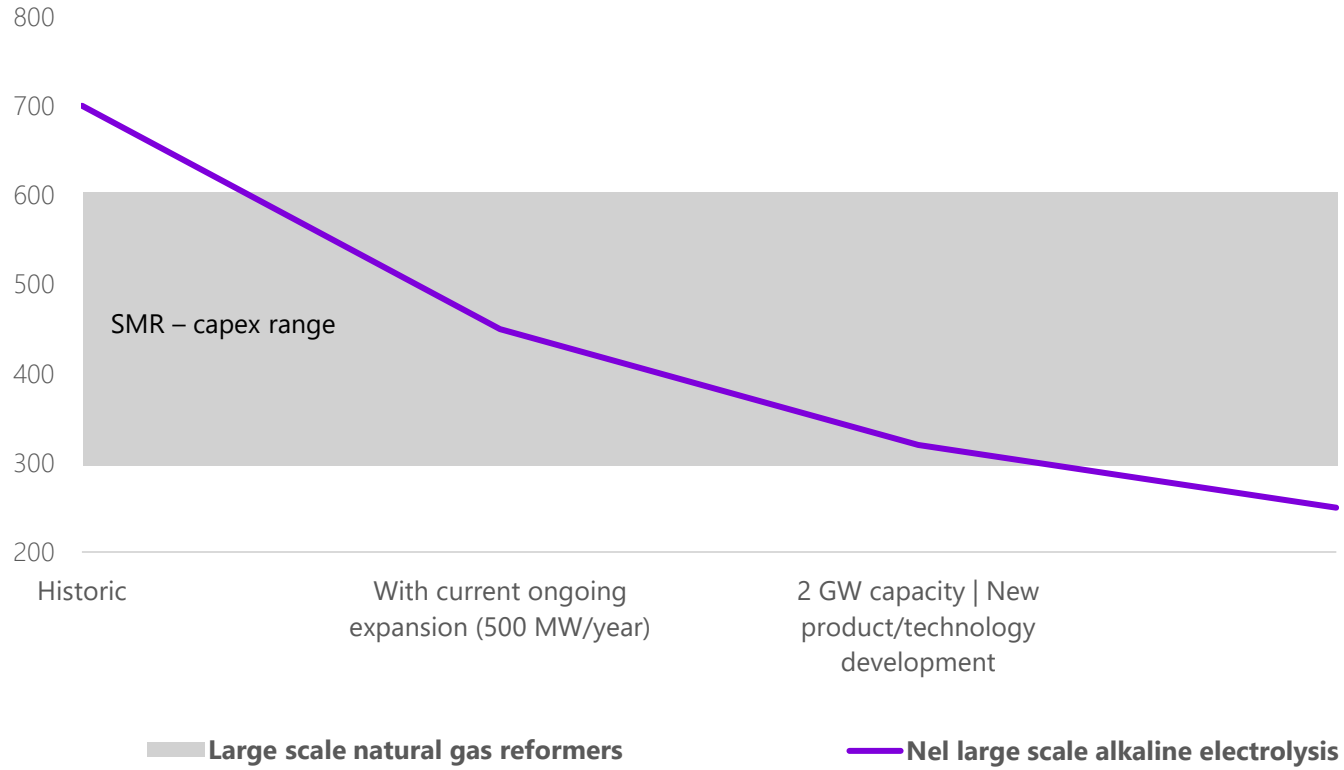


Herøya, an industrial gamechanger

- The world´s largest and first fully automated electrolyser manufacturing facility
- Leading race towards fossil parity
- Finished on time and budget
- From new year, production running at 3 shifts
  - Line tuning during Q4, 2021
- New production records every week

Growth in renewable hydrogen will accelerate with reduced capex for electrolysers

Capex of steam methane reformers (SMR) vs. Nel's alkaline electrolysers



- Steam methane reforming (SMR) dominates hydrogen production using natural gas and steam
- Nel establishing new manufacturing plant targeting >40% cost reduction – further capex reduction expected due to increased production volume and further size scaling
- Nel targets capex to drop below SMR over time
- Electrolysis expected to be preferred production method if opex (i.e. power prices) is low enough, or at parity, with alternative production methods

Source: Company analysis and projections, hydrogen production plant excluding installation, civil works and building.

Q4 2021

Unprecedented evolution of pipeline

2 x increase since Q3

>12 billion USD	>1 000 projects
>22 GW	>2 000 MW Single largest

Record-high pipeline presents opportunities for Nel:

- Scalable technology
- Reliable systems
- World-class efficiency
- Leading Total Cost of Ownership (TCO) for the customer
- Fueling agreements levelling up to multi station contracts

3. Execution strategy

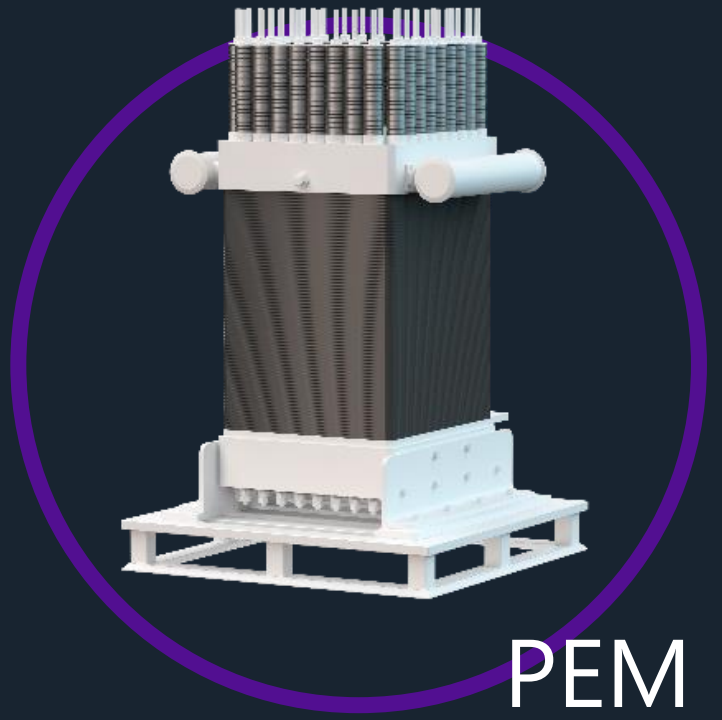
Key trends currently and towards 2025

Execution strategy:

Large-scale concepts based on a scalable solution with high quality and low cost

A technology leader on two platforms

Alkaline



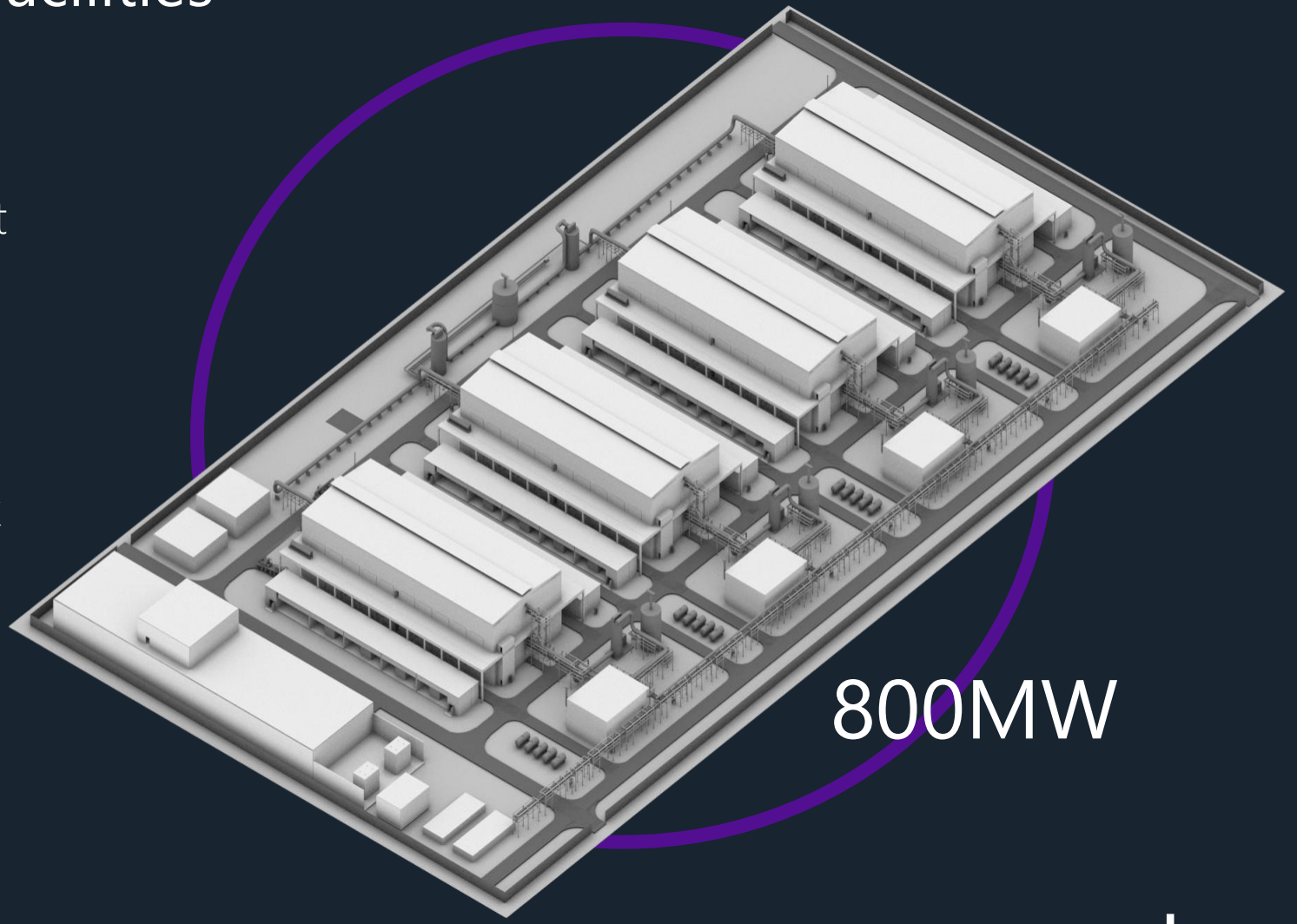
PEM

- Provides flexibility and positions us for growth in different market segments around the world

EXECUTION STRATEGY

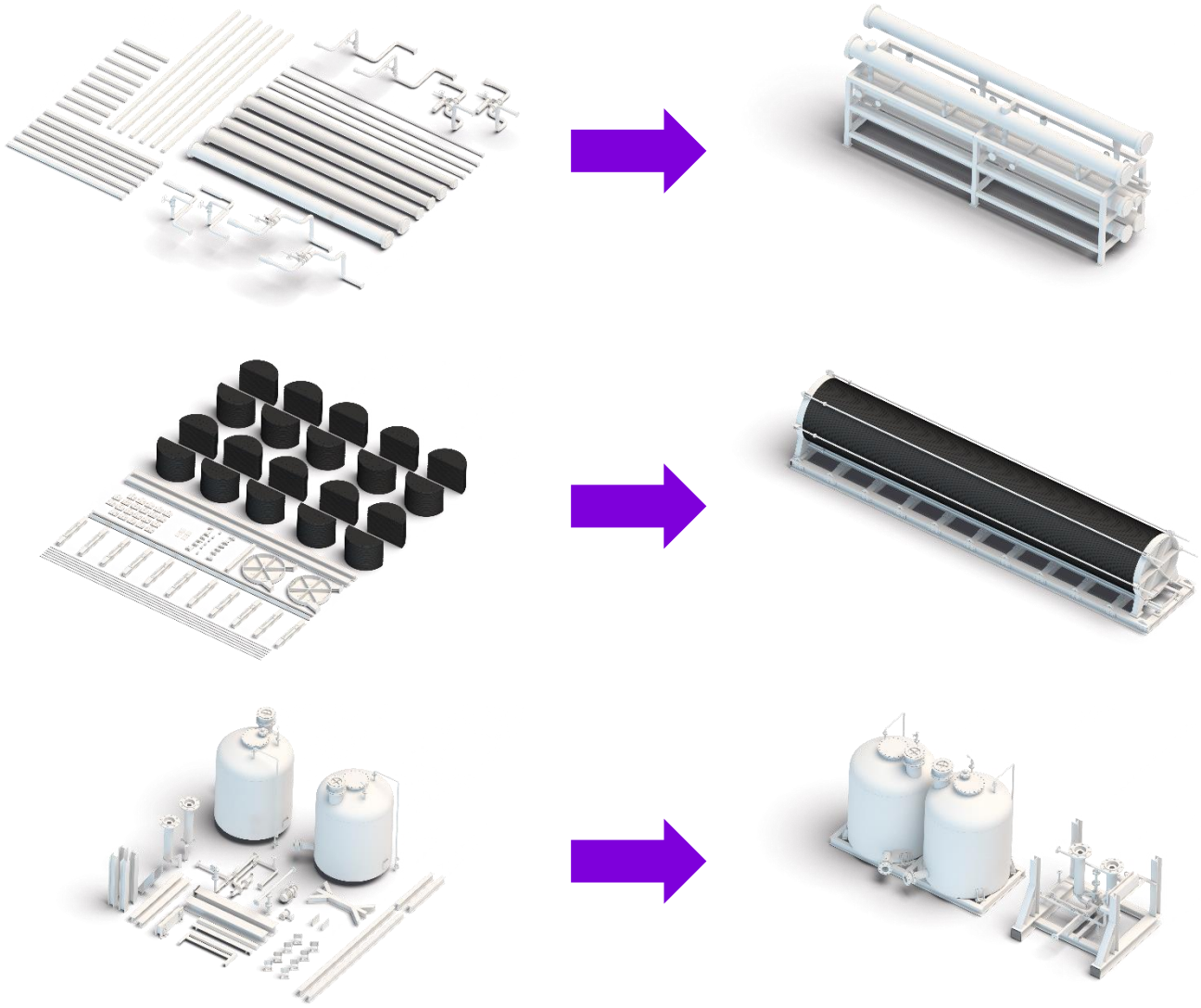
Building blocks that enable scalable solutions to meet customers' need for larger facilities

- Completed design for 800MW green renewable hydrogen production plant
  - Based on 200MW building blocks
- Have "consolidated" Balance of Plant elements to optimize overall CAPEX, realizing synergies to reduce cost
- Nel only company w/large-scale track record
  - Bankable, proven technology with performance guarantees



EXECUTION STRATEGY

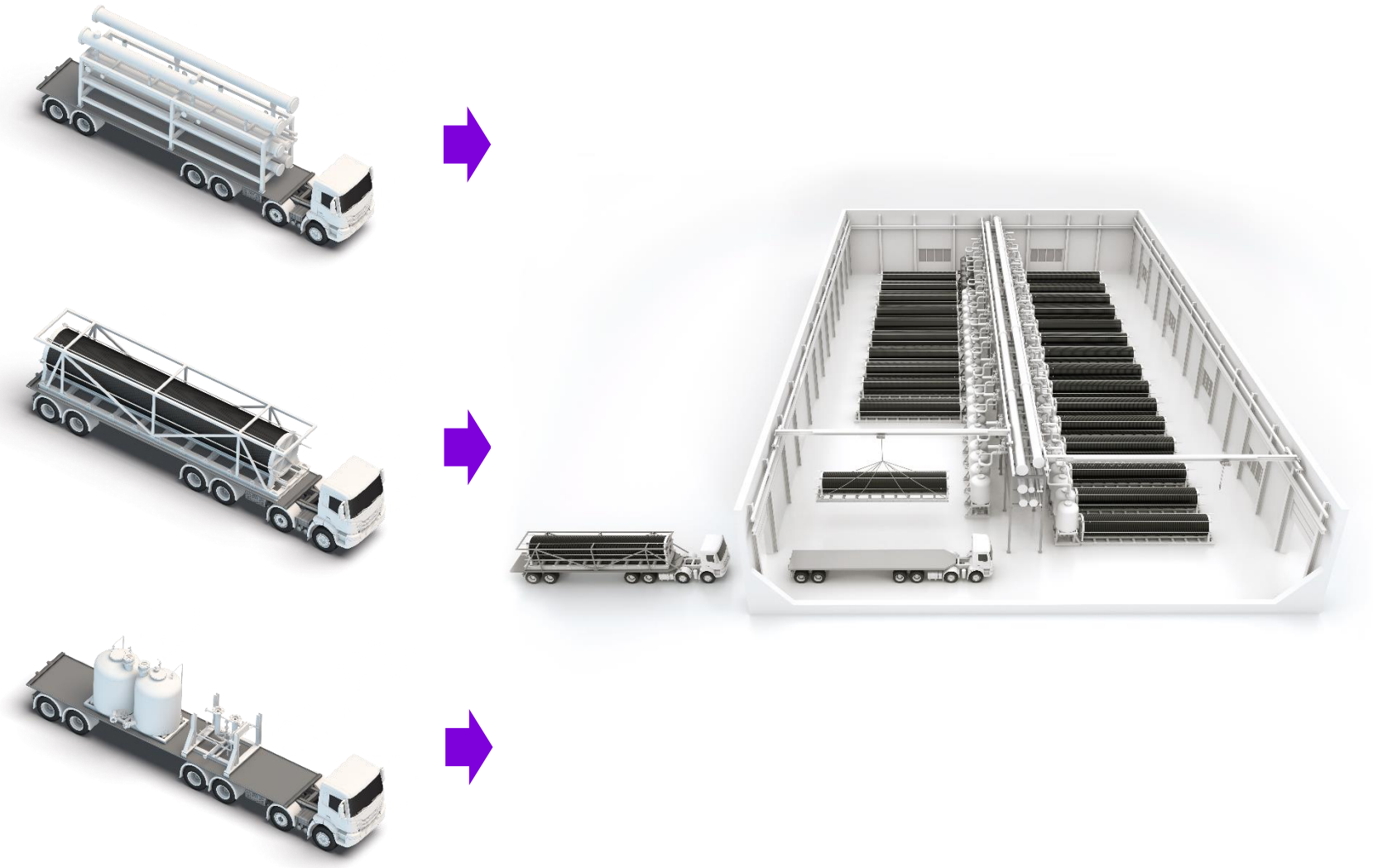
Safe, cost-efficient and hassle-free installation



- Pre-assembled pipes, stacks and separators, ensures hassle-free installation in a safer and more efficient way
- Reduces time and cost for customers
- Produced by pre-qualified contract manufacturing partners

EXECUTION STRATEGY

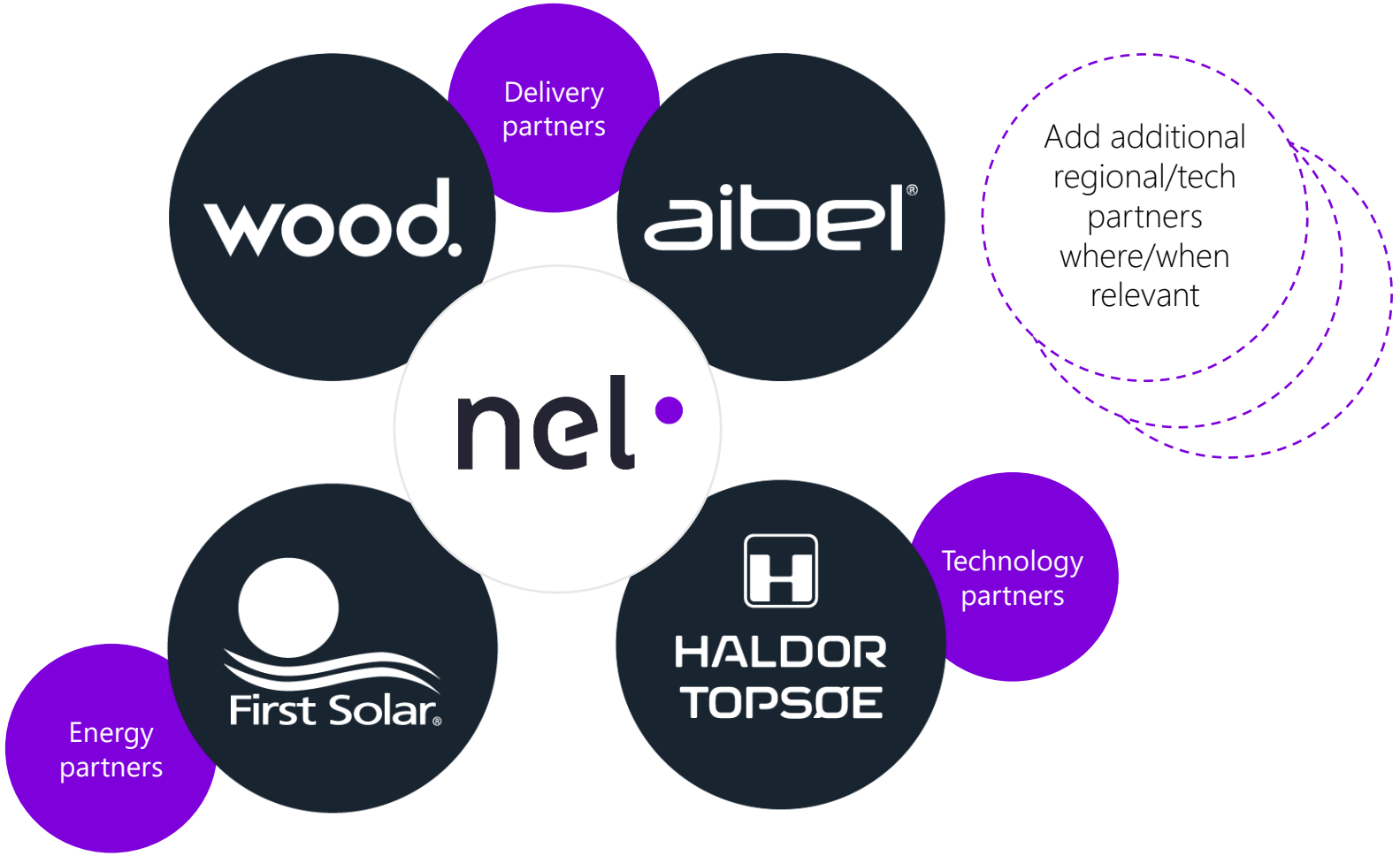
Safe, cost-efficient and hassle-free installation



- Develop a skid that is easy to transport
  - Easy to unload
  - Easy to assemble
- Ensures scalability from 20 to 800 MW plants and beyond

EXECUTION STRATEGY

Leveraging on our independent partnership model



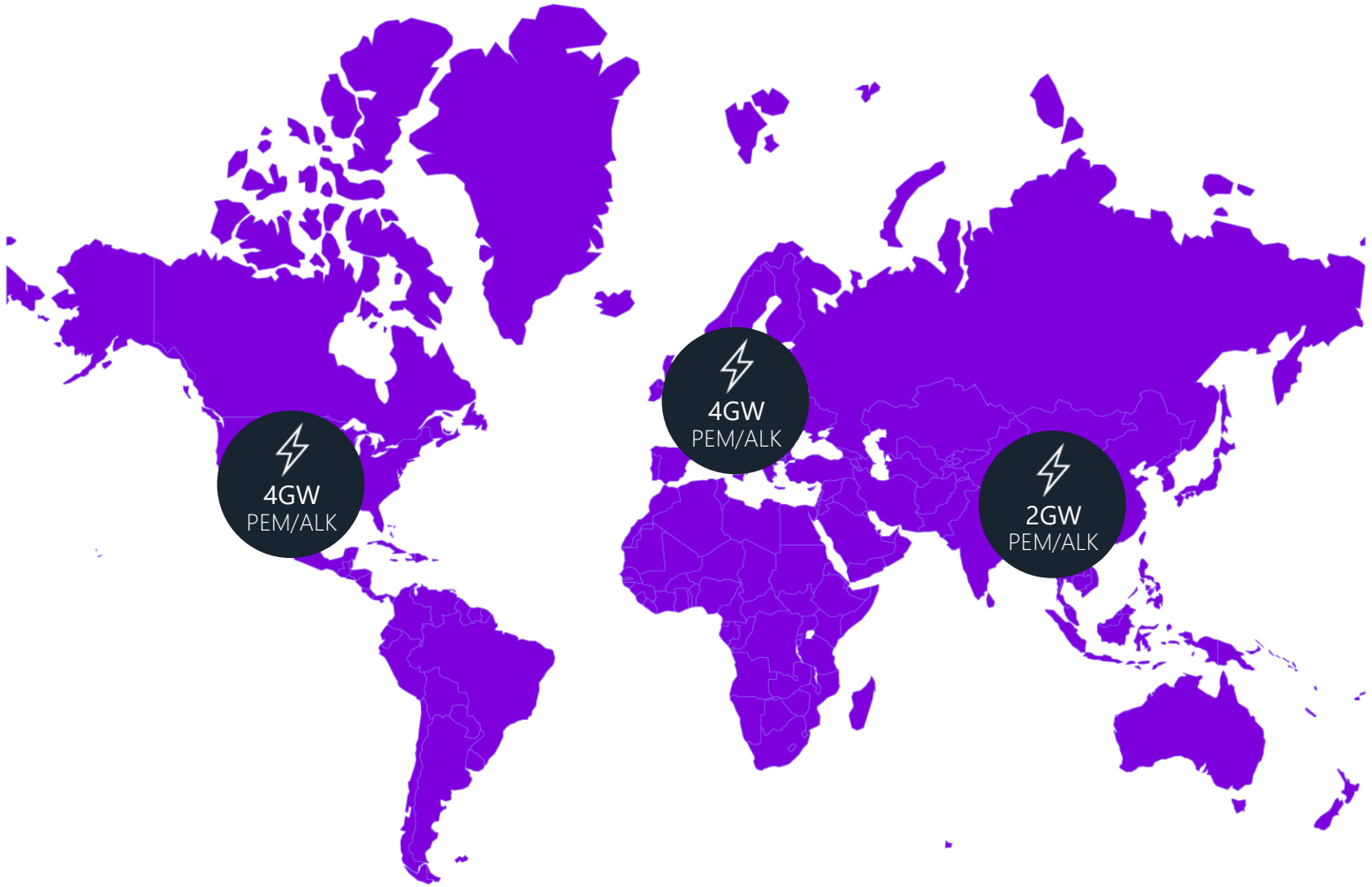
- Successfully developing the partnership model
- Flexibility and independence increasingly important:
  - Projects ranging from 2-20-200-800 MW plants and beyond
  - Broader specter of customers
  - Broader geographical scope
- Partnerships with the leading companies within their fields
- Continue to add regional/tech partners where/when relevant

Execution strategy:

Target large-scale production capacity in key geographical regions, continue to evolve both ALK & PEM platforms

EXECUTION STRATEGY

Global technology production capacity to address global market



- Apply same operational and industrialization principles across technology platforms (PEM & ALK)
- Produce both PEM & ALK under same roof in large GW-facilities
- Have initiated site selection process for large-scale technology production facility (PEM & ALK) in the U.S.

4. Summary and outlook

Nel a global leader within hydrogen technologies

Proven track record and established market leader

- Pure play, independent hydrogen technology company
- Decades of experience in PEM and alkaline electrolyser platforms
- Technology leadership, large-scale concepts ready to go

Scalability & cost leadership

- First to announce ambition on green hydrogen cost at USD 1.5/kg by 2025, reaching fossil parity
- Initiated site selection and will continue to add capacity when required by the market
- Expect to break order-size records in 2022

Strong partnership strategy

- Global delivery and execution muscle for large-scale, complex projects
- Partnerships for development of complete applications for end-users
- Preferred partner across the green hydrogen value chain

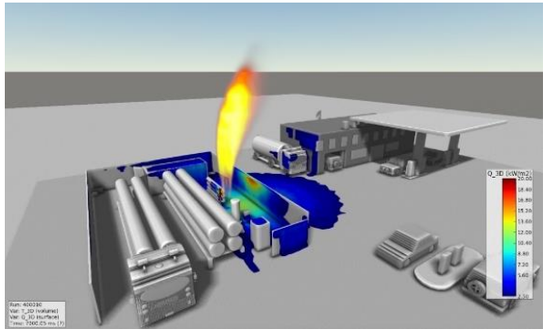

Thanks for the ride, dinosaurs.
We'll take it from here!

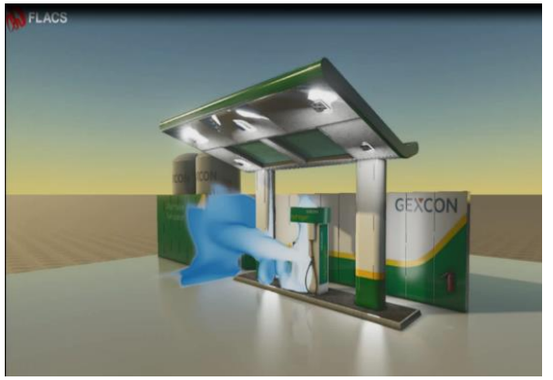
GEXCON

Practical Approach to Process Safety for Hydrogen Systems

Expertise in hydrogen safety

- Gexcon has a strong experience on various H_2 related projects
  - Process safety and safety reviews
  - Assistance for conceptual phase: safety distances, arrangement/layout optimization
  - Regulation and ATEX compliance
  - Optimization of ventilation and gas detection
  - Modeling of accidental events: dispersion, explosion and fire
  - Prevention and mitigation measures
  - Design of structures and equipment to withstand accidental events

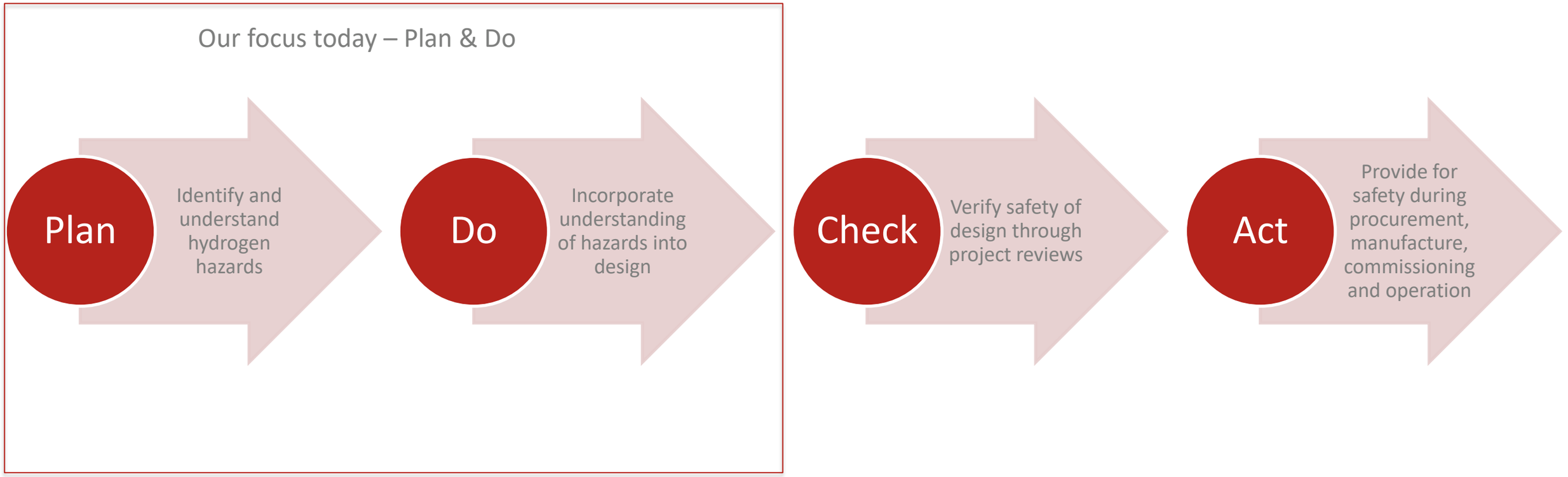




PRODUCTION | STORAGE | TRANSPORT | DISTRIBUTION | MOBILITY

Plan-Do-Check-Act for hydrogen safety

Simple, practical steps towards achieving strong process safety



PLAN - Understanding hydrogen hazards

Full scale test

Eye-opener for Gexcon’s competence and capacity

HySEA Container Experiments Test no. 09

24 vol% H_2

No vent devices

Internal pressure approximately 1.1 bar

Full scale test

Vented deflagration

Test no. 24

21 vol% H_2

Plastic foil vent devices in ceiling

Very low overpressure

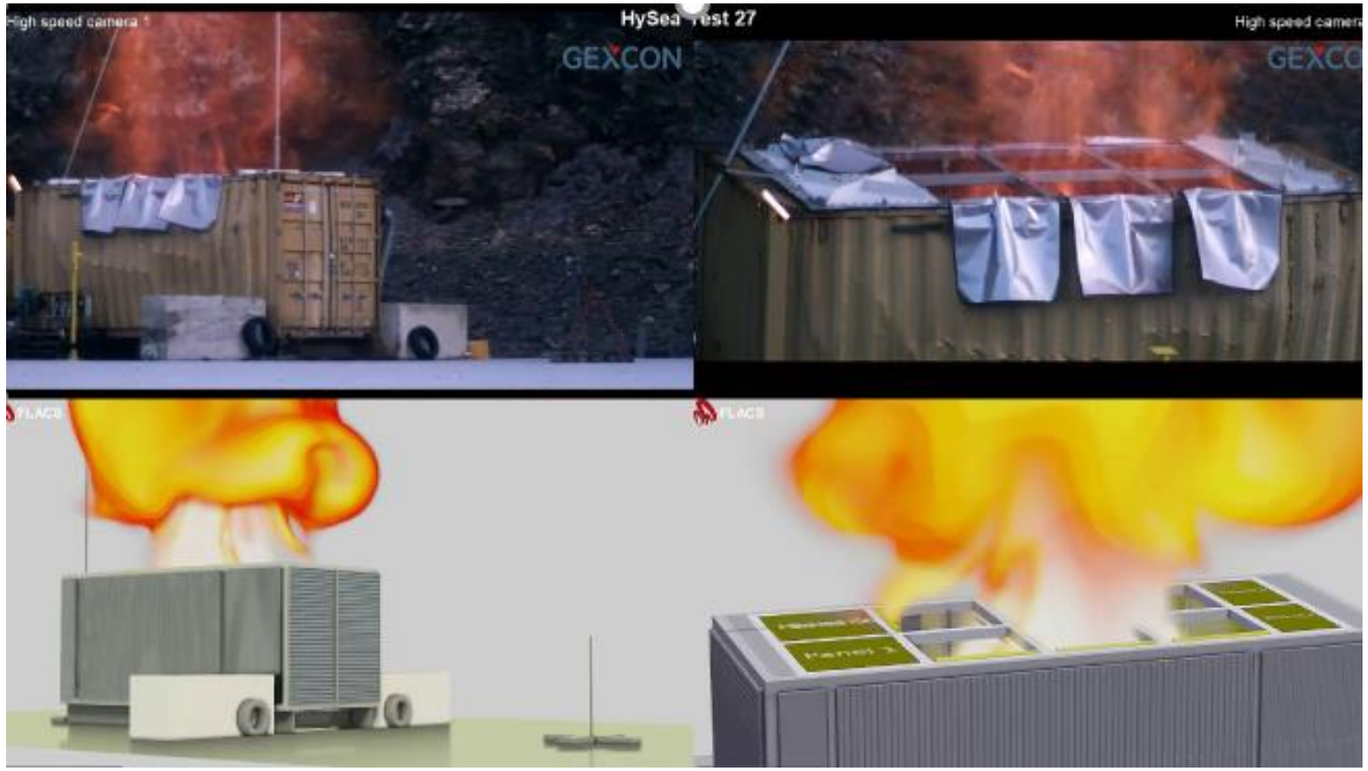
<u>Significant learning:</u>

Explosion pressures can be directed away from area of occupancy

Implemented in software

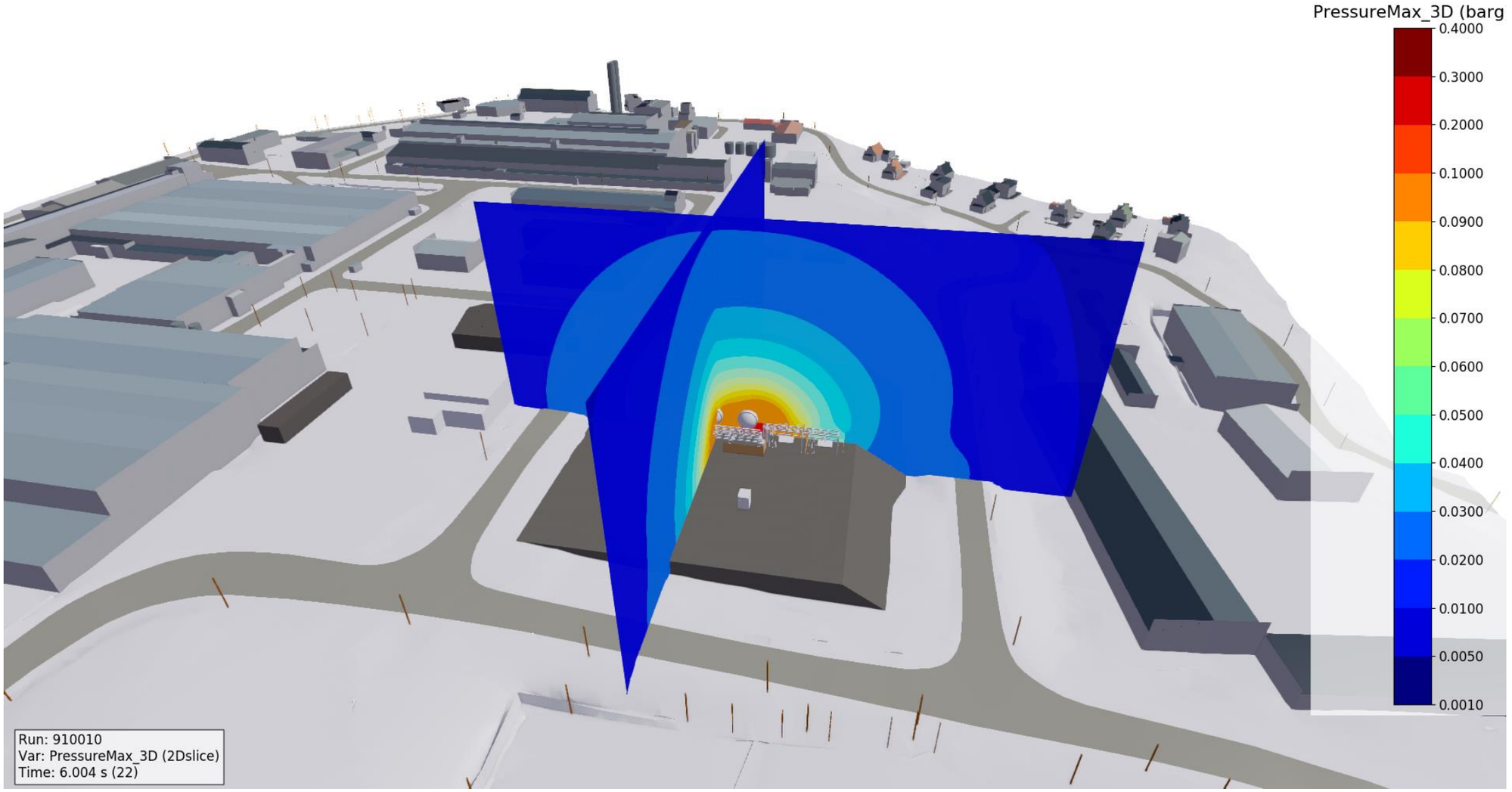
- Various dummy equipment configurations to mimic vehicle fueling compressor stations
- Framework in ceiling to accommodate explosion vent devices
- FLACS has been calibrated against large-scale explosion experiments at the Gexcon test site.

The experiment to the right is a 20ft container filled with 21% Hydrogen.



Liquid H2 Dispersion

Explosion simulations



Do - Incorporate hazards into design

Good design practices

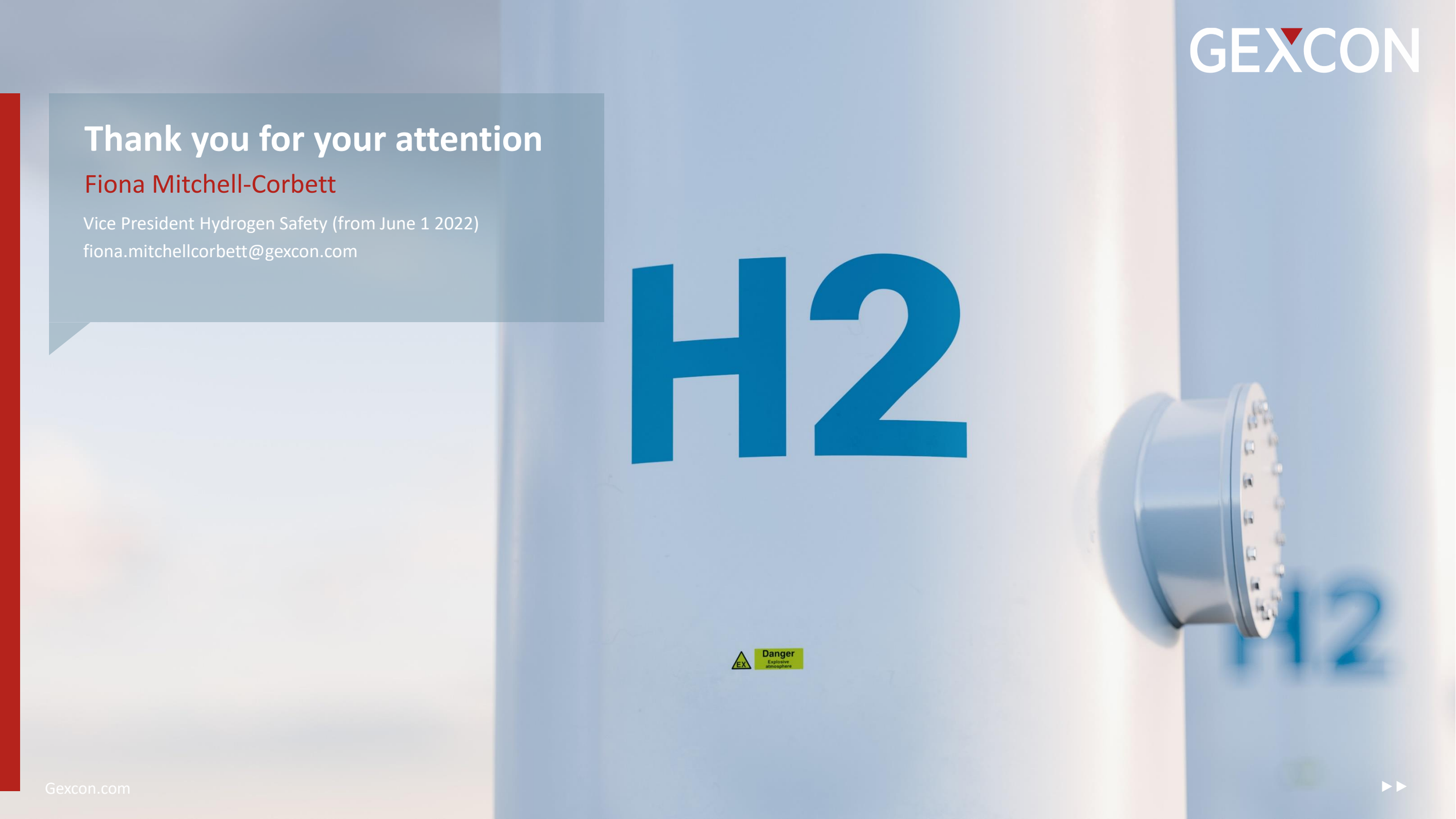
- Natural ventilation where possible
- Avoid possibility for accumulation of buoyant gas
- Reduce or eliminate detonation potential
- Limit site congestion
- Limit potential leakage sources
- Use of safe separation distances or alternative strategies to manage risk
- Detection of leakages by detectors where appropriate as part of safeguarding philosophy
- Fully paved areas under pressurised systems
- Avoid asphalt paving under cryogenic systems
- Ignition source control

Thank you for your attention

Fiona Mitchell-Corbett

Vice President Hydrogen Safety (from June 1 2022)

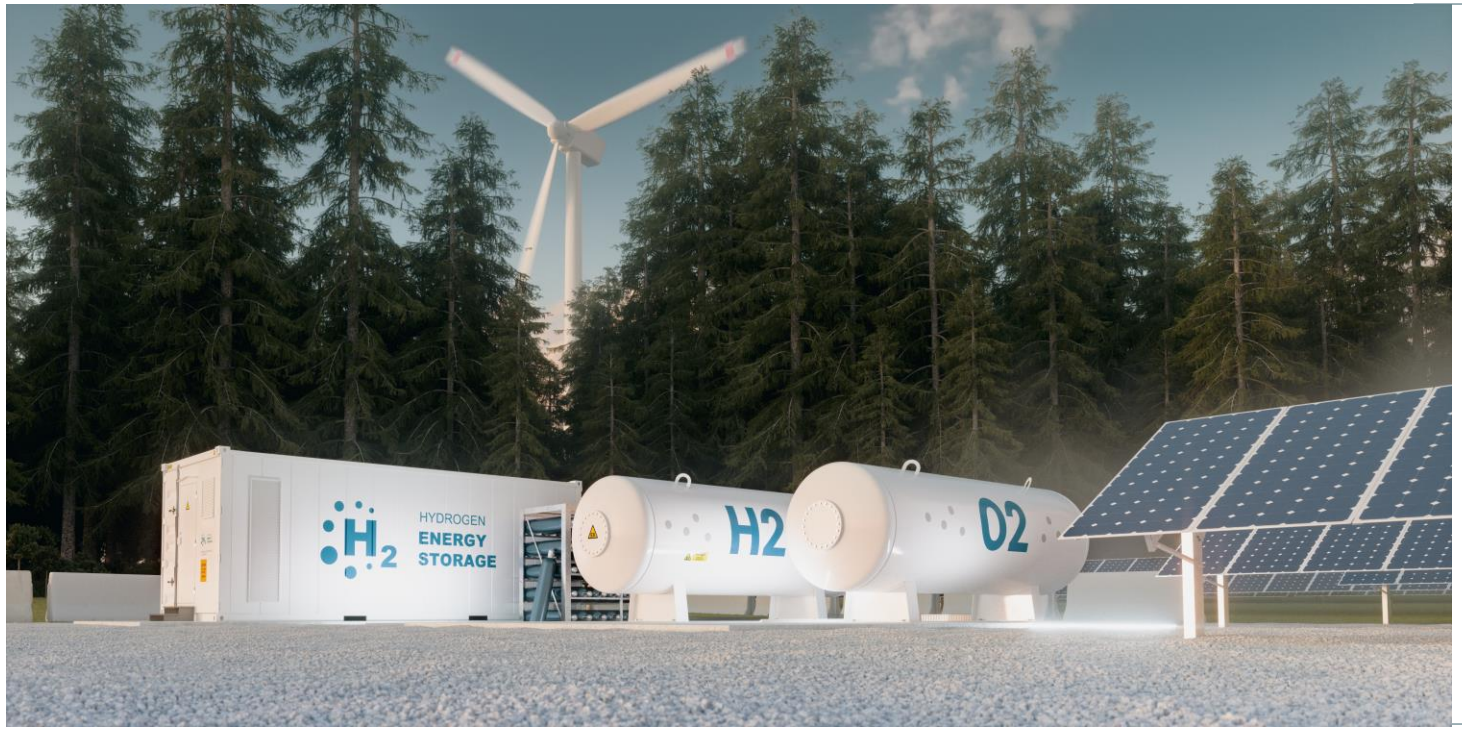
fiona.mitchellcorbett@gexcon.com



Norconsult

New hydrogen infrastructure – Some early phase observations

Norwep Hydrogen & CCS Webinar – Europe - May 11th 2022



WHO

WHAT WE DO

ABOUT THE GASES

SOME OBSERVAIONS

Key figures

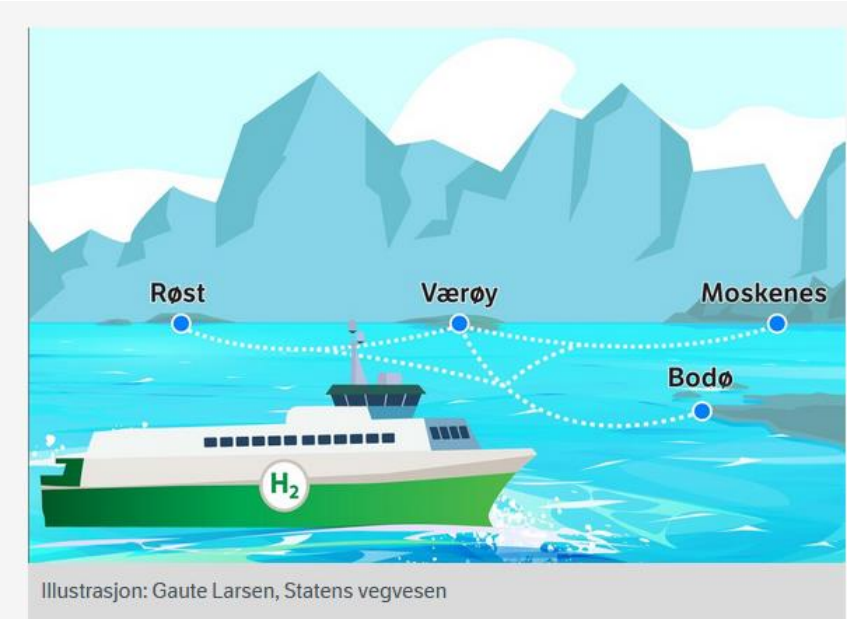
- **5 100** Employees
- **127** Offices
- **11** Business areas
- **20 000** Projects
- **7,4** Billion NOK revenues*

* As of 31.12.2021

Ill.: LPO arkitekter

The developers are in the following areas:

- Transport :
  - Public transport
  - Trucks
- Sea transport :
  - Ferries
  - Speedboats
  - Seafood
- Industrial processes:
  - Hybrit - iron pellts
  - Yara - fertilizer
  - Celsa – steel
  - Hydro – Aluminium



Illustrasjon: Gaute Larsen, Statens vegvesen

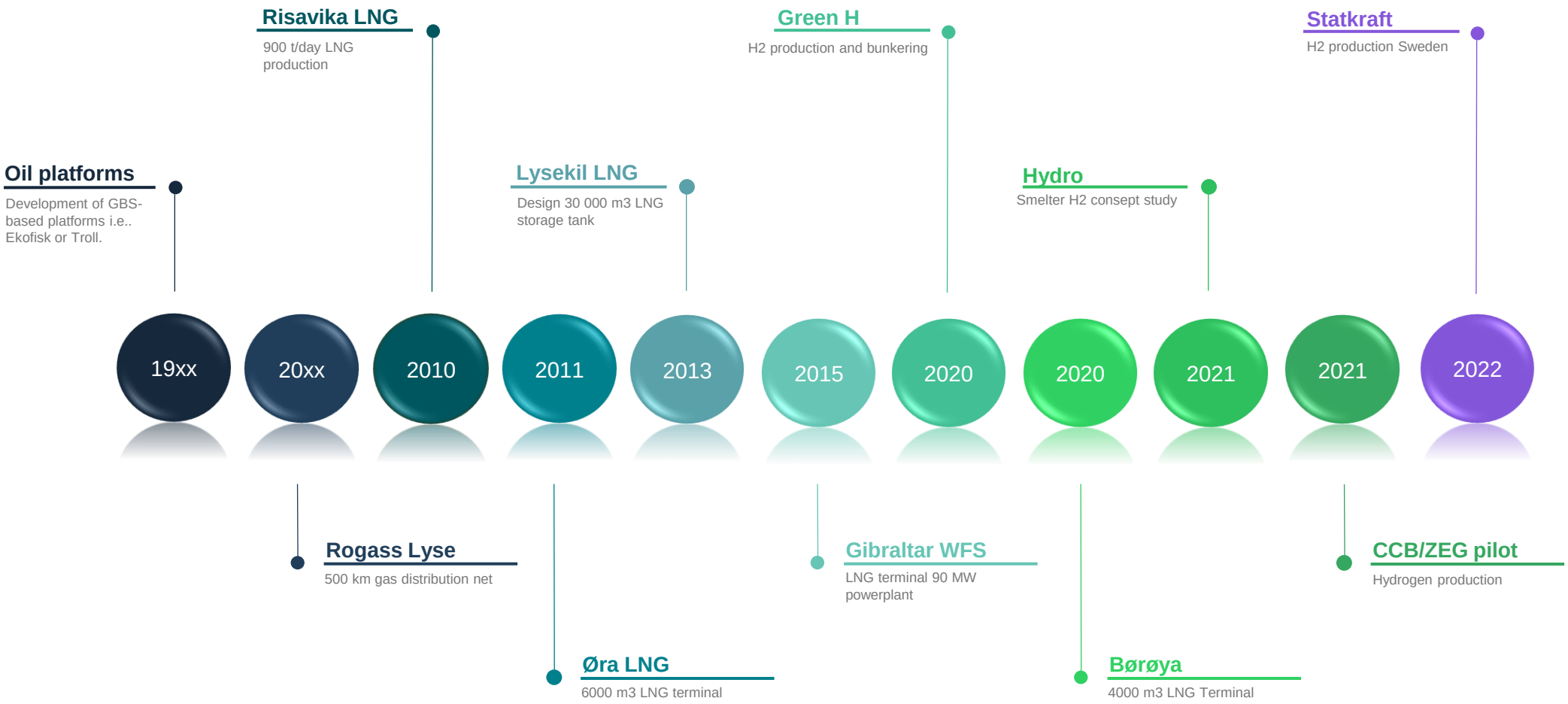
7 april 2021 – HYBRIT: SSAB, LKAB och Vattenfall bygger unik pilot för storskalig vätgaslagring för en kvarts miljard i Luleå

SSAB, LKAB och Vattenfall påbörjar bygget av ett bergrumslager för fossilfri vätgas i pilotskala i...

Foto: Nicola

Norconsult

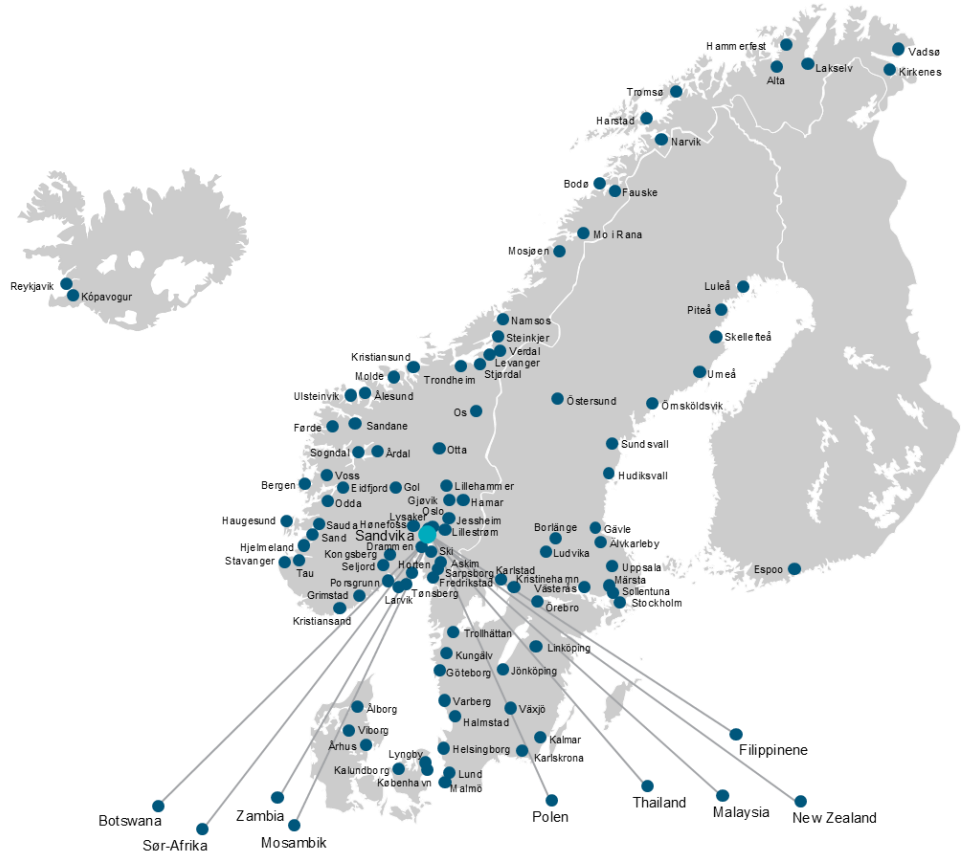
Norconsult from North Sea to hydrogen



Norconsult

More than 30 energy gas projects since 2018

2022 –Ammonia Project – Permitting Management frame agreement.
2022 –Greenfield Ammonia Project – Process support.
2022 – Green ammonia, Concept study for production plant, Egypt
2022 - Ammonia, Design study for ammonia pipeline from green ammonia facility and NH3 bunkering solutions
2022 – Hydrogen, Concept study for production plant
2022 – Hydrogen, Concept study for ENOVA application #3
2022 – Hydrogen, Concept study for ENOVA application #2
2022 – Hydrogen, Concept study for ENOVA application #1
2022 – Green Hydrogen production by renewable energy sources, wind and solar
2022 –Ammonia project – Project Management support
2021 – Hydrogen, Concept Study for containerized production plant
2021 - Ammonia, Pre-Feasibility study for production plant
2021 – Hydrogen, Pre-Feasibility study for production plant
2021 – Hydrogen plat, red flag review
2021 – Hydrogen production, Concept study for green hydrogen
2021 – Hydrogen, concept study for production plant
2021 – Hydrogen, concept study for production plant
2020 – Hydrogen, Pre-Feed study for production and liquefaction for supply to ferries
2020 - CO2, Pre-Feed logistic study for transport of CO2 from capture plant to CO2 terminal
2021 – CO2, Concept study for small-scale CO2 value chain
2021 – CO2, Concept study for CO2 terminal
2020 - CO2, Pre-Feed study export terminal in Kristiansand
2021 – Liquid Hydrogen, bunkering tower review.
2021 – Hydrogen, production plant with CO2 capture
2020 – Hydrogen, Pre-Feed study for hydrogen to ferry operation Bodø
2020 – Hydrogen, Pre-Feed study for hydrogen to ferry operation Fiskå
2020 – Hydrogen, Pre-Feed study for Container vessel Kollsnes
2019 – Hydrogen, Production and logistic supply chain study
2018 - Hydrogen, Production at Kollsnes
2018 - Hydrogen, NB Solar Zambia storage plant study



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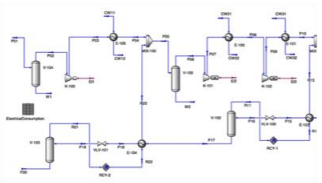
Services and disciplines

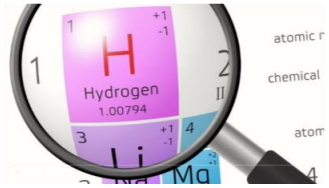
Production

Liquifaction

Dynamic simulation



Permitting processes

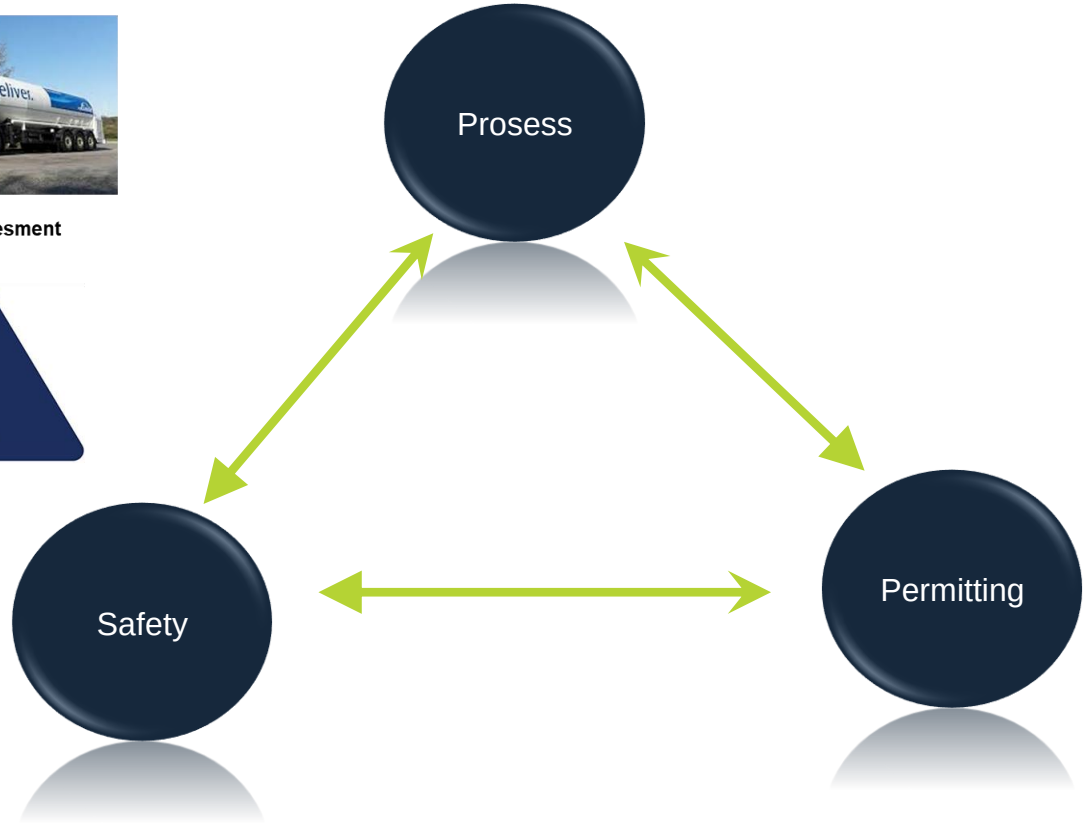


Storage

Prosject management

Logistic

Safety and risk assesment



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Some permitting aspects – safety is an issue!

- New of hydrogen and ammonia infrastructure
  - Many want to establish themselves in the market
  - Time-consuming government processes
    - Zoning plan / EIA (Municipality)
    - Power concession (NVE)
    - Fire and Explosion Protection Act (DSB)
- Other authorities
    - County Governor
    - The Norwegian Maritime Directorate
    - The Norwegian Coastal Administration
    - DNV
- Quite time-consuming processes (1,5 – 2 years maybe)

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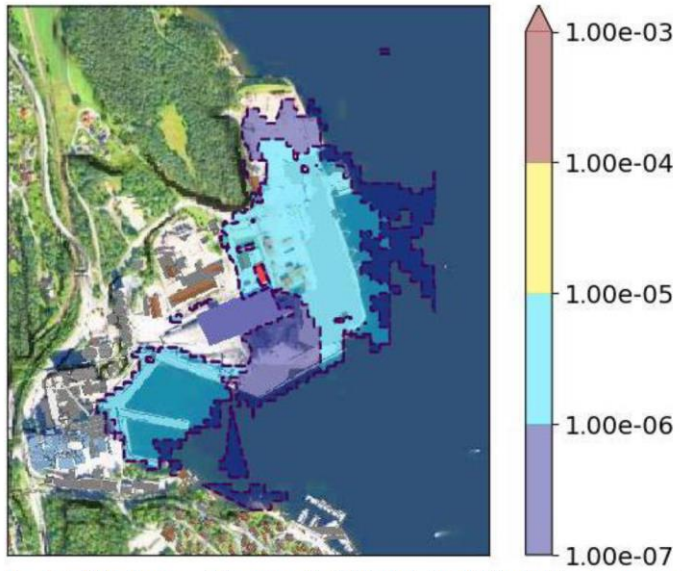
Green energy – safety issues

- Heat radiation
  - H2 is very flammable
  - H2 almost self ignite under ambient conditions
- Toxic
  - NH3
  - CO2
- Pressure waves
  - H2 gas stored in bottles. 300 – 900 bar
  - H2: will most likely explode if leaked out
  - Dangerous pressure waves



Figur 7-3: Risikokonturer 2.5 m over sjø nivå for individuell årlig dødelig eksponering beregnet med RIVM metode

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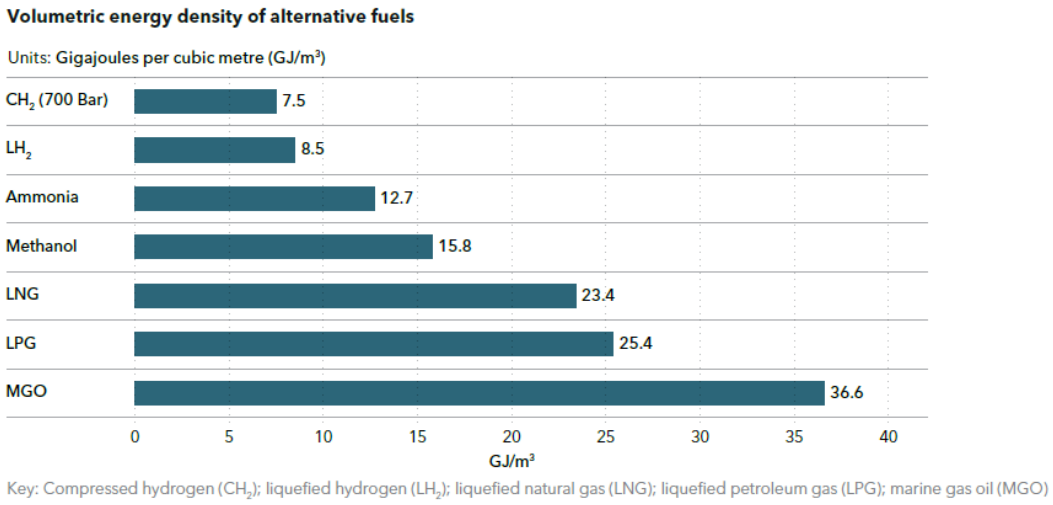
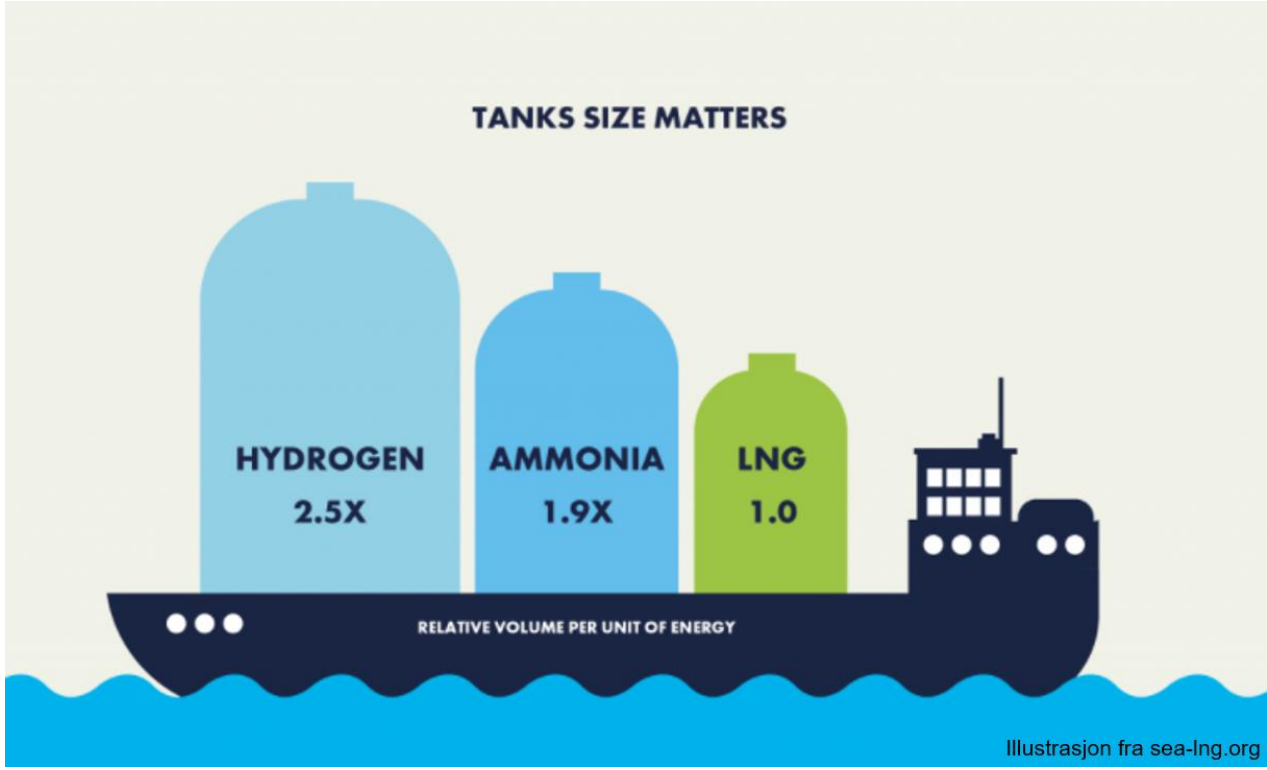
Energy density in practice

- Some aspects of the energy transition from HO / MGO to hydrogen or ammonia:
  - Larger vessels – higher CAPEX
  - Less space for cargo
  - Less profit for owner

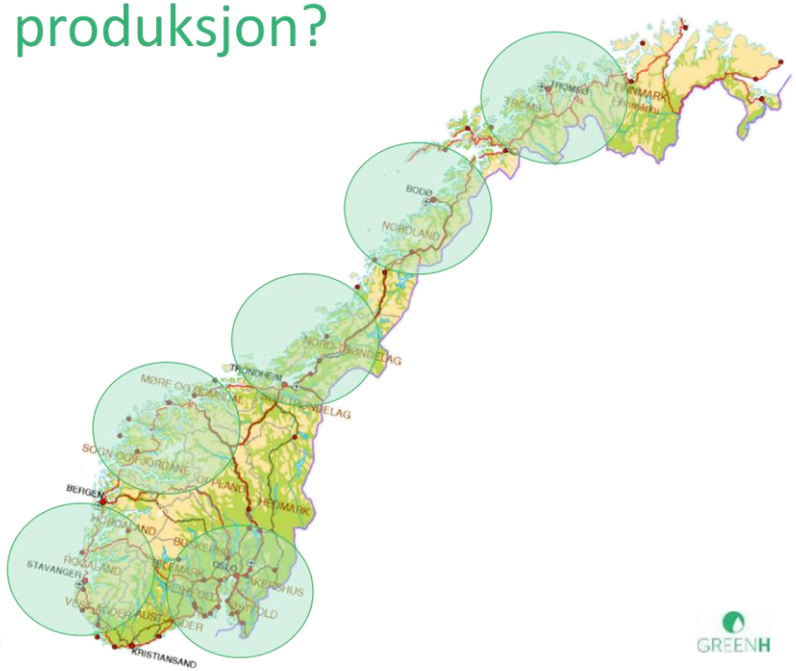




Infrastructure for hydrogen and ammonia

- National hydrogen strategy towards 2030:
  - “a network of geographically dispersed and demand-based hydrogen hubs in line with the supply of vessels and vehicles”
- Low energy density – costly logistic
  - Smaller developers establish local production mainly for road sector
  - Large developers want to establish close to the sea (Mainly for export purposes)
- One 40 feet ISO container containing 1 ton of hydrogen have a gross weight of 25 tons.
  - Roughly bunker for 200 nautical miles for conventional coastal freighter

Storskala eller **lokal** produksjon?



Industrial scale or distributed production?

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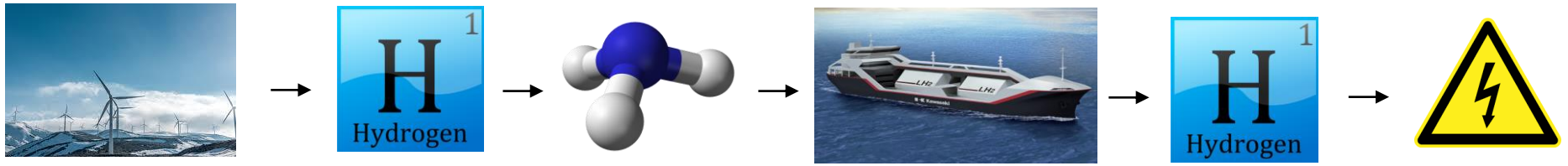
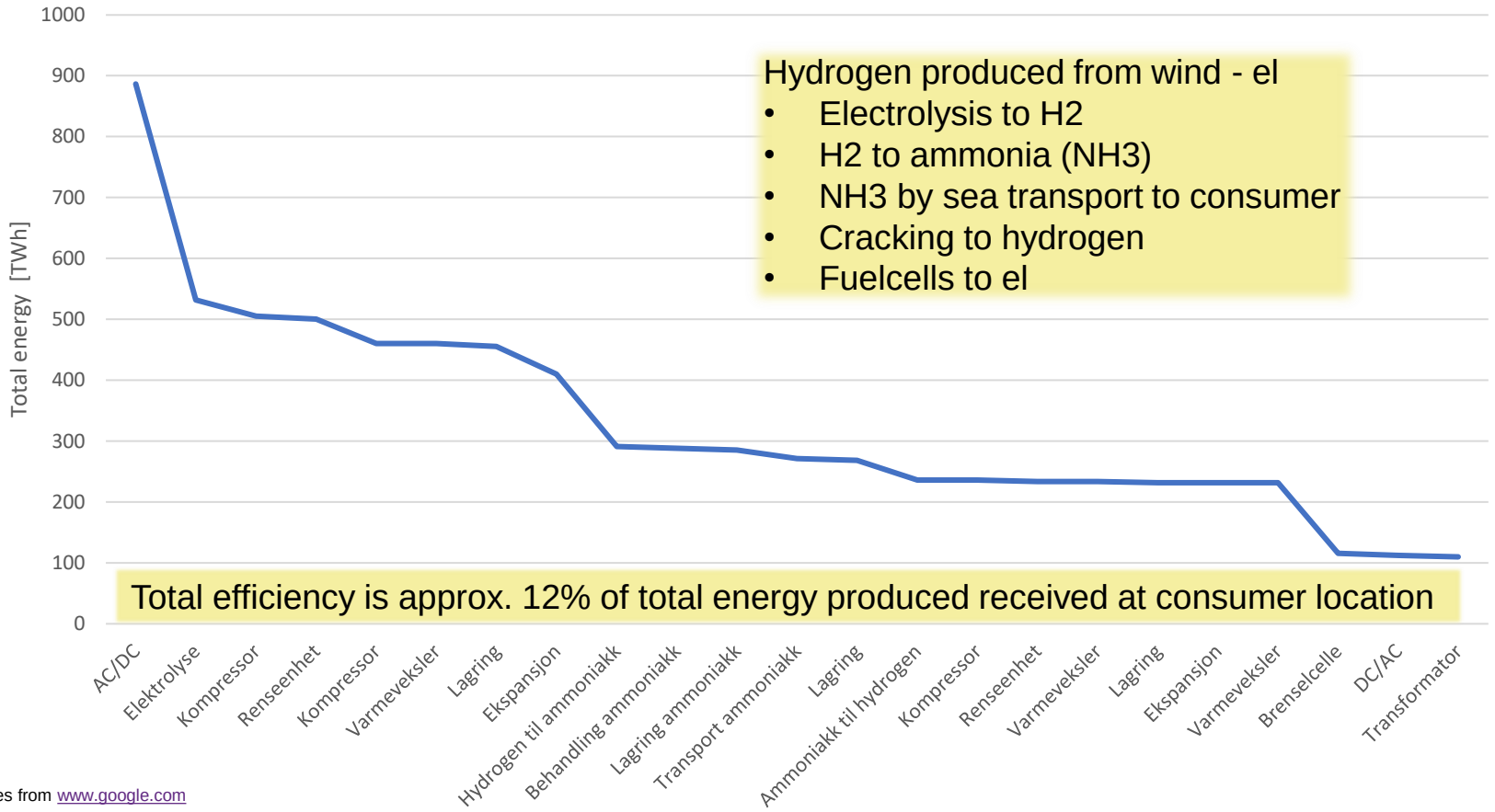
Island fuel logistic case based on hydrogen and ammonia





Hydrogen produced from wind - el

- Electrolysis to H2
- H2 to ammonia (NH3)
- NH3 by sea transport to consumer
- Cracking to hydrogen
- Fuelcells to el

Total efficiency is approx. 12% of total energy produced received at consumer location

Pictures from www.google.com

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Summary of observations

- A “green gas” solution has at least same safety issues as fossil
- A “green gas” solution has energy losses similar to fossil
- A “green gas” solution has higher CAPEX than a fossil
- A “green gas” solution has some logistically challenges
- Even though we see a positive development and high learning curve between the actors.

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Every day we improve everyday life