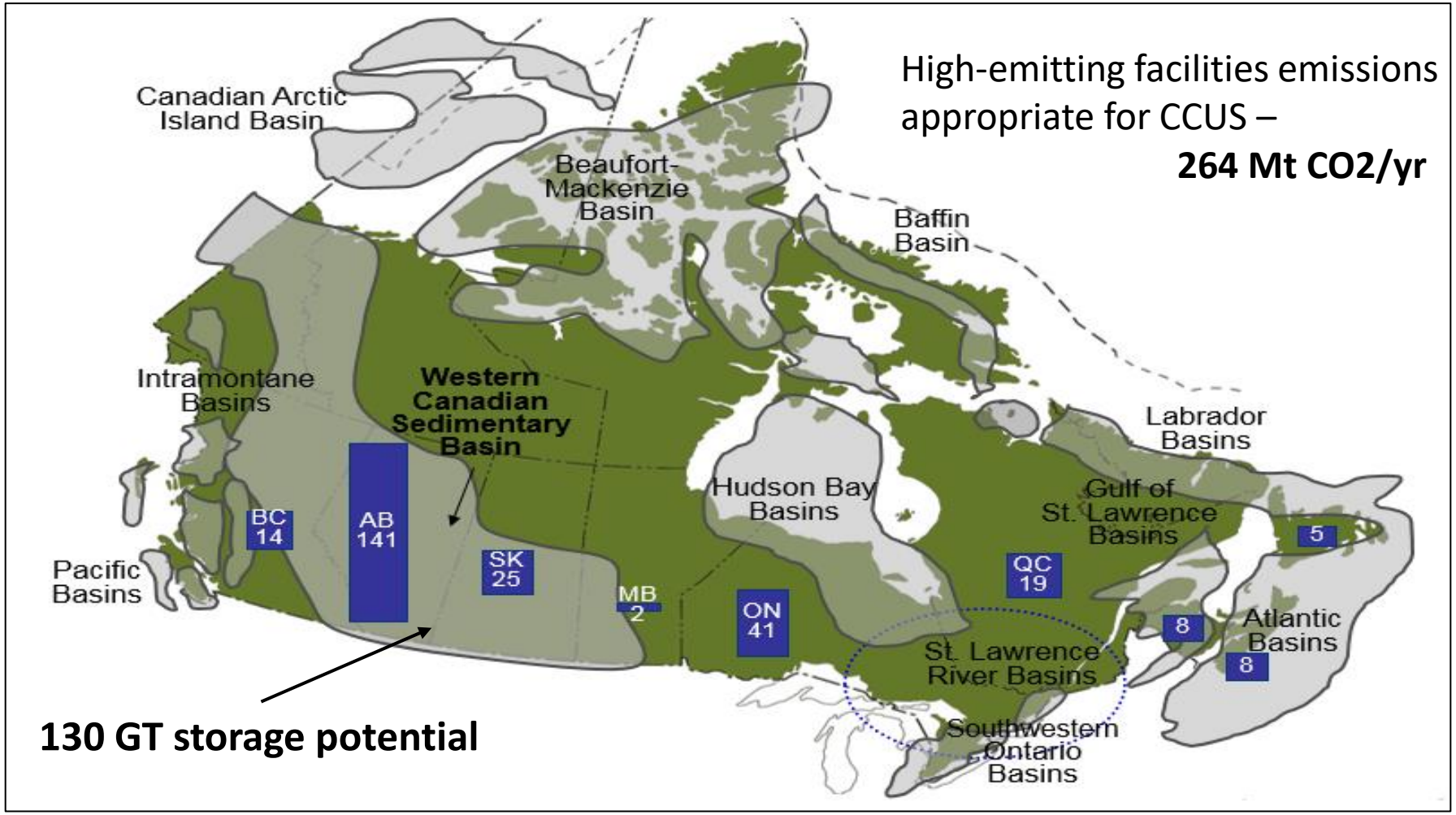
Overview of CCUS in Canada

Eddy Chui, Director, CanmetENERGY Ottawa

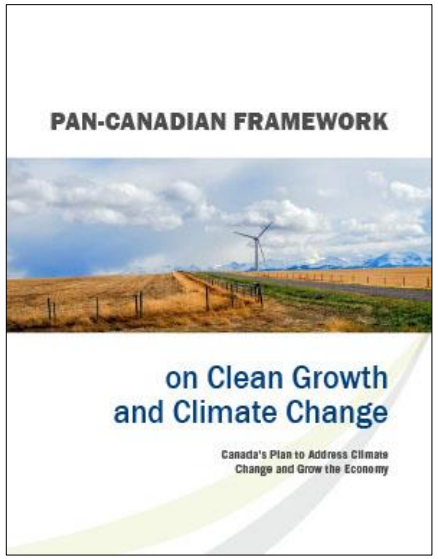
Canada's potential for CCUS: Abundant Storage

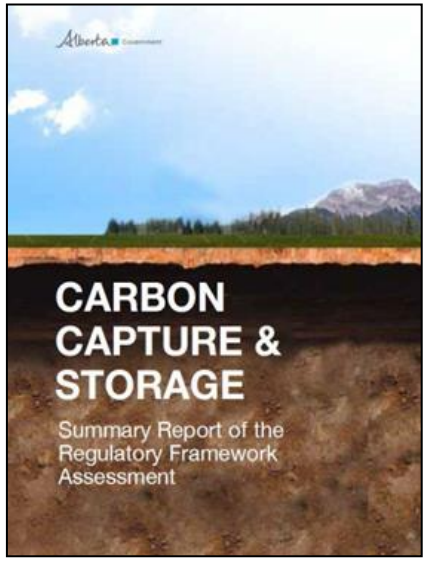


Source: Environment and Climate Change Canada GHG Reporting Program 2018 data

CCUS Potential: Enabling Policy and Regulatory Environment

- Carbon pricing systems (federal or provincial equivalents)
- Clean Fuel Standard (in development with CCUS compliance pathways – in force in Dec 2020)
- Regulation on coal-fired power generation (phase-out of unabated coal by 2030)
- Provincial frameworks refined to accommodate large-scale CCUS
- Federal/provincial participation in ISO CCUS standard development process
- Investment Tax Credit for CCUS in development



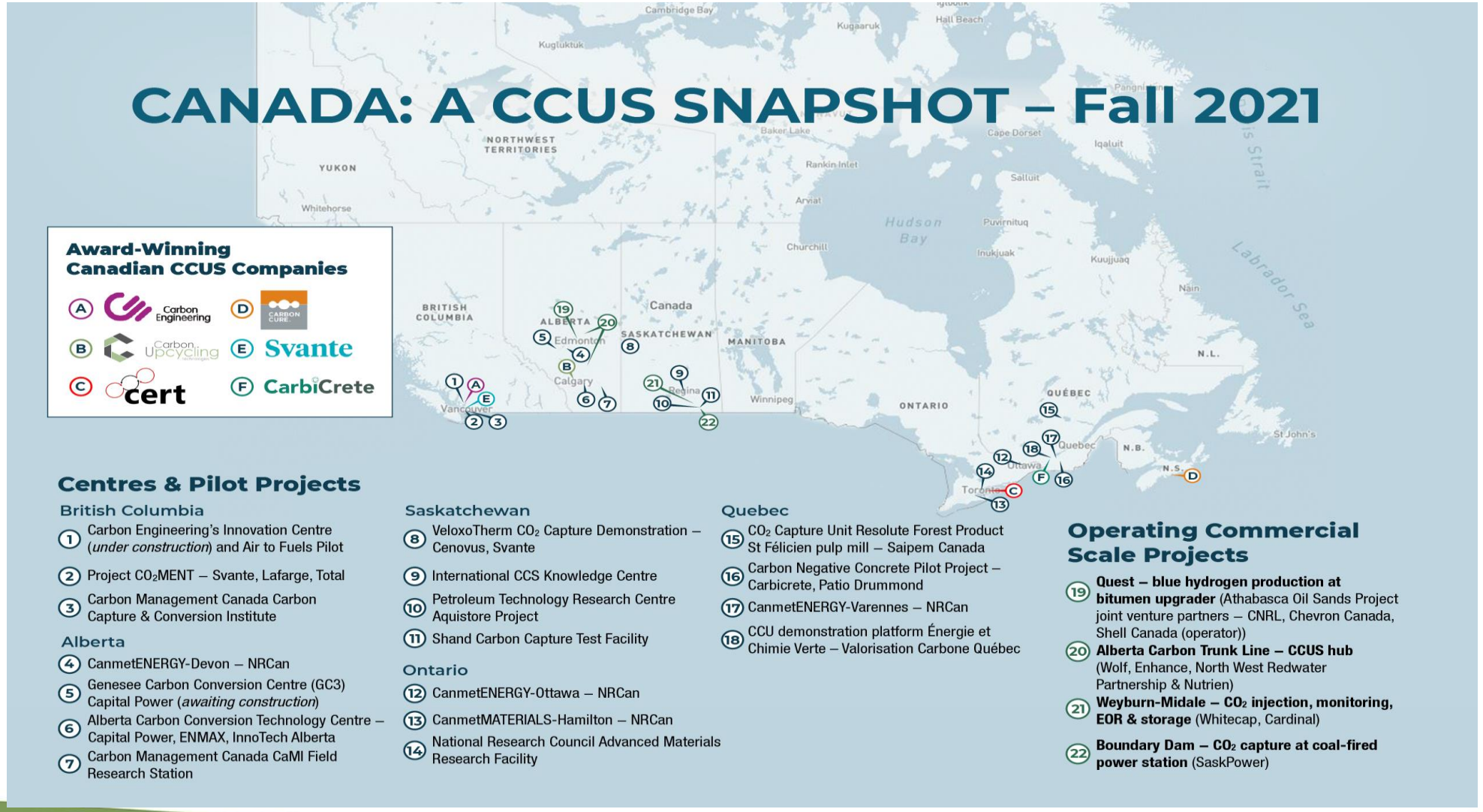


Canada has been making significant investments* in CCUS

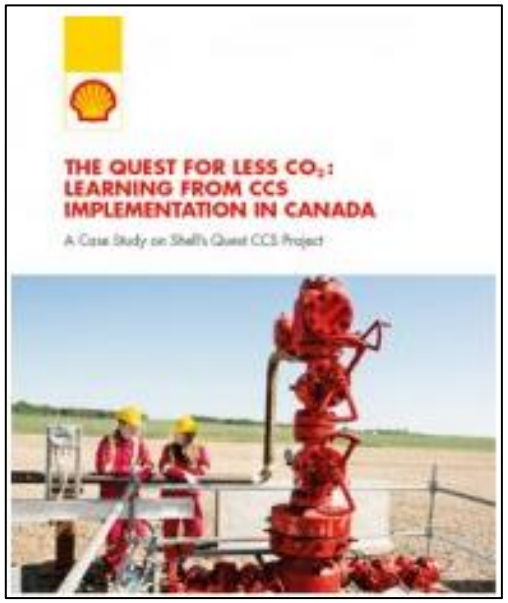
- Since 2009, the Government of Canada has invested **over $600M** in CCUS RD&D, and together with the provinces and the private sector **over $4.5B** (with $2B public funding) towards CCUS initiatives
- Since 2015, Natural Resources Canada has launched multiple funding programs (>$200M/yr) with components supporting CCUS
- **Breakthrough Energy Solutions Canada** ($40M) launched in 2019 with Breakthrough Energy Ventures with 3 out of 10 winning innovators focused on CCUS
- Canada's strengthened climate plan (Dec 2020) calls for a comprehensive **CCUS strategy for Canada**
- Federal budget 2021 designates **$319M** over 7 years to advance the commercial viability of CCUS technologies, and an **investment tax credit** by 2022 for capital invested in CCUS projects

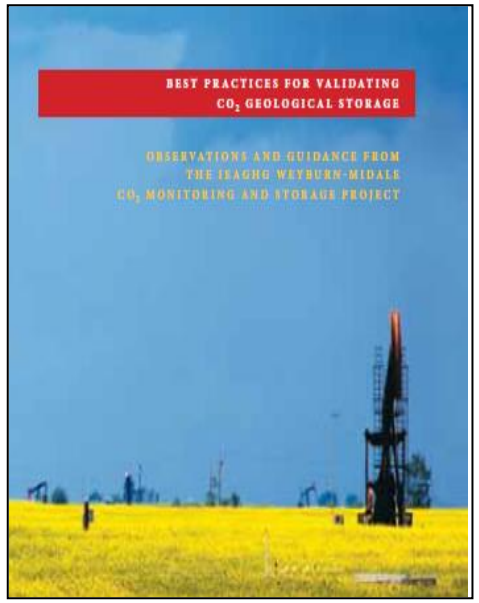
Note – Administered by NRCan Office of Energy R&D (OERD)

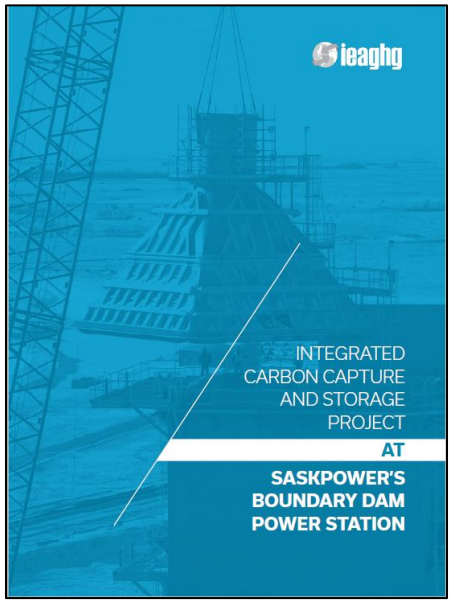
CCUS Projects & Players across Canada

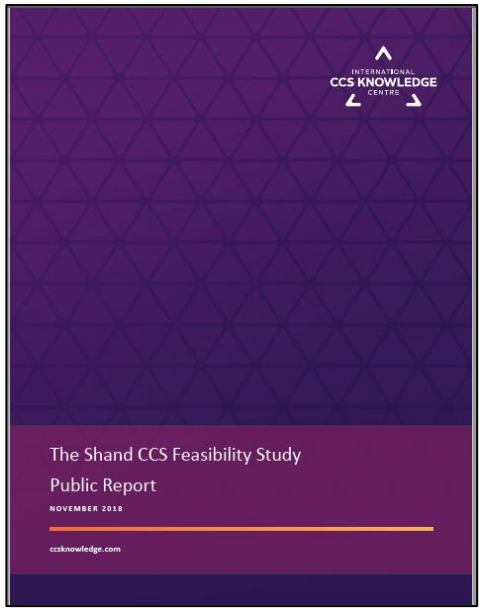


The commercial scale projects continue to generate important learnings









A Federal CCUS Strategy

The draft presents a **strategic vision** and **set of recommended federal actions** to accelerate CCUS

Areas for Action:

- CO2 Storage, Infrastructure and CCUS Hubs
- Innovation and RD&D
- Policy Environment
- Trade & Investment

NRCan has engaged with key partners and stakeholders to inform the draft, receiving input from:

- Teams across the federal, provincial and territorial governments
- Stakeholders, Group of CCUS Thought Leaders
- The general public

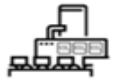
Six low-carbon pathways where CCUS will be key to a prosperous net-zero economy, clean growth, green jobs, investment attraction & regional opportunities


Decarbonizing heavy industries


Low-carbon dispatchable power


Negative emissions technologies to support carbon dioxide removal


Low-carbon hydrogen production


CO_2 based industries


Cleaner oil and gas

State-of-the-art testing facilities supporting CCUS scale-up

- Near-commercial scale testing
- Testing venue for COSIA XPRIZE
- Open to other global technology providers in future
- 1-25 tonnes of CO_2/day capacity
- Operating since Fall 2019

Alberta Carbon Conversion Technology Centre*

- Federal laboratory
- Bench / pilot-scale facilities 1 to 3 tonnes of CO_2/day
- R&D on all aspects of CCUS with focus on ow cost high efficiency capture technologies

CanmetENERGY-Ottawa*

- Smaller-scale testing and piloting of capture and conversion technologies
- Up to 1 tonne of CO_2 / day capacity
- Commissioned and operating

Carbon Capture and Conversion Institute*

- Investigate amine post-combustion capture technologies
- 120 tonnes of CO_2 / day capacity.
- Operating since June 2015

Shand Carbon Capture Test Facility

Note – With significant investments administered by NRCan Office of Energy R&D (OERD)

CanmetENERGY is a key federal CCUS RD&D performer

Focused on a) CCUS technology developments & scale-up and

b) stakeholder engagement:

- Multiple novel pressurized oxy-combustion technologies being advanced with technology developers and ready for pre-commercial demo
- New hydrogen generation approaches with integrated carbon capture
- National CCUS framework assessment to help identify clusters and hubs based on CO_2 sources and sinks and technology options, supporting scenario analyses and CCUS strategy developments for industrial stakeholders and governments
- Bio-energy CCS for carbon removal
- Novel carbon conversion processes with Canadian innovators to maximize efficiency and product yield
- Expand CO_2 storage options especially for GHG emissions from regions with heavy industries
- Established national network with Canadian CCUS stakeholders including academics, research institutes, innovators and industrial end-users

Three-storey high oxy-combustion pilot plant designed to operate at max 85 times atmospheric pressure for steam/heat/power generation with high efficiency and near zero emission

MAJOR PLAYERS ACROSS THE CCUS VALUE CHAIN IN CANADA

CAPTURE | **TRANSPORT** | **STORAGE** | **UTILISATION**

Direct-Air-Capture (providers and adopters)

Carbon Engineering, Huron Clean Energy, Low Carbon Ventures

CAPTURE TECHNOLOGY PROVIDERS

Svante, Delta CleanTech (Capturing Sustainability), NETPOWER, Fluor, CLEAN O2, Air Liquide, Entropy

CAPTURE TECHNOLOGY ADOPTERS

Power

SaskPower (Powering our future), Capital Power, Carbon Corp

Capture & conversion (Genesee)

Chemicals

Dow, Nutrien

Cement

Lehigh HeidelbergCement Group, Project CO2MENT: Lafarge (Building better cities), Total

Fuel production (e.g. hydrogen, methanol/ethanol)

Athabasca Oil Sands Partnership - Quest: Shell, Canadian Natural, Chevron

Air Products, NWR (North West Redwater Partnership), Cenovus Energy, Nauticol, Co-op (Federated Co-operatives Limited)

Partners: ATCO, Suncor Energy

MEG Energy

Cenovus Energy, Imperial, Suncor Energy, MEG Energy, Canadian Natural, ConocoPhillips Canada

Oil Sands Pathways to Net Zero

TRANSPORT & STORAGE HUBS

CarbonAlpha, Tundra Oil & Gas, Enbridge, Polaris: Shell

Partners: TC Energy, Pembina

AB Carbon Trunkline: Wolf Midstream, enhance

ENHANCED OIL RECOVERY (EOR)

enhance, Cardinal Energy Ltd., Cenovus Energy, Whitecap Resources Inc.

MINERALIZATION

Teck, Canada Nickel Company, Planetary Hydrogen, BlueSky Technologies

FUELS

StormFisher, SAF+ Consortium

Air-to-Fuels: Carbon Engineering, Huron Clean Energy

CHEMICALS

cert, quantiam technologies inc.

BUILDING MATERIALS

Carbon Corp, Carbon Upcycling Technologies, CarbonCure, CarbiCrete

note: Canadian firms are outlined in red

Natural Resources Canada | Ressources naturelles Canada

Canada

International CCUS Collaboration

Mission Innovation (MI) – Carbon Dioxide Removal (CDR) Mission

- Enable CDR technologies to achieve net reduction of 100 million metric tons of CO2 per year globally by 2030, co-leading with US and Saudi Arabia.

Clean Energy Ministerial (CCUS Initiative)

- Enhance government-private sector collaboration to accelerate financing CCUS projects/hubs, while promoting opportunities for our industries
- Collaboration with Oil and Gas Climate Initiative (OGCI) to accelerate the identification and development of CCUS hubs

Carbon Sequestration Leadership Forum (CSLF) Technical Group

- 25 countries plus EC focused on developing cost effective CCUS technologies (chaired by Norway with vice chairs from Australia, Canada and Japan); Canada's participation since the commencement of CSLF in 2003

IEA Greenhouse Gas R&D Programme (IEAGHG)

- 30+ international members to accelerate energy technology innovation to reduce GHG emissions; Canada is a founding member since 1991

Selective bilateral mechanisms for CCUS cooperation

Moving forward, Canada will continue to focus on:

- **Learning by doing**: Supporting, implementing, and learning from industrial scale projects with enabling regulatory framework and investment incentives.
- **Cutting-edge R&D**: Working with industry, provincial governments and other partners to address technical and cost challenges to wide spread CCUS implementation in Canada.
- **Collaboration**: Collaborating with domestic and international partners under a variety of mechanisms to leverage resources and expertise to advance global CCUS.

Norwegian Energy Partners | Norway in Canada, Royal Norwegian Embassy in Ottawa

Global Affairs Canada, Trade Commissioner Service | Affaires mondiales Canada, Service des délégués commerciaux

Feb 15, 2022

CESAR Canadian Energy Systems Analysis Research

David B. Layzell, PhD, FRSC.
Energy Systems Architect, The Transition Accelerator
Professor & Director, Canadian Energy Systems Analysis Research (CESAR) Initiative, U. Calgary,
E: dlayzell@ucalgary.ca; W: www.transitionaccelerator.ca

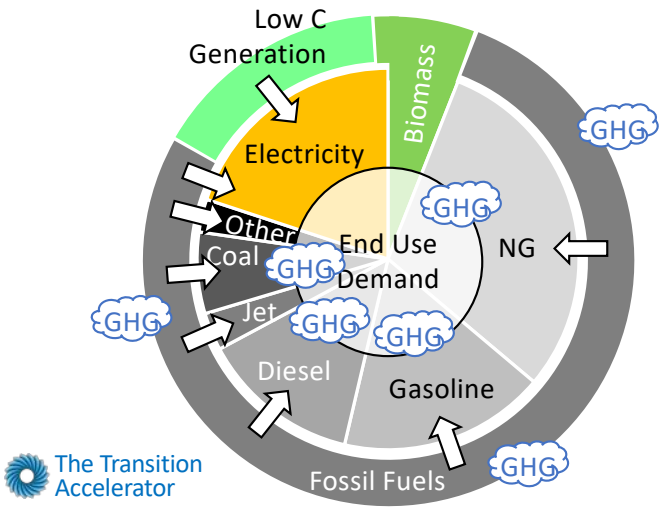
Net-Zero Emissions by 2050

...Committed to by Canada, USA and dozens of other Countries

The Transition Accelerator | L'Accélérateur de transition

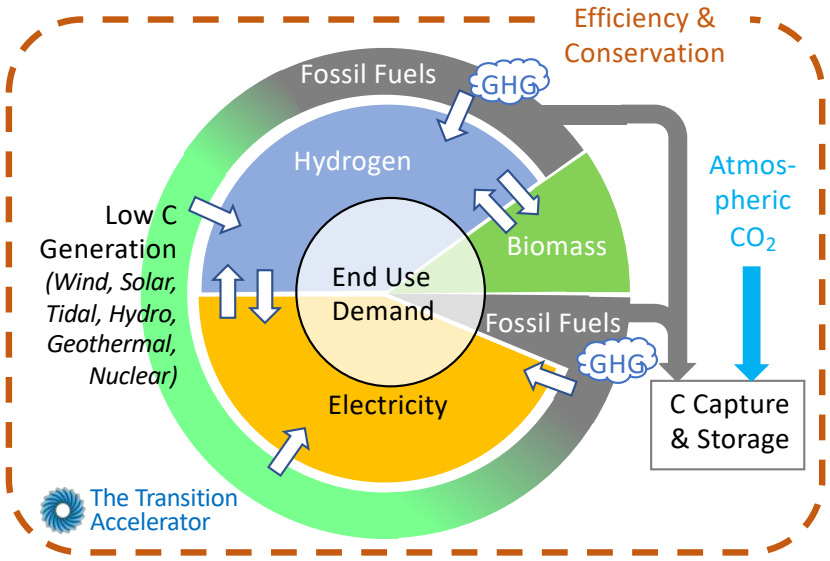
- *How can Canada 'win'?*
- *What are the best transition pathways?*

Existing Energy System



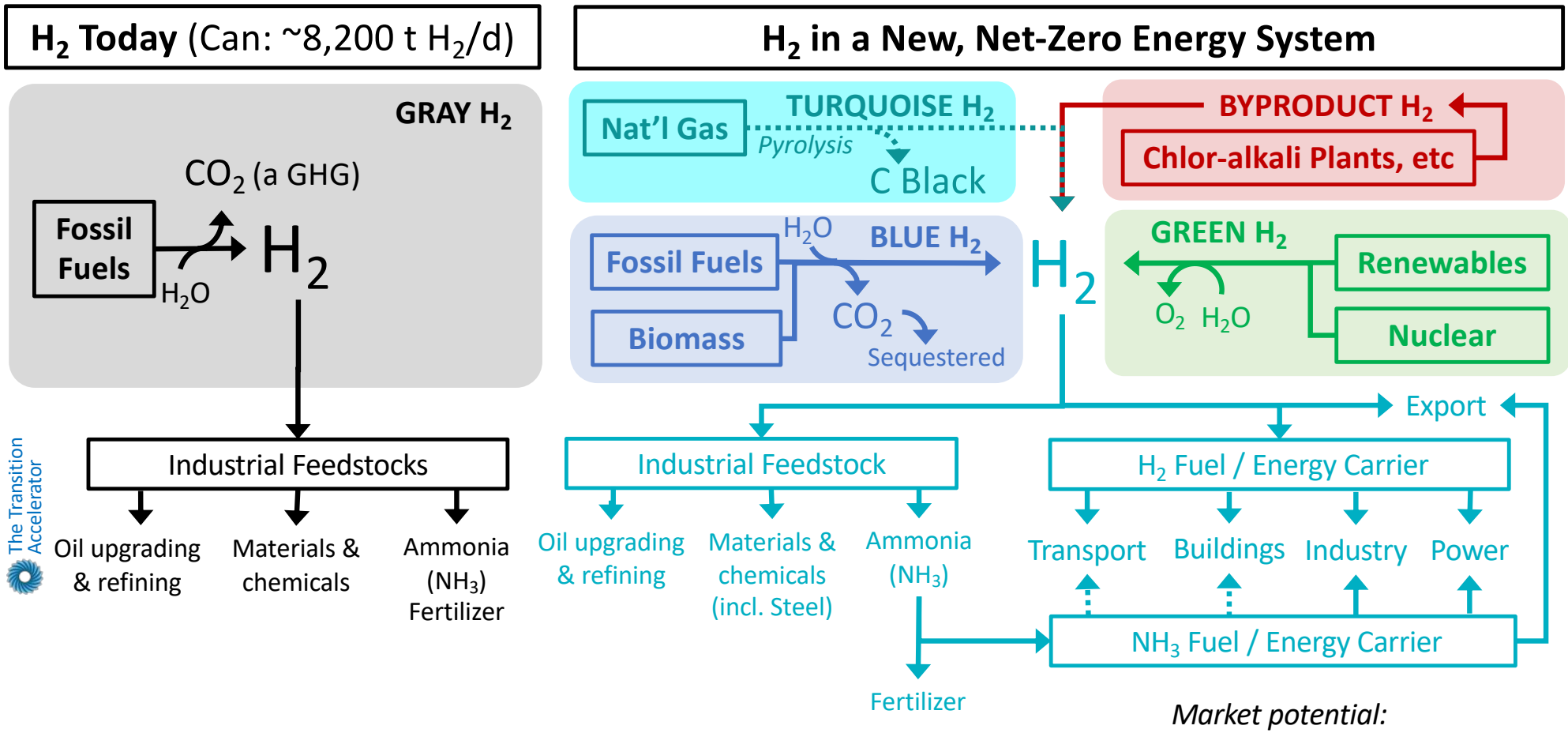
Replacing our energy carriers...

Net-Zero Energy System



* https://sdg.iisd.org/news/73-countries-commit-to-net-zero-co2-emissions-by-2050/

Towards a New Hydrogen (H_2) Economy

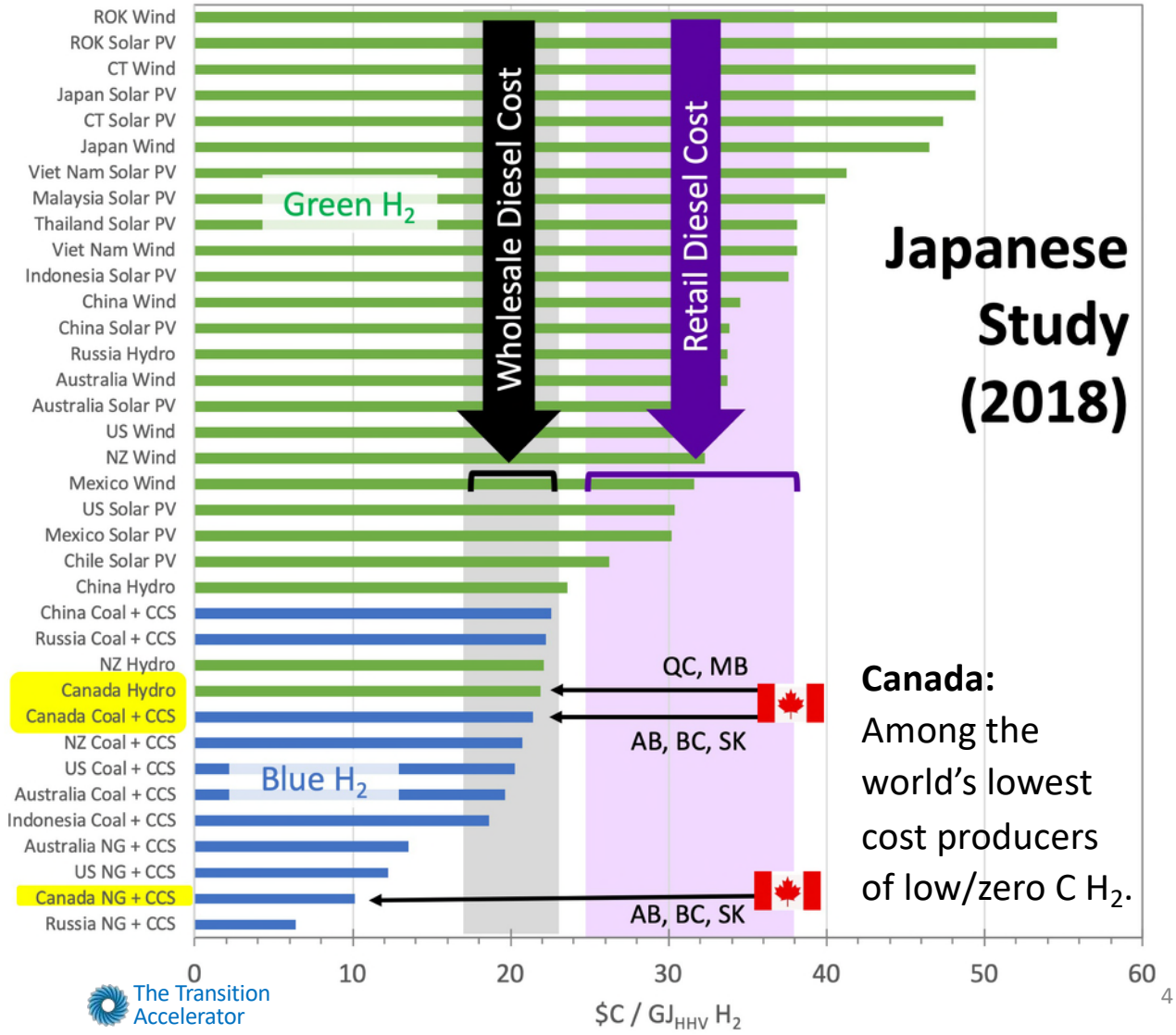


From
Layzell et al. 2020

Canada: Among the World's Lowest cost producers of 'Blue' & 'Green' H_2

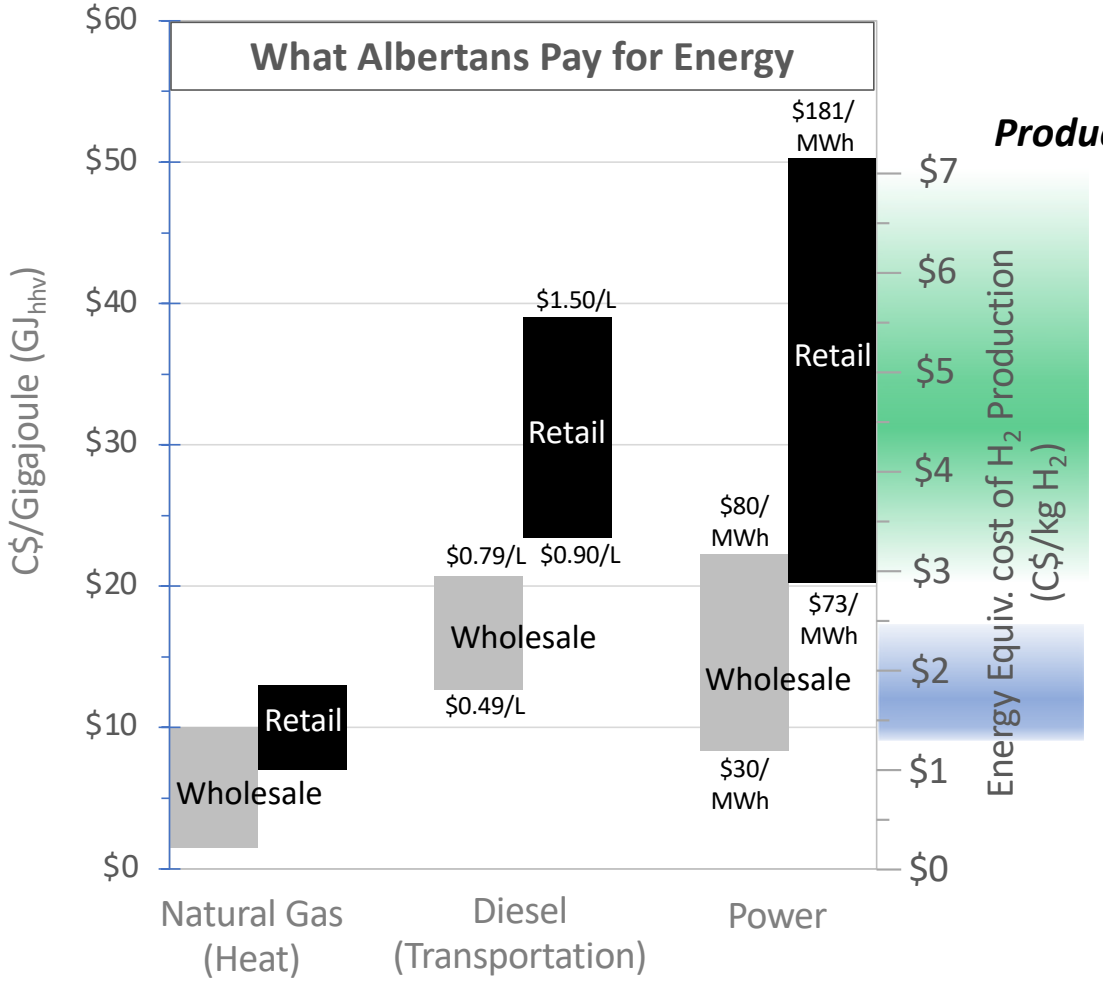
From fossil fuels (NG) coupled to carbon capture and storage (CCS)

From water electrolysis using very low C electricity (wind, PV, hydro, nuclear)



Adapted from Asia Pacific Energy Research Centre. 2018. Perspectives on H_2 in the APEC Region. (Figure 3.4) https://aperc.ieej.or.jp/file/2018/9/12/Perspectives+on+Hydrogen+in+the+APEC+Region.pdf

What Markets for Hydrogen are Most Promising?…



Green H_2
(Costs expected to decline to ~$2/kg by 2030 @ <$20/MWh$_e$)

Blue H_2
(Lower costs @ larger scales)

Heavy Transportation:

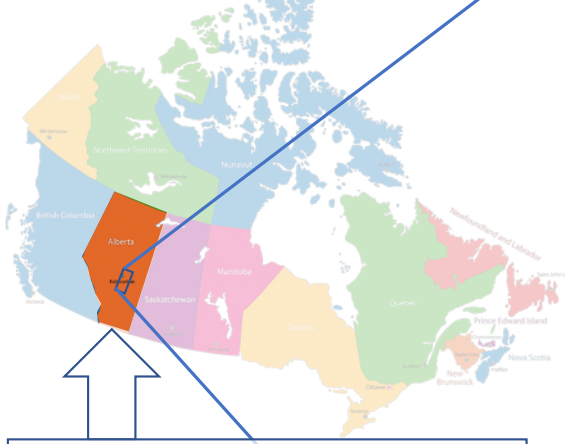
Offers the market where H_2 is most likely to be **economically viable** in the short to medium term.

More Challenging:

- ❑ Space/water heating
- ❑ Industrial Heating
- ❑ Peak power generation

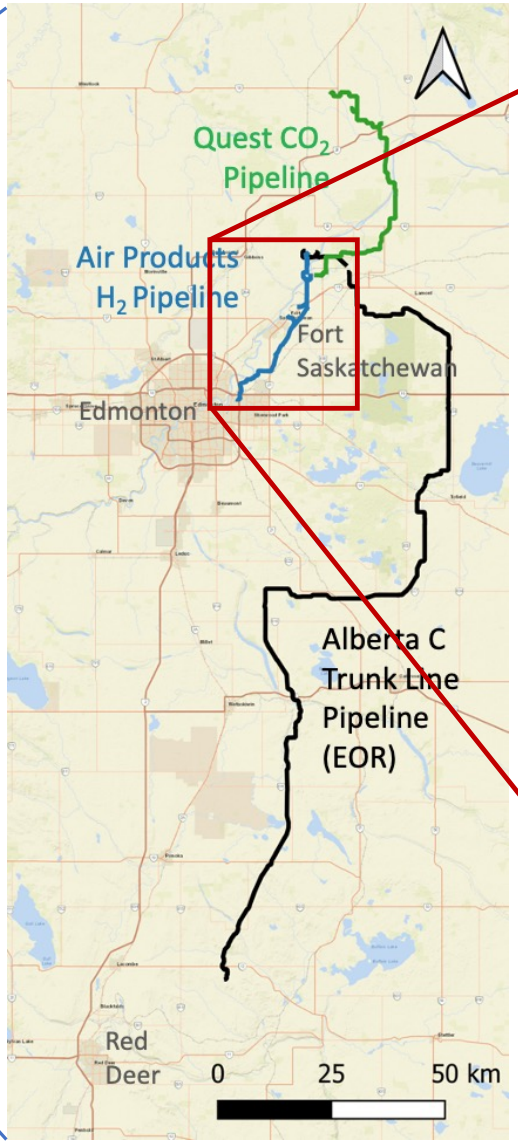
… but H_2 is likely to be the best net-zero choice for these sectors.

Hydrogen in Alberta

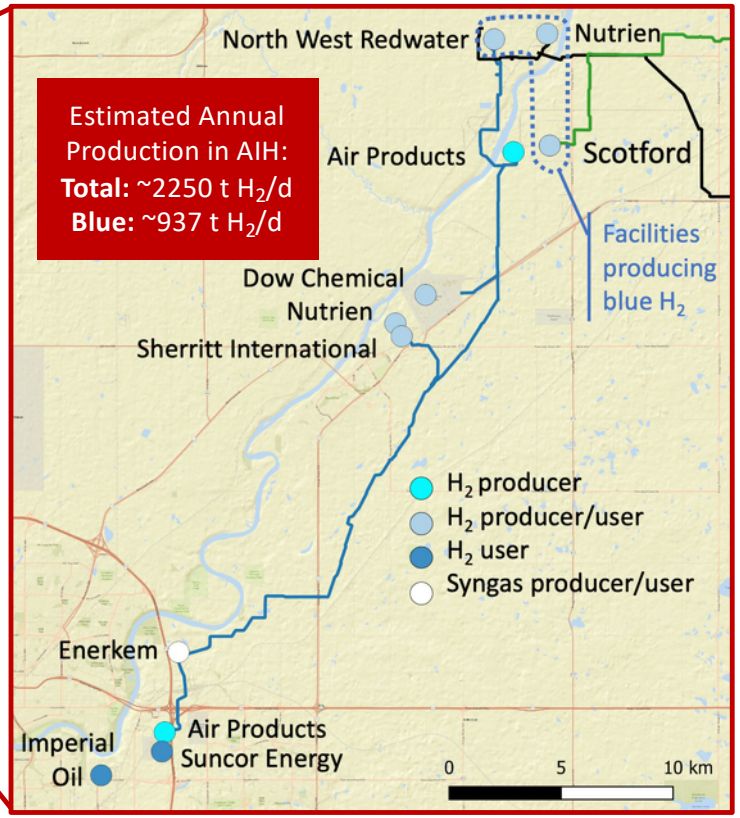


Alberta currently produces:

- ❑ ~5,400 t H_2/day
- ❑ 2/3rd of Canadian production
- ❑ For use as industrial feedstock
  - ✓ Fertilizer production
  - ✓ Oil upgrading/refining
  - ✓ Chem & material production



The Alberta Industrial Heartland (AIH)

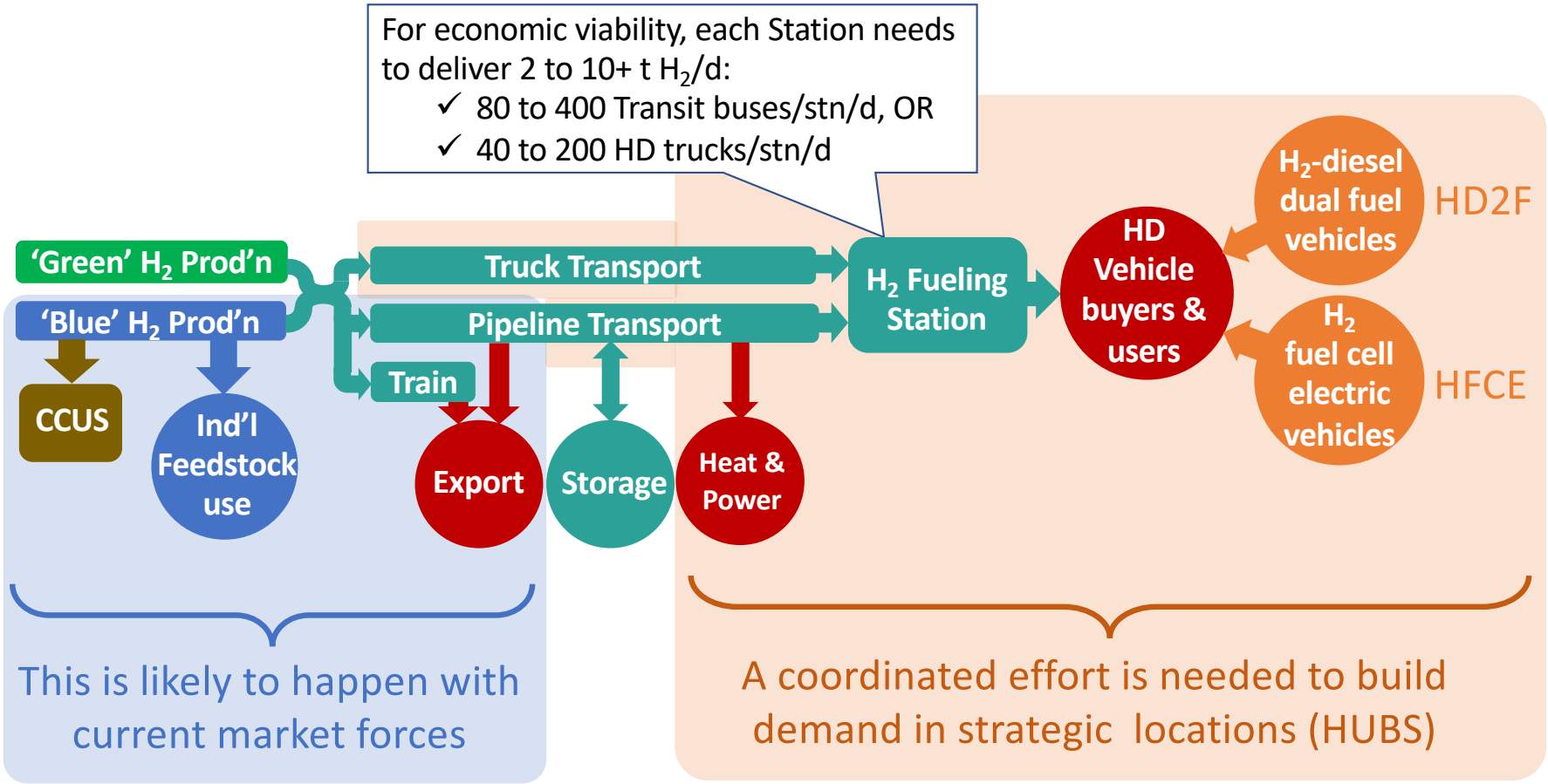


New Blue H_2 initiatives

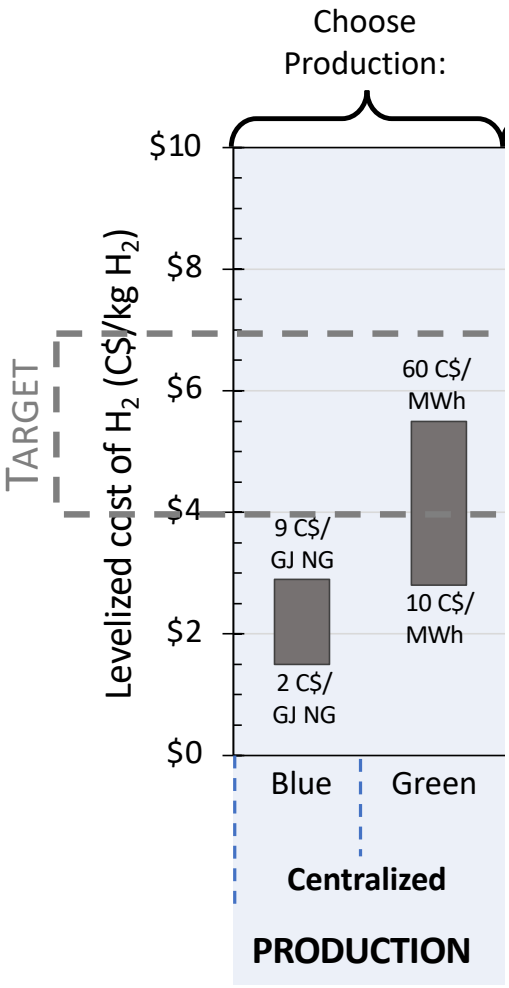
May 2021: Suncor/ATCO for ~2027
June 2021: Air Products for ~2024
July 2021: Scotford CO_2 infrastructure
Aug 2021: Petronas-Itochu H_2/NH_3 export
Sept 2021: Mitsubishi-Shell Canada H_2/NH_3
Nov. 2021: Northern Petrochem. Corp. H_2/NH_3

EDMONTON REGION Hydrogen HUB

In AB, building a new value chain is 90% 'Demand'



Key Cost Components for a Fuel H_2 Value Chain



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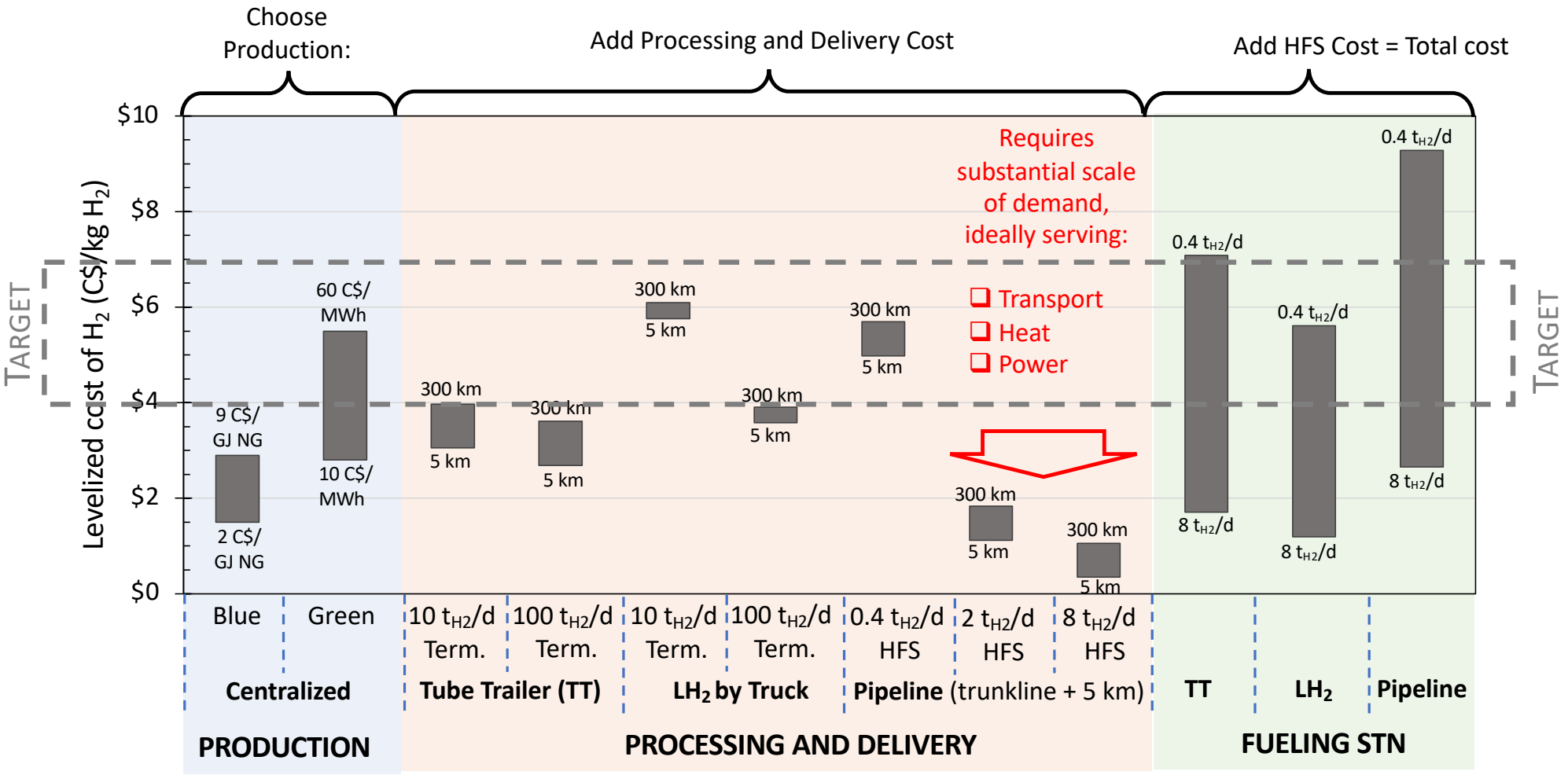

EDMONTON REGION
Hydrogen HUB

AZEHT
ALBERTA ZERO-EMISSION HYDROGEN TRANSIT

City of Edmonton
Strathcona County
(Calgary, Bow Valley)

H_2 fuel cell electric buses on road in Edmonton & Strathcona in Q3, 2022

AZETEC
ALBERTA ZERO-EMISSION TRUCK ELECTRIFICATION COLLABORATION

AMTA Alberta Motor Transport Association

63.5 t GVW

H_2 fuel cell electric trucks on road in Edm-Calg Corridor Q2, 2023

PETRO-PASS

HYDROGEN FUELING STATIONS FOR HEAVY-DUTY TRUCKS AND BUSES

CP

HYDROGEN-POWERED LINE-HAUL FREIGHT LOCOMOTIVE

- ❑ First HFCE locomotive on the tracks in 2022
- ❑ Two other trains being converted in next year or two.

H_2-DIESEL DUAL FUEL TECHNOLOGY

hydra

On road trials in Q3 2022

- Various projects to advance H_2-diesel dual fuel technology
- Important to build out fueling network

Cummins

UNIVERSITY OF ALBERTA

Bob Koch lab.

NORTH AMERICAN CONSTRUCTION GROUP

The Transition Accelerator | L'Accélérateur de transition

Conclusions

- All pathways to net-zero involve replacing gasoline, diesel & natural gas with zero-emission energy carriers (e.g. electricity, hydrogen, ammonia, biofuels);
- H_2 produced with low/zero emissions provides a cost-effective strategy for the O&G sector to engage in providing the zero-emission fuels of the future;
- The focus needs to be **on building H_2 demand** in Hubs and Corridors.

Norwegian Energy Partners | Norway in Canada, Royal Norwegian Embassy in Ottawa

Global Affairs Canada / Affaires mondiales Canada
Trade Commissioner Service / Service des délégués commerciaux

Feb 15, 2022

CESAR CANADIAN ENERGY SYSTEMS ANALYSIS RESEARCH

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Energy Systems Architect, The Transition Accelerator
Professor & Director, Canadian Energy Systems Analysis Research (CESAR) Initiative, U. Calgary,
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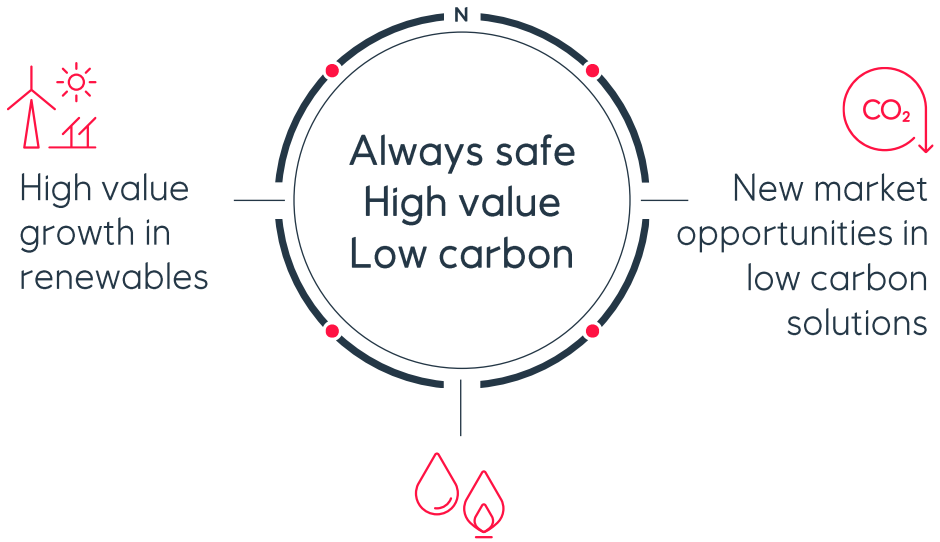
Equinor's hydrogen and CCS activities

Frida Eklöf Monstad

NORWEP Hydrogen & CCS Symposium – Canada, February 2022

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

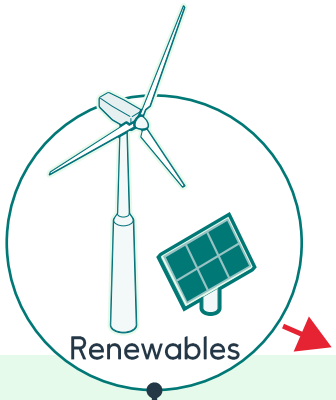
40%

Reduce net carbon intensity by 2035
Net zero by 2050

>50%

Of gross investments to renewables and low carbon solutions by 2030

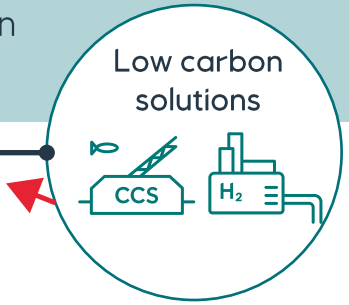
Decarbonising energy systems



Easy ⟵ Complexity to decarbonize ⟶ Hard

	Easy		Hard
Transport	Light vehicle Battery	Train Hydrogen	Shipping Hydrogen
Power	Daily storage Battery	Medium storage Hydropower	Back-up for variable power Hydrogen
Industry	Light industry Power	Heavy industry Natural gas+CCS Hydrogen	Heavy industry CCS
Heat	Heat pumps Power	Heating Hydrogen	Long-term storage Hydrogen

Multiple technologies to address the challenge



Carbon Capture & Storage | 3 roles

Emissions from our own operations

Being industry leading in carbon efficiency

Stand alone business

CCS as a service to industries

Decarbonise O&G products

Enables **blue** hydrogen production

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

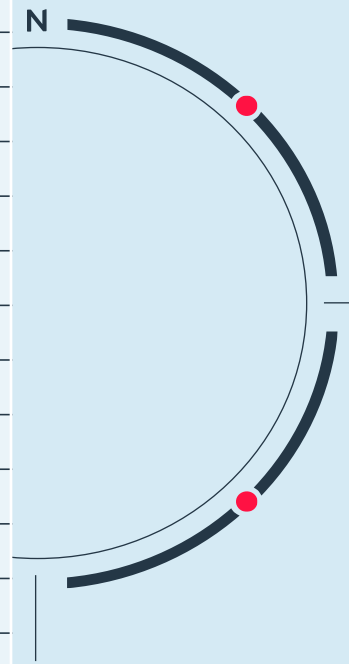
Clean hydrogen projects by 2035

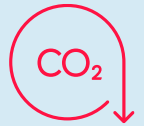
>10%

Clean hydrogen market share in Europe by 2035

CCS & hydrogen portfolio

Project name	Project type	Country	Timeline
Northern Endurance Partnership	CCS Infrastructure	UK	2026
Northern Lights	CCS Infrastructure	NO	2024 -2026
Barents Blue Polaris	CCS	NO	2027?
Net Zero Teesside	Clean power	UK	2026
Keadby 3	Clean Power	UK	2026
Peterhead	Clean power	UK	2028
H2HSaltend	H2 fuel switch	UK	2026
Keadby Hydrogen	Clean power	UK	2028
H21	H2 fuel switch	UK	2030+
H2M Eemshaven	Blue H2	NL	2028
H2BE	Blue H2	BE	2028
Aurora Energy	Green H2	NO	2025
Clean Hydrogen to Europe	Blue H2	NO	2028
Barents Blue	Blue ammonia	NO	2027
Tri-State Energy Hub	Blue H2	US	2028+
Cheyenne	Blue H2	US	2030+
Aquaventus	Green H2	GE	2035
NortH2	Green H2	NL	2030





New market opportunities in low carbon solutions

A leading company in the energy transition

Frida Eklöf Monstad, Senior advisor Business models | Low carbon solutions

Oil Sands
Pathways to Net Zero

The Pathways Vision

Canadian Natural
cenovus ENERGY
ConocoPhillips Canada
Imperial
MEG Energy
Suncor

The Pathways goal

- The **Pathways goal**, working collectively with the Federal and Alberta governments, is to achieve **net zero greenhouse gas (GHG) emissions from oil sands operations by 2050** to help Canada meet its climate goals, including its Paris Agreement commitments and 2050 net zero aspirations.

- The goal is to reduce current total oil sands GHG emissions of **68 Mt of CO_2e/yr**[1,2] in three phases by 2050.

- The **Oil Sands Pathways to Net Zero** initiative is an alliance between Canada's six largest oil sands producers, who operate facilities accounting for 95% of oil sands production.

Canadian Natural

cenovus ENERGY

ConocoPhillips Canada

Imperial

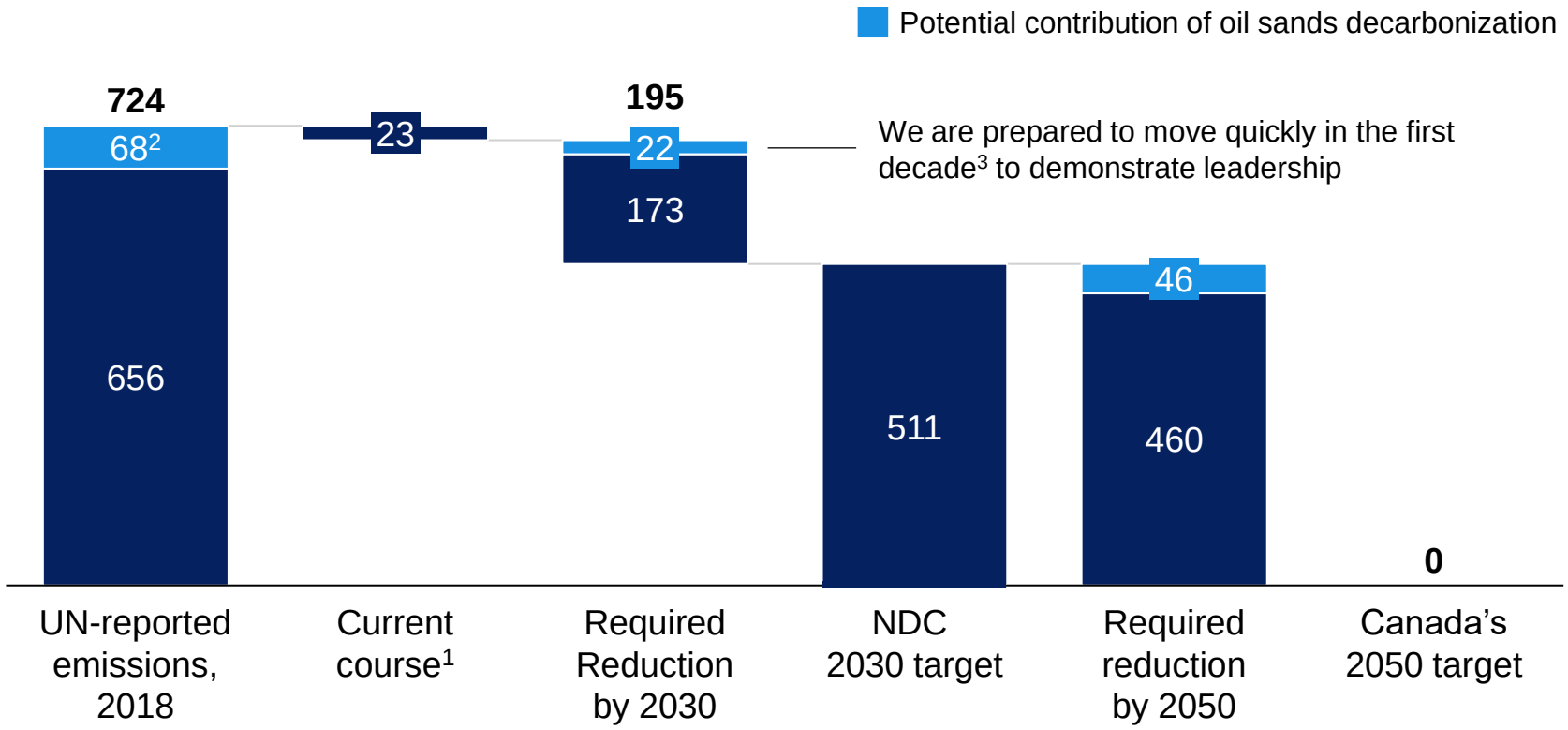
MEG Energy

Suncor

[1] Current oil sands emissions estimate based on Government of Alberta emissions inventory (2018). Reconciliation of estimated emissions from different sources available in Supplementals.
[2] Megatonnes (million tonnes) of carbon dioxide equivalent per year.

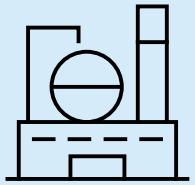
Canada's oil sands industry can be a first mover and key contributor to achieving our Paris targets

Canadian emissions and Paris Agreement target, Mt CO_2e/yr



1. Based on estimated trajectory under a 2019 Reference Case (BR4) scenario from the Government of Canada
2. Alberta GHG emissions for 2018, plus 1Mt of CO2e from incremental upgrading excluded under the 100 Mt cap methodology.
3. Base plan allows the oil sands to contribute more than its share of emissions reductions in the first decade; 11% of Canada's required incremental reduction by 2030 for Paris targets

Source: StatsCan, Government of Canada



Decarbonizing oil sands represents a sizeable opportunity to reduce Canada's carbon emissions and we have a plan to deliver **net zero from the industry** by 2050

Address 10%+

of Canada's total footprint

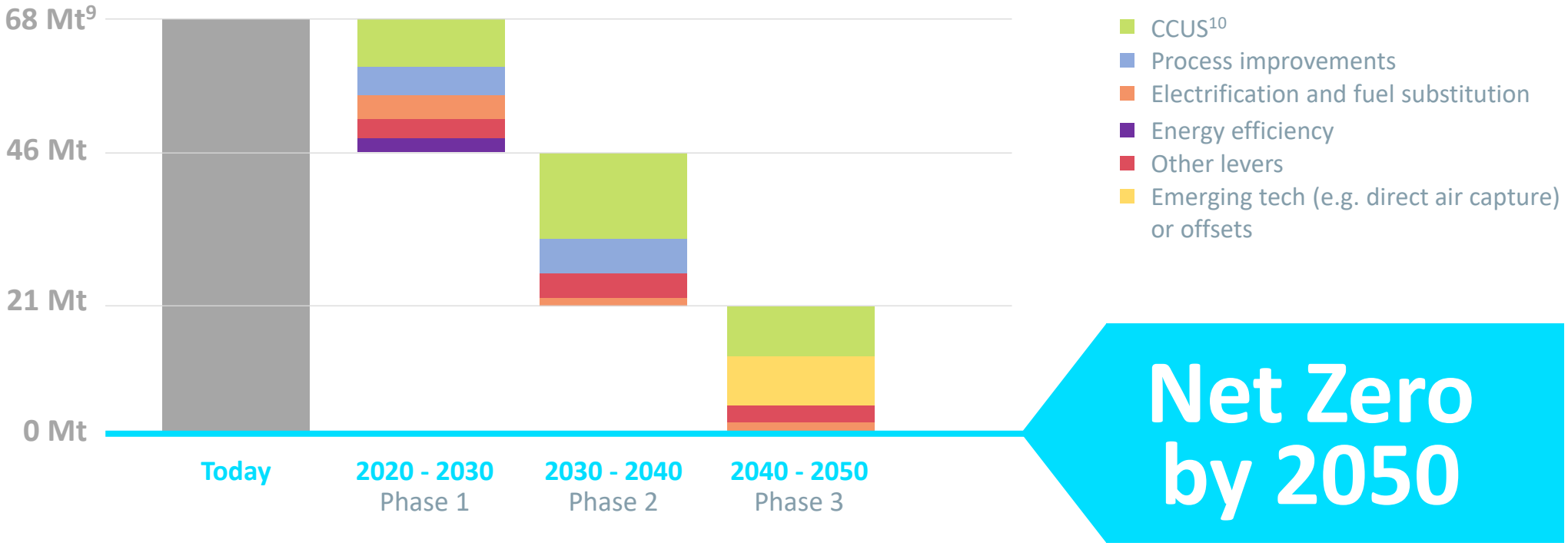
68 Mt CO_2e/yr

Reduce emissions by 68 Mt CO_2e/yr[2], with material impact this decade

The Pathways to net zero

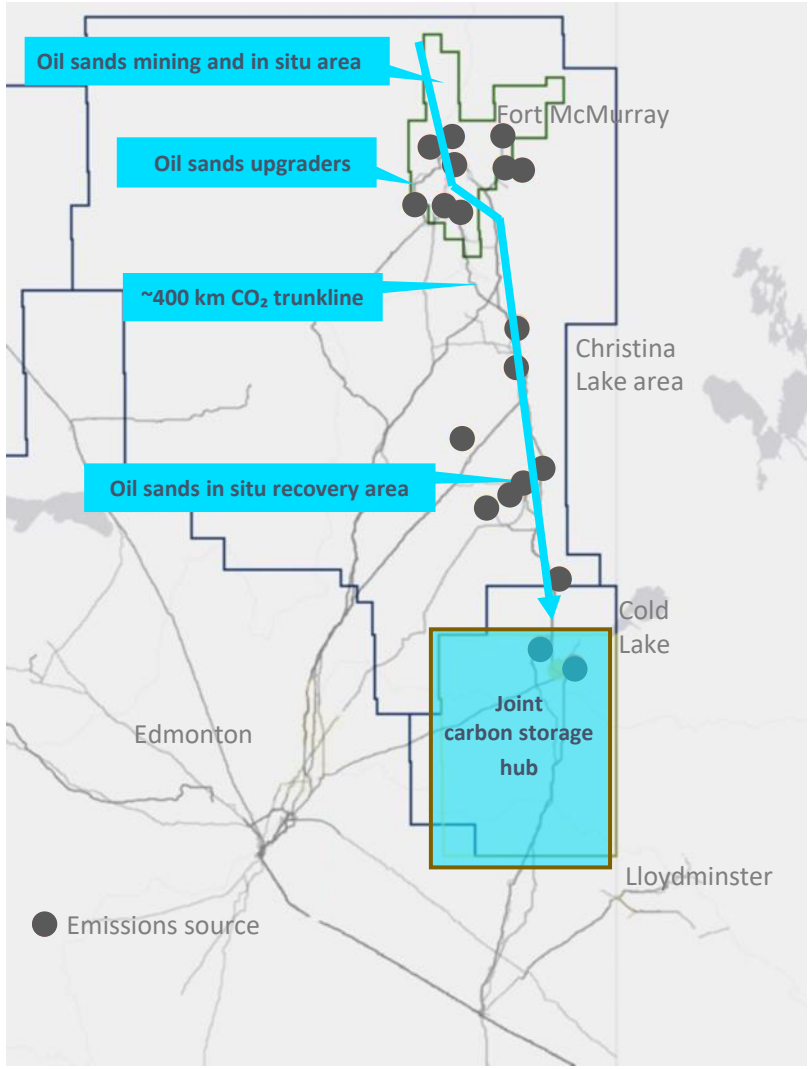
No single solution gets us to net zero – multiple parallel pathways are needed.

Proposed emissions reductions by phase, Mt CO_2e/yr[8]



[8] Magnitude of reductions in each decade can be adjusted based on chosen investment level.
[9] Alberta GHG emissions for 2018, plus 1Mt of CO2e from incremental upgrading excluded under the 100 Mt cap methodology
[10] Carbon capture in Phase 1. In Phase 2 or 3, could include carbon capture technology, nuclear and/or hydrogen

The Pathways foundational project



- The Pathways vision is anchored by a **major carbon capture utilization and storage (CCUS)**[3] **system and transportation line** connecting oil sands facilities in the Fort McMurray, Christina Lake and Cold Lake regions of Alberta to a carbon storage hub near Cold Lake.

- The CCUS transportation line would be able to be expanded in phases to gather captured CO_2 from 20+ oil sands facilities and transport it to the Cold Lake storage hub.
    - Phase 1 - volumes of 8.5 Mt/yr from 8 facilities
    - Phases 2/3 - expansion capability for a total of up to 40 Mt/yr

- The transportation line and storage hub would also be available to other industries interested in capturing and sequestering CO_2.

[3] CCUS involves using safe and proven technologies to capture CO_2 from fuel combustion or industrial processes, transport it via pipeline or other methods and use the CO_2 to create valuable products or permanently store it deep underground in geological formations.

Carbon capture can address major stationary sources of Oil Sands emissions

$$$$ = relative cost of CO_2 capture

Fired heaters

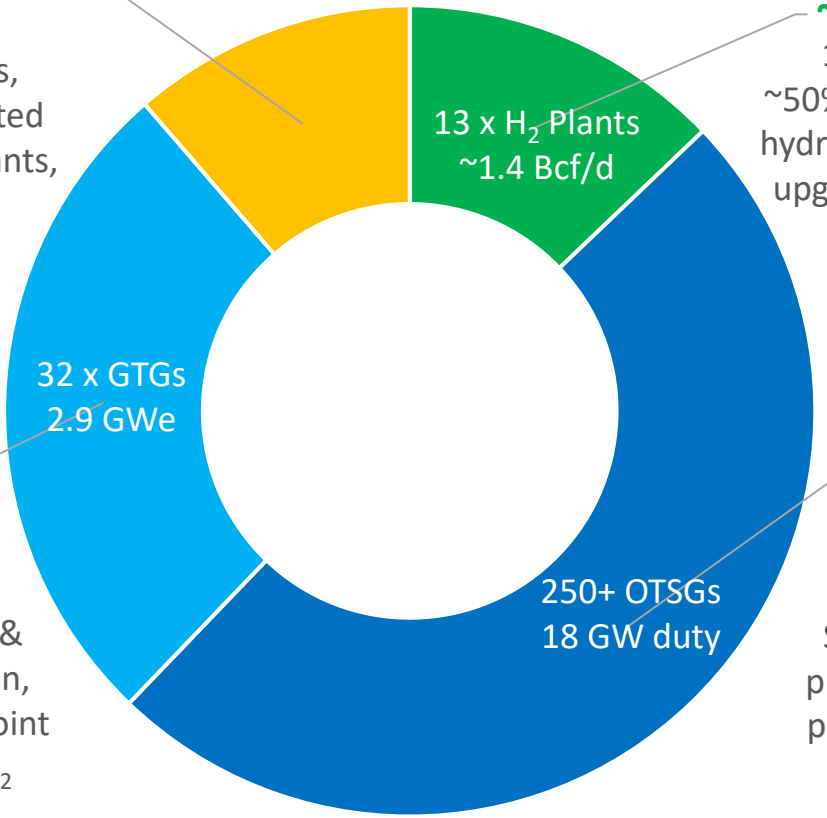
~8 Mt/yr

8-9% CO_2
Upgrading process, brownfield /congested locations, contaminants, ageing assets
$$$$

Hydrogen via Steam Methane Reforming (SMR)

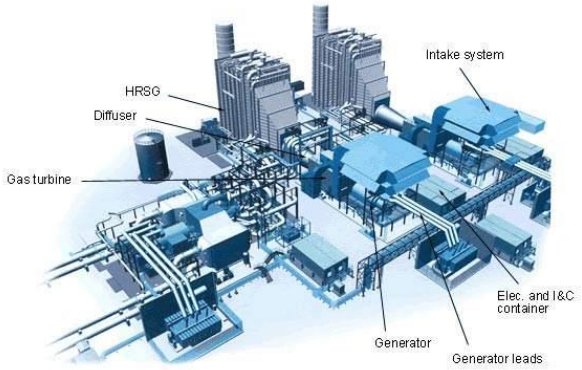
~9 Mt/yr
12-99% CO_2
~50% at high purity hydrogen supply for upgrading process
$-$$

Shell Quest CCUS facility



Gas Turbines + Heat Recovery Steam Generators (GTG/HRSG)

~18 Mt/yr



4-5% CO_2
Combined heat & power generation, large but dilute point sources, high O_2
$$$

Once Through Steam Generators (OTSGs)

~34 Mt/yr

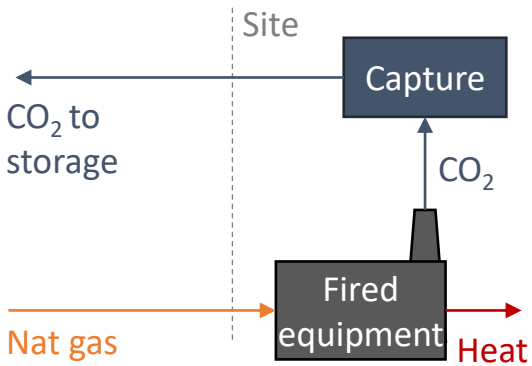
8-9% CO_2
Steam for In situ projects, variety of plant layouts / age
$$

1. Approximate emissions from various baseline years from stationary combustion & industrial processes at Oil Sands assets. Includes cogen (operated & third party). Excludes flaring, fugitives and mine trucks. Not intended to add to 68 Mt target.

Blue Hydrogen can also be a viable route to decarbonization

- Pathways is evaluating retrofitting fired equipment to burn blue hydrogen ("pre-combustion") as an alternative to post-combustion capture
- Many equipment types capable of up to ~30vol% hydrogen with minor modifications, but closer to 100% hydrogen required for material CO_2 reductions
- Potentially competitive for high cost, hard to access, or dilute streams with high post combustion capture costs

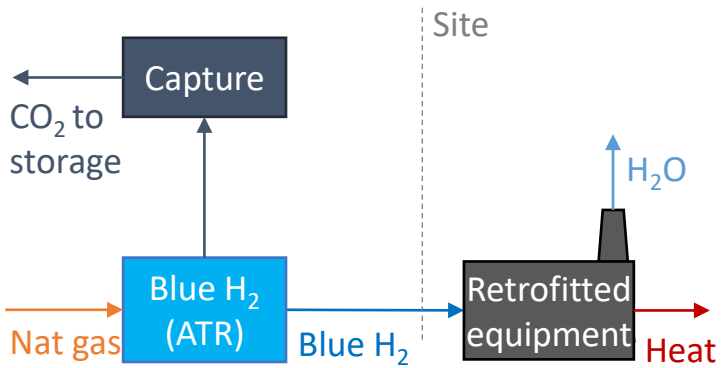
Post combustion capture



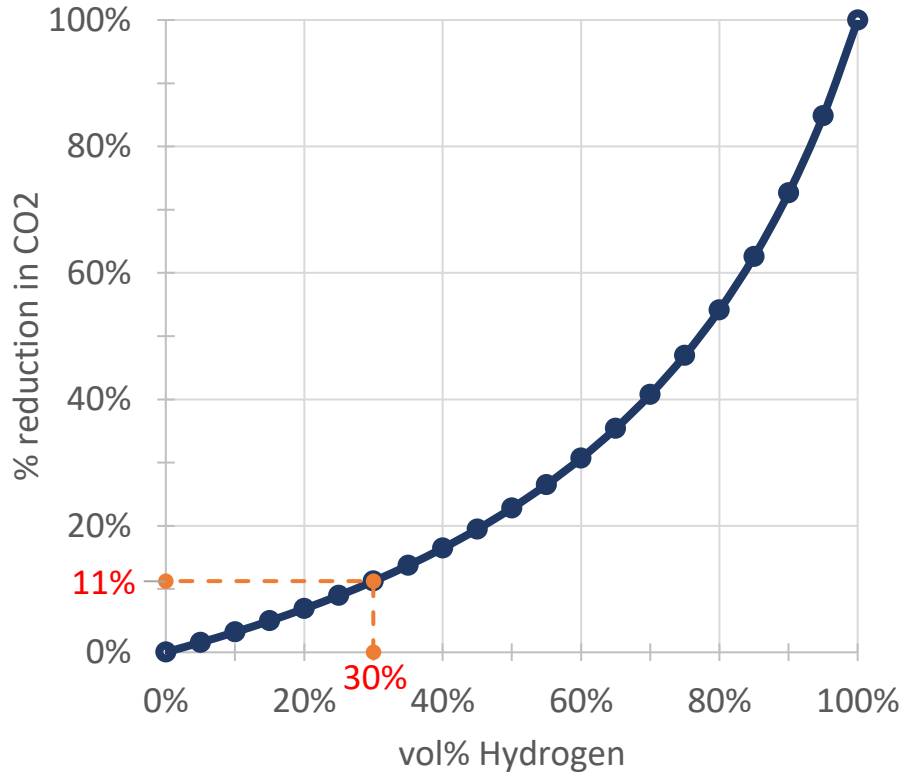
- OTSG
- GTG / HRSG
- etc.

Pre combustion capture

(Blue H_2 firing)



Emissions reduction from H2 blending



Comparable projects

	Northern Lights[4] (Norway)	Porthos (Netherlands)	Pathways
Developers	Equinor, Shell, & Total	Port of Rotterdam, EBN, Gasunie[5]	Suncor, CNRL, ConocoPhillips Canada, Cenovus, MEG, Imperial
CO_2 capture	0.8 Mt/yr from cement and waste-to-energy plants near Oslo (~C$1.1B capital costs[6]), plus 3rd party volumes	ExxonMobil, Shell, Air Liquide and Air Products refineries and H_2 plants near Rotterdam	8.5 Mt/y by 2030, up to 40 Mt/y by 2050
Transport & storage	1.5 Mt/yr capacity (~C$1.4B capital costs) liquefied CO_2 700km by ship, then 110km offshore pipeline	2.5 Mt/yr capacity (~C$740M capital costs[7]) - gathering and 20km offshore pipeline to depleted gas field	400km pipeline to sequestration zone
Government support	Funding ~2/3rds of capital costs and first 10 years of operating costs (C$2.4B of C$3.6B)	Up to C$3B in top-up subsidy to bridge total cost of capture to European carbon price over first 15 years for capture participants	Government support is required
Timeline	Final investment decision – Dec. 2020, in service 2024	Final investment decision – 2022, in service 2024	In service late 2020's

[4] Northern Lights is the transport & storage portion of the overall "Longship" project, which includes carbon capture.
[5] State owned entities.
[6] Converted NOK to CAD at 6.88:1.
[7] Transport capital costs ~€500M, capture costs unavailable.

Collaboration

Working together, we're confident this unprecedented challenge can and will be solved by Canadian ingenuity and leadership

- The launch of the Pathways initiative followed announcements from the Government of Canada and the Government of Alberta of important support programs for emissions-reduction projects and infrastructure.
- The Pathways initiative is ambitious and will require ongoing collaboration between industry and government, including making significant investments together to advance the research and development of new and emerging technologies.
- The companies involved look forward to continuing to work with the federal and Alberta governments, and to engaging with local Indigenous communities, to make this major emissions-reduction vision a reality.

Advisory

Cautionary Statement: Statements of future events or conditions in this presentation, including projections, targets, expectations, estimates, and business plans are forward-looking statements. Forward-looking statements can be identified by words such as achieve, aspiration, believe, anticipate, intend, propose, plan, goal, seek, project, predict, target, estimate, expect, forecast, vision, strategy, outlook, schedule, future, continue, likely, may, should, will and/or similar references to outcomes in future periods. Forward-looking statements in this presentation include, but are not limited to, references to the viability, timing and impact of the Oil Sands Pathways to Net Zero initiative collaboration and the development of pathways in support of a net-zero future; support for the pathways from the Government of Alberta and the Government of Canada; the ability to enable net zero emissions from oil production and preserve economic contribution from the industry; the continued role of fossil fuels as part of a diversified energy mix; and the deployment of technologies to reduce GHG emissions, such as CCUS, process improvements, energy efficiency, fuel switching, electrification, infrastructure corridors and new emissions-reducing technologies. All net-zero references in this announcement apply to emissions from oil sands operations (defined as scope 1 and scope 2 emissions).

Forward-looking statements are based on current expectations, estimates, projections and assumptions at the time the statements are made. Actual future results, including expectations and assumptions concerning: demand growth and energy source, supply and mix; amount and timing of emissions reductions; the adoption and impact of new facilities or technologies, including on reductions to GHG emissions; project plans, timing, costs, technical evaluations and capacities, and the ability to effectively execute on these plans and operate assets; that any required support for the pathways from the Government of Alberta and the Government of Canada will be provided; applicable laws and government policies, including climate change and restrictions in response to COVID-19; production rates, growth and mix; general market conditions; and capital and environmental expenditures, could differ materially depending on a number of factors. These factors include global, regional or local changes in supply and demand for oil, natural gas, and petroleum and petrochemical products and the resulting price, differential and margin impacts; political or regulatory events, including changes in law or government policy and actions in response to COVID-19; the receipt, in a timely manner, of regulatory and third-party approvals including for new technologies; lack of required support from the Government of Alberta and the Government of Canada; environmental risks inherent in oil and gas exploration and production activities; environmental regulation, including climate change and GHG regulation and changes to such regulation; availability and allocation of capital; availability and performance of third-party service providers; unanticipated technical or operational difficulties; project management and schedules and timely completion of projects; reservoir analysis and performance; unexpected technological developments; the results of research programs and new technologies, and ability to bring new technologies to commercial scale on a cost-competitive basis; operational hazards and risks; general economic conditions, including the occurrence and duration of economic recessions; and other factors referenced by the companies' in their most recent respective annual reports and management's discussion and analysis, as applicable.

Forward-looking statements are not guarantees of future performance and involve a number of risks and uncertainties, some that are similar to other oil and gas companies and some that are unique to the companies. Actual results may differ materially from those expressed or implied by its forward-looking statements and readers are cautioned not to place undue reliance on them. The companies undertake no obligation to update any forward-looking statements contained in this presentation, except as required by applicable law.

Oil Sands
Pathways to Net Zero

oilsandspathways.ca

Canadian Natural · cenovus ENERGY · ConocoPhillips Canada · Imperial · MEG Energy · Suncor

WHEN TRUST MATTERS

Global Developments, Trends and Opportunities

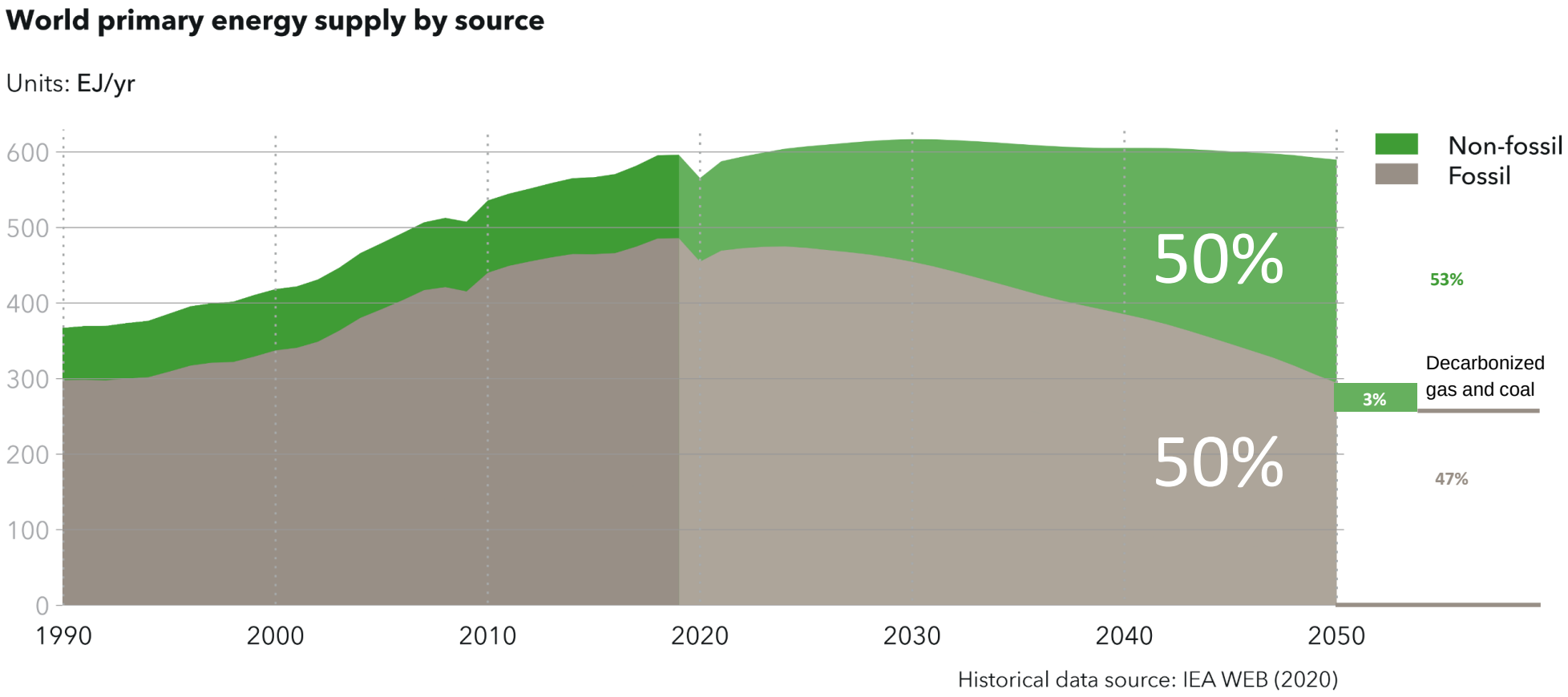
Laith Amin & Martha Ramos-Gomez

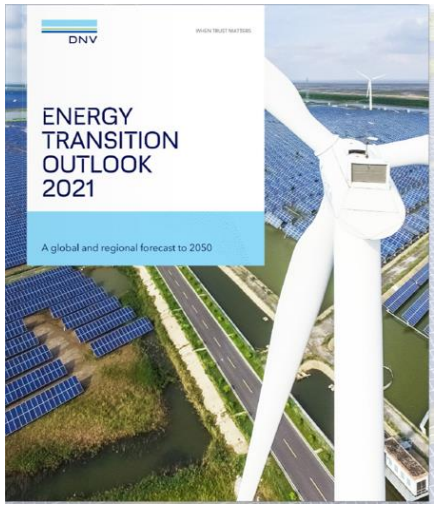
15 February 2022

Canada leads the world in CCS development and deployment

- Regulatory & financial systems
- Executed safely – QUEST
- Key enabler: recognizing the need for transparency to build public confidence prior to deployment
- Built an excellent, adaptive MMV plan
- Supported by 3rd part Verification

Our ETO Report shows that by 2050, we will have decarbonized 3% gas & coal energy production…





CCS Hubs: Getting more stakeholders involved

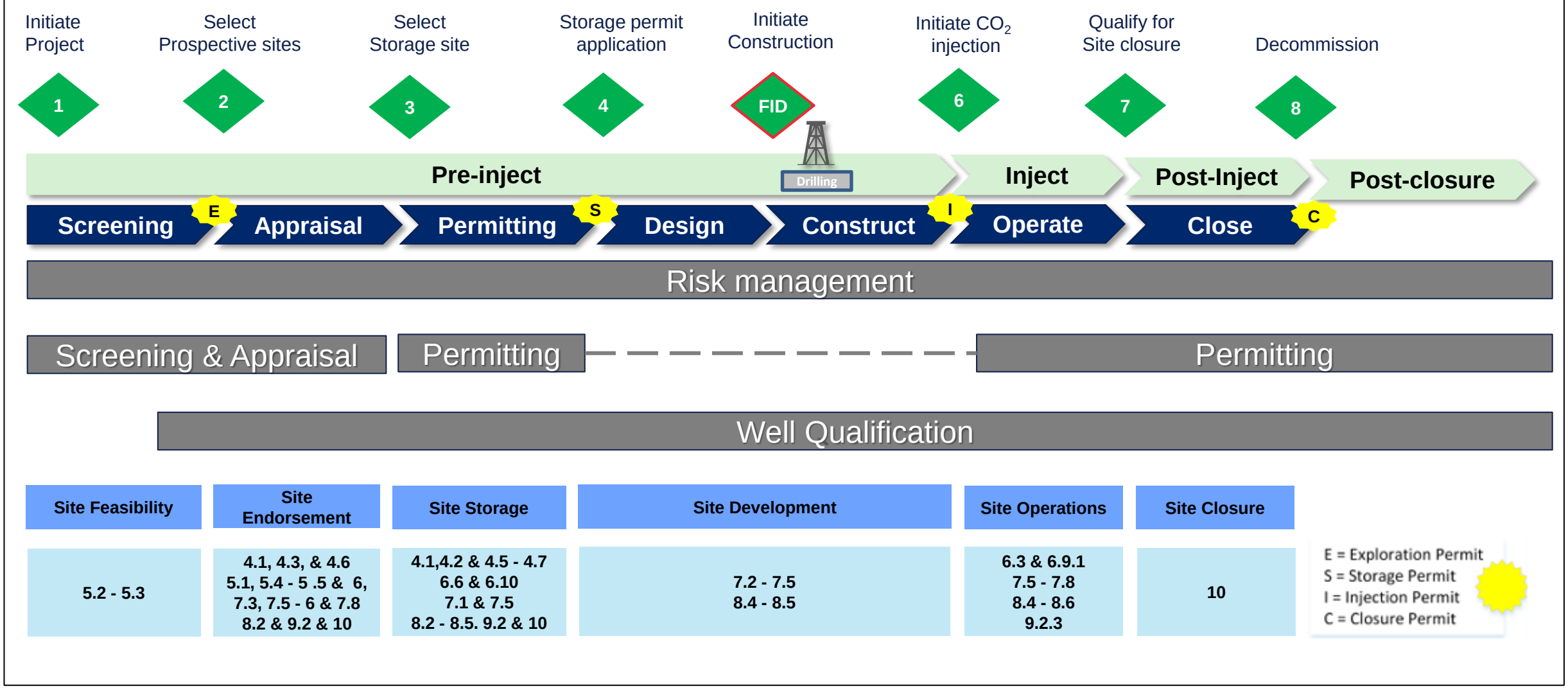
Courtesy: OGCI

…will the public endorse: *faster,* at-scale common user CCS Hub development?

3rd party verification can expedite projects

Public consent	Independent verification of disclosures and assumptions builds trust, especially for ‘first of a kind’ developments
Partnerships & investments	Verification/certification at site feasibility and appraisal stages can expedite farm-ins, investments. Risks are shared
Regulatory	Recommended practices and standards can help bankability where the regulatory environment hasn’t kept pace
Safety & integrity	3rd party independent verification is always a pathway to better project safety and integrity outcomes

When certification can be used



DNV certification of conformity

Clauses in ISO 27914 for each project stage

DNV
CCUS & Hydrogen Teams

Laith Amin
Martha Ramos-Gomez

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www.dnv.com

DNV

AKER CLEAN HYDROGEN

An Efficient Hydrogen Value Chain Integrator

Hydrogen & CCS Symposium

February 2022

PLANET-POSITIVE: AKER HORIZONS ECOSYSTEM

Three pillars driving demand for clean hydrogen for industrial use

1

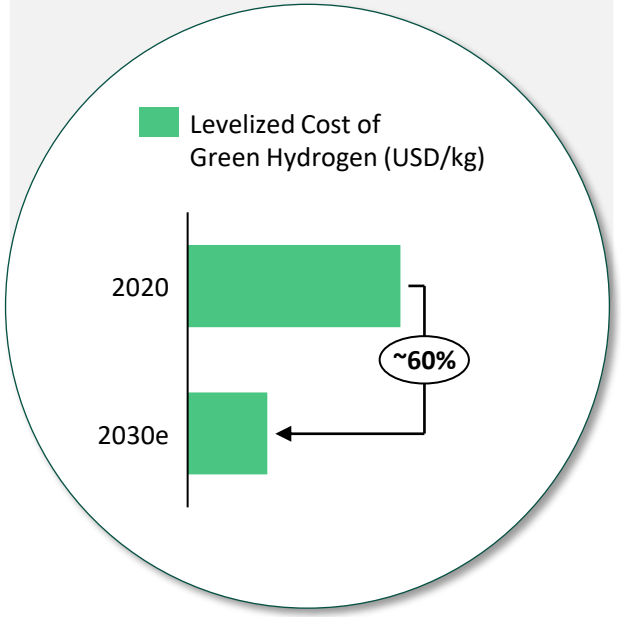
Demand for emission-free products

2

CO_2 taxes and regulatory incentives

3

Cost reductions of clean hydrogen production



AKER CLEAN HYDROGEN

Aker Clean Hydrogen in brief

Integrated clean hydrogen producer

Develop, build, own, and operate hydrogen facilities

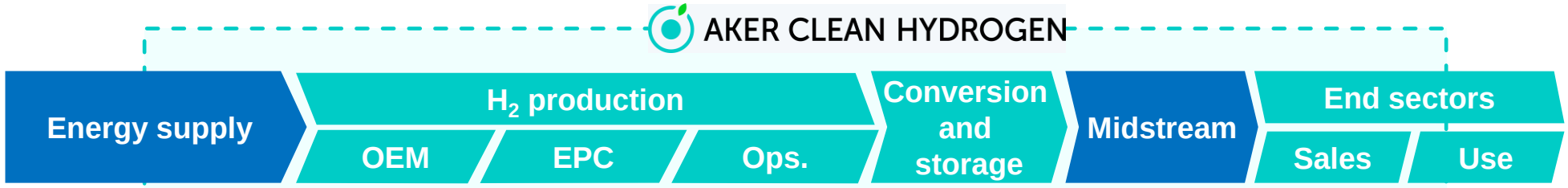
>1.8 GW net capacity project & prospect portfolio

Projects and prospects in Norway, Chile, and Uruguay

Target of 5.0 GW net installed clean hydrogen capacity in 2030

Meaningful impact of reducing 9.4 million tons CO_2 emissions per year

Affordable hydrogen…



INTEGRATED HYDROGEN PRODUCER
Develop, build, own and operate hydrogen facilities

- **End-to-end optimized design and operations** - from energy mgmt. to plant operations, storage and output (e.g. right-sizing)
- **Partnering** with **strong players** along the value chain
- **Cost-leading** modular architecture based on product catalogue and serial production
- Value optimized project with **short timeline from FID to first production**
- Fully digitalized **integrated concept screening** and simulation with early cost estimate
- **Digitalized and cost-leading** operating model
- **Safe** design, development and operatorship through Aker know-how built up over 180 years of industrial excellence

AKER CLEAN HYDROGEN

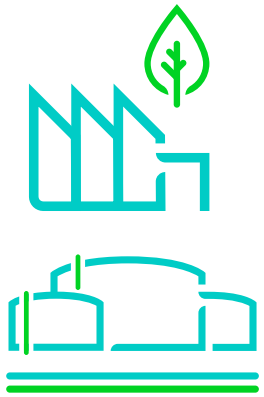
Affordable, safe and easy hydrogen - to the end-user

Understanding the-full-value chain

Sustainability, Reliability & Pricing

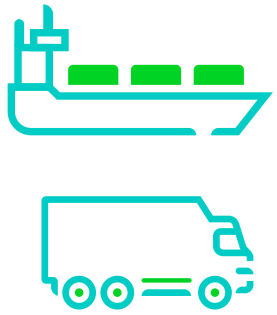
Energy & feed supply

Efficiency & Safety



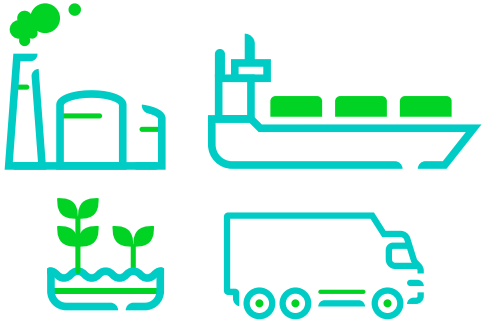
H2 production, conversion & storage

Distance, Infrastructure & Volume



Distribution

Requirements, Safety, & Modifications

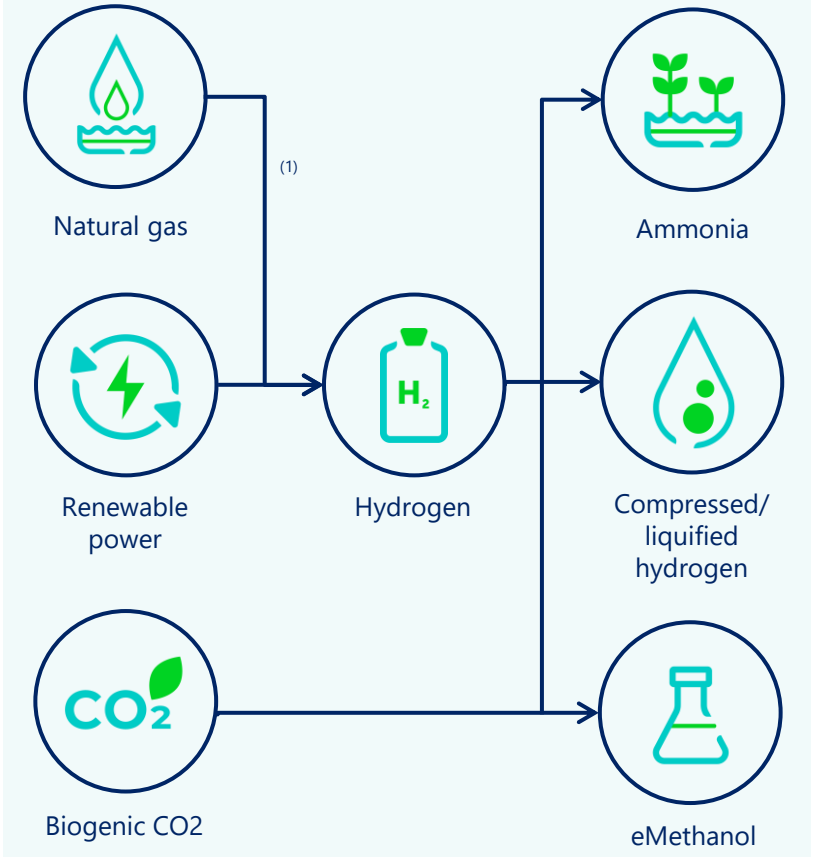


H2 consumers / End-users

AKER CLEAN HYDROGEN

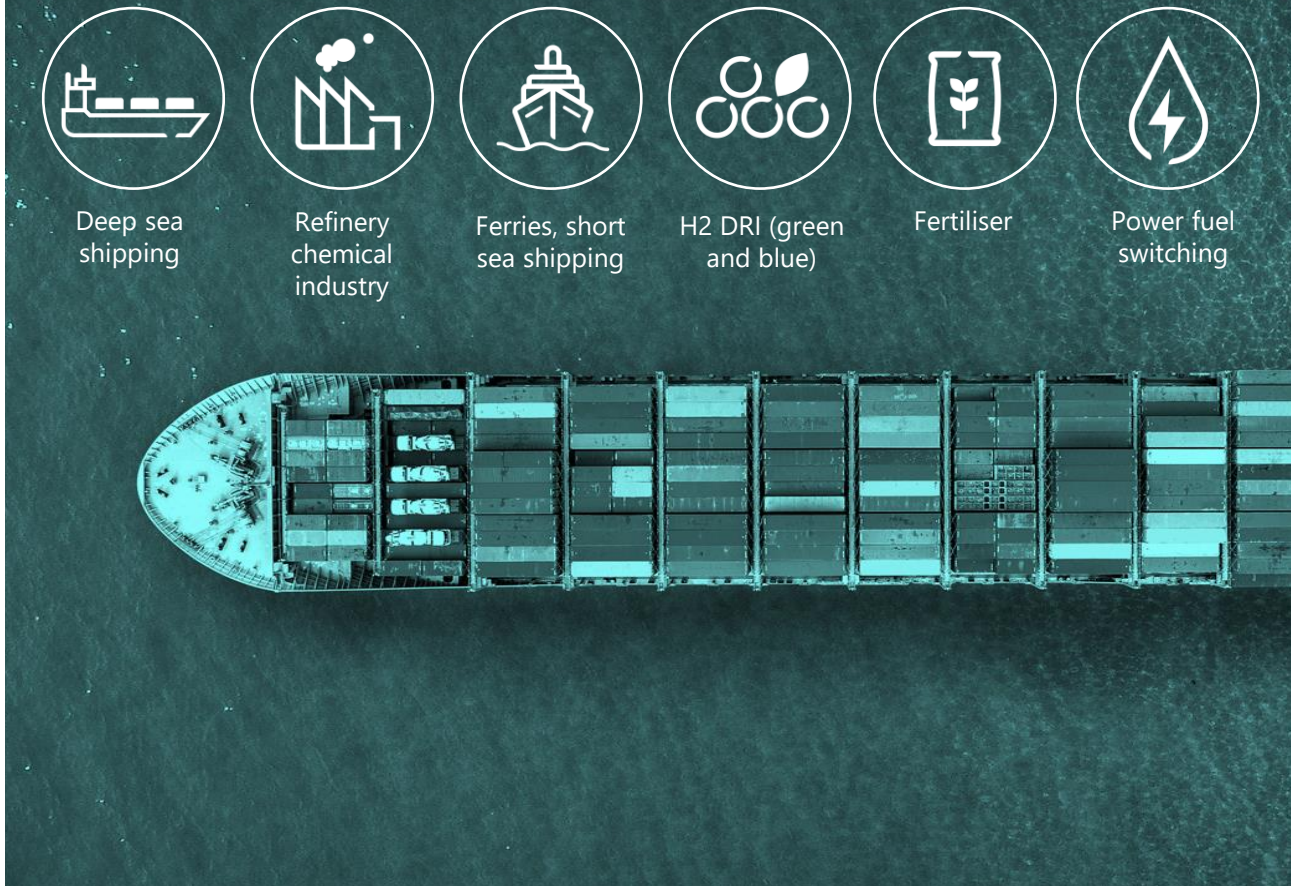
Producing Affordable Hydrogen for Hard-To-Abate Sectors

DEVELOP, BUILD, OWN, OPERATE



Integration, storage and logistics

ACTIVE DIALOGUE WITH OFFTAKERS IN HARD TO ABATE SECTORS



1. In the case of blue hydrogen (using natural gas), the hydrogen process will capture CO2 that need to be permanently stored

AKER CLEAN HYDROGEN

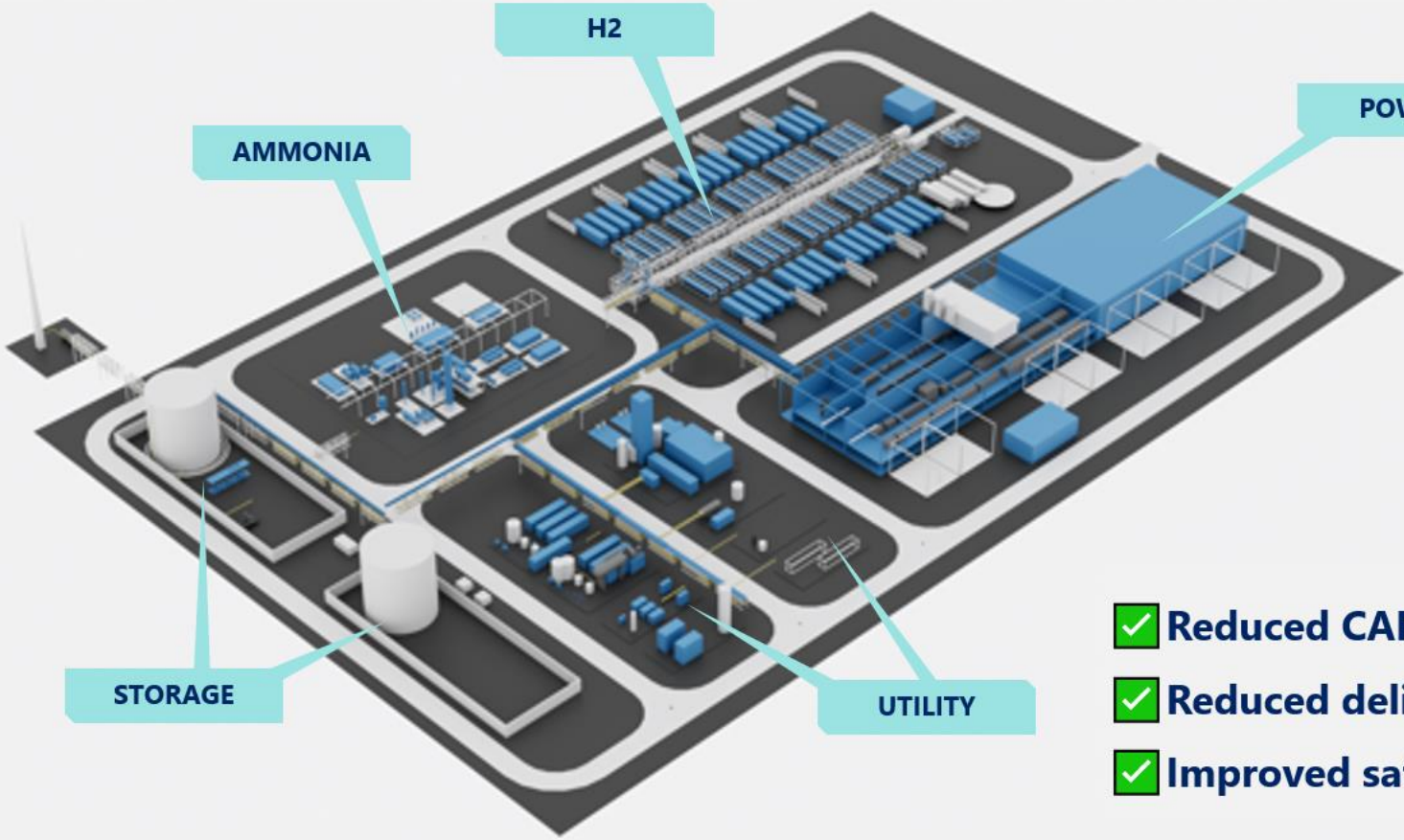
Green Ammonia Berlevåg | Understanding the-full-value chain

AKER CLEAN HYDROGEN

Green Ammonia Berlevåg | Understanding the-full-value chain

# STRATEGIC VENDORS	
2	Electrolyser stack
	Balance of plant equipment
1	Control system
2	Power-substation
1	Ammonia plant
1	Integration, utility, piperack's, civil, storage, buildings

ACH STANDARDIZED PLANT – ENABLED THROUGH STRATEGIC VENDORS



- ✅ Reduced CAPEX
- ✅ Reduced delivery time
- ✅ Improved safety

AKER CLEAN HYDROGEN

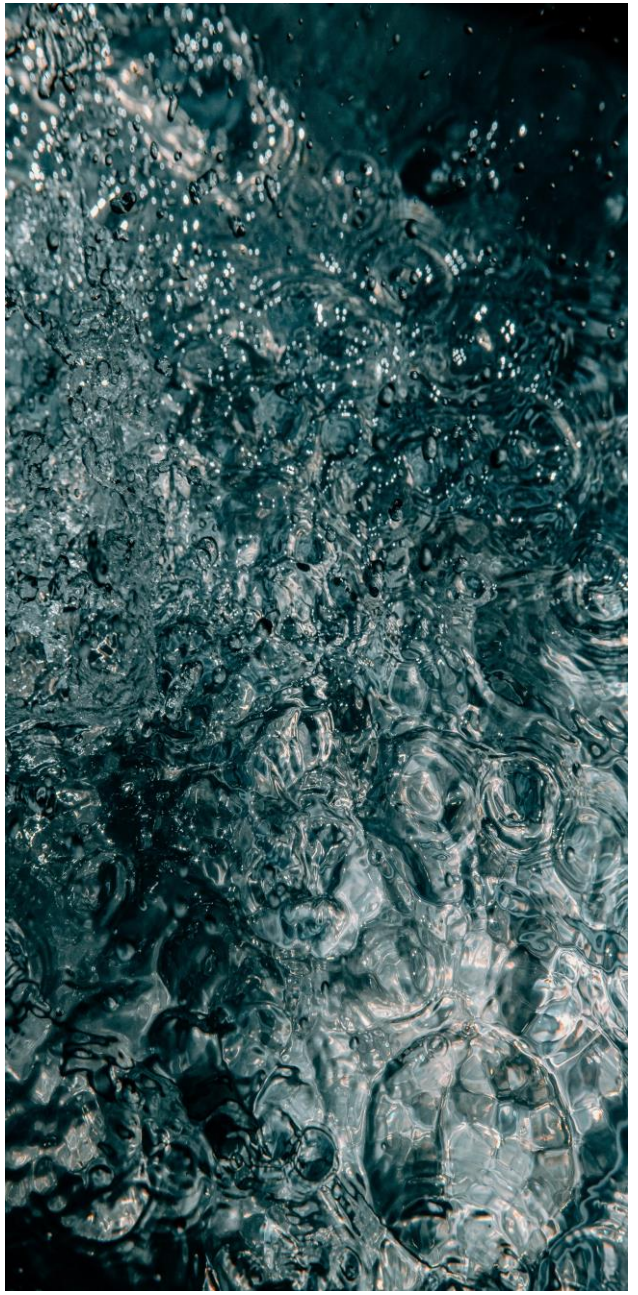
AKER CLEAN
HYDROGEN

Hydrogen & CCS Symposium – Canada 15 Feb

Erik Bolstad, CCO

Hydrogen pro

Content



About HydrogenPro

Introduction

- Founded 2013 by core team with several years of experience from electrolyser industry from Norsk Hydro
- Headquartered in Porsgrunn, Norway
- Focused on high pressure alkaline technology
  - Core technology developed through a combination of Norwegian and Chinese electrolyser competence and experience
- IPO and stock listing at Oslo Stock Exchange in October 2020
- Ownership of next generation electrode technology

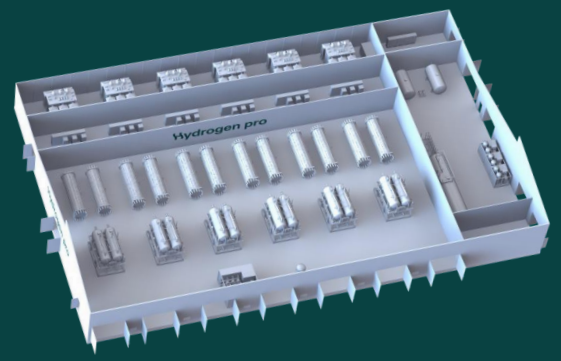
HydrogenPro key markets

Large scale hydrogen plants

Renewable Electricity

Water

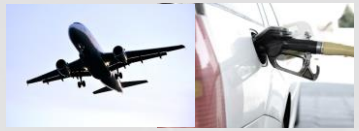
Hydrogen pro

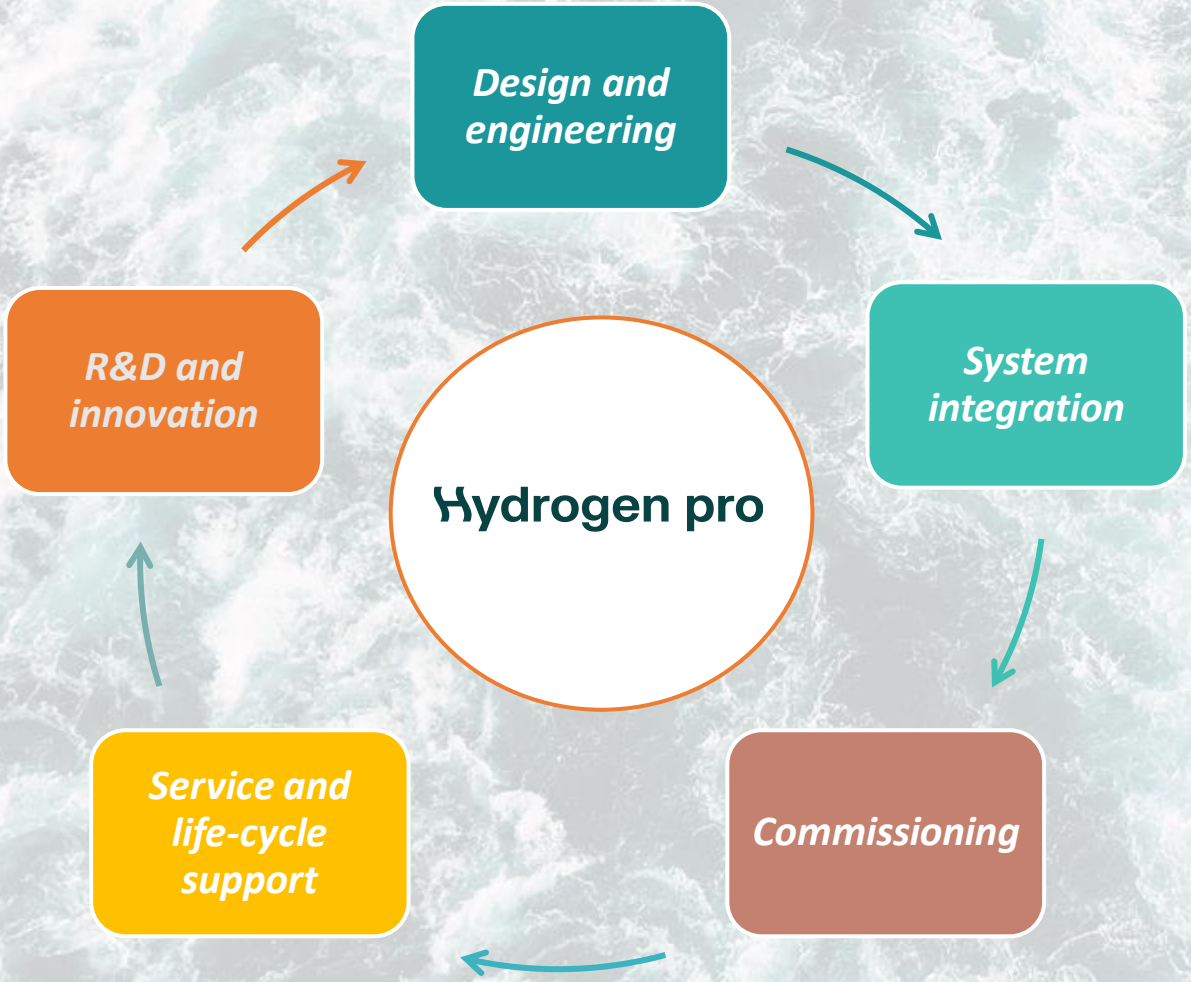


Large-scale Hydrogen Plant

1
H
Hydrogen
1.008

- Power to X
- Balancing of grid
- Refinery Decarbonization
- Synthetic Fuel
- Fertilizer/ ammonia
- Steel Production





MITSUBISHI POWER

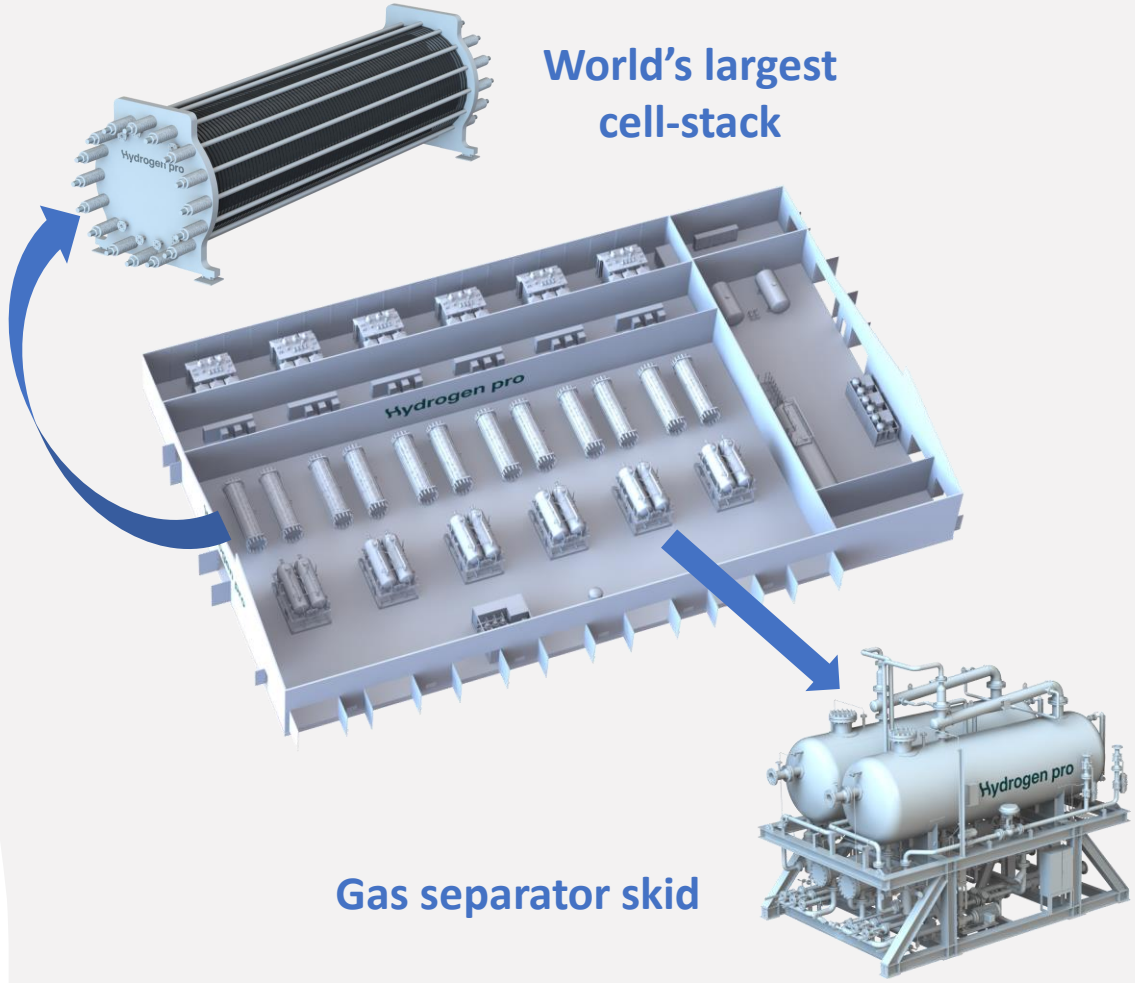
ABB

MITSUBISHI HEAVY INDUSTRIES

Technology advantages

- High pressure alkaline technology
- Plant efficiency
  - Compact size due to pressure and cell-stack size
- Capex efficiency
  - Large scale
  - Design limits of components
  - Modular and standardized
  - Easily scalable with customer requirements
- Opex efficiency
  - Advanced electrode technology
  - Reduced need of cooling water
- Operation window well suited for renewable energy production
- No use of noble metals or polyfluorinated alkyl substances (PFAS)

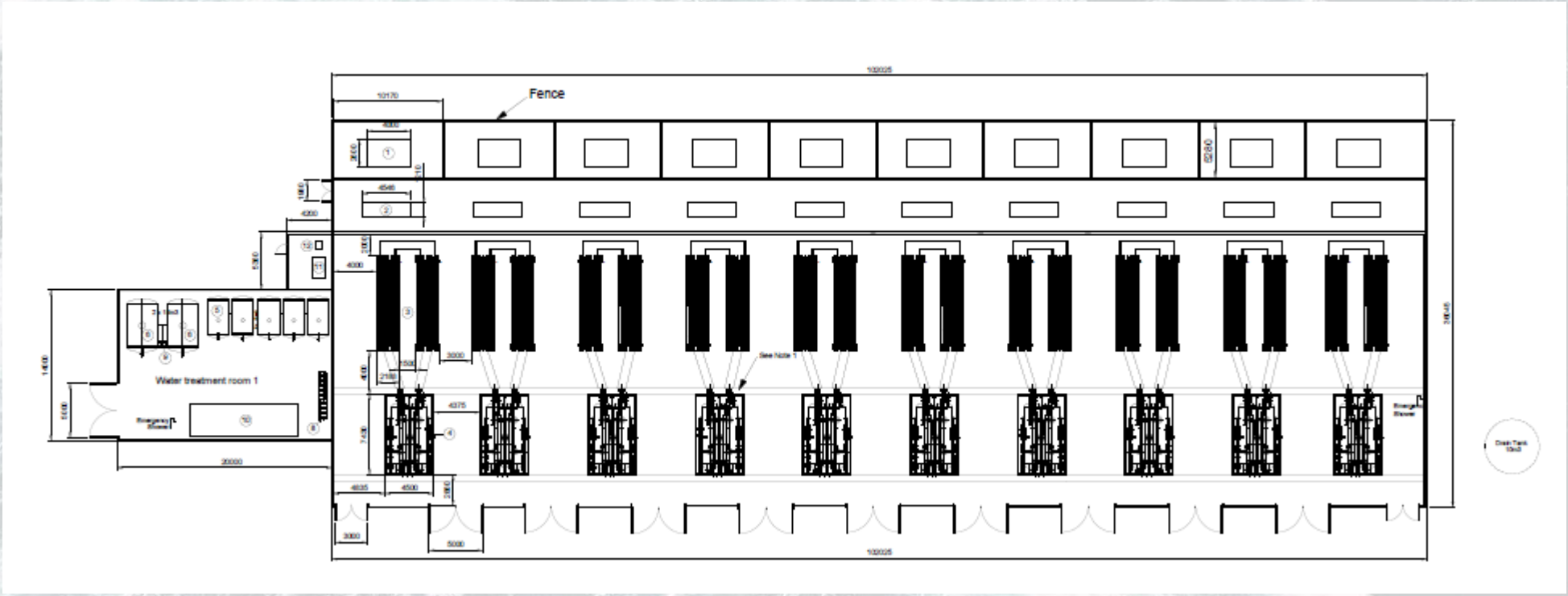
Large-scale modular hydrogen plant



Hydrogen pro

HydrogenPro technology

Layout example for large scale electrolyser plant



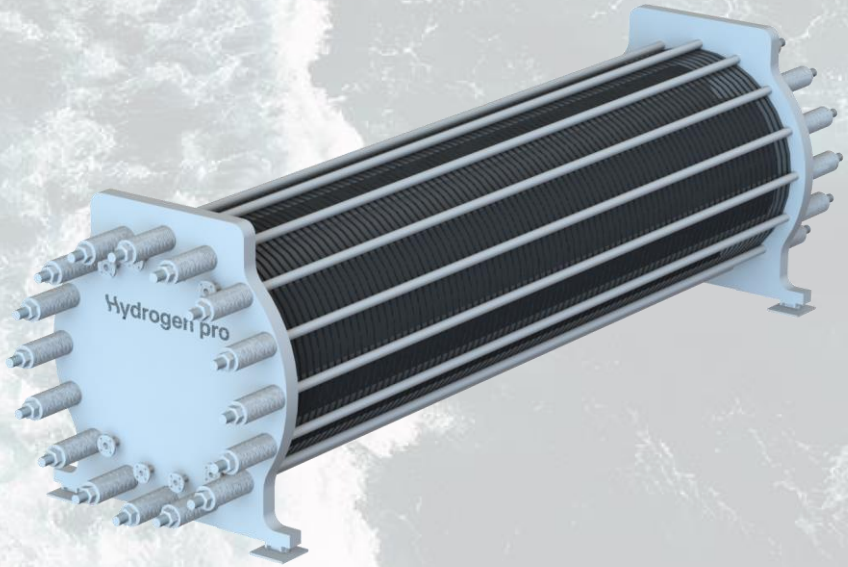
HydrogenPro technology

World largest single cell stack

- **HydrogenPro has developed the world largest single cell stack**
  - 30% larger than the largest stack delivered
  - Producing 1100Nm^3/h (~99 kg) H_2 at 15 bar
  - Length 8 m, diameter 2,5 m, weight approx. 50 tons

- **Benefits with the new cell stack:**
  - Optimization of standard electrical equipment
  - Reduction of BoP equipment
  - Lower CAPEX

- Mitsubishi Power has already ordered a pilot of the stack to be tested at Herøya, Norway

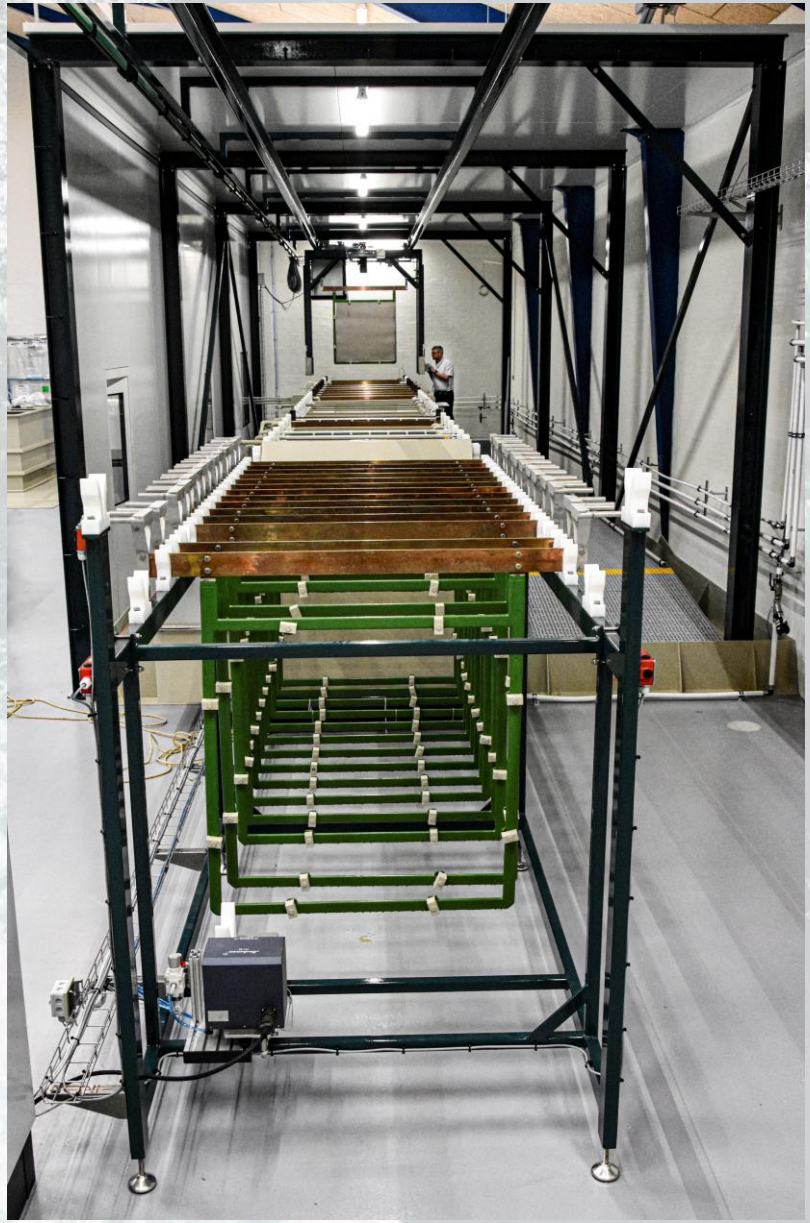


HydrogenPro technology

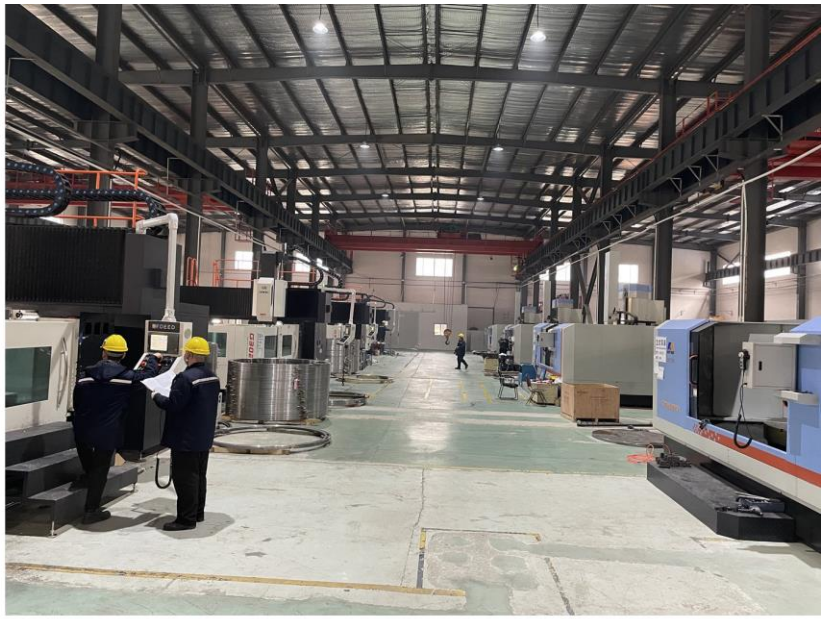
New advanced electrode technology

About the new advanced electrode technology

- Developed with partners in Denmark over the last 5 years
  - Acquisition of 100% of the shares in Advanced Surface Plating in December 2020
- Ownership of technology
  - Proprietary next-generation advanced electrode technology
  - Lower the voltage for hydrogen formation -> increased efficiency
  - Potential to improve operating efficiency of electrolysers with up to **14%**
    - Current electrolyzers consume **4.4 MW** to produce **90 kg H_2/hour**
    - Tests show that this is reduced to **3.8 MW**
    - Reaching an efficiency factor of **93%** of theoretical maximum capacity
- Full-scale plating facility ready Sept 2021 in Aarhus, Denmark



HydrogenPro China manufacturing and Electrode production in Denmark



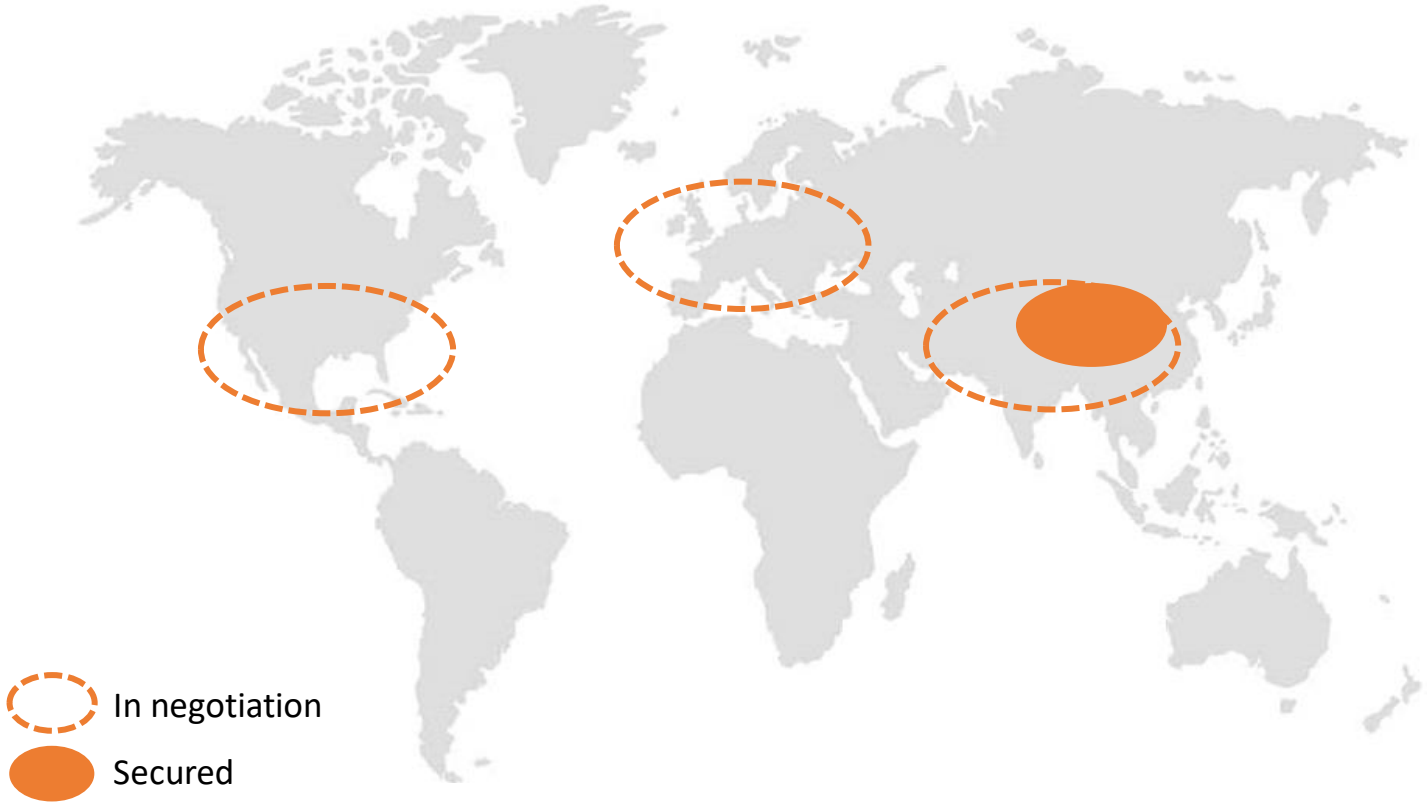
Located in Tianjin, China

- ✓ Major milestone in global technology and manufacturing strategy
- ✓ Full control over IP and core technology
- ✓ Extend to 300MW production capacity by Q2/22

Located in Aarhus, Denmark

- ✓ Advanced surface plating production
- ✓ 100MW production capacity
- ✓ Extension under preparation

Global fabrication set-up to maintain cost leadership and ensure local presence



- Preparing for three main production hubs located in Europe, US and APAC
- Dynamic, flexible and asset light supply chain
  - Reduces upfront cost related to establishing own fabrication sites
- Partner with world-class fabrication & construction partners
  - Jointly develop supply chain aligned with market demand

First milestone: >1GW global production capacity

HydrogenPro to become #1 large-scale provider of green hydrogen production plants

TECHNOLOGY LEADER	✓ Global IP rights for core technologies ✓ Owner of next-generation advanced electrode technology ✓ HydrogenPro's efficiency advantage is a game changer, reducing levelized cost of hydrogen significantly
STRATEGIC PARTNERSHIPS	✓ Strategic partnership to scale up fast and take a leading position in high-growth markets. ✓ Combine key competencies of each party
GLOBAL FABRICATION STRATEGY	✓ China manufacturing 300MW production capacity ✓ Production hubs in Asia, Europe and the US to maintain cost leadership and ensure high local activity in end-markets
HIGHLY SCALABLE PRODUCT OFFERING	✓ Large-scale solutions for a wide range of end-users in all segments and continents ✓ Easily scalable to meet end-user criteria ✓ Productivity improvements, cost reductions in design & standardization
LIFE CYCLE PARTNER	✓ Technology and innovation - Design and engineering - System integration - Commissioning - Maintenance and operation support

Hydrogen pro

Hydrogen pro

www.hydrogen-pro.com

clean *green* hydrogen

Gen$_2$ Energy

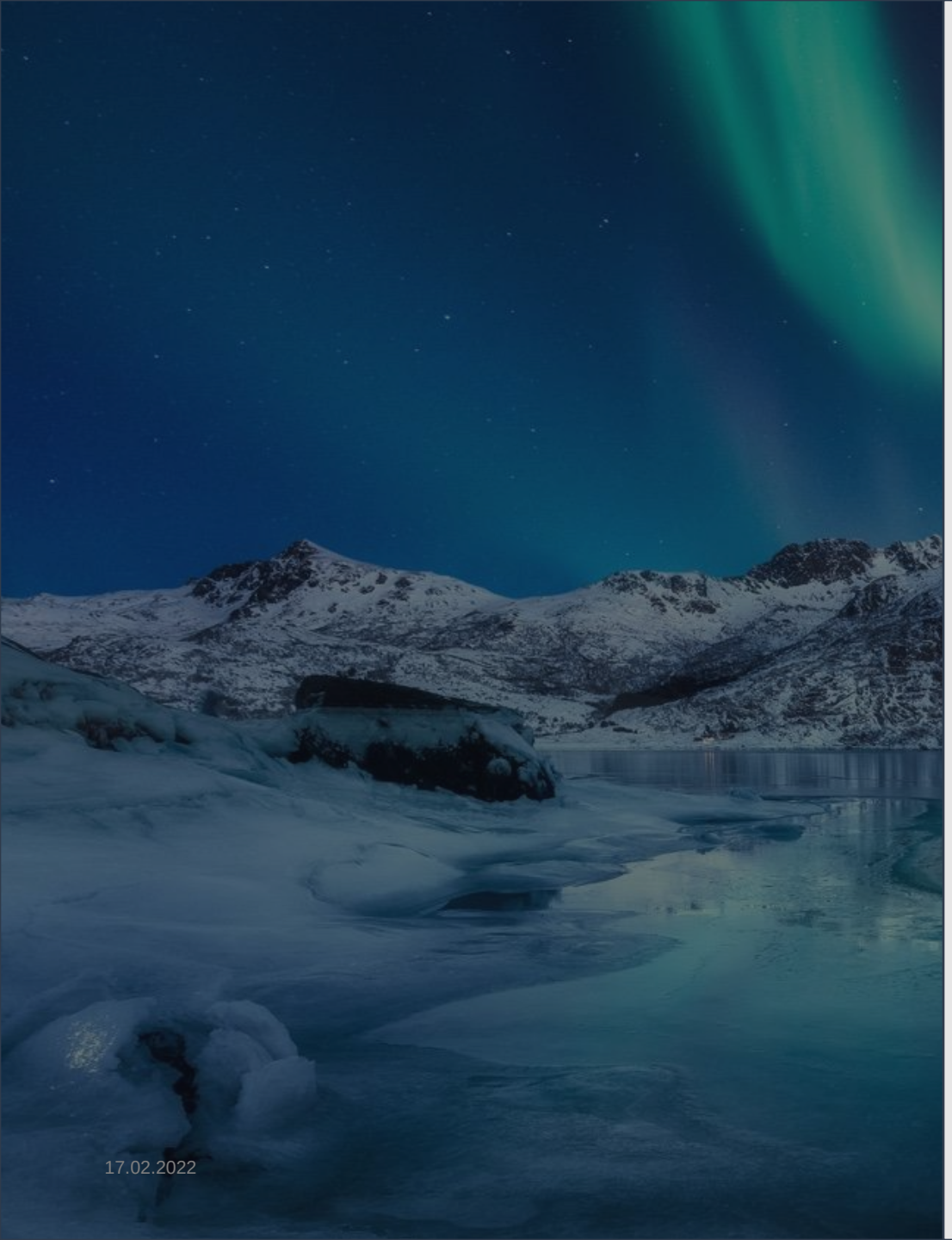
Green Compressed Hydrogen from Norway to Europe – how to make it work internationally

CTO Odd-Arne Lorentsen, PhD

February 2022

odd-arne.lorentsen@gen2energy.com

www.gen2energy.com



- Gen2 Energy (G2E) in short
- Challenges with large volumes of H_2
- G2E’s solutions to production
- G2E’s solutions to H_2 storage
- G2E’s solution to H_2 transport
- G2E’s customer focus
- G2E’s first H_2 production site

1: Gen2 Energy's Vision

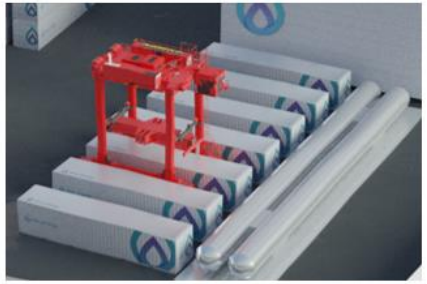
Green Hydrogen
To be a cost-competitive key supplier of certified clean green hydrogen in Europe

Circular Economy
To be the preferred partner for clients with focus on circular use of resources.

Local Value Creation
To engage, create value and energize where we are

1: Gen2 Energy's value chain

Production (electrolysis) using green hydrogen, hydropower



Storage of compressed hydrogen in containers

Transport of containers onboard vessels, car or train

Interim storage of compressed hydrogen in containers

Use of compressed hydrogen directly from containers at end-users' site

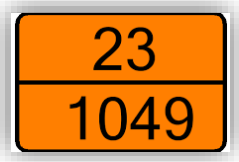
Transport of empty containers back to production site

Safety first!

Gen2 Energy

2: Challenges with handling large volumes of H_2

- Safety first – large volumes not handled before
- Site for production with
  - Green power
  - Clean water
- Compliance - Regulations and approvals for transport needed
  - Containers for hydrogen
  - Vessels for containers (IMDG approval for sea transport)
  - Road transport @high pressure (ADR approval)
  - Rail transport @high pressure (RID approval)
- Financials
- Efficient transport/logistics
- Satisfy customers' needs
  - Solutions and cost of hydrogen



3: Site for production – “First we take Norway, then…”

- Norway still has excess competitive green power with poor transmission lines out of the region
- Access to clean water is not a problem in Norway
- Access to industrial sites near power lines
  - Last miles issues to be handled
- Strong competence and long experience within electrolysis and materials technology
  - 3 Norwegian electrolyser suppliers

Gen2 Energy

4: G2E's solutions to H_2 storage - Compressed hydrogen (CH2)

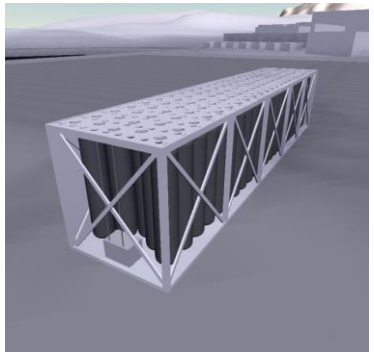
PROS

- Well known technology
  - Low technology risk
- Easy to make
  - Compression
- Easy and fast to store
  - Compressed tanks
- Easy & safe to transport
  - Small quantities per unit
  - Compressed mostly used near consumption site

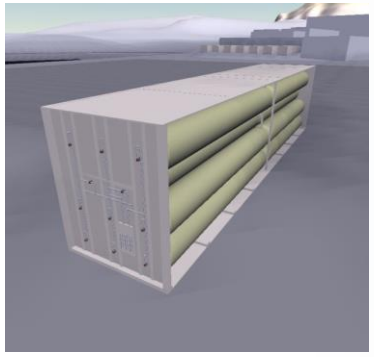
CONS

- Low density
  - Costly to store and transport
- **Transport approval** for large volumes @sea, @road and @rail
  - Soon to come
  - Fastest track to allow for large volumes of hydrogen being transported

Steel



Carbon fibre



Glass fibre

Gen2 Energy

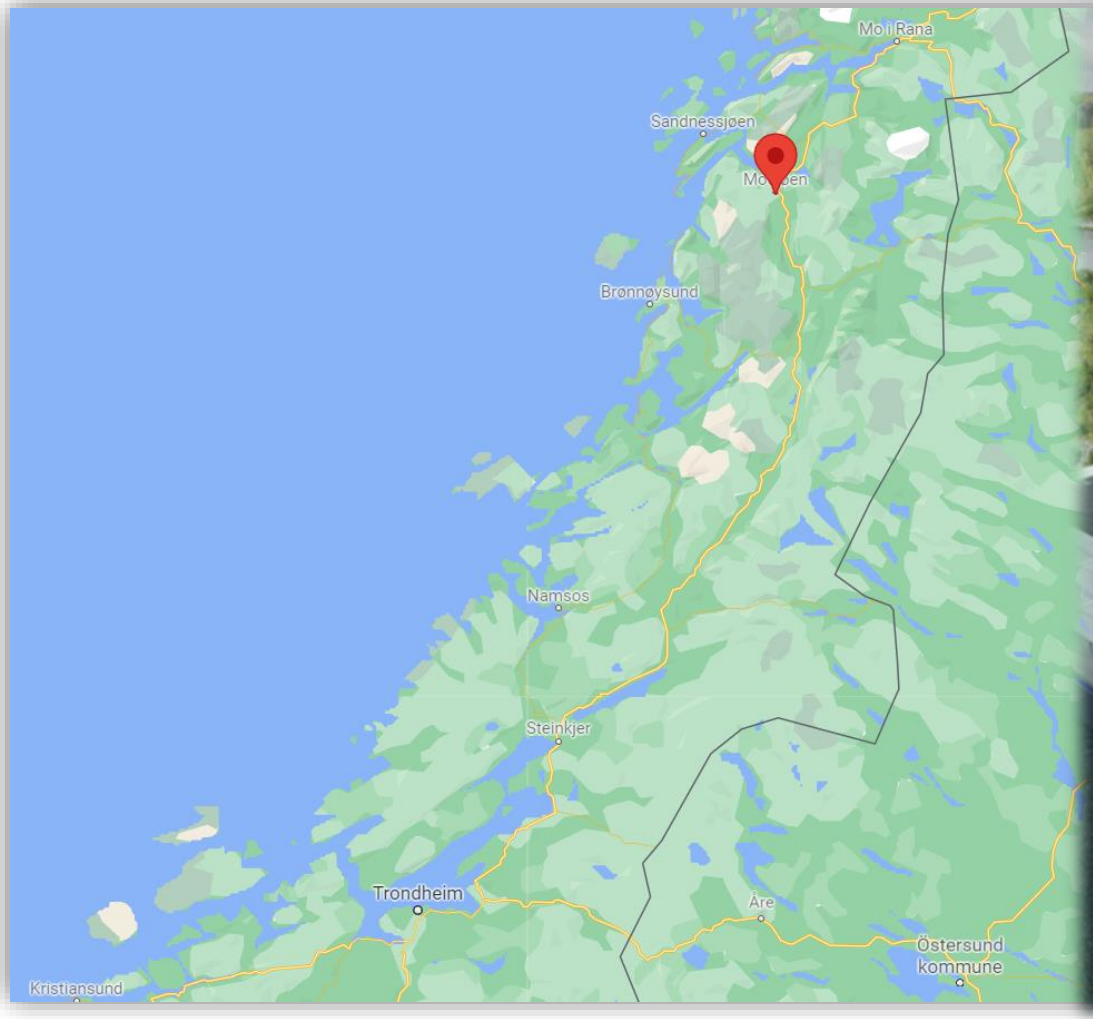
5: G2E's solution to H_2 transport

- In order to maximize the benefit of cheap production (power), one needs a lean and efficient logistic.
  - Carry large volumes of containerized compressed hydrogen @350 bar is efficient and economic sensible
  - **Transport at sea** is cheapest and safest
  - Route planning and timing makes sense
    - Sensoring and tracking
    - Not only fast, but timely without wasting transport fuel, time at ports, traffic jam etc.
    - Containers in use or on the move "all" the time!

6: G2E's customer focus

- **G2E wants to deliver hydrogen as a service**
- **Local hydrogen market in Norway**
  - Few, but many are interested – need a gentle push
  - Small, but growing
  - Some interesting markets:
    - Ferries & coast boats
    - Yellow fleet
    - Industry (heating)
- **External hydrogen markets**
  - Hungry for hydrogen – NOW!
  - Many can accept deliveries at the port
    - Avoid last mile transport
  - Some interesting markets
    - European gas grids
    - Steel industry
    - Transport
      - Heavy-duty trucks
      - Rail
    - Yellow fleet
    - Distilleries

7: First production site in Mosjøen

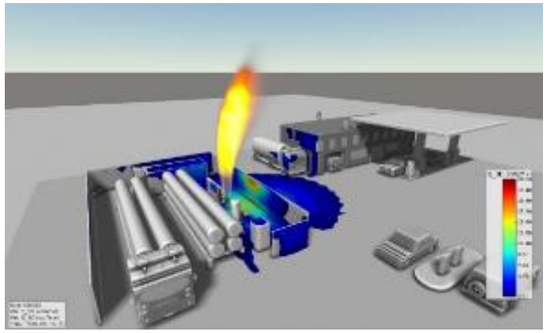


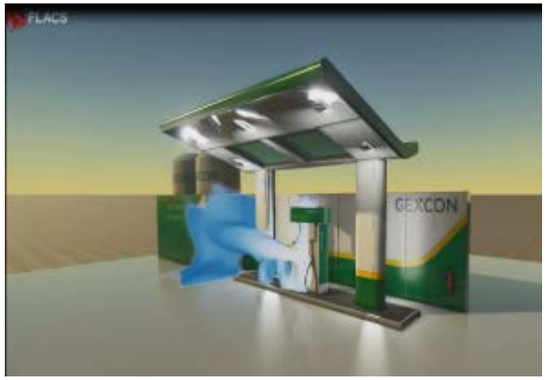

The future is green

GEXCON

Practical Approach to Process Safety on Hydrogen Systems

Expertise in Hydrogen safety

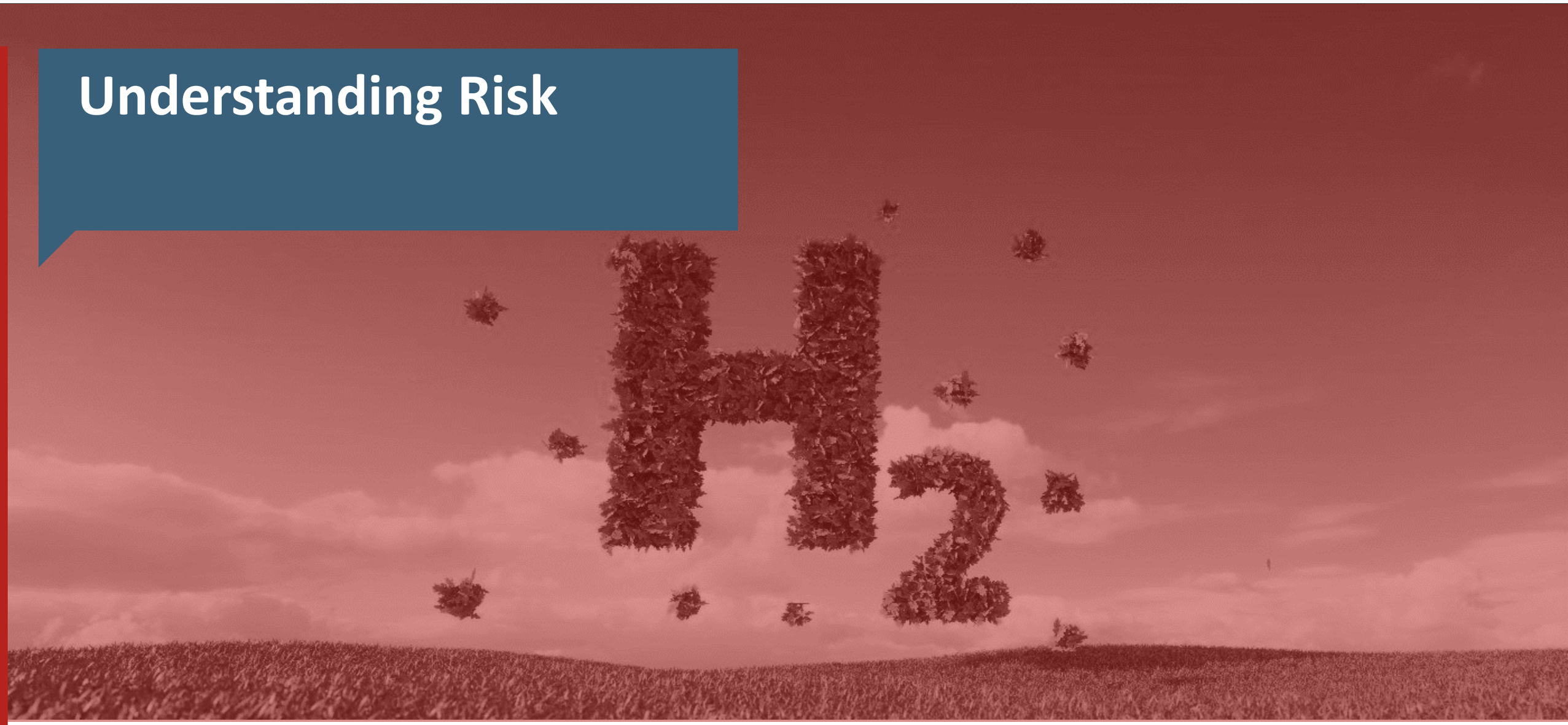




- Gexcon has a strong experience on various H_2 related projects
  - Process safety and safety reviews
  - Assistance for conceptual phase : safety distances, arrangement/layout optimization
  - Regulation and ATEX compliance
  - Optimization of ventilation and gas detection
  - Modeling of accidental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

PRODUCTION STORAGE TRANSPORT DISTRIBUTION MOBILITY

Understanding Risk



Full scale test

Eye-opener for Gexcon's competence and capacity

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

Significant learning:

Explosion pressures can be directed away from area of occupancy

Implemented in software

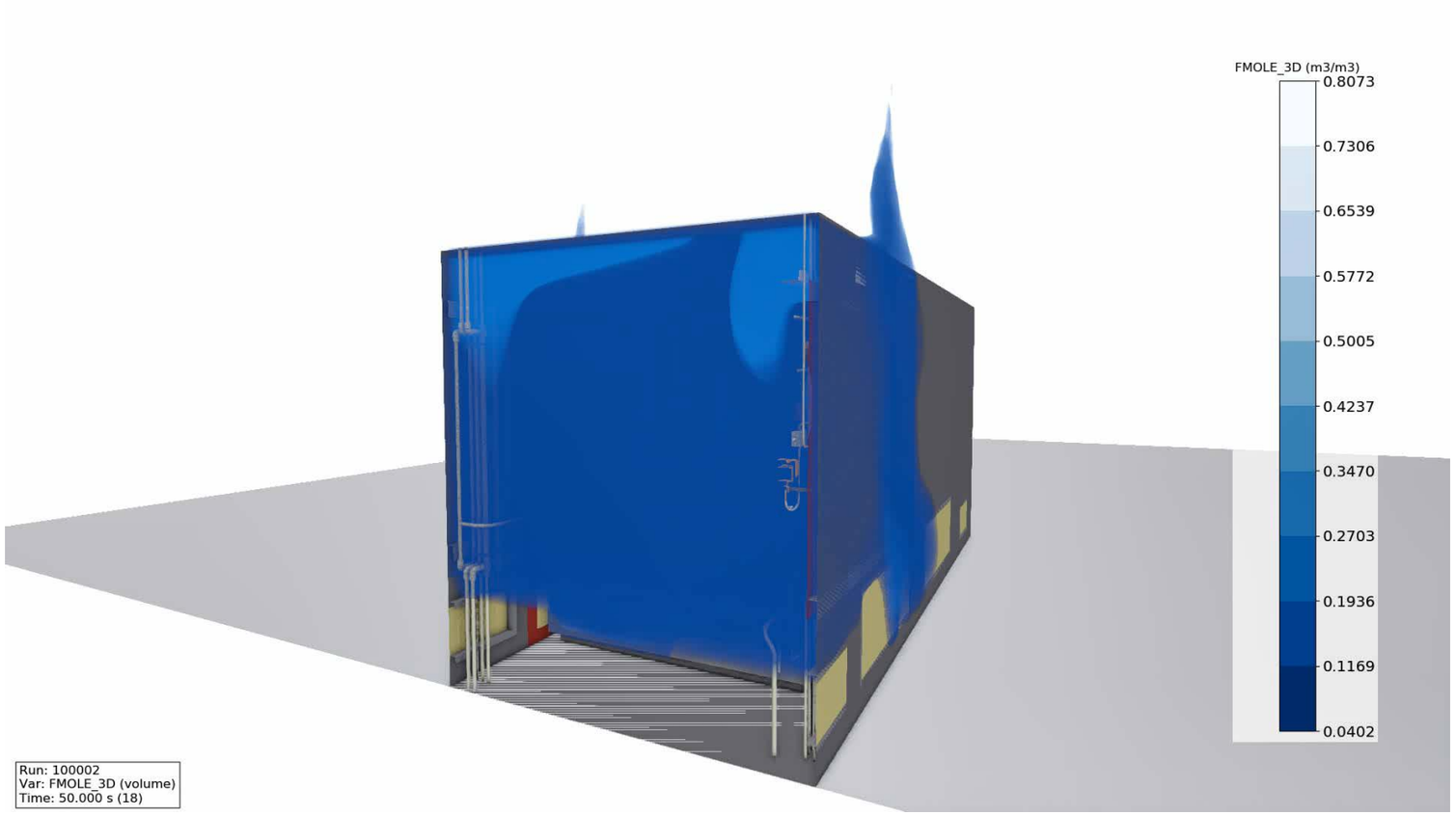
- Various dummy equipment configurations to mimic vehicle fueling compressor stations
- Framework in ceiling to accommodate explosion vent devices
- FLACS has been calibrated against large-scale explosion experiments at the Gexcon test site.

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

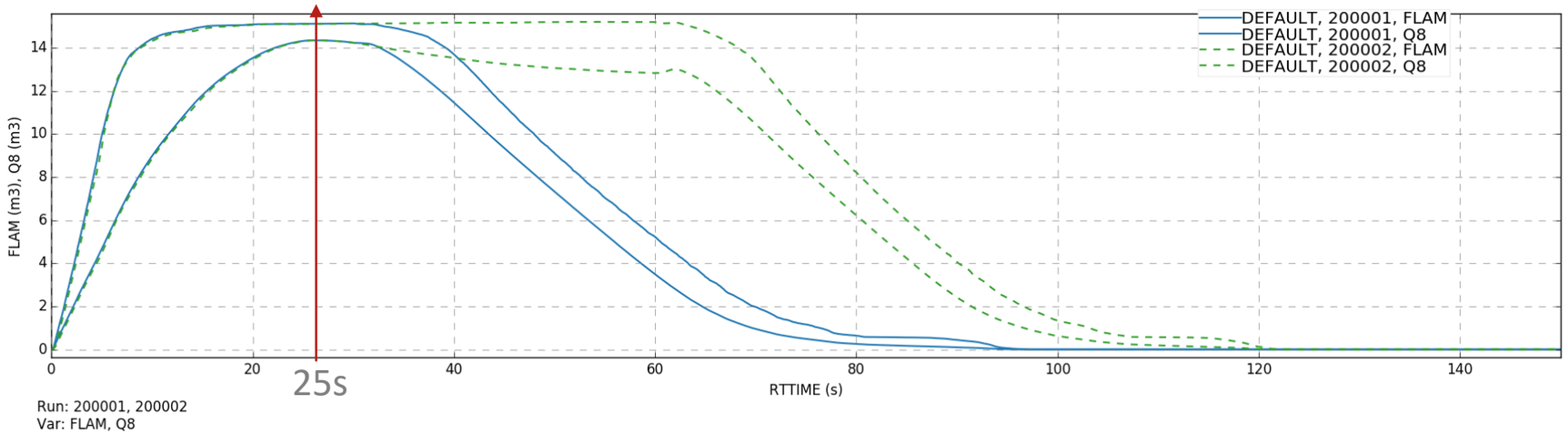
Fuelling Compressor Container

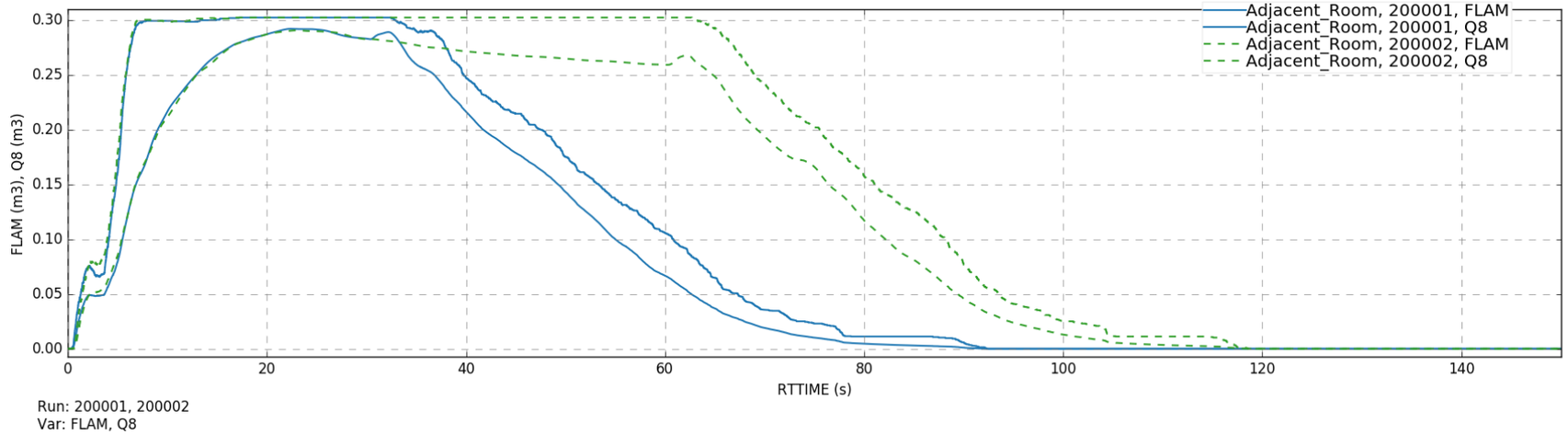
Dispersion

- Transient leakage profile
- Effect of ventilation, including sensitivity
- Estimation of flammable cloud, including concentration profiles



Dispersion results – 0.5mm² leak hole



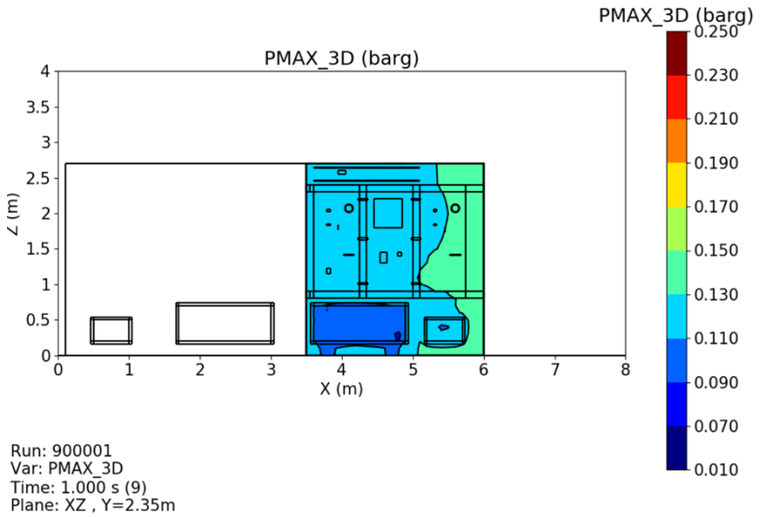


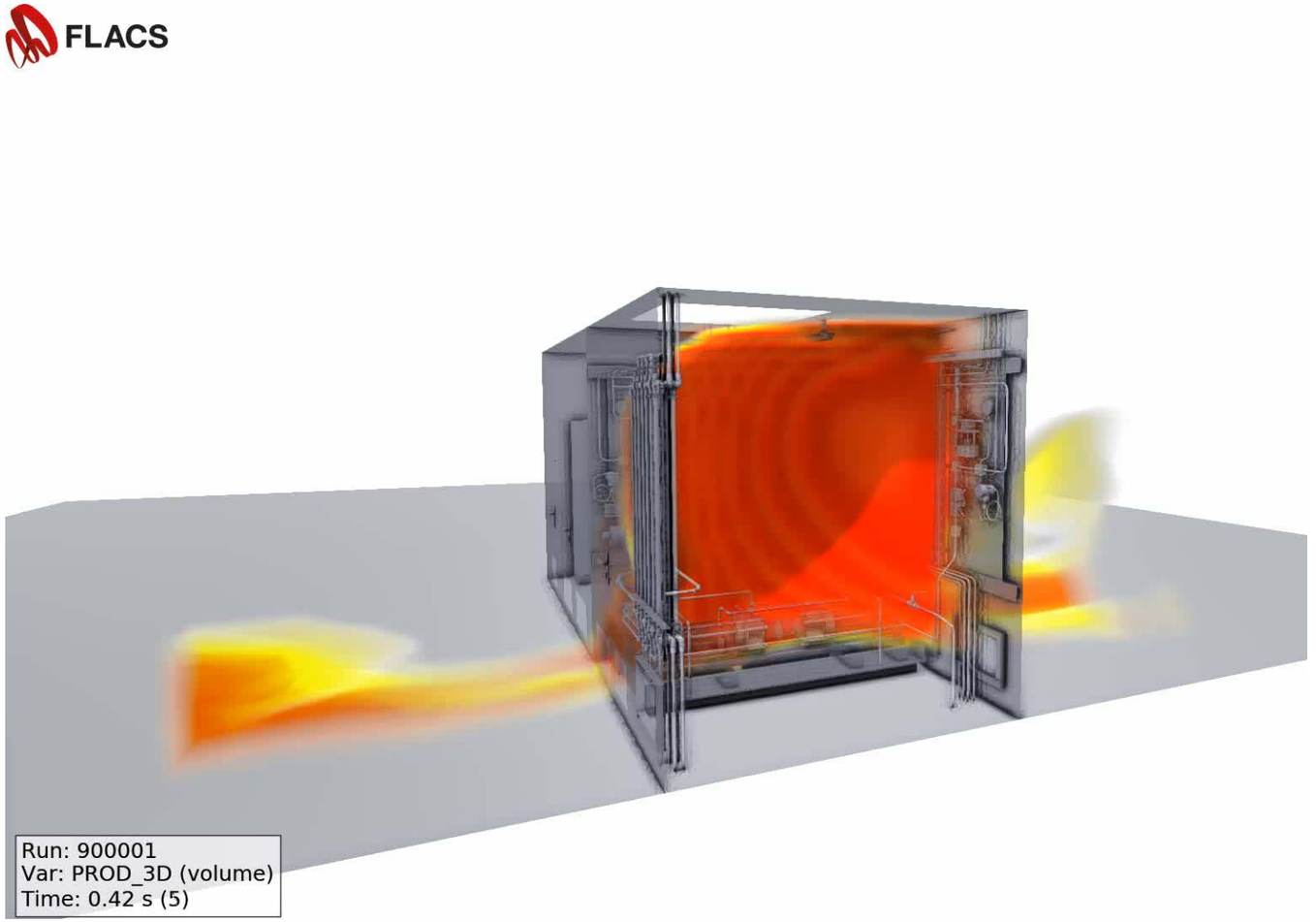
- In this case, the cloud reaches its maximum reactivity at **25 s**. This cloud is very reactive (Q8 close to FLAM).

- Definitions
- FLAM – Volume of flammable mixture
- Q8 – Volume of equivalent stoichiometric mixture

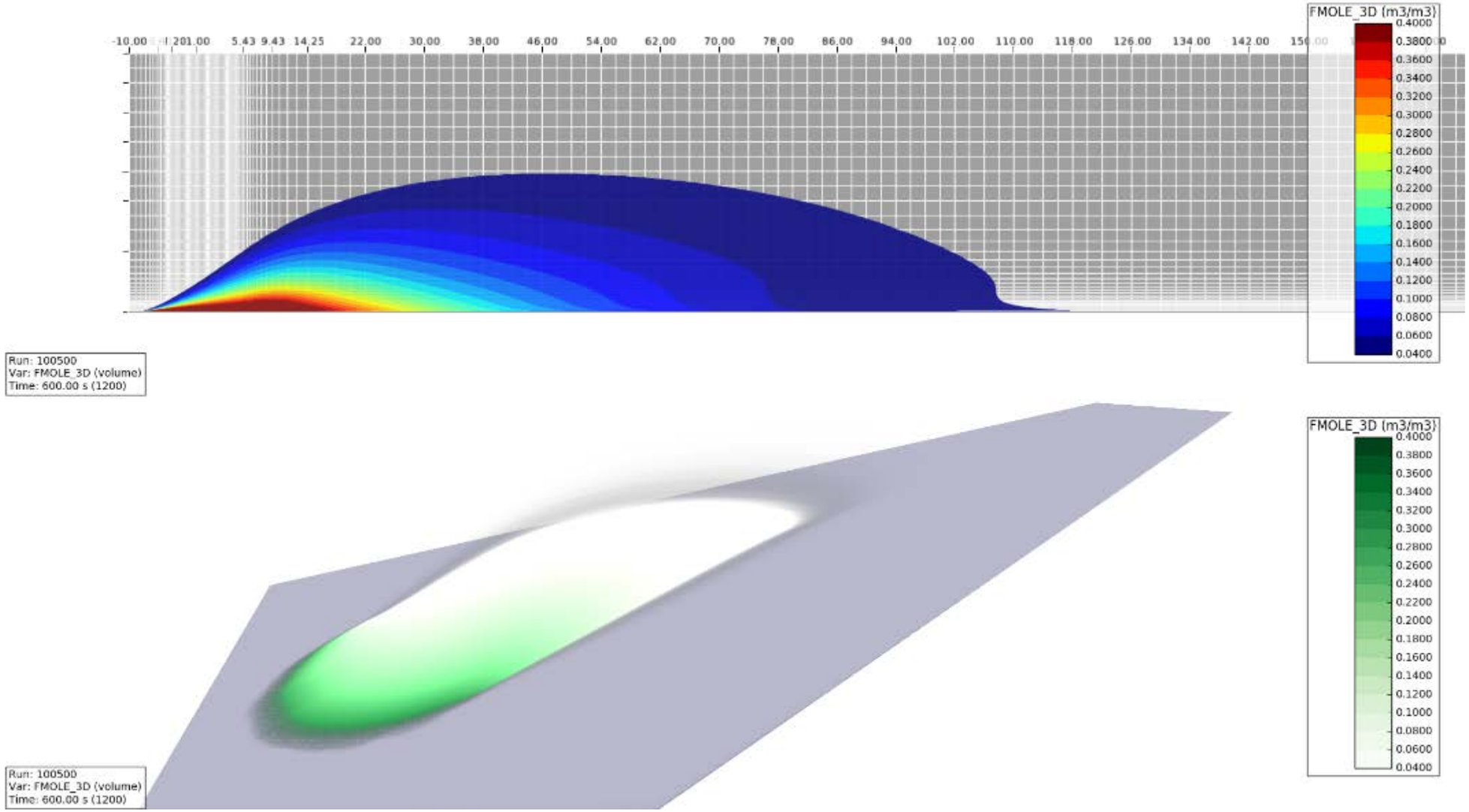
Fuelling Compressor Container

- Explosion loads on structural elements
- Verification of explosion relief panel size and location





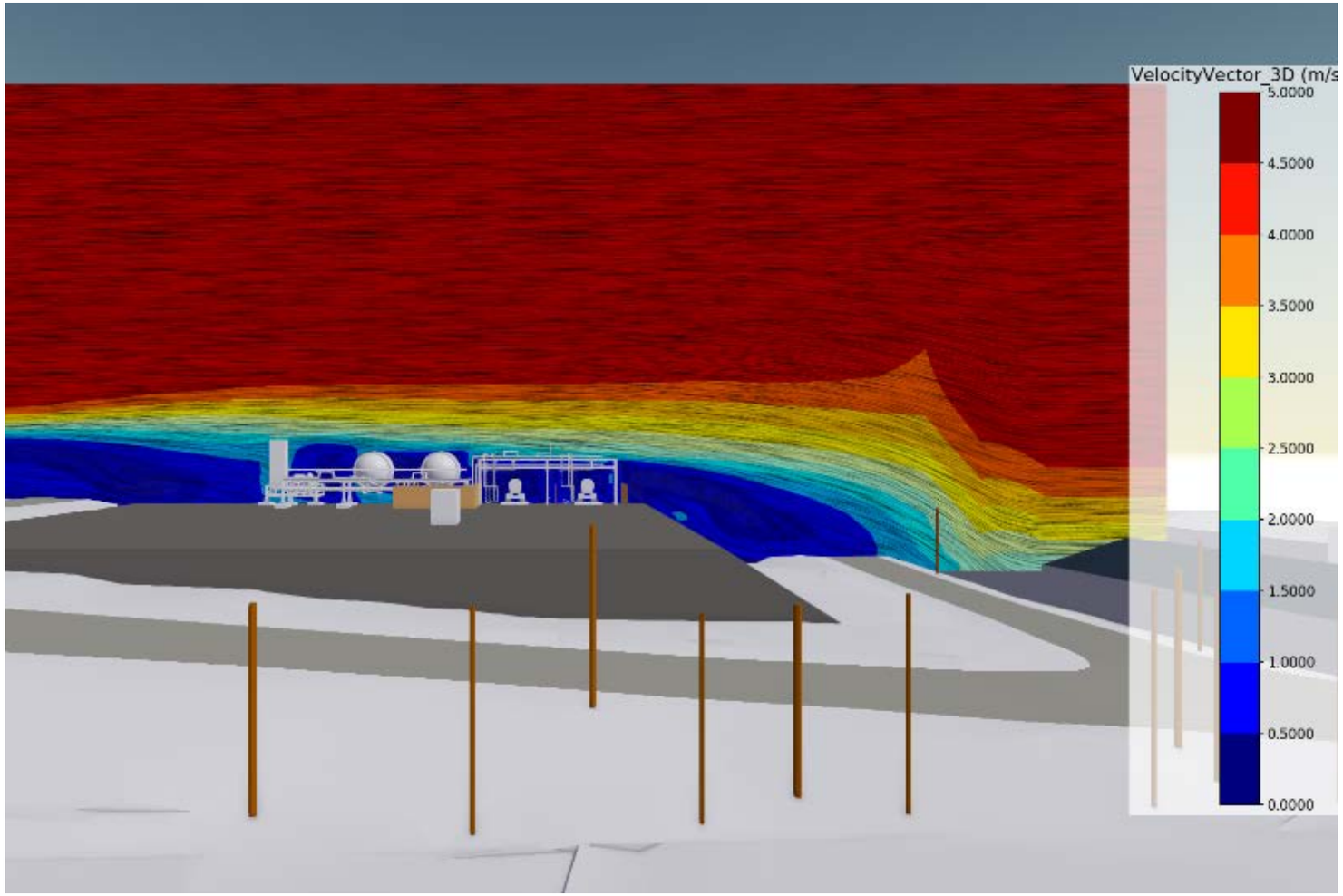
Dispersion – open field

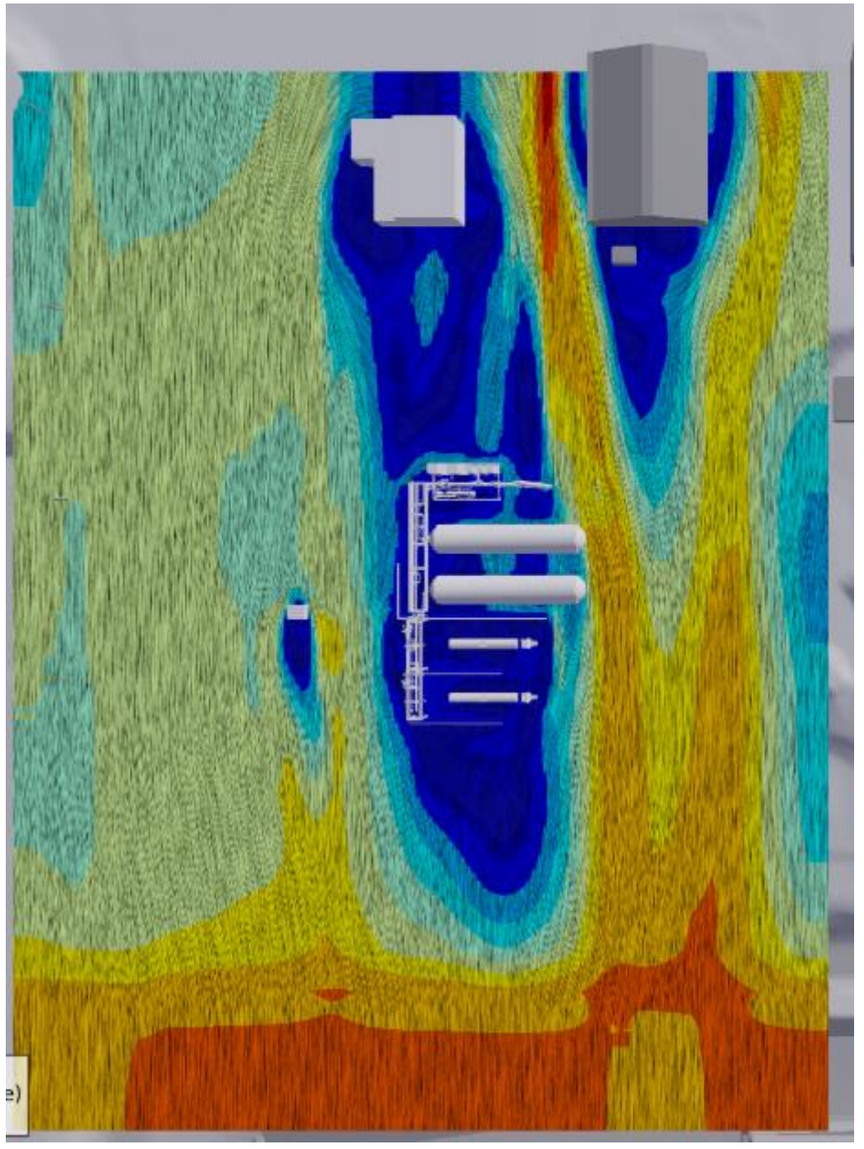


Consequence modelling

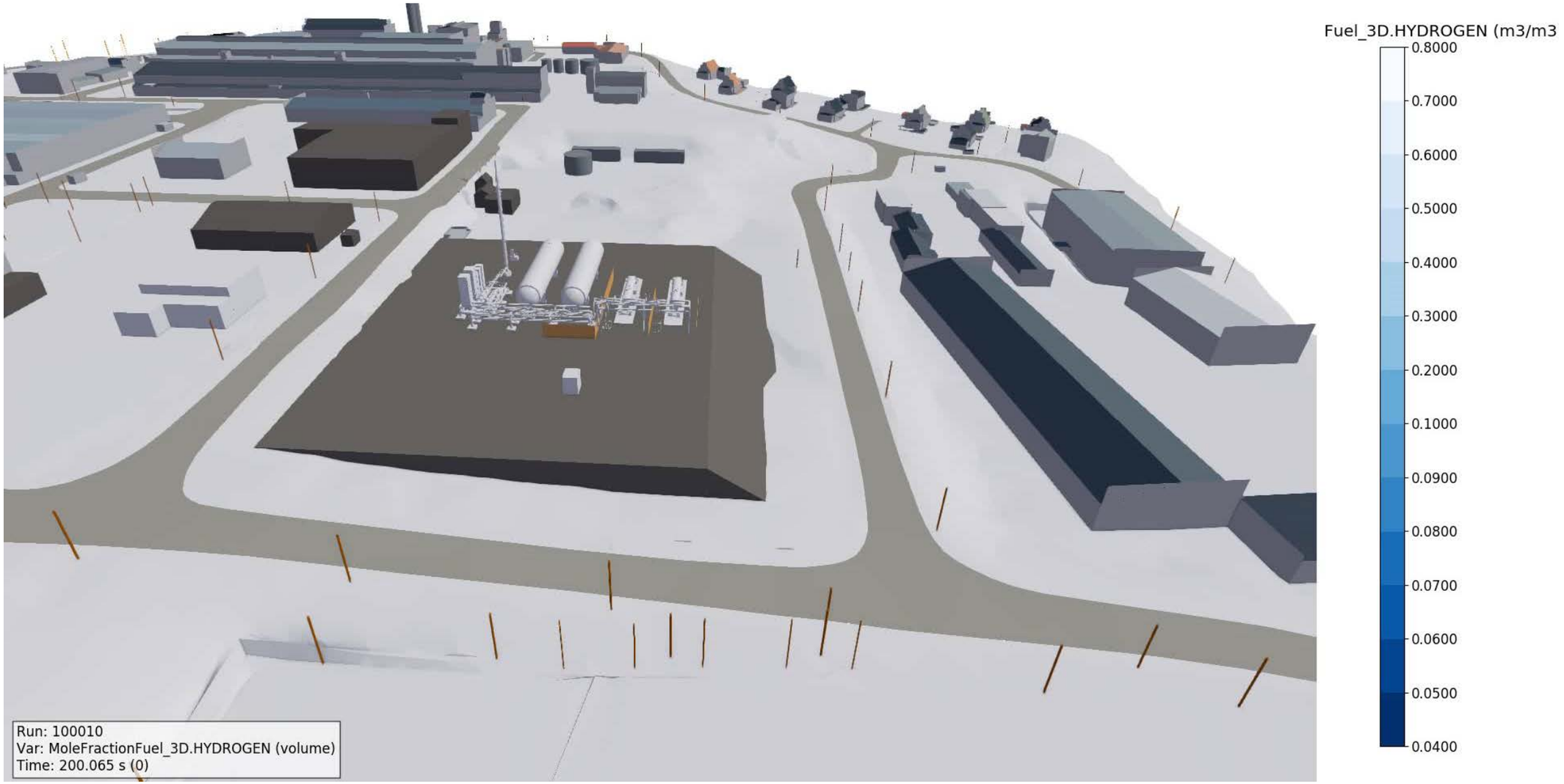
- 3D FLACS model generated by Gexcon, landscape and buildings included

Ventilation Simulations

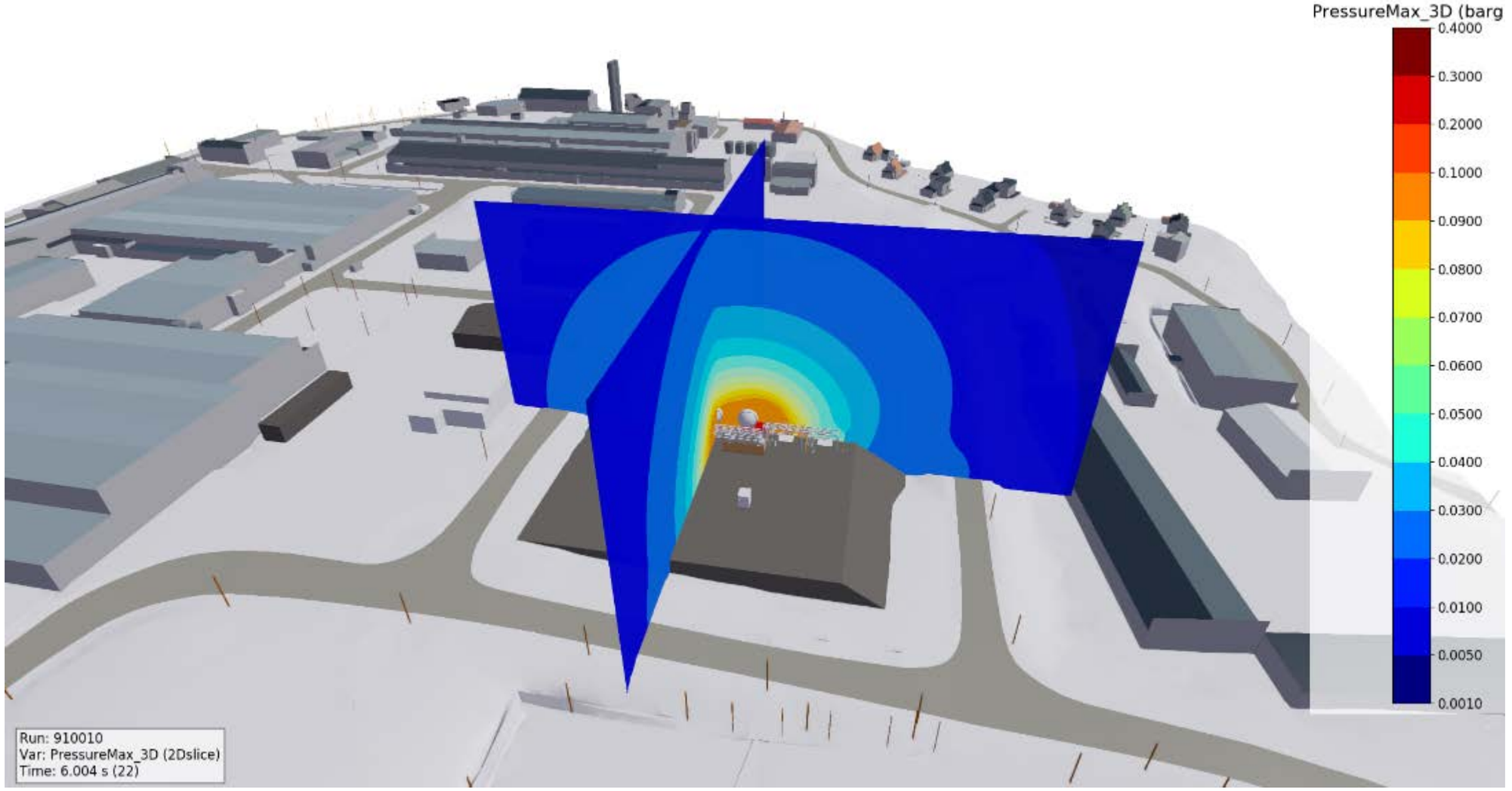




Liquid H2 Dispersion



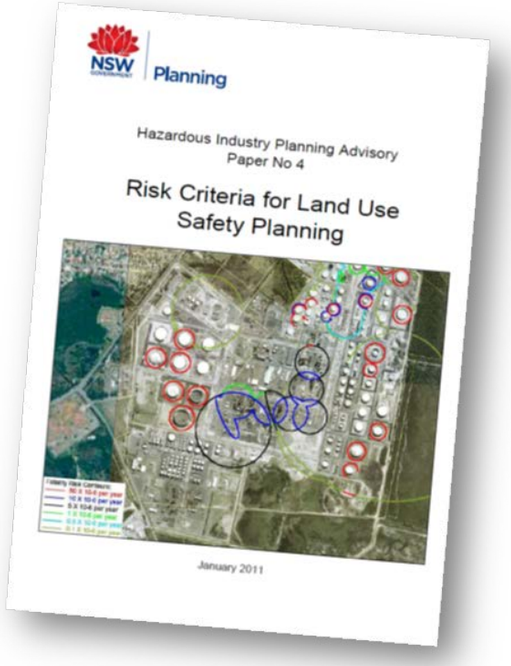
Explosion simulations



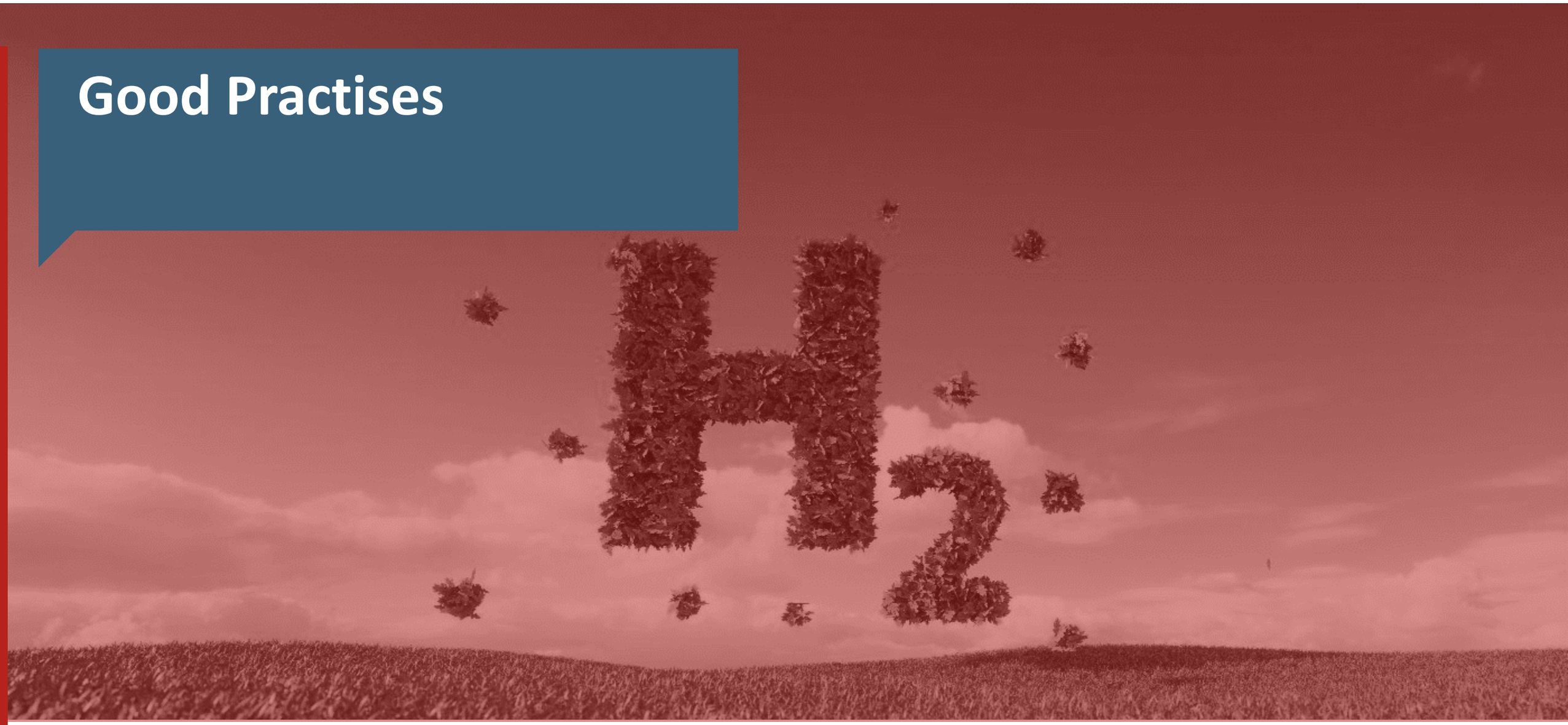
Risk Analysis for licensing

Risk Contours

- Individual fatality contours
- Measurements against applicable risk acceptance criteria



Good Practises



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
- Detection of leakages by detectors plus improved control system algorithms
- Fully paved areas under pressurised systems
- Avoid asphalt paving under cryogenic systems
- Ignition source control ATEX IIC T1, or IIB + H2
- Develop suitable maintenance and inspection procedures

Activities to verify Safety

- Hazard Identification to ensure that all relevant risks are captured and covered in risk management
- Hazard and Operability Study to ensure that any deviation from normal process conditions are detected and actions are to prevent development into a hazardous situation
- Ventilation and dispersion studies to assess the likely sizes and locations of flammable clouds in the event of leakages, and that extend of ATEX zones and locations of detectors are suitable
- Fire and explosion modelling to verify that events can be controlled so that risk to personnel and third parties is controlled

Major Hydrogen clients to date

Thanks for your attention

Geirmund Vislie

Vice President Hydrogen Safety

Geirmund.Vislie@gexcon.com

Horisont Energi | Hydrogen & CCS Symposium, Canada

15 February 2022 – Rasmus Holmer, CCS

Horisont energi

Horisont Energi at a glance

Based in Norway and UK

- Founded in 2019
- Head offices in Stavanger
- Strong strategic and investor line-up

Key focus areas in our company

- Focus on learning, innovation and results
- Development of strong industrial sized projects and partnerships

Extensive competence and experience from

- Oil & Gas subsurface activities
- Offshore facilities developments
- Onshore hydrogen and ammonia facilities development

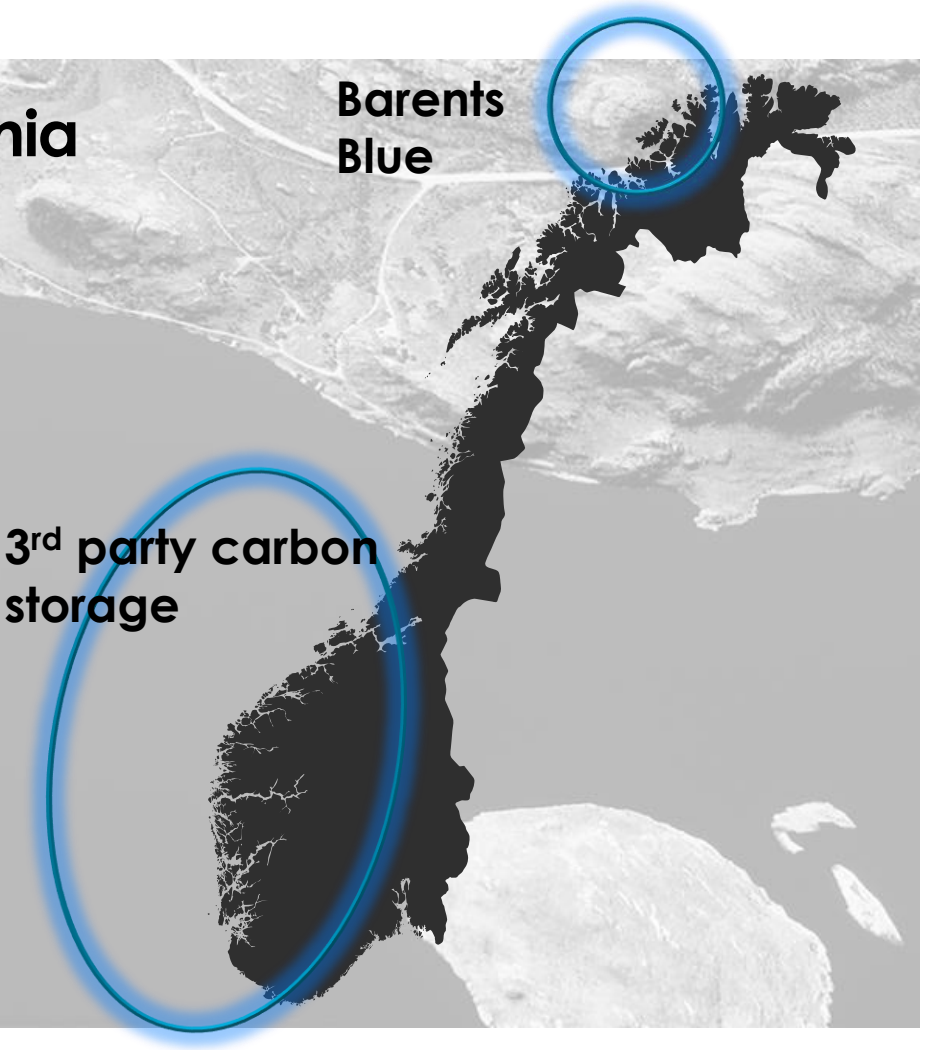
Objective ► Top-ten European Clean Energy Company

1 First to market with world scale clean ammonia

- Deliver cost-competitive clean ammonia to the global market
- Become the preferred supplier of clean ammonia in Northern Europe

2 The carbon storage cost leader

- Europe's preferred carbon storage provider
- Europe's leading carbon storage asset developer



European Commission

Norwegian IPCEI hydrogen candidate project

Horisont energi · vår energi · equinor

Europe's first world-scale clean ammonia plant

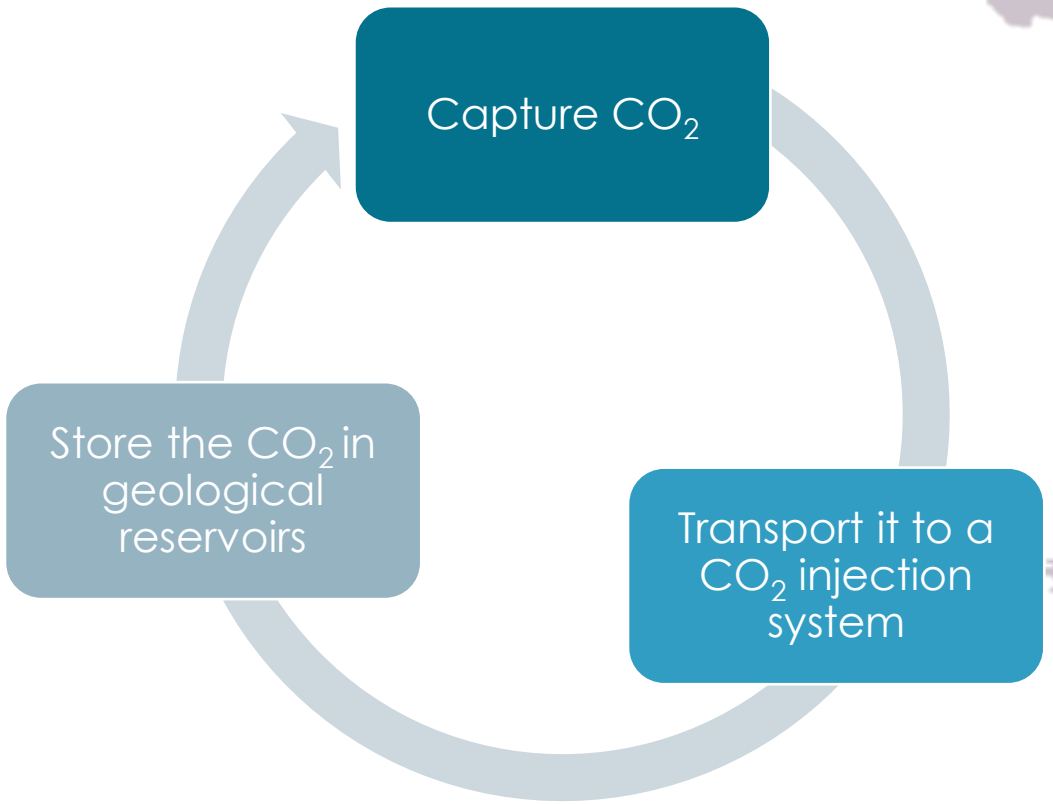
PROJECT BARENTS BLUE

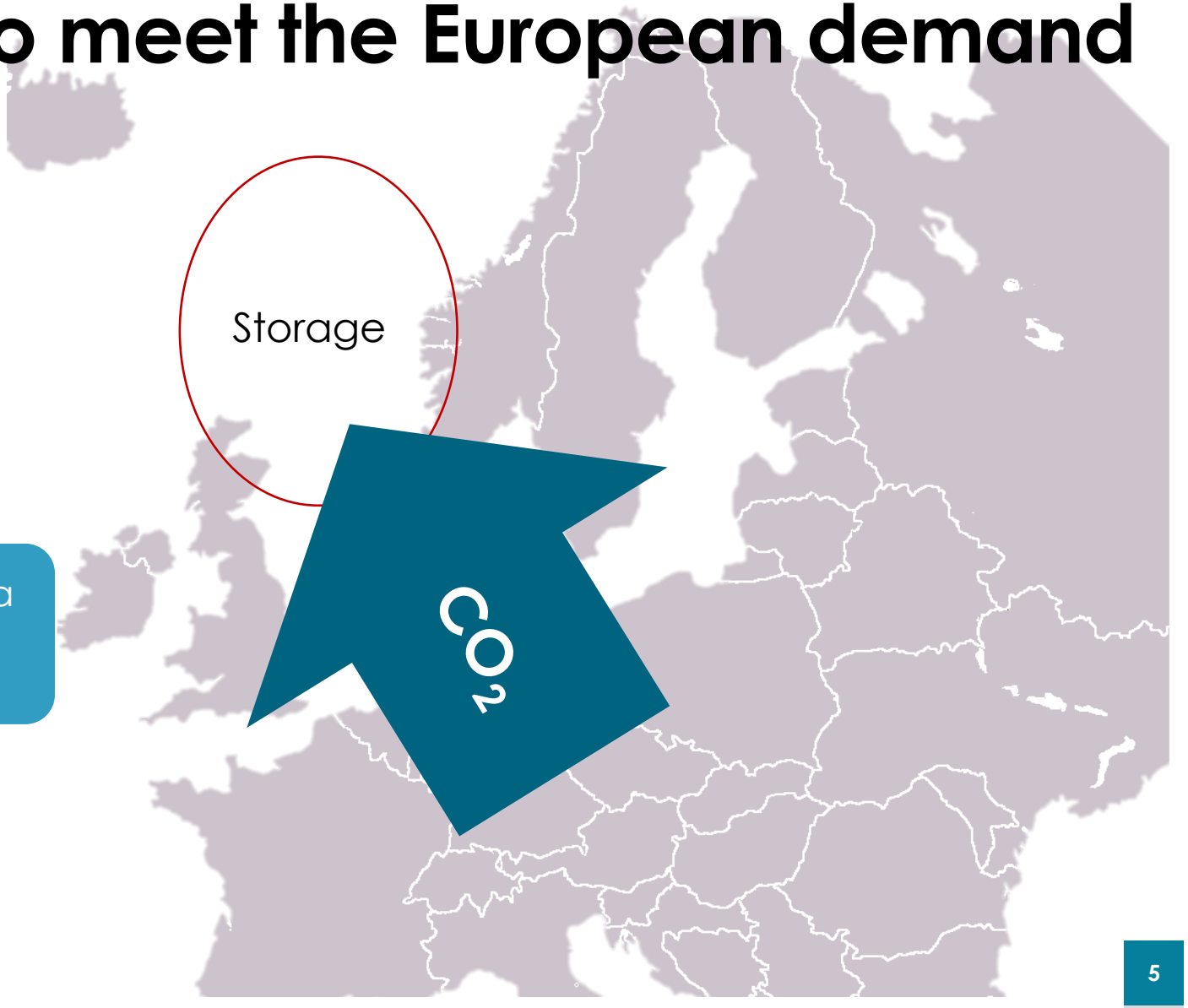
Developing the most carbon and energy-efficient ammonia plant in the world

- Mostly **self-sufficient on power**, limited renewable electricity from the grid
- **Zero emissions** and environmentally-friendly plant
  - Focus on **sustainable solutions and circular practices** in design and in selection of consumables
  - Focus on **avoidance of sound and light pollution**
- **Compliance with the EU Taxonomy**

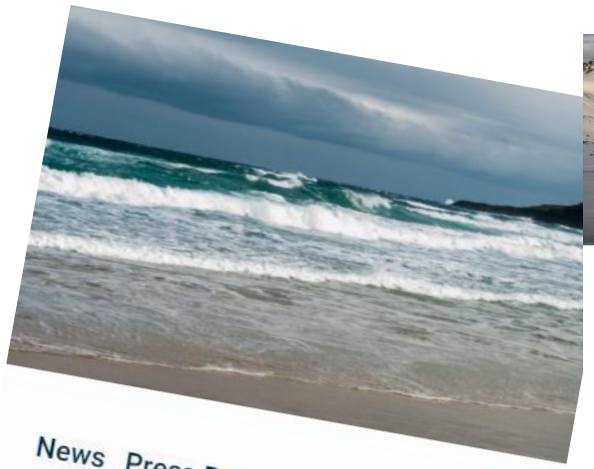
- **Start-up year: 2025-26**
- **Daily input pr train (gas): 2.8-8.4 million Sm3/d (train 1-3)**
- **Annual output (NH3) by 2030: 1-3 million ton/yr (train 1-3)**
- **Overall CO_2 capture rate: above 99%**
- **CO2 injection: 2-6 million ton/yr (train 1-3)**

Horisont Energi works to be the carbon transport & storage cost leader to meet the European demand





Horisont Energi is in the forefront of the energy transition



News Press Release

Baker Hughes and Horisont Energi Sign MoU

News Press Release

Barents Blue Project one of five Norwegian projects under consideration for IPCEI

equinor

vår energi

Publisert den 3. May, 2021 av signy

Horisont Energi inngår samarbeid med Bellona om virkemidler for karbonfangst og lagring. Selskapet skal produsere hydrogen og ammoniakk og la dioksid i et lager under h mark. Bellona he lagring av

BELLONA

Discussing innovation and new sustainable business development with the Prime Minister

Horisont Energi was invited by the Prime Minister of Norway, Erna Solberg, to contribute to a joint...

risont Energi
4 followers

edia's summary of the recent German-Norwegian energy dialogue oval where Horisont Energi participated.

...see more

argus
argusmedia.com

1970-2020

Takeaways

- Industrial scaled projects are needed to activate the ENERGY TRANSITION NOW!
- Clean ammonia and CCS – considered a marginal business ► Cost efficiency is key!
- Strategic partnerships and cooperation in the value chain are critical enablers

Horisont energi

THANK YOU

"ACCELERATING THE TRANSITION TO **CARBON NEUTRALITY THROUGH PIONEERING PROJECTS**