Hydrogen Valley Denmark

15 years of "connecting the dots"

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By 2030 global greenhouse gas emissions need to be halved in order to limit global temperature increase to 1,5 degree Celsius by 2100. And by mid-century, global emissions must essentially be brought down to net-zero.

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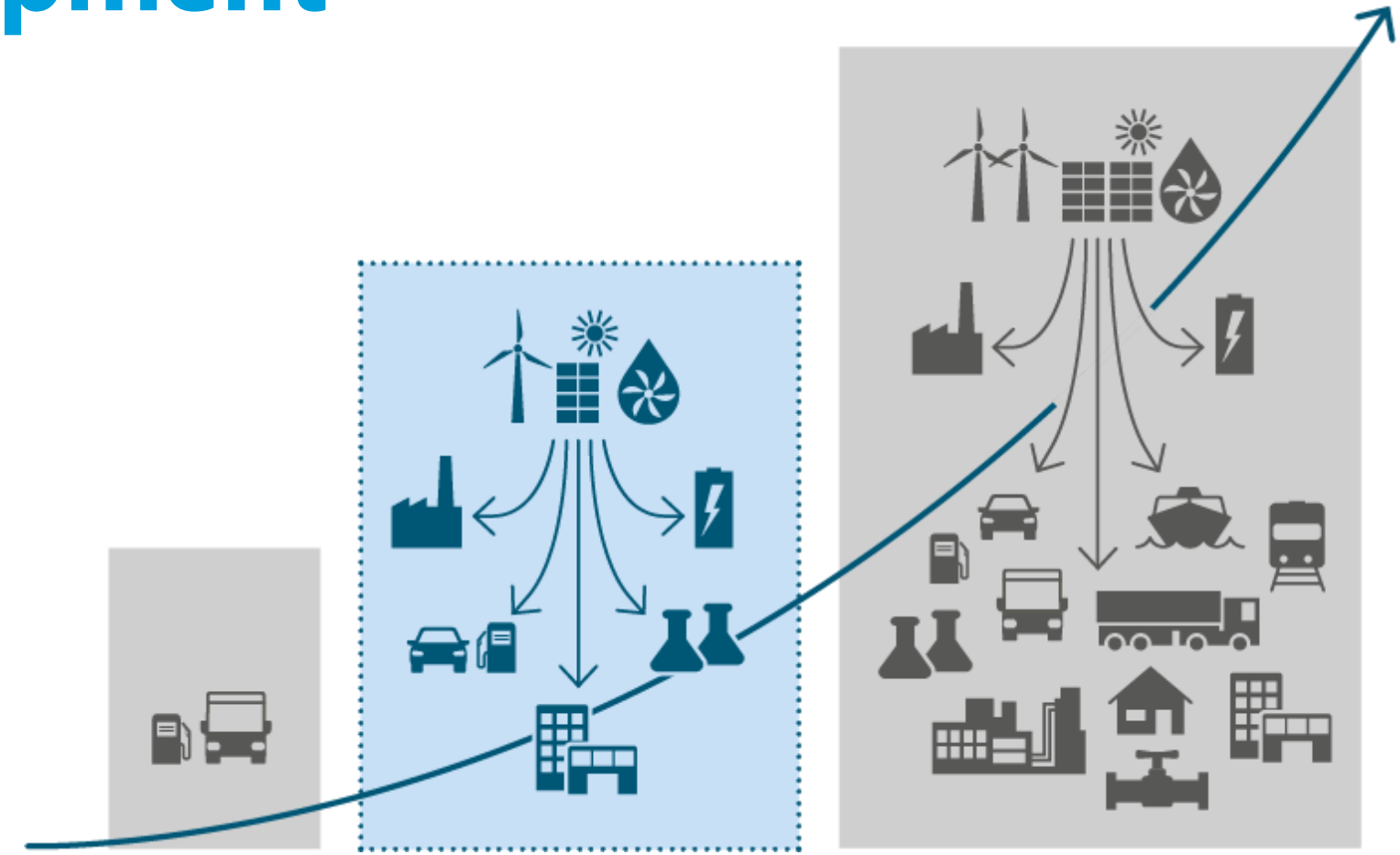
Strong hydrogen demand growth and the adoption of cleaner technologies for its production will enable hydrogen and hydrogen based fuels to avoid up to 60 Gt CO2 emissions in 2021-2050 in the Net zero Emissions Scenario, representing 6% of total cumulative emissions reductions.

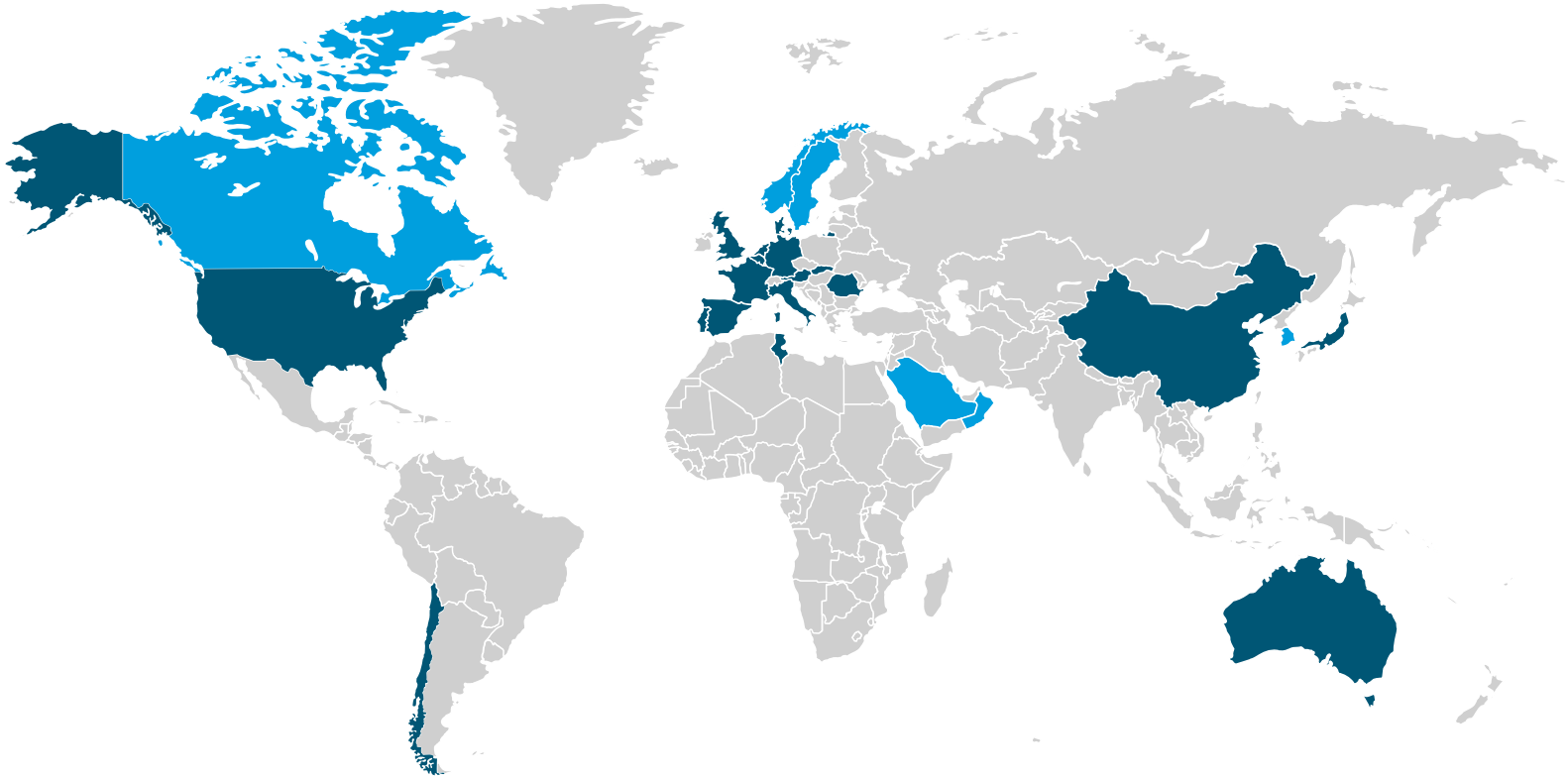
Source: *IEA, Global Hydrogen review, 2021*

Hydrogen Valleys as a catalyst for market development



Source: Clean hydrogen, JU, Roland Berger

A fast-growing landscape of globally leading projects …



> 80 valleys
from 32 countries

> 1,500
data points

10 in-depth
best-practice
profiles

+100 new hydrogen
valleys in Europe
before 2030

Countries with hydrogen valleys on the initial platform

Additional countries with major hydrogen valley activity where outreach is ongoing

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Hydrogen Valley Denmark at a Glance

Established in **2002**

Established in **2007**

Part of **37** Globally **valleys**

Collaborating with **100+** companies/ partners

Participating in **25+** networks and clusters

+50M Euro Flagship / Peer-to-peer projects

4,500 m² Green tech office space

2,000 m² test facilities

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Empowering Green Transitions

Mission

We want to create a base to growth and work places within sustainable energy and materials

Vision

We want to become preferred Power-to-X partner and facilitator in green transitions

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KnowHow2

Hydrogen
Technologies

Carbon
Capture

Hydrogen
Enrichment/ Conversion

Hydrogen
Usage in Industry Sector

Hydrogen
Usage in Transport Sector

Hydrogen
Usage in Energy Sector

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KnowHow2

Cases

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- Demonstration of hydrogen in energy systems, by wind power as source
- Air Liguide continues operation of site

HyBalance

- CO2 capture on Vindø Tegl
- Test site to other plants by Randers Tegl

RANDERS Tegl

- Complete power-to-methanol plant with electrolizer unit included
- EUDP project, Consortium: 11 partners

POWER2MET

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- Retrofit, Læsø Færgen
- Pre-study to ferry line running on methanol and fuel cells

Læsøfærgen.

- MeSAF
- e-methanol to aviation
- Aalborg Lufthavn

AALBORG
LUFTHAVN | AIRPORT

- Small vehicles, such as luggage handling, powered by hydrogen-based fuel cells
- EUDP project, 3 partners

HyFlexDrive

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- Hydrogen-based fuel cell soslution as back-up power generation
- EUPD project, Consortium: 4 partners

CROSSCUT

- Int. education and training course focused on fuel cell powered vehicles
- Erasmus+, 6 project partners

FCH TRAIN

- Pre-study Carbon Capture solution, Aalborg Portland's cement plant in Aalborg DK
- EUDP project, Consortium; 8 partners

GreenCem

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Biogas for CCS and PtX

Circular economy from biomass

SECTOR:
Energy

- Assessing possibilities of using CO2 from biogas production for e-Methane or methanol
- Sindal Biogas handles approx. 200,000 tonnes of biomass per year and produces around 20 million cubic meters of biogas.
- Approx. 30.000 tonnes of CO2 ready for CCUS
- Simulations combined with CapEx and OpEx provides different and optimal scenarios for investments.

We believe that capturing CO2 in the long run can form a significant part of our business, in levels matching our existing production of biogas.

Morten Glenthøj, business developer for Sindal Biogas.

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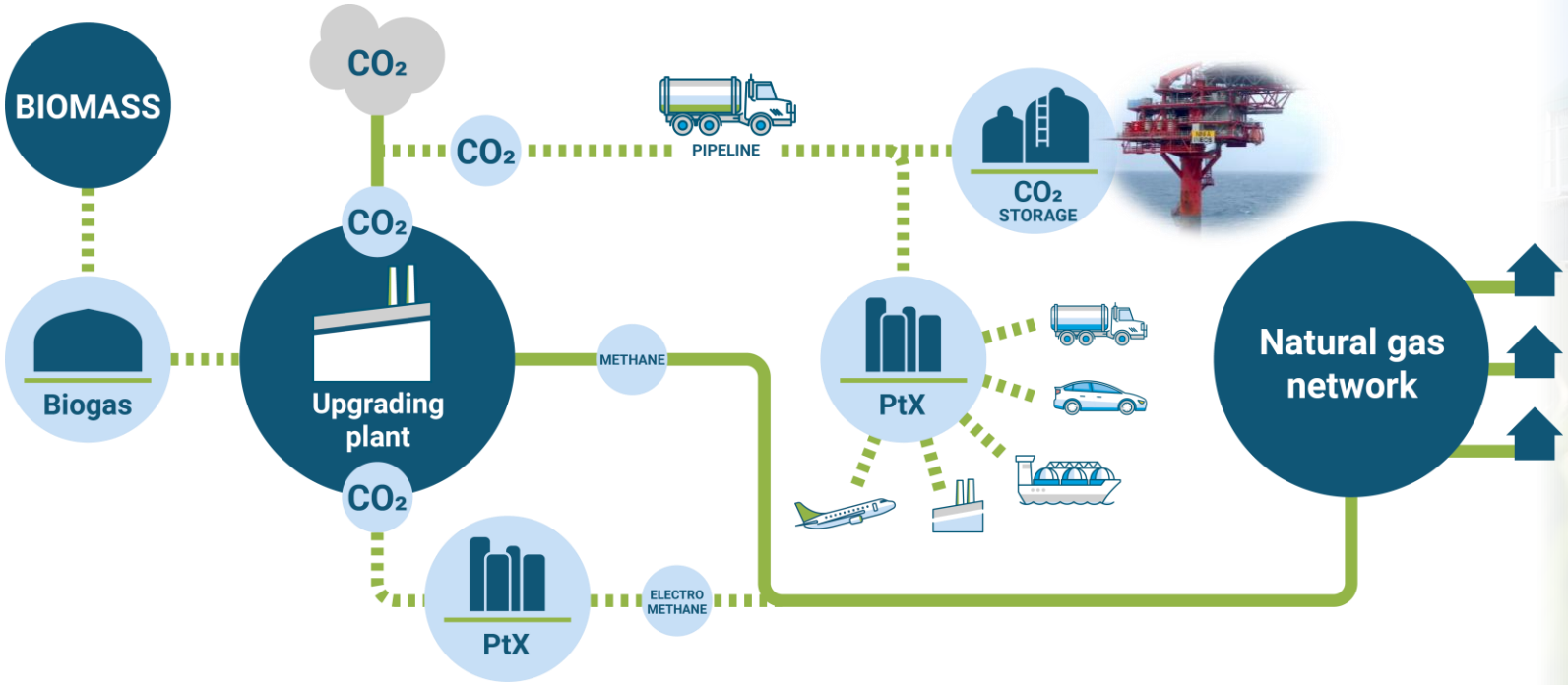
Biomass in PtX

- the path to storage



*Injecting hydrogen into biogas process can increase methane output from biogas with 60-70%, without additional need for more biomass.

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Simulate for RoI

- to decide on pace and paths

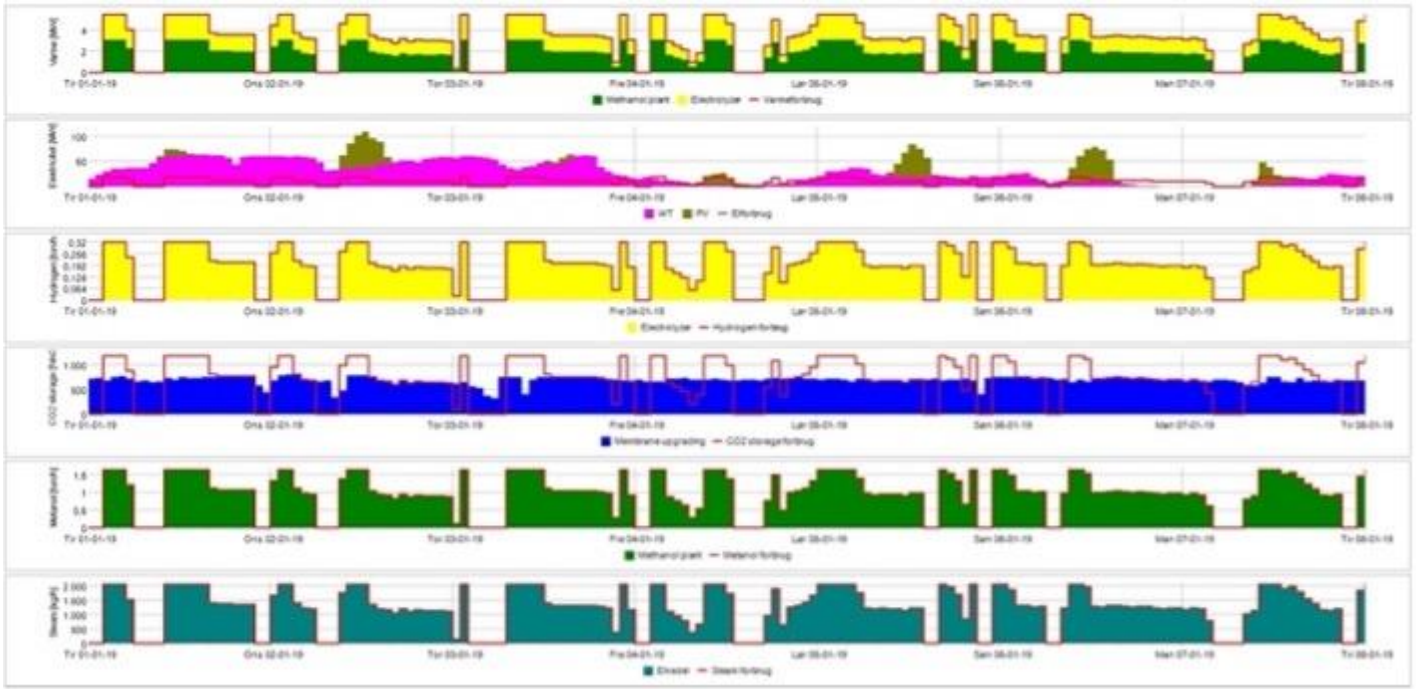

Illustration: *Ex. of simulation of methanol production against the background of a biogas plant's production of CO2. In simulation, the values can be adjusted and, on that basis, potentials for several scenarios can be projected. The figures from such simulations combined with CapEx and OpEx over time, which can be 10 years or more, give the biogas supplier a clear overview to be able to make decisions about investments and tracks to follow in relation to operating capacity.*

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Challenges

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H2 production – Electrolysis explained

- Input & Output

SECTOR:
Technologies

H2 production

- Renewable energy required: approx. 50-55 kwh/1 kg H2.
- To produce 1 kg of hydrogen, 9-11 kg of mineralized water are required.
- Process benefits:
  - ✓ Production of Green Hydrogen
  - ✓ Grid balancing
  - ✓ District heating for Industry or municipalities
  - ✓ Green Oxygen to industry

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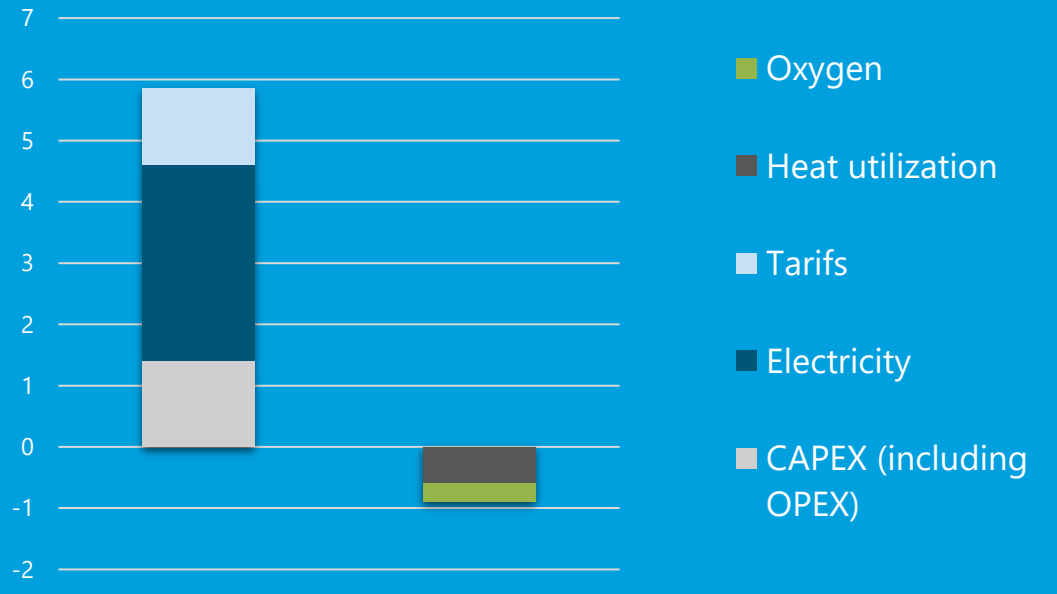
Levelized cost of hydrogen

SECTOR:
Technologies



Fictitious case example from Hydrogen Valley

- H2 projects deviates depending on business concepts e.g. grid connection, Island mode, Behind the meter hybrid …
  (depends on %uptime factor)
- Utilization of waste heat in local areas and potential off-take of oxygen can strengthen business case
- The energy content in hydrogen molecules are high, but the density is very low. This comes with great challenges …
- Subsidy level remains uncertain in EU
  (… unlike IRA in US)

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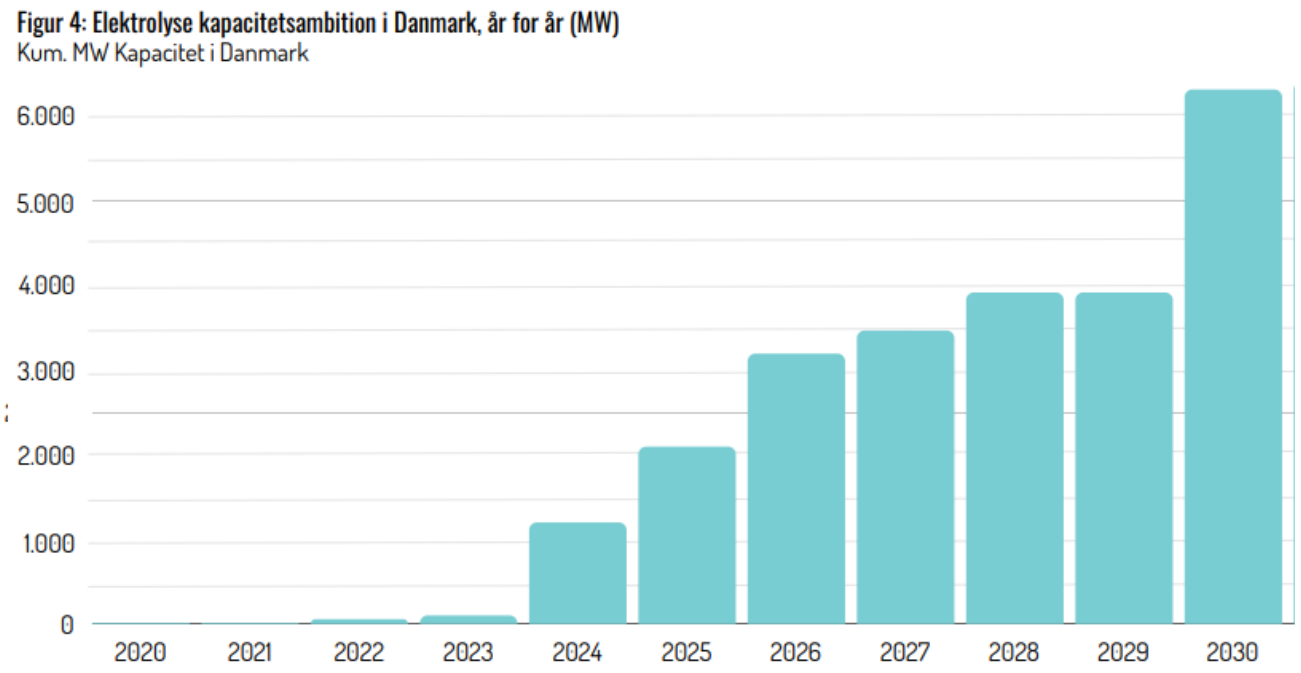
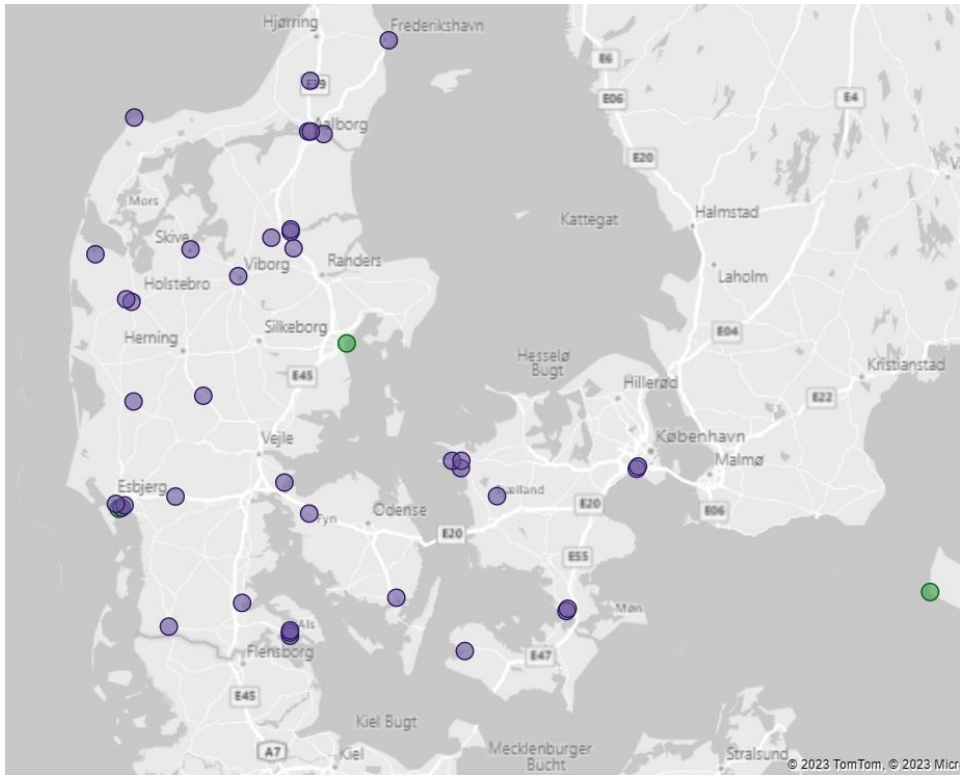
From MW to GW… (6+ GW)



Source: Brintbranchen, 2021



Source: Brintbranchen, 2022

Multiple H2 GW projects in pipeline powered by onshore renewables and later tapping into offshore wind from the North Sea.

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Next stop - infrastructure

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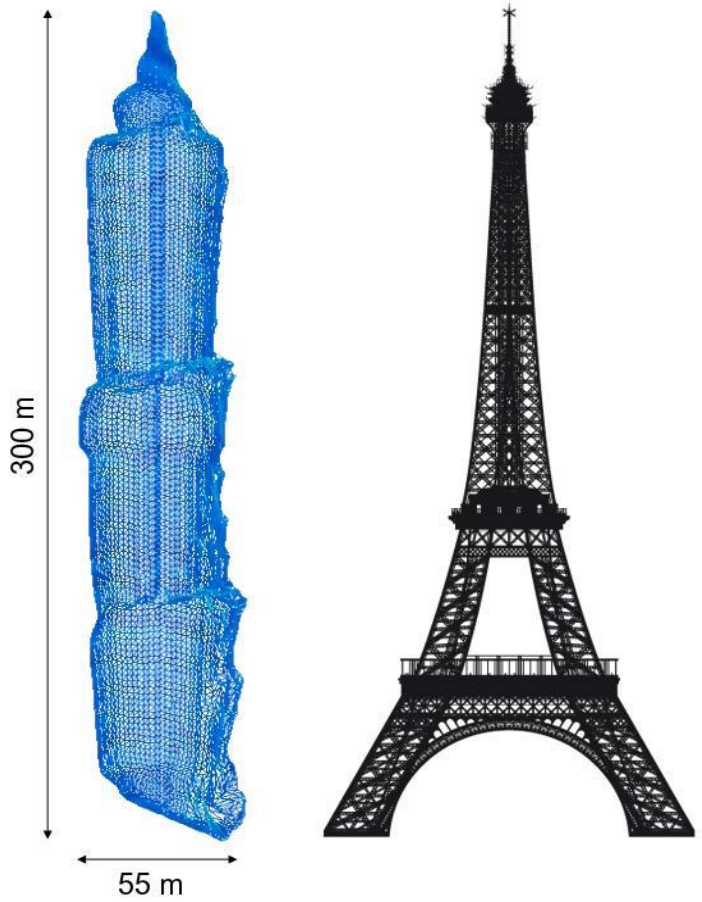
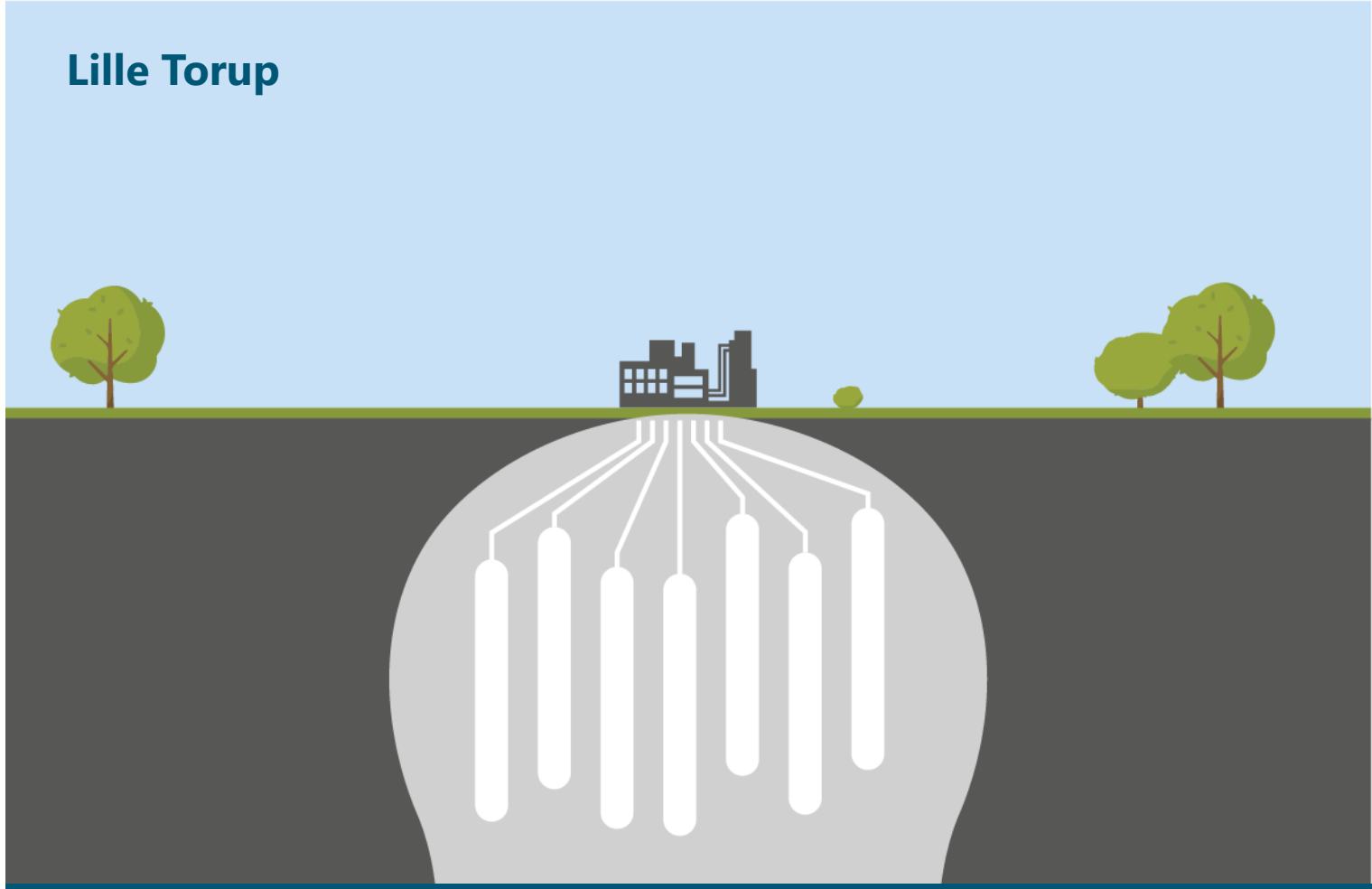
Caverns



Cavity

Eiffel Tower

Lille Torup



- Cylindrical salt dome, 5 km in terms of height and diameter
- 7 salt caverns
- The top of each cavern is situated 950-1400 m under ground surface
- The caverns are 300 m high
- Volume: 4,965 GWh (435 mio. Nm3)

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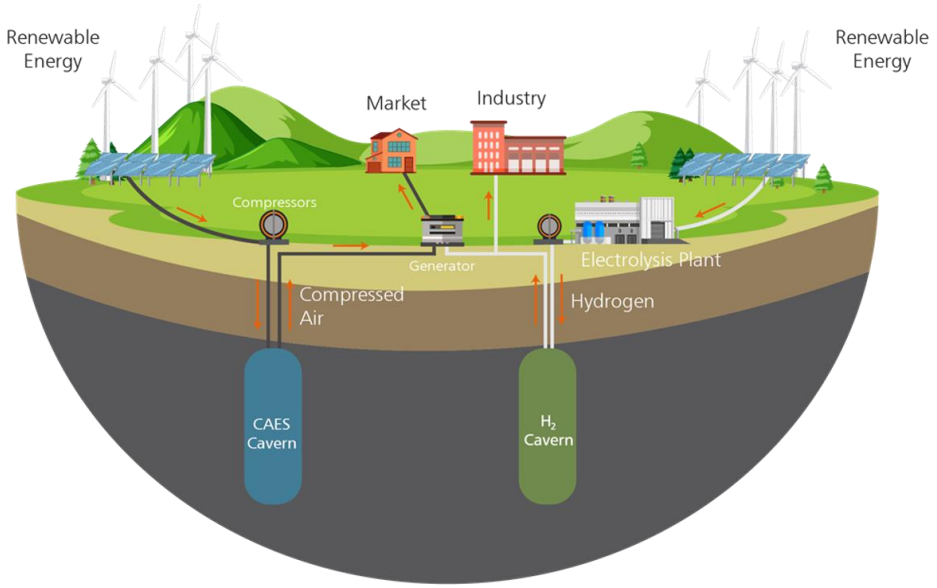
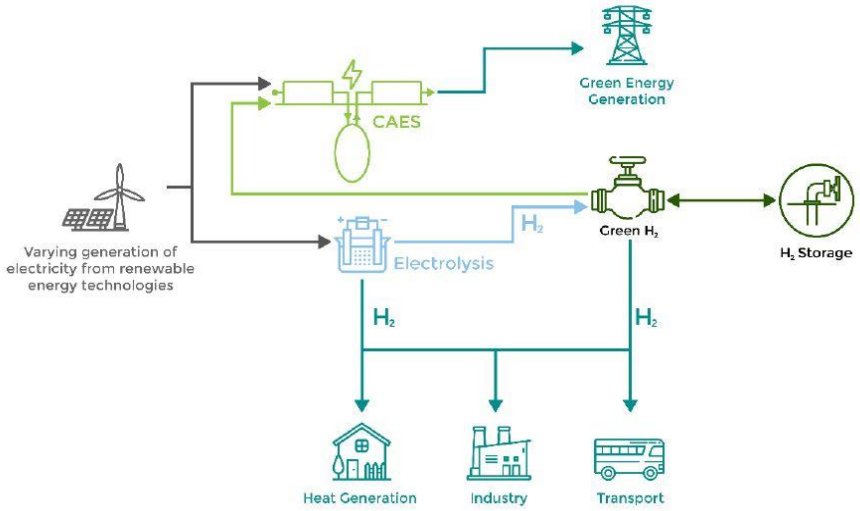
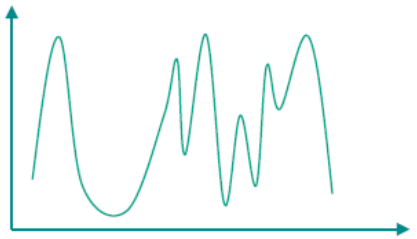
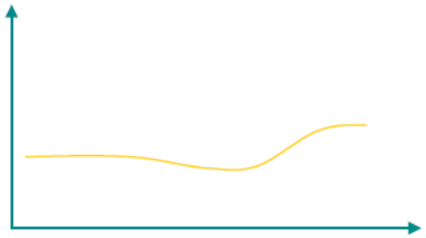
Green Hydrogen Hub provides balance to the Energy system

Project Type	Green Hydrogen Hub
Location	Lille Torup, Denmark
CAES Capacity	200 GWh
CAES Generator	320 MW
H_2 Capacity	117 GWh
Electrolyze Capacity	200-300 MW
Financial Close	2025
Operational From	2027









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Hydrogen System 1.0

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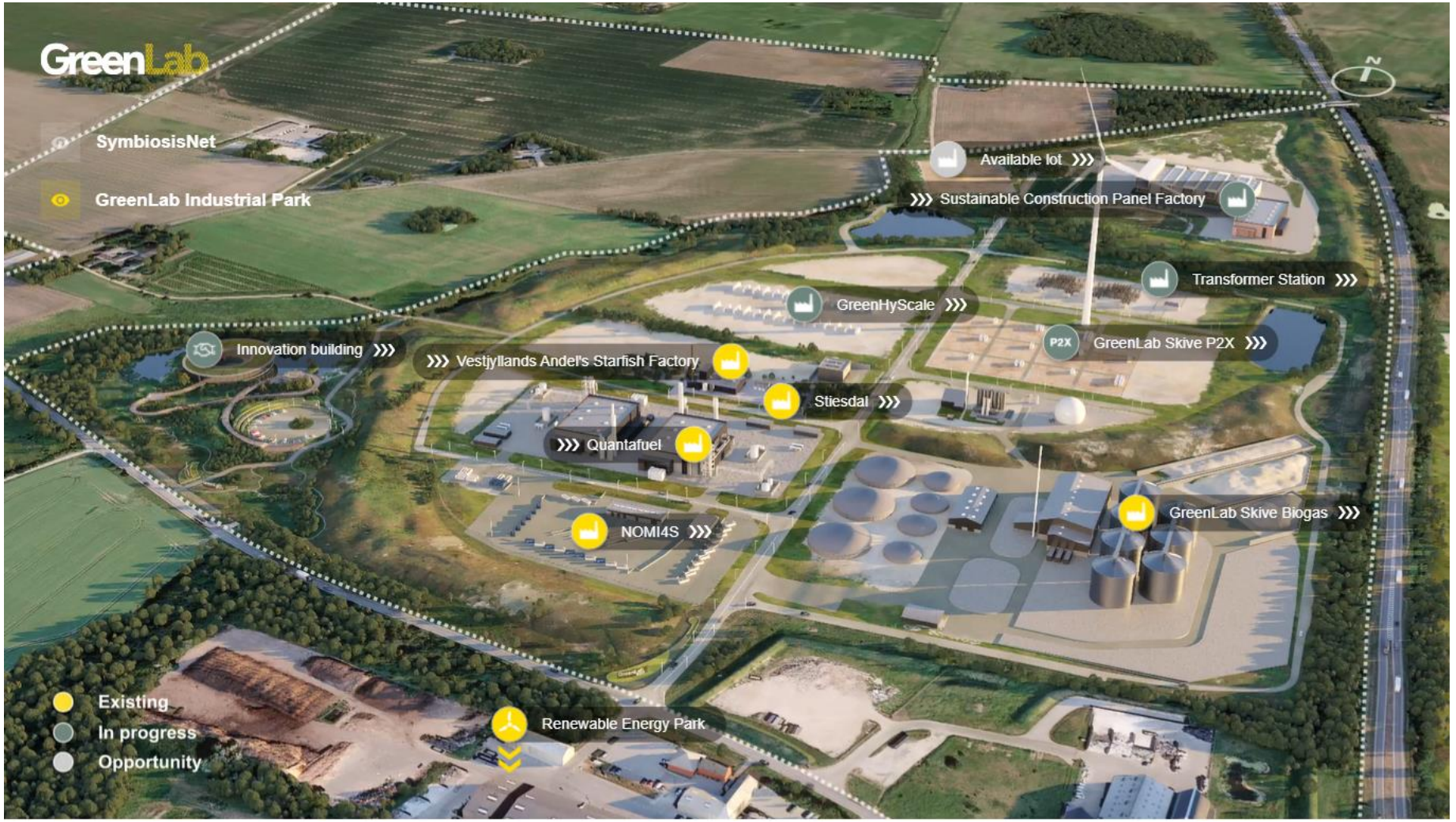
Hydrogen System 2.0



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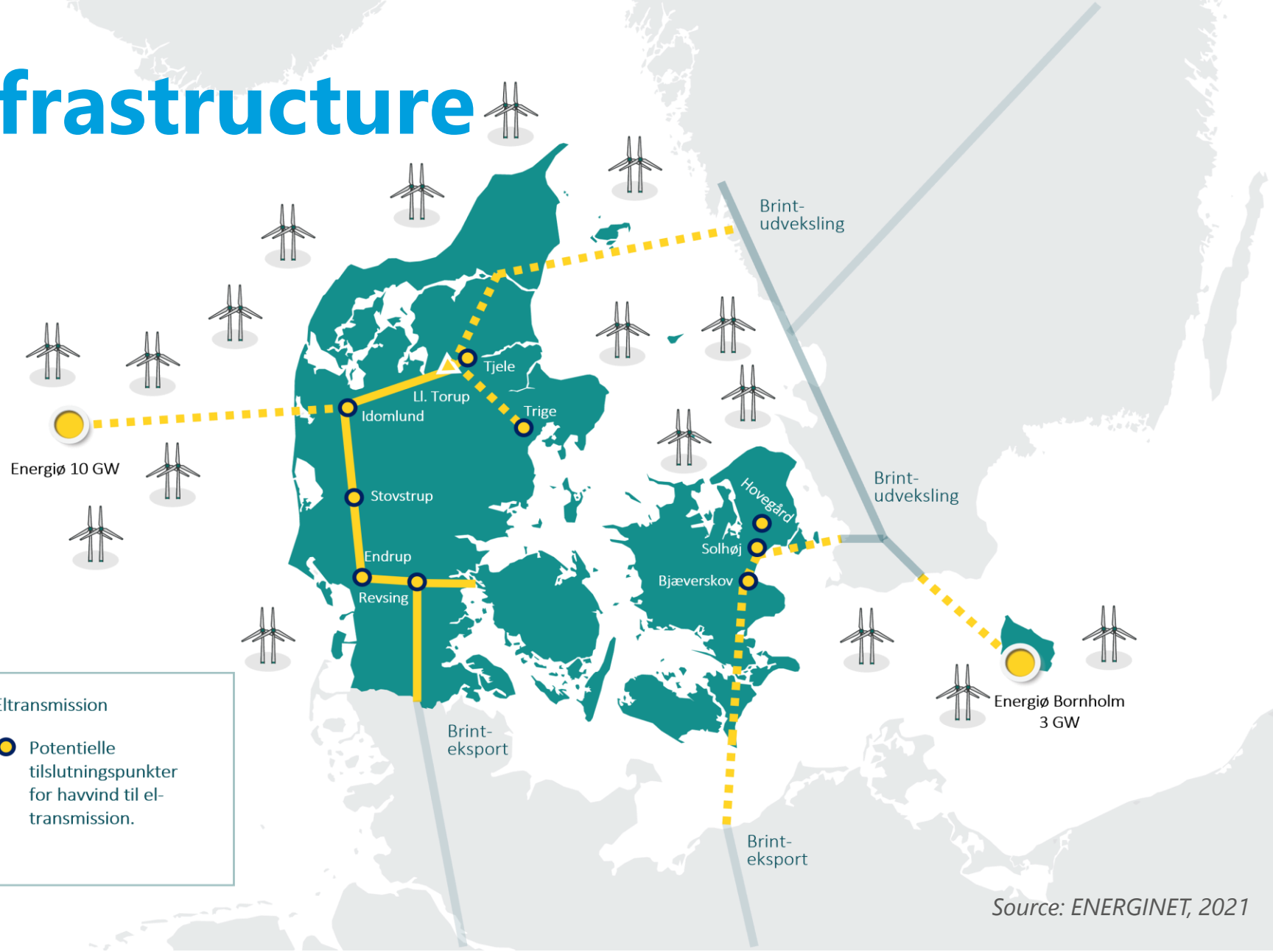
Hydrogen infrastructure in Denmark

Hydrogen would otherwise be transported in tube trailers, or if liquid, by cryogenic tank trucks.

E.g. The energy needed to liquefy hydrogen is 20% -40% of the total energy content of hydrogen gas.



Source: ENERGINET, 2021

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Hydrogen System 3.0

— Piped infrastructure
A Aalborg
B Eurowind Energy
C Gas Storage Denmark
D Greenlab

ClusterNorthH$_2$

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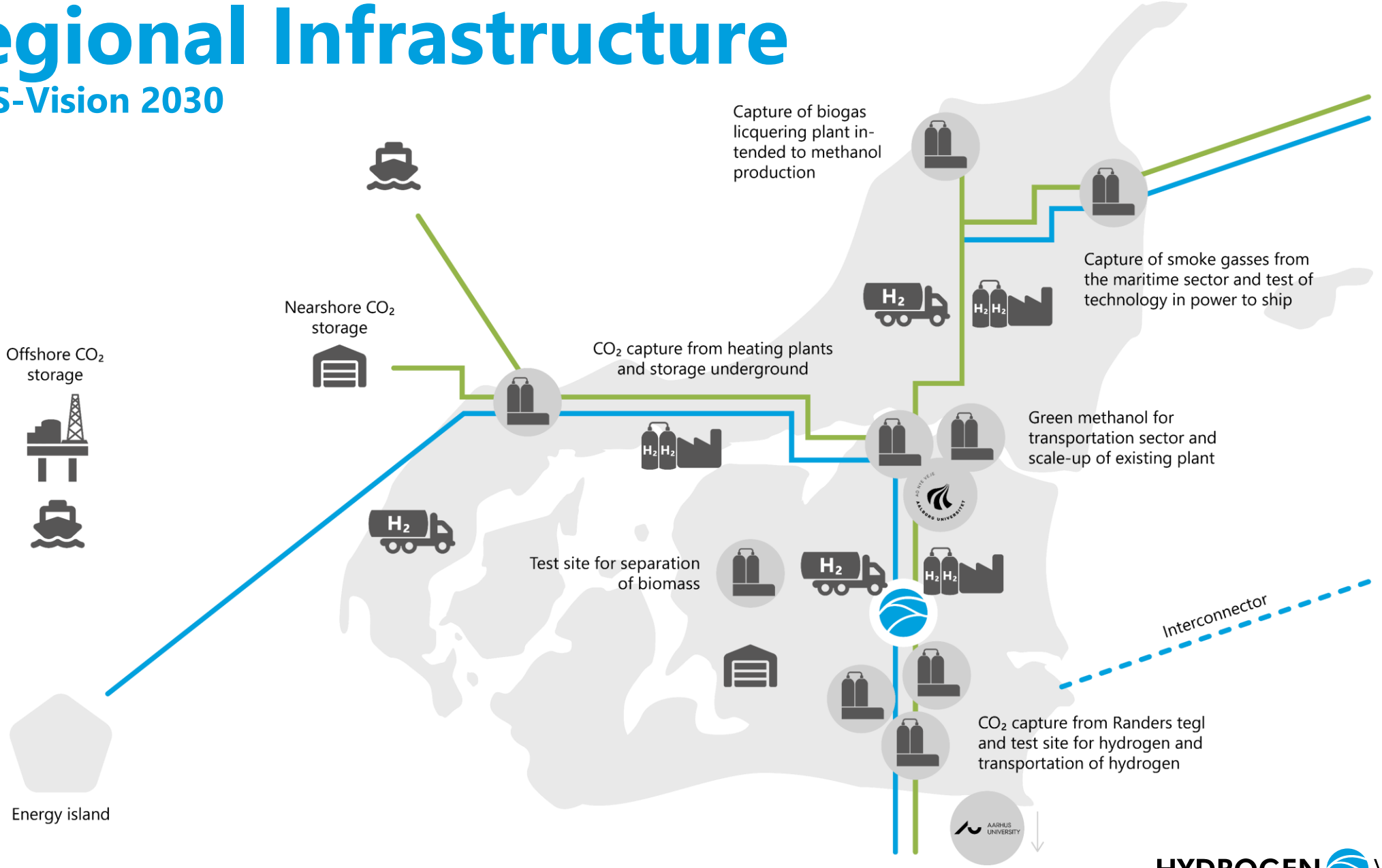
Regional Infrastructure

CCUS-Vision 2030



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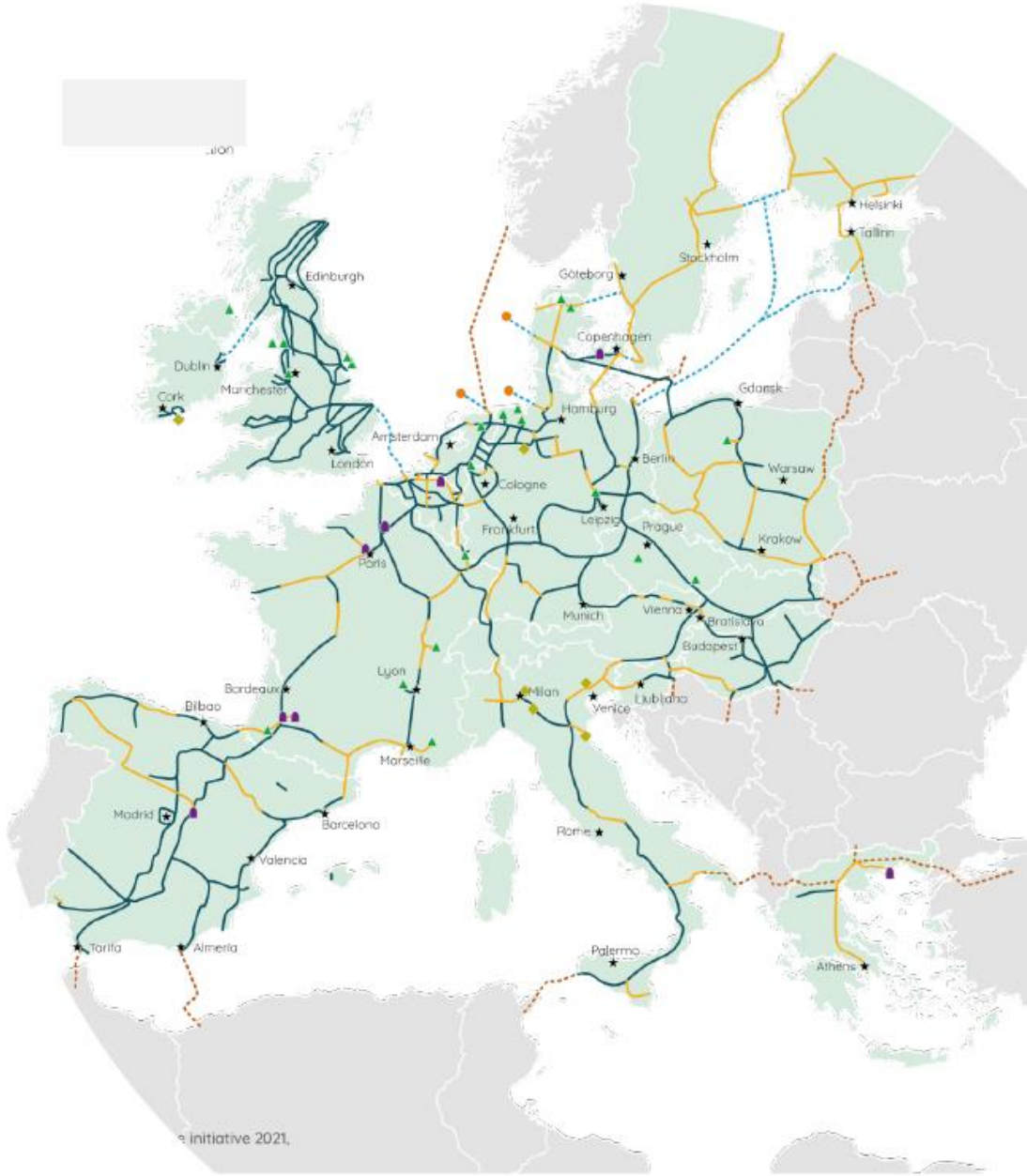
European Hydrogen Backbone Vision

- 40,000 km hydrogen pipeline in 2040 parallel methane- and hydrogen systems
- 75% of ”backbone” from existing not new gas pipes
- Costs are 75-90% less in re-use vs. rebuild



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KnowHow2

Services

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Pre-feasibility services in Hydrogen Valley

Due dilligence and business case

- Strategy
- Project mgt.
- Feasibility studies
- Market analysis
- Value chain partners set-up

Energy technical design

- Design of technical modelling
- Stimulations / Calculations
- Recommendations to set-ups

Project economic assessment

- OpEx & CapEx
- Technology comparisons
- Recommendations for investments into material
- Sensitivity analysis
- Risk management
- Bankable business case

Financing and funding

- Screen for funding options
- Help concept and setting up partners in consortiums
- Write applications and project mgt. to applications

Communication and stakeholder engagement

- Communications strategy
- Implementation of strategy
- PR
- Website and other digital comm. platforms, e.g. podcasts, webinars, videos
- Events

Regulatory and operational feasibility

- Advice on safety and regulations
- Implementation strategies and further dev.

KnowHow2 Academy

- Project mgt. / sessions on site and digital
- Technical training sessions on-site and digital
- Test and operations site
- 3D showroom

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15 years of "connecting the dots"

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