### COWI

### The Hydrogen Vector

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### Agenda

- > Intro to COWI
- > Why Fuels?
- > Significance of Hydrogen
- COWI's Perspective on PtX
- Green Fuel Pathways
- Presentation of COWI Projects



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- COWI is committed to having 100% of our revenue come from projects which improve sustainability.
- Sustainable energy is one of our four strategic market areas.
- The technologies we need to transform our energy systems are all there. Our focus is on rolling them out and strengthening the value chain that connects renewable energy, Power-to-X (PtX) and carbon capture.
- These technologies are the key to zero emissions, fully coupled energy systems.







**Offshore renewables** 

**Green fuels & PtX** 



Carbon capture, storage & utilisation

Sector coupling & energy efficiency



# End-to-end services across the entire value chain



#### COWI AS AN ENERGY CONSULTANT:

- Strong commitment to sustainability.
- Global competences combined with local market presence and knowledge.
- Years of experience from marine engineering, wind energy, biogas, thermal power, oil & gas and more.
- Customer centric delivery model, understanding our customers KPI's and expectations.





- Delivery across the full project life cycle, including connections to power grids and power-to-X facilities.
- Supporting world first projects like energy islands and floating wind through our technical competences.



- Combined expertise in thermal power, process engineering and the production of green molecules.
- Ability to support sector coupling within industry, transportation and buildings.



- Ability to provide end-to-end carbon capture, transport and storage solutions.
- Geological survey expertise for locating and assessing reservoir sites.



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10000 km, 0.6 kt, 7.4 kt bat. 1000 km, 0.3 kt, 0.2 kt bat.

**Batteries are too heavy** 

for heavy long -

**Require extreme** charging system

### The Significance of Hydrogen

- > Carbon is the basis for life
- > Hydrogen is the basis for green
- Methane / Natural Gas CH<sub>4</sub> –
- > Ammonia NH<sub>3</sub> -
- > Methanol CH<sub>3</sub>OH
- > Jet fuel / Diesel C<sub>n</sub>H<sub>2n+2x</sub>

 $CO_2 + 4H_2 = 2H_2O + CH_4$   $3H_2 + N_2 = 2NH_3$   $CO_2 + 3H_2 = H_2O + CH_3OH$  $nCO_2 + (3n+x)H_2 = 2nH_2O + C_nH_{2n+2x}$ 

Sustainable Substitutes for Fossil Fuels





### **Reverse Engineering of Fossil Fuels:** The Hydrogen Transition

#### **BROWN HYDROGEN**

Produced from fossil fuels,

typically coal. Gasification

reactions produce hydrogen

High emissions.

and carbo dioxide.

#### **GREY HYDROGEN**

High emissions.

Produced from natural gas. Methane is heated with steam to produce hydrogen and carbon monoxide.

#### **BLUE HYDROGEN**

Low emissions.

HYDROGEN COLOR SPECTRUM

Grey and brown hydrogen production employing carbon capture and/or utilisation technology to offset the emissions.

#### **GREEN HYDROGEN**

#### Zero emissions.

Produced by the renewable energy powered *electrolysis* of water. The water is split into it's constituent hydrogen and oxygen atoms.







(bio-methanol and e-methanol)

Ammonia (green ammonia)



### Examine Different Feedstocks from a Mass and Energy Balance Perspective

Hydrogenation of CO & CO<sub>2</sub>

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> Reverse water gas shift reaction

1  $CO + 2H_2 \leftrightarrow CH_3OH$ 2  $CO_2 + 3H_2 \leftrightarrow CH_3OH + H_2O$ 3  $CO_2 + H_2 \leftrightarrow CO + H_2O$ 

 $\Delta H_{298K} = -91 \text{ kJ/mol}$  $\Delta H_{298K} = -49 \text{ kJ/mol}$  $\Delta H_{298K} = +41 \text{ kJ/mol}$ 



### Green Fuels: Technology Pathways



E - biofuels

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### Utilization of Hydrogen: Building Blocks

- > Transportation accounts for 25% of GHG, globally
- > Transition demands flexibility
- > Pure Hydrogen economy
- > Hydrogen carriers
  - > CH<sub>3</sub>OH
  - > CH<sub>4</sub>
  - > NH<sub>3</sub>
  - >  $C_nH_m$  Sustainable Aviation Fuel (SAF)

C = Element of Life
N = Element of Air
H = Element of Green Fuels

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### Develop by Demonstration: Denmark

- Danish Climate Act: Reduce carbon emissions 70% by 2030 and run 100% on renewable energy, with 80% from wind.
- For global shipping, green MeOH and NH<sub>3</sub> are seen as ideal marine fuels.
- Airlines are pursuing synthetic kerosene and methanol as green fuels.

- By 2030, PtX is estimated to reduce up to 3.5 million tons of CO<sub>2</sub> emissions in Denmark alone.
- > PtX industry is in a similar place as wind turbines 20 years ago. Unlike then, Denmark is not a 'first mover'.

## Reaching targets will require a large increase in renewable energy



#### DANISH RENEWABLE ENERGY FORECAST

Installed capacity of Offshore Wind will increase 347%

Installed capacity of **Onshore Wind** will increase **39%** 

Installed capacity of **Solar** will increase **633%** 



#### **Renewable Power**

### Plans for offshore wind in North Sea and Baltic Sea







### 670 wind turbines – each 260 meters tall



Source: Energistyrelsen: Cost benefit analyse og klimaaftryk af energiøer i Nordsøen og Østersøen (2021)



### Offshore renewables for PtX:





#### **BRINTØ – HYDROGEN ISLAND**

Brintø is a proposal from Copenhagen Infrastructure Partners for an artificial island in the North Sea, to produce green hydrogen from 10 GW of offshore wind. When operational in 2030, one million tons of hydrogen per year will be produced, to supply Denmark and neighbouring countries. COWI is a cooperation partner on the project.



#### H2RES

H2RES is a demonstration project from Ørsted, combining offshore wind with electrolysis. The facility is expected to produce 1000 kg of green hydrogen per day. COWI is the consultant and advisor for the project, developing the concept and project description, detailed design for the plant, and budget and design of tender documents.



### Electrolysis of green hydrogen:



#### **GREEN FUELS FOR DENMARK**

Green Fuels for Denmark is a unique partnership to develop hydrogen and green fuel production facilities. COWI is a knowledge partner on the project, which is being developed in three stages. By 2030, the fully scaled facility will have an electrolysis capacity of 1.3 GW, and supply the transport sector with 250,000 tons of green fuels annually.



#### **ENERGINET GREEN DEAL**

Denmark's climate targets require all sectors of society to transition to green electricity and green fuels. COWI has a leading position in Energinet's Green Deal tender to realize this. This involves technical design work for the handling of green fuels, including installations and connections to the planned Energy Island in the North Sea.





### Hydrogen to green fuels:



#### **HØST PTX ESBJERG**

Høst is a ground – breaking new green ammonia production plant. The 1 GW PtX facility will be one of Europe's largest once in operation. COWI is assisting on many aspects of the project, including spatial planning, risk analysis, safety and environmental assessments, planning and early project maturation.



#### **TRIANGLE ENERGY ALLIANCE**

The TEA consists of 13 companies in the energy and transport sector, including COWI, and seven Triangle Region municipalities. The focus of the alliance is establishing industrial scale Power-to-X (PtX) facilities, and using renewable energy to create green hydrogen, and subsequently green fuels such as ammonia and methanol.



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### COWIs approach to PtX

- > Adapt designs to acheive zero emissions
- Collaborative partnerships to attain full value chain
- Utilizing natural resources wherever possibleessential for H<sub>2</sub> backbone
- Planning footprints and integration in brownfields
- > Estimating future markets & scale for greenfields
- > Benchmark designs against safety analysis



## **THANK YOU** FOR YOUR TIME





### Technology readiness level (TRL)

