Solving the challenges for a sustainable future

Introduction about the Envision's Green Hydrogen Business

Envision Group aspires to solve the challenges for a sustainable future, and create a world of beautiful energy

Envision Business

Envision Energy
World's champion on wind turbine, energy storage and green hydrogen

Envision Digital
World's largest AIoT operating system EnOS™

Envision AESC
Leading battery supplier with best safety track record

Envision Ventures
Leading global green tech investor

Envision Racing
Top 5 in 2021 Formula E World Championship

Global Innovation & Production

Biosynthetic Industry

EV Industry

New Industry

Envision-Sequoia Capital
Net Zero Fund

Power Semiconductor Device Industry

DRI direct reduced iron

100 Net Zero Industrial Parks

New Infrastructure

Net Zero Energy System

New Coal

Envision Smart Wind Turbine
Envision Energy Storage

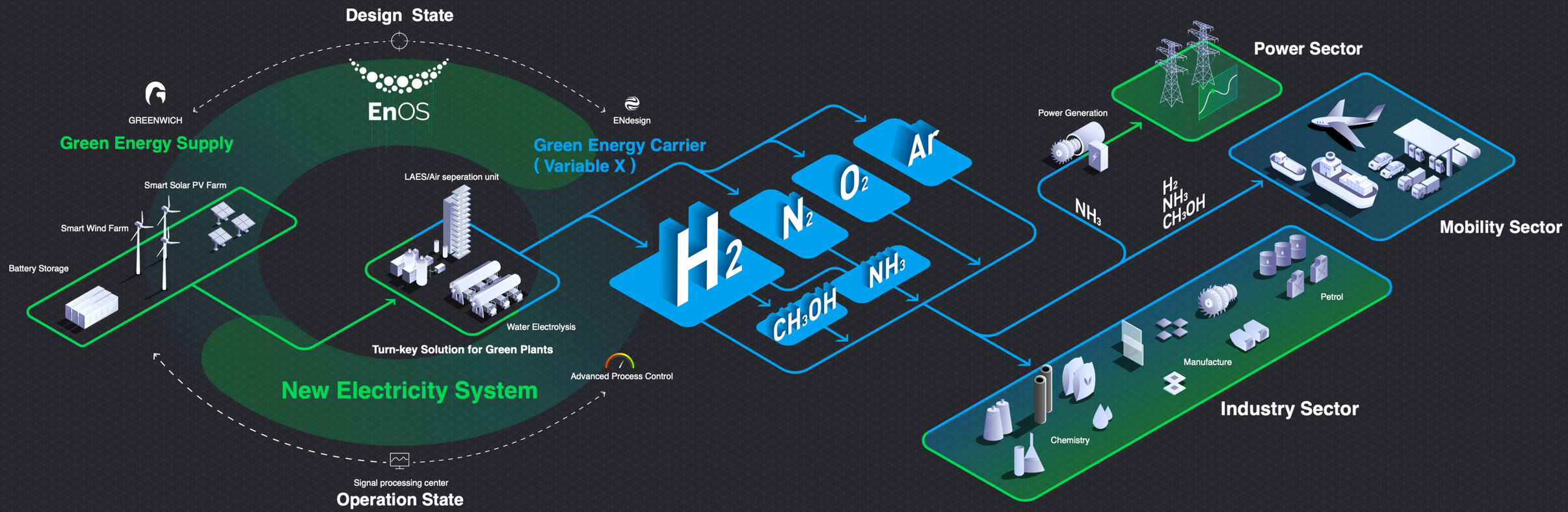
New Oil

Envision AIoT Battery
Envision Hydrogen

New Grid

EnOS

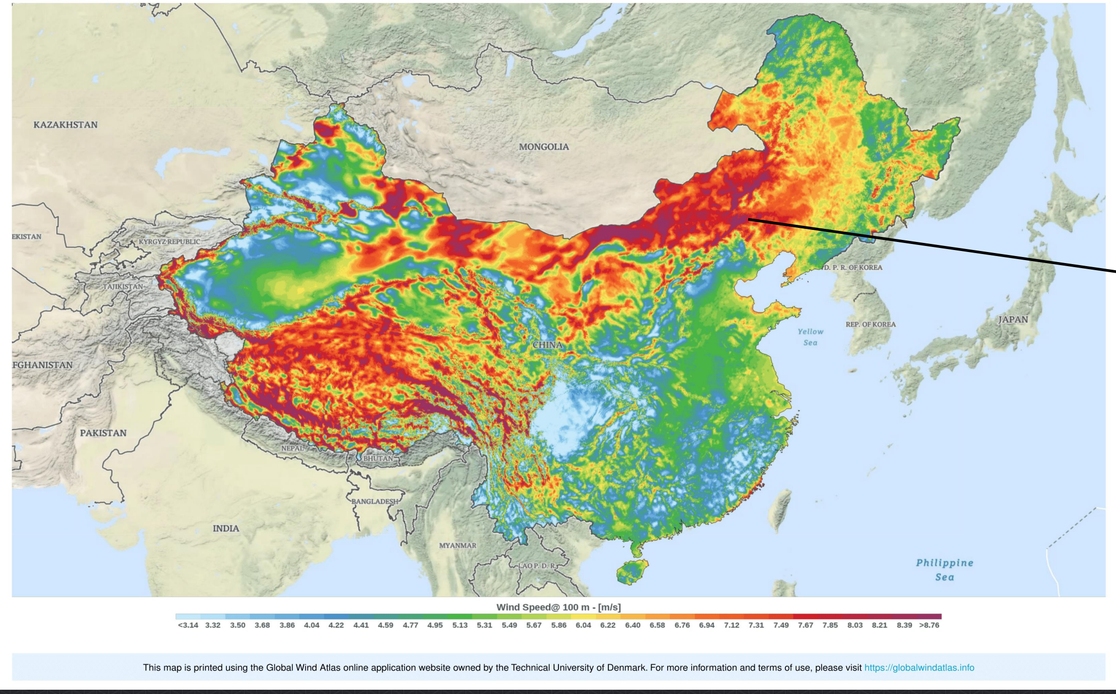
Envision Hydrogen-Provide the integrated value chain solution



GLOBAL WIND ATLAS

MEAN WIND SPEED MAP

CHINA



This map is printed using the Global Wind Atlas online application website owned by the Technical University of Denmark. For more information and terms of use, please visit https://globalwindatlas.info

Green Hydrogen and Ammonia Project in China

1520K

1520K ton per year Green Ammonia

- P0-20K Ton per year green ammonia/Onstream at Sept, 2023
- P1-300K Ton per year green ammonia/Onstream at Dec, 2024
- P2-300K Ton per year
- P3-900K Ton per year
- P2 and P3 will be started per the demand in market.
- Green Methanol is being planned by sourcing bio CO2 locally.

20K

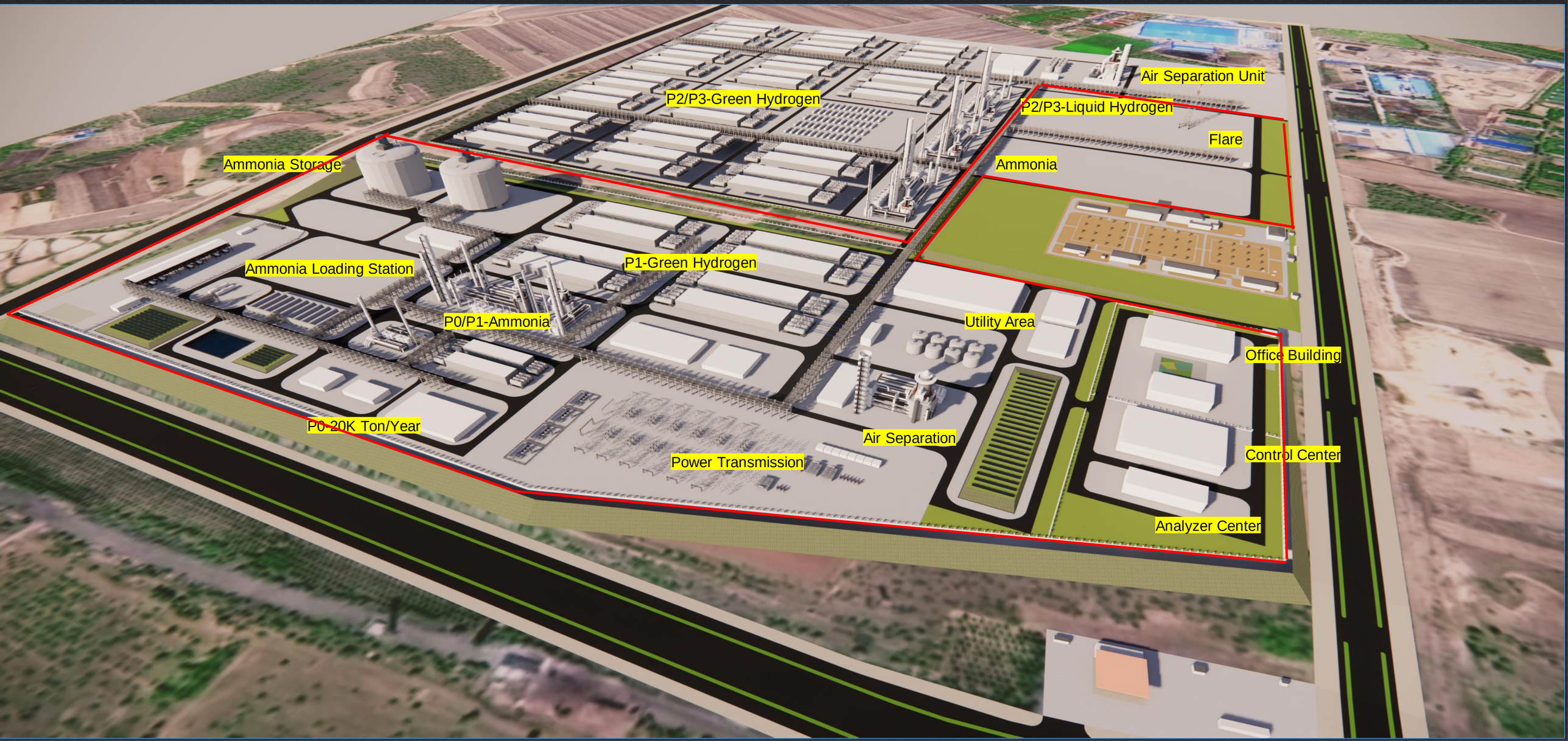
20K Ton per year Green Liquid Hydrogen

Jinzhou Port

80000M3 ammonia storage vessel and 100000DWT capability for marine vessel

Onstream at end of 2024

Aerial View of Site-Total Space is around 800 acre for P0,P1 and P2

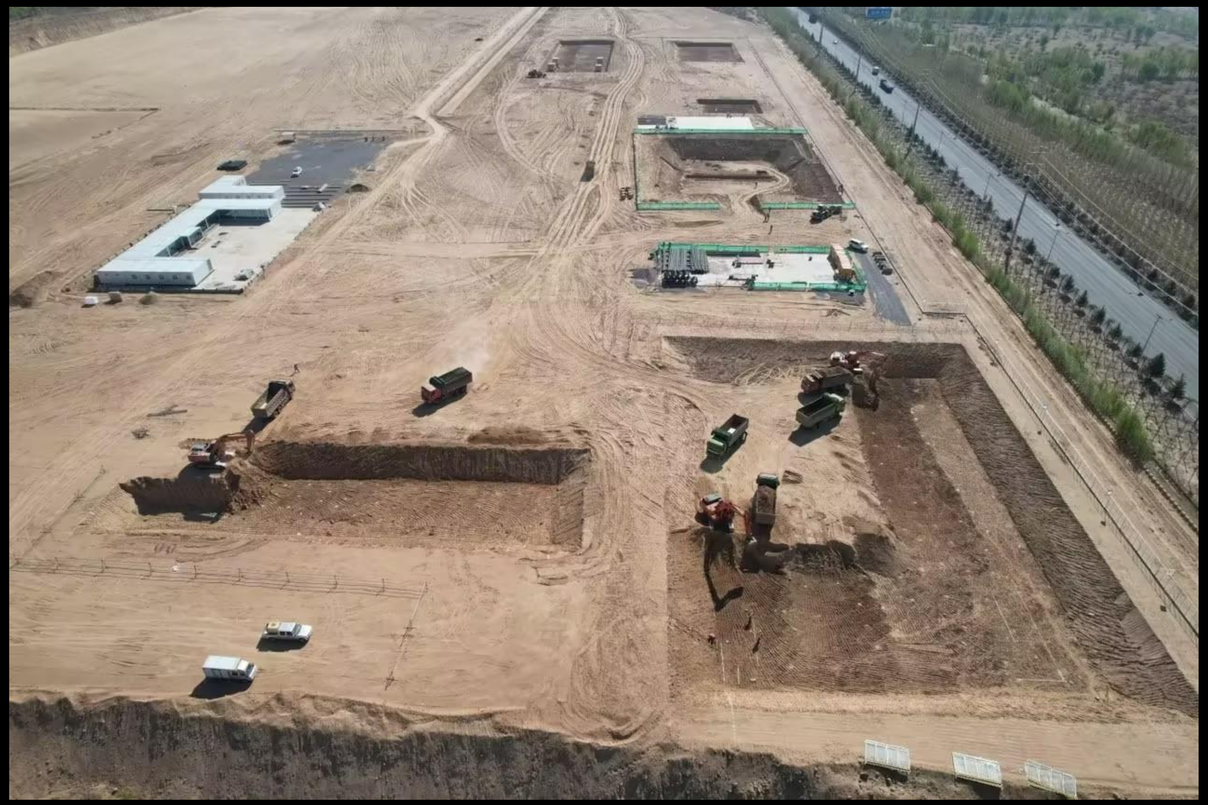


Aerial View of the site before construction

The construction was kicked off at 15th Sept, 2022

Envision | Net Zero Tech Partner

Civil construction underway. Picture taken at 9th May, 2023.



Project site overview at 2023-5-30

Thank You

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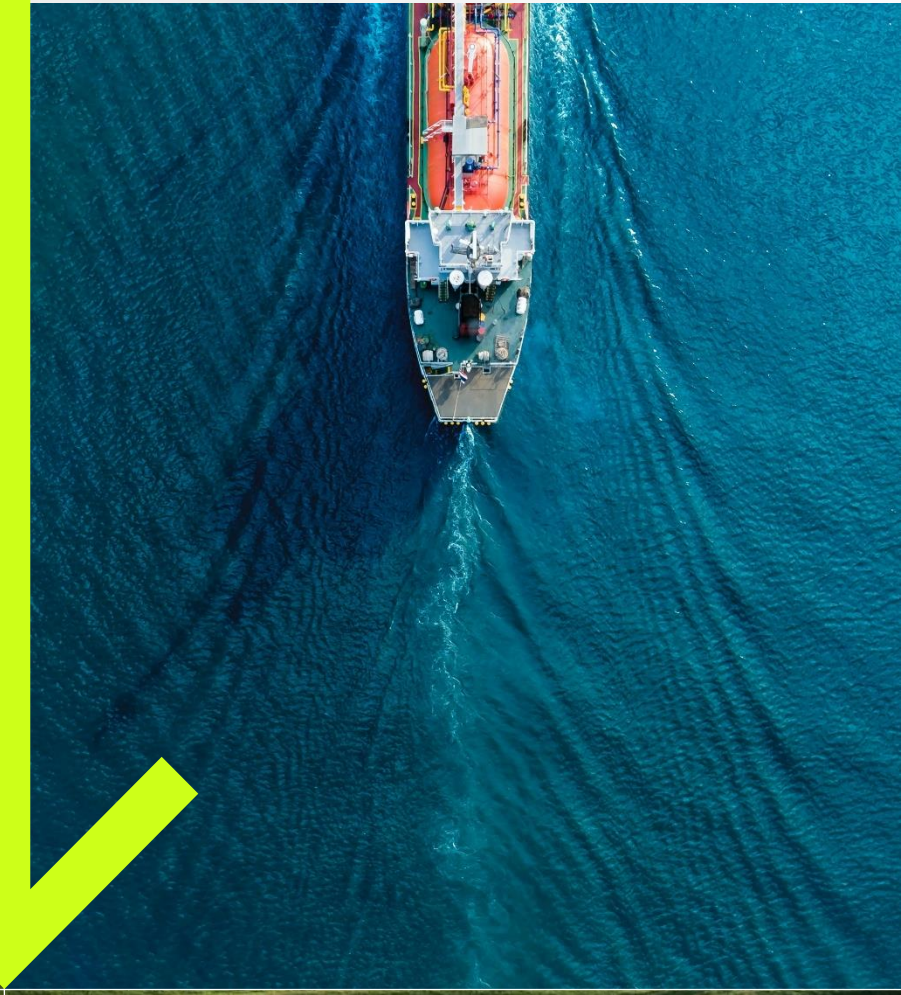
FLEXIBLE AMMONIA PRODUCTION

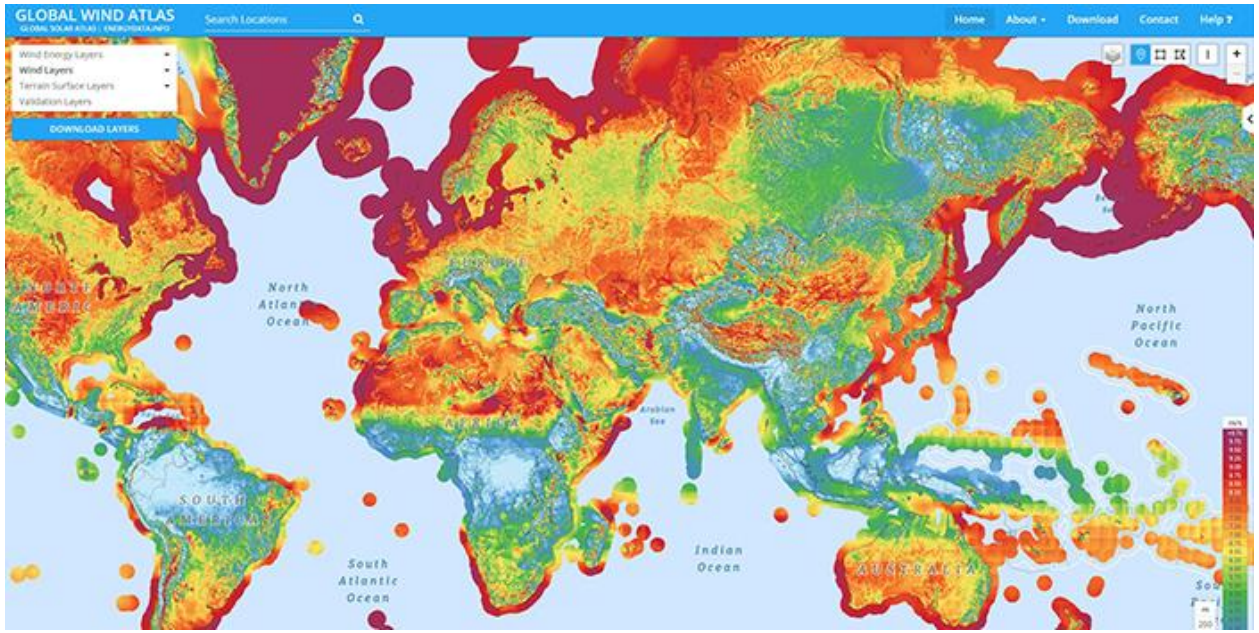


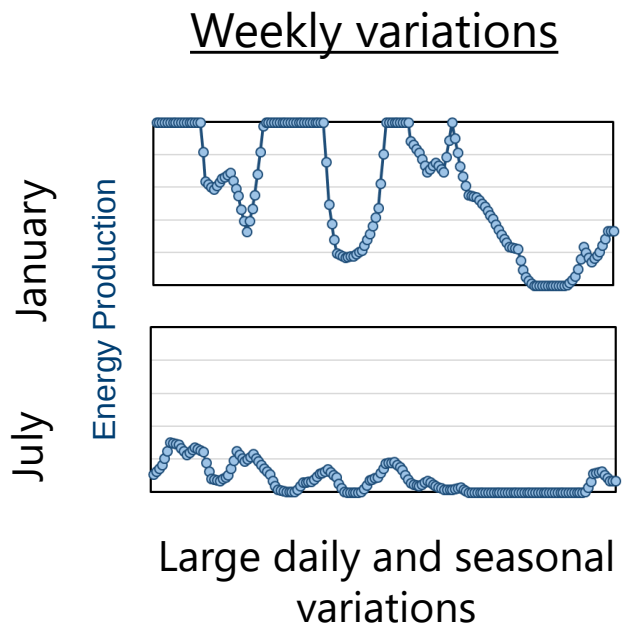
TOPSOE

Per Aggerholm Sørensen

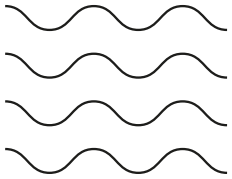
INTERMITTENCY OF RENEWABLE ENERGY SOURCES

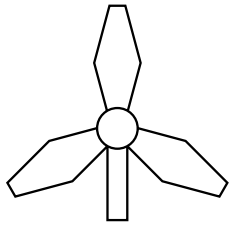
Daily and seasonal variabilities of renewable energy sources affect energy availability and costs

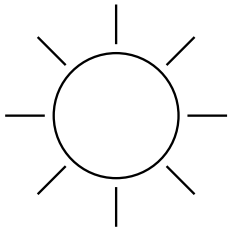




IMPACT OF ENERGY INTERMITTENCE ON DESIGN STRATEGY OF POWER-TO-AMMONIA PLANTS







Costs of renewable energy system typically exceed those of a Power-to-X plant

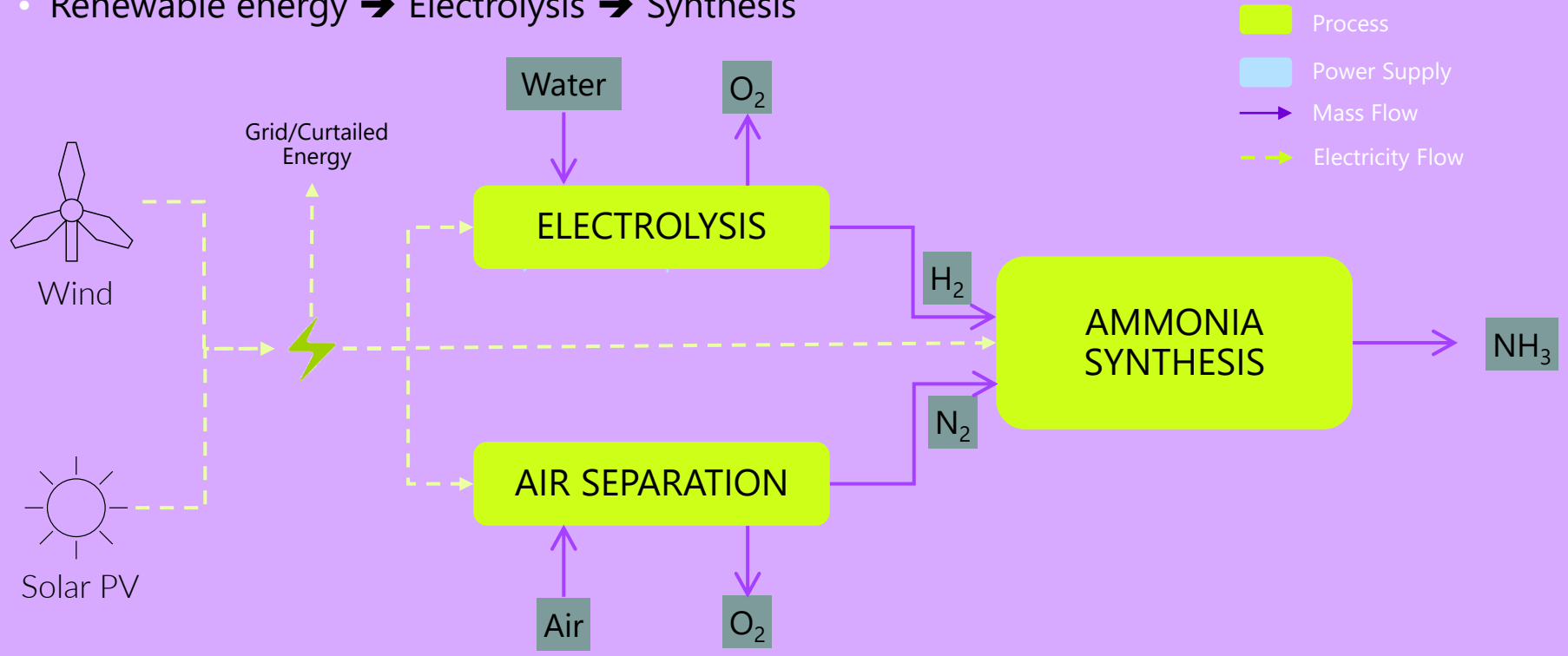
- Flexibility can be obtained though proper design considerations
  - Source(s) and capacity of renewable energy
  - Grid connection or curtailment
  - Energy or Hydrogen storage
  - Dynamic operation

- Dynamic plants will ramp up/down according to available energy

DYNAMIC AMMONIA PLANT

Electricity Source | *Feed Preparation* | *Ammonia Synthesis*

- Renewable energy ➔ Electrolysis ➔ Synthesis



10-100% plant load

No H_2 Storage

Low CAPEX

Grid Balancing

Optimal Integration

THE RENEWABLE DYNAMIC DISTRIBUTED AMMONIA PLANT (REDDAP) PROJECT:

- Worlds first green ammonia plant operating in “dynamic” mode
- 10 MW electrolyzer directly coupled to 12 MW wind turbines and 50 MW solar panels.
- Construction is ongoing, and production is scheduled to start in first half of 2024
- Funding granted from

SKOVGAARD ENERGY
POWER TO UNFOLD

Vestas

TOPSOE

EUDP

The Energy Technology Development and Demonstration Programme

MINTAL HYDROGEN AMMONIA PROJECT

- 1800 MTPD green ammonia plant located in Baotou, Inner Mongolia
- Plant will directly coupled to renewable power and will be the first Chinese dynamic Power-to-X project
- Basic engineering is ongoing, and production is scheduled to start in 2025
- Production of green ammonia will eliminate more than 2 million tonnes of carbon dioxide (CO_2) per year

THANK YOU!

Per Aggerholm Sørensen
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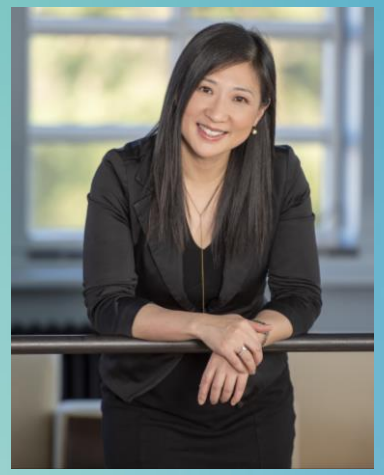
TOPSOE

Scaling flexible ammonia production in China to gigawatt-size

31 May 2023



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Institute for Sustainable Process Technology

ISPT (Institute for Process Technology) programs

Electric Cracking

Circular Carbon

Human Capital

Digitalization

Circular Plastics Initiative

Heat Integration Platform

Green Hydrogen

Clean Ammonia Platform

Drying &
Dewatering

Mild Fractionation for Food

Industrial Fluids
Processing

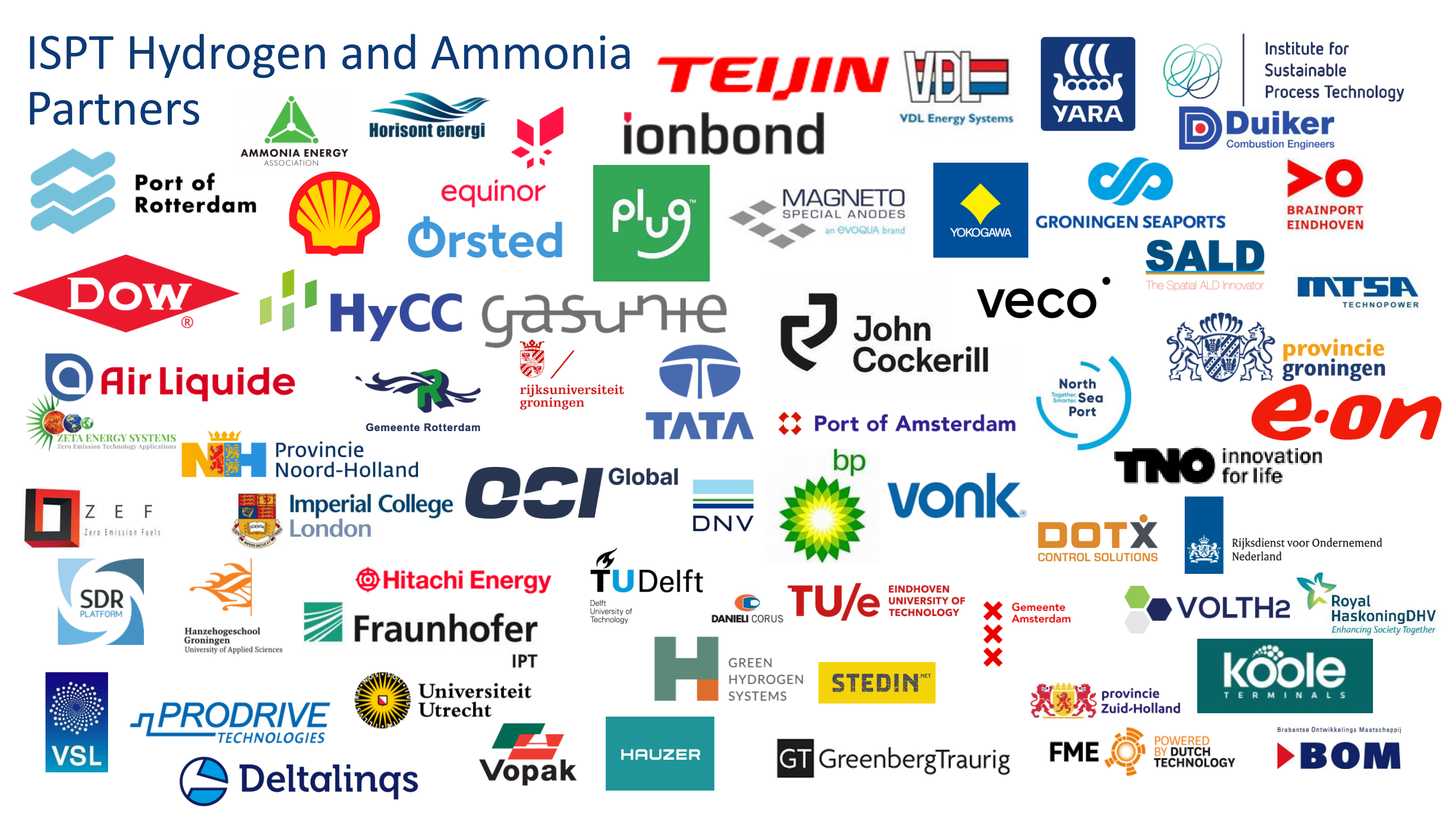
Deep Eutectic
Solvents

Tekenkamer
van de Industrie

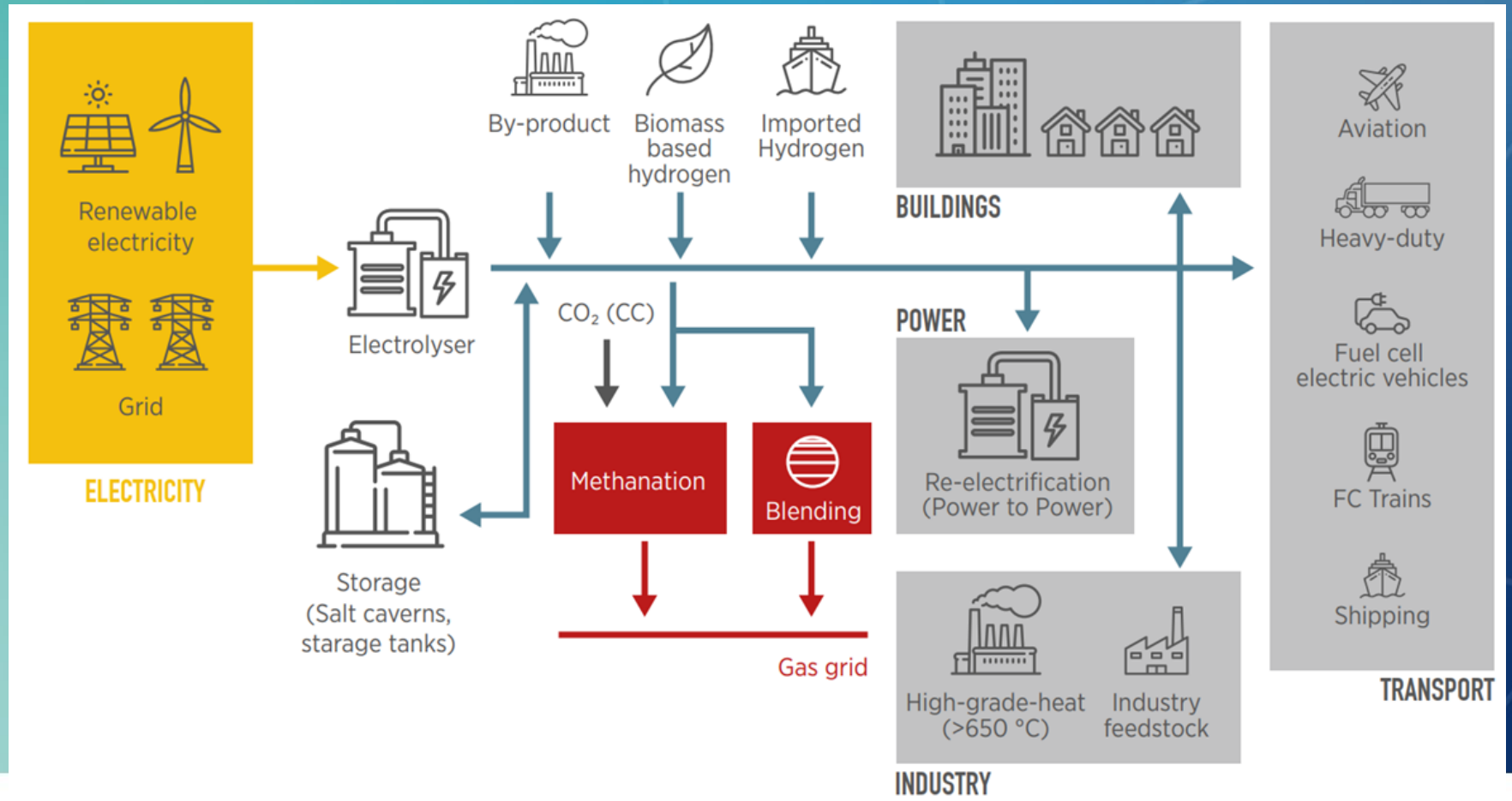
Utilities and
Optimal Use of Heat

Building Blocks
from Waste

ISPT Hydrogen and Ammonia Partners



Why do we need hydrogen and ammonia?



Picture from Irena Report 2018

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What is a one GW scale electrolyser plant

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1 GW electrolyser produces about ~150 kiloton H2 a year

The Dutch inudstry requires about ~ 1500 kton H2 a year(10 GW)

40 GW (~6 Mt H2 a year produced in EU 2030

Net Zero Emissions (IEA) target 850 GW (~128Mt) Worldwide in 2050

https://www.youtube.com/watch?v=fw5zPUbPo1Q

Opportunities and Challenges

Pros	Cons
Achieve Climate Goal	Infrastructures for e and H2
The hydrogen market is very large (850GW)	Green Hydrogen market
Lot of renewable energy	Supply Chain shortage (e.g materials, production capacity Electrolysers etc)
Create job opportunities	Limited space
A lot of Money available	Uncertain Policy for Renewables
	Lacking Human Capital

How does ISPT help ?

- Cost reduction of electrolyser techology and design
- Safety and standardisation
- Hydrogen strategy import and export
- Innovaton new technologies (SOEC technogy, components new and improved)

We are working with more than 100 partners from the industry, knowledge institues, governments, sea ports, technolog providers etc.

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Clean Ammonia Platform

Economical

- Clean ammonia roadmap
- Clean ammonia trade flow modelling
- Use cases green ammonia, infrastructure connections

Technical

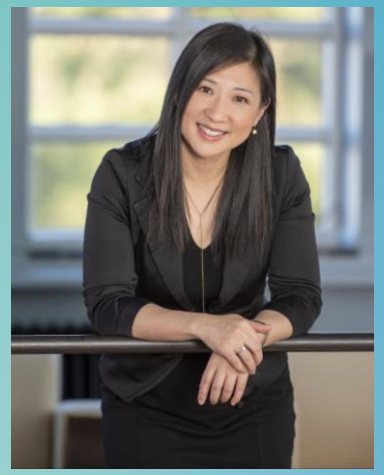
- Clean ammonia Import
- Clean ammonia cracking
- Clean ammonia cracking Pilot plant

Societal

- Clean ammonia safety project
- Emissions green ammonia
- Communication and stakeholder dialogue

AMMONIA ENERGY ASSOCIATION

Thank you!



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Back up slides

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GigaWatt Scale Electrolyser Plant Design

- 1 GW Alkaline and PEM electrolyser plant
- Greenfield plant
- In the Netherlands
- Industrial zone in port area
- Offshore wind power
- Ready to operate in 2030
- 0-100% Operational window
- Hydrogen 99,99% pure, 30 bara

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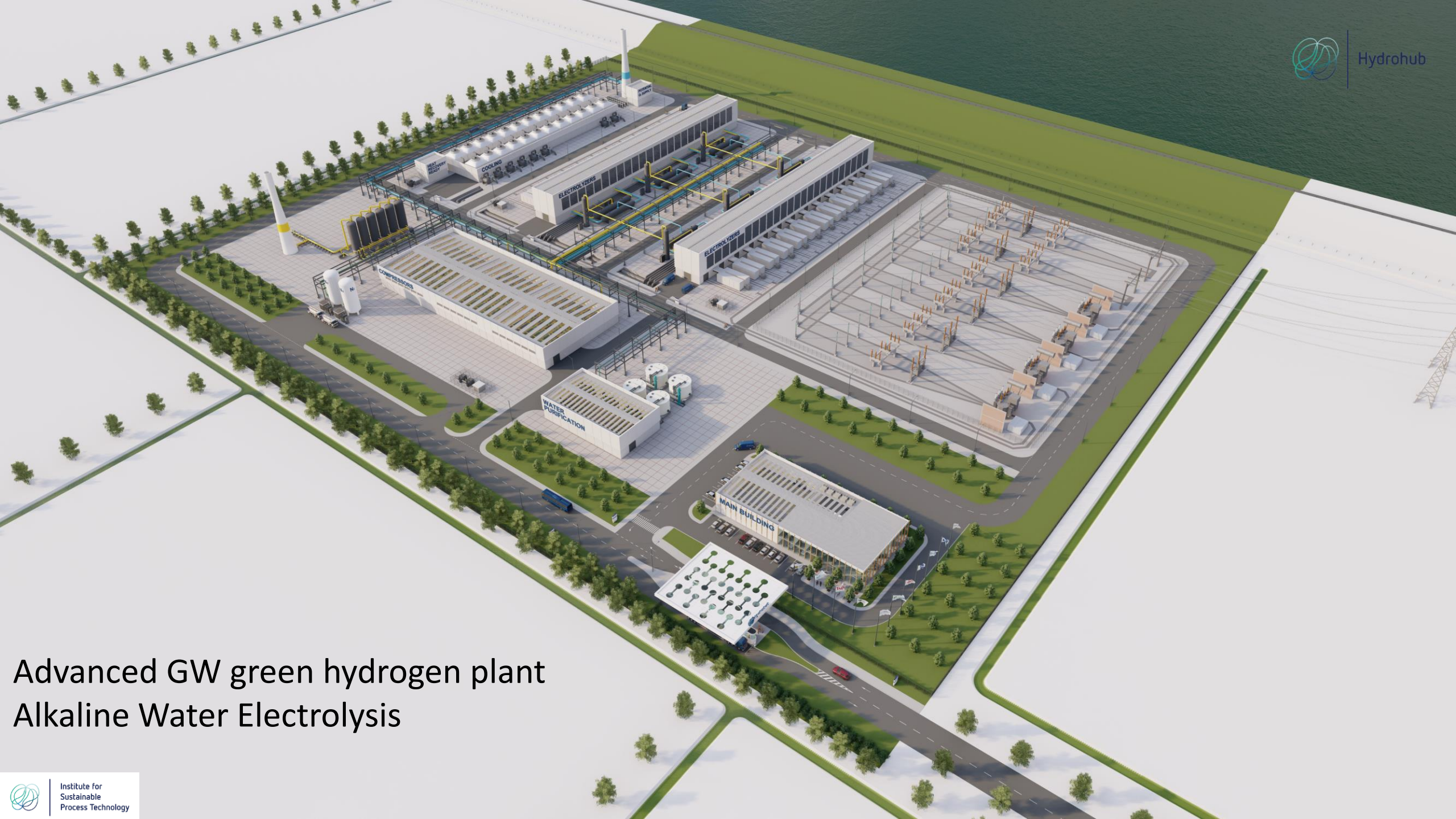

Advanced GW green hydrogen plant
Alkaline Water Electrolysis

Institute for Sustainable Process Technology

CAPEX cost breakdown - Alkaline Technology

- Total Installed Costs from 1400 €/kW reduced to **730 €/kW**
- Direct costs from 780 €/kW reduced to **420 €/kW**
- FCHJU ~400-500 €/kW (without Power supply and electronics, Civil, Installation)
- ISPT ~300 €/kW (without Power supply and electronics, Civil, Installation)

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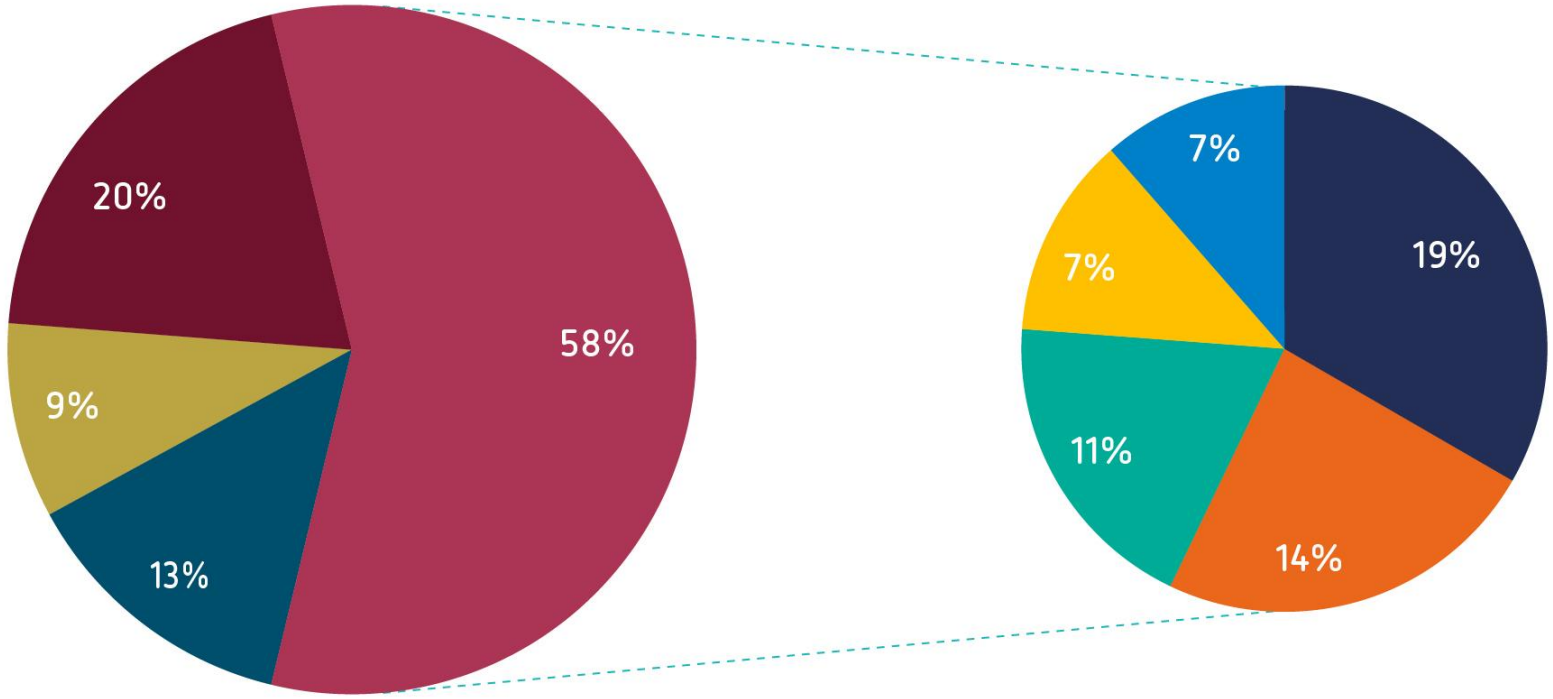
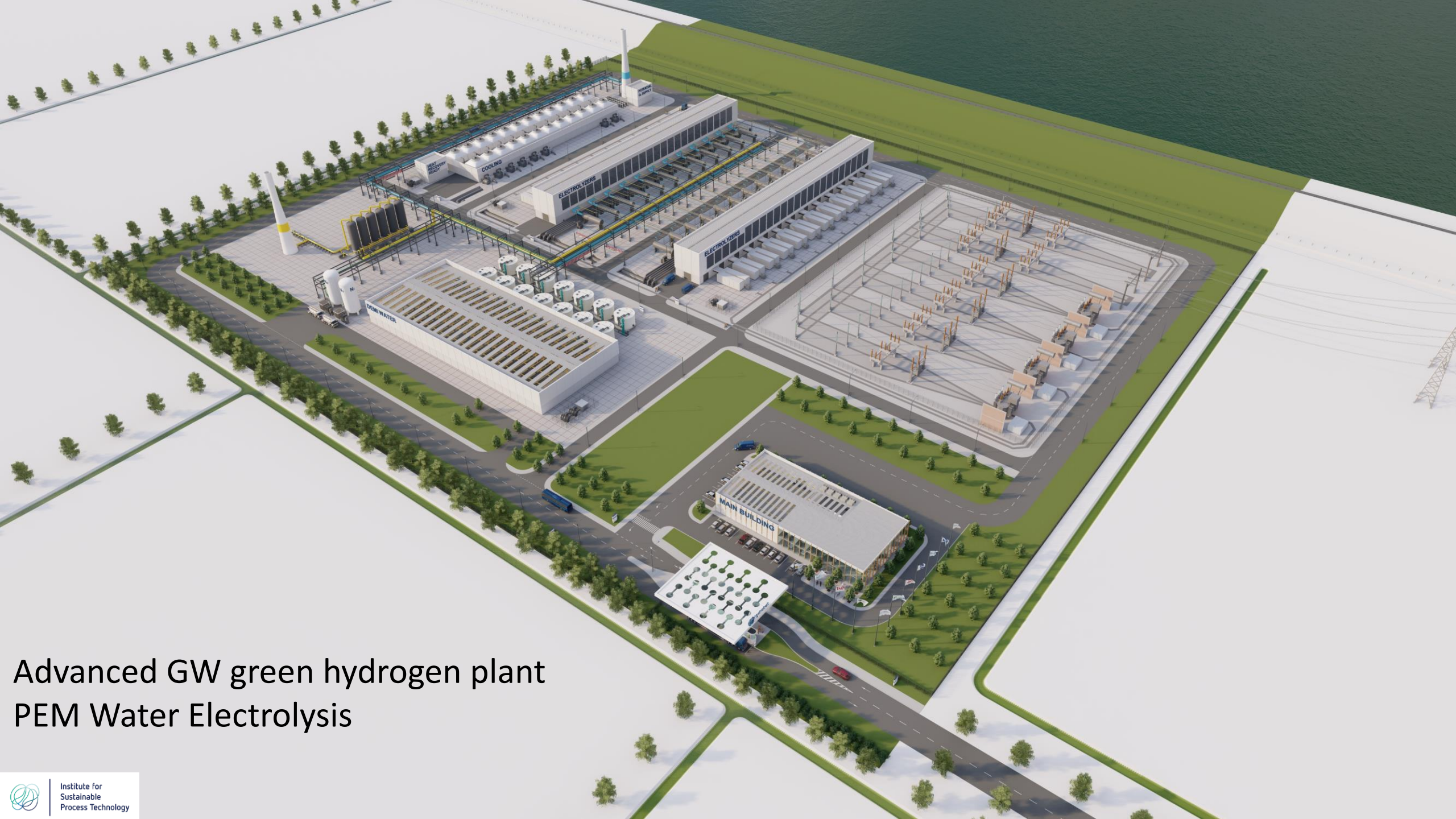
CAPEX breakdown AWE technology

Total installed costs 730 €/kW 1580 €/(kg/d)

Directs costs 420 €/kW





Advanced GW green hydrogen plant
PEM Water Electrolysis

Institute for Sustainable Process Technology

CAPEX cost breakdown - PEM Technology

- Total Installed Costs from 1800 €/kW reduced to **830 €/kW**
- Direct costs from 1014 €/kW reduced to **450 €/kW**
- FCHJU ~400-500 €/kW (without Power supply and electronics, Civil, Installation)
- ISPT ~300 €/kW (without Power supply and electronics, Civil, Installation)

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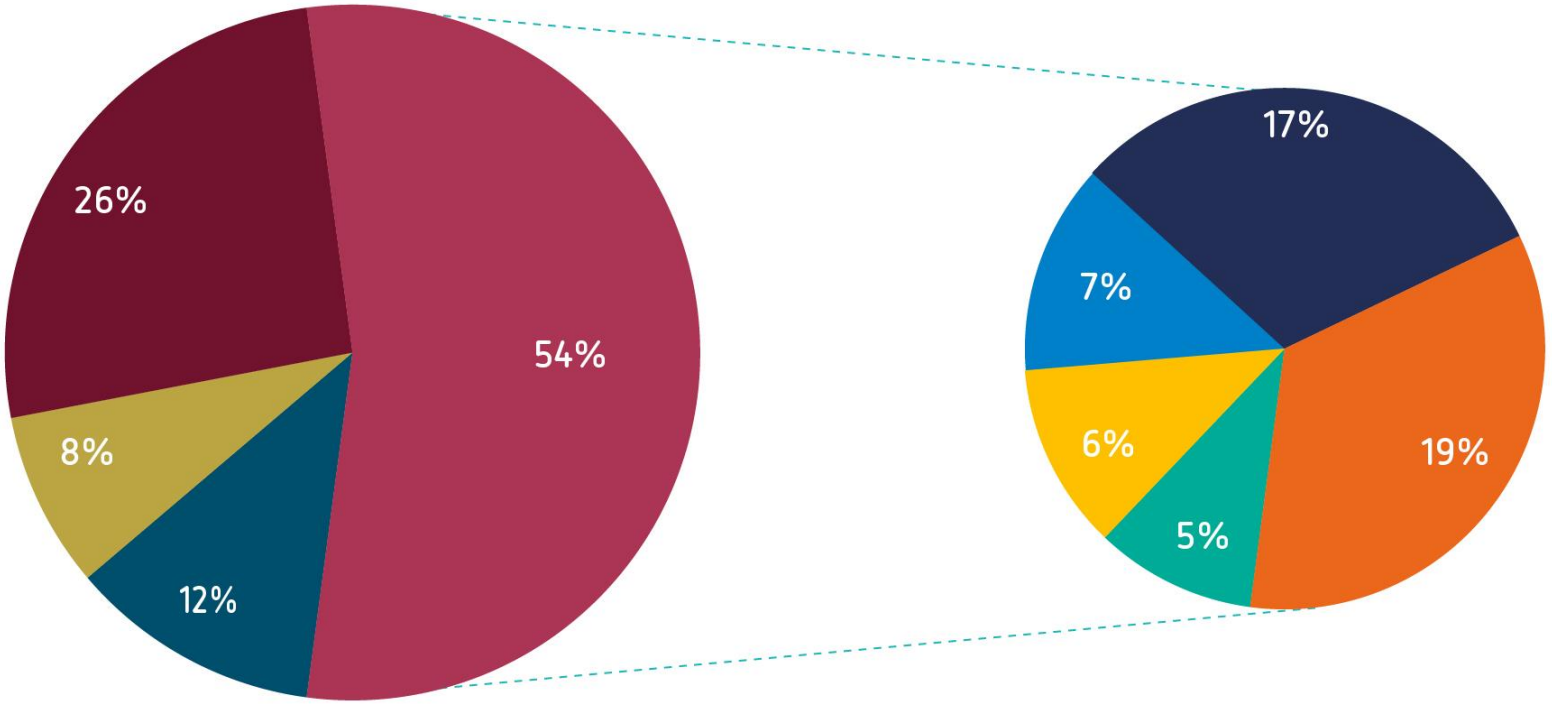
CAPEX breakdown PEM technology

Total Installed Costs 830 €/kW 1770 €/(kg/d)

Directs Costs 450 €/kW



What needs to be done?

2023
Innovations and Ready to market technologies and Supply Chain

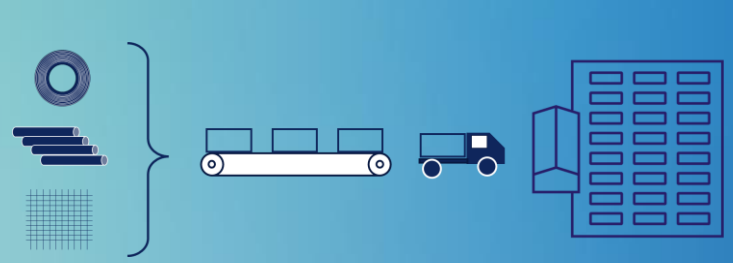
2026
Preparation For investment

2028
Final Investment Decision (FID)

2030
Ambition:
- NL 4 GW
- EU 40 GW
- Worldwide 90 GW

Klimaat-akkoord

2050
Net Zero Emissions (IEA)
850 GW Worldwide



Ammonia Project Features

(Wednesday 31 May, 3PM CET, online via Zoom Webinar)

Scaling flexible ammonia production in China to gigawatt-size

Per Aggerholm Sørensen
R&D Director eChemicals and Synthesis Technology, Topsoe

TOPSOE

Carol Xiao
Director Business Development, ISPT

Institute for Sustainable Process Technology

Lili Lu
Business Development Director, Envision Hydrogen

Envision
Net Zero Tech Partner

In conversation with:

Kevin Rouwenhorst
Technology Manager, AEA

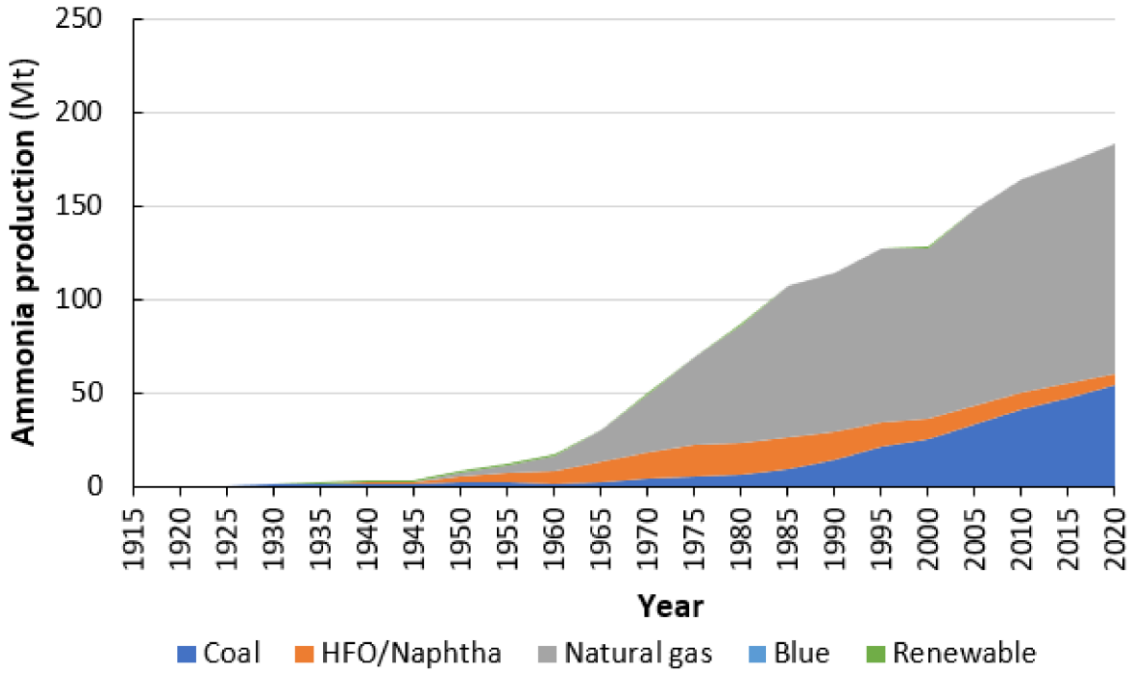
AMMONIA ENERGY ASSOCIATION

AMMONIA ENERGY ASSOCIATION

Ammonia manufacturing in China

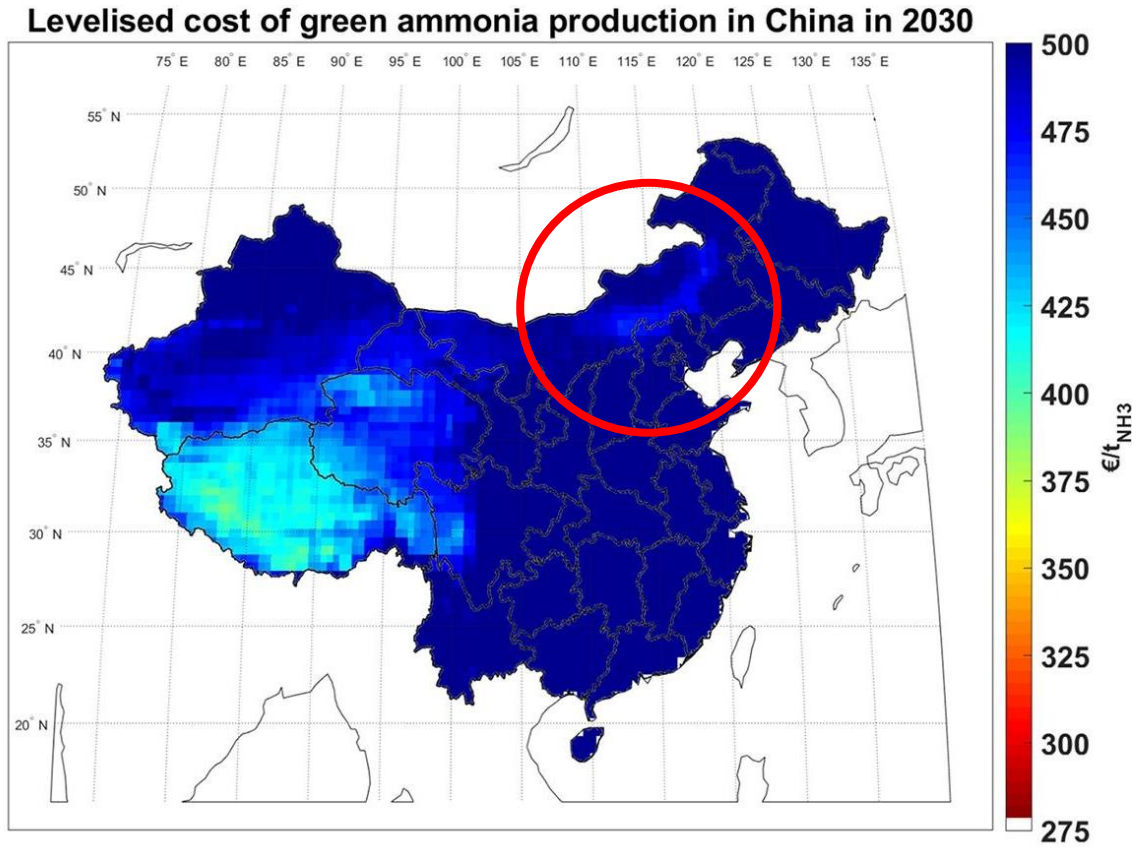
- China is the largest ammonia producer (54 Mt/y in 2018), mainly based on coal as feedstock
- **Coal-based ammonia production**: 4 tonne CO_2 per tonne ammonia (Scope 1)

- Coal-based ammonia production more expensive than natural gas-based ammonia production & low cost electrolyzers in China
- Small cost gap with electrolysis-based ammonia production in China
- Emission trading system is starting in China



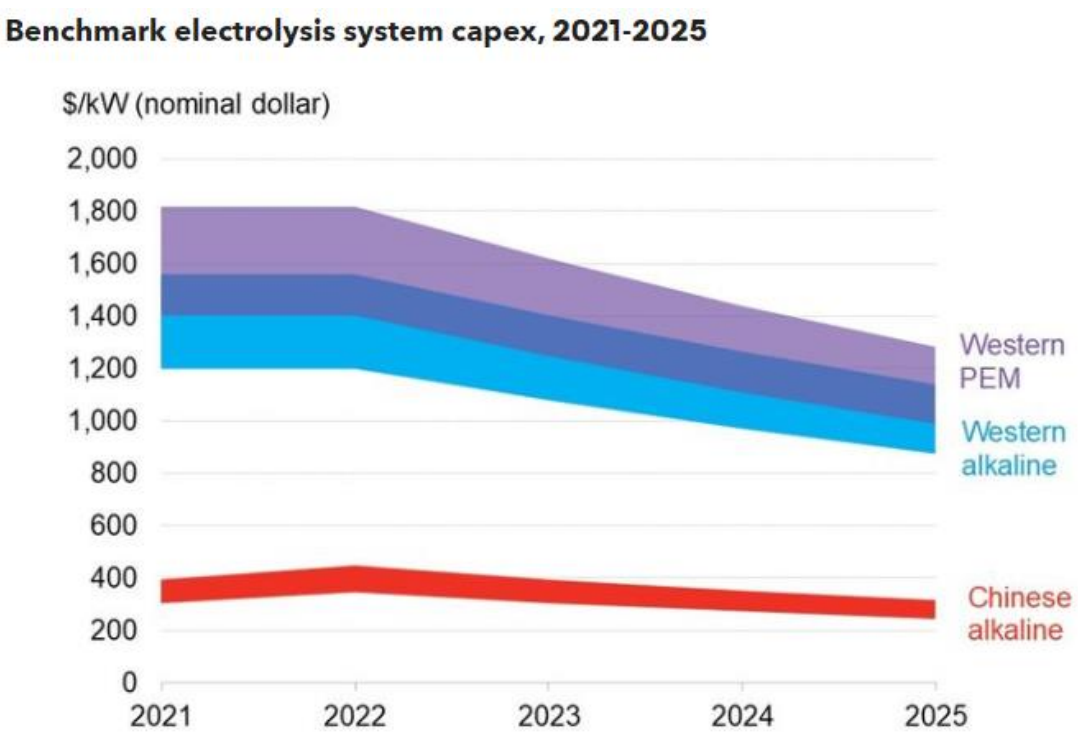
Link: https://www.mdpi.com/2673-4079/3/2/11

Ammonia production and potential in China



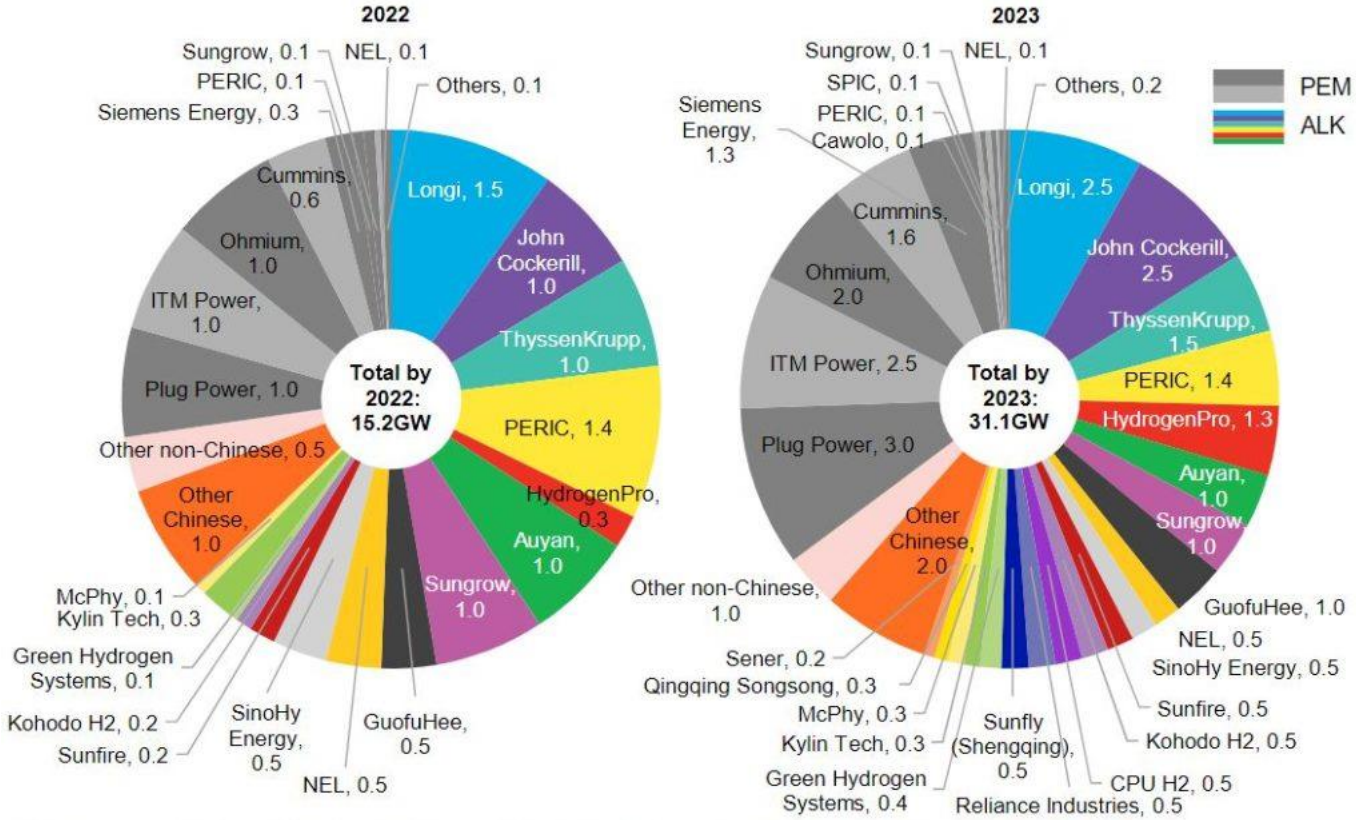
Link: https://www.sciencedirect.com/science/article/pii/S0306261920315750

Chinese electrolyzer manufacturing



Source: BloombergNEF

Note: Year is when equipment order is placed. Capex includes EPC, excludes development and grid connection fees. System size assumed 10MW for 2021 and 100MW for all other years. 'Western' markets use Europe and the US as the reference.



Source: Company filings, industry sources, BloombergNEF. Note: The values refer to year-end capacities.

Link: https://about.bnef.com/blog/a-breakneck-growth-pivot-nears-for-green-hydrogen/

Renewable ammonia projects in China

The Da'an project (Jilin Electric Power Company):

- 180 KTPA

Baotou project (Mintal Hydrogen):

- 390 KTPA (2025), Topsoe as licensor (1800 TPD)

Chifeng project (Envision):

- 20 KTPA (2023, pilot)
- 300 KTPA (2024-2025)

Link: https://www.ammoniaenergy.org/wp-content/uploads/2022/10/Envision-Hydrogen-Green-Hydrogen-and-Green-Ammonia-Business-AEA.pdf