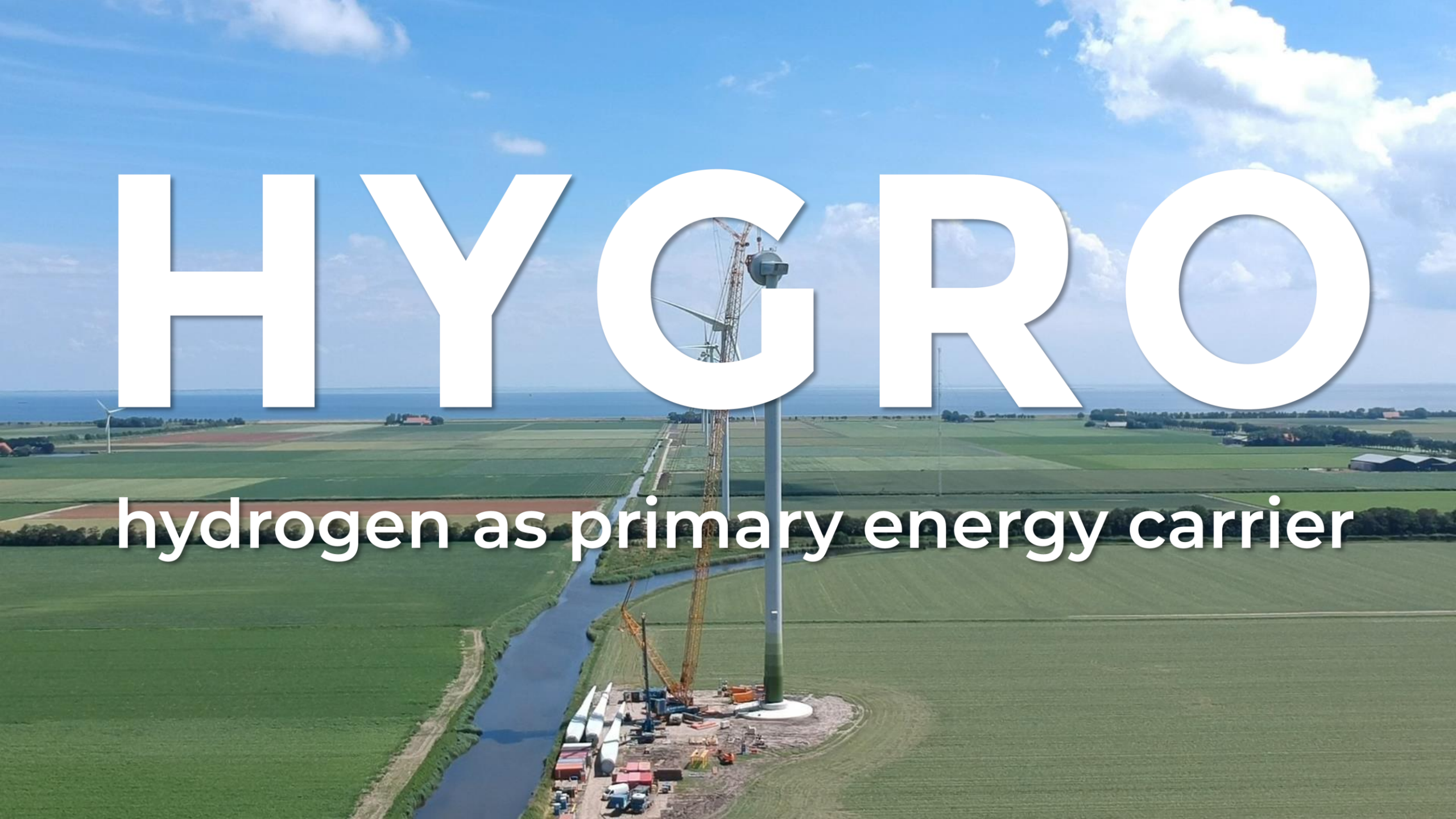

HYGRO
hydrogen as primary energy carrier

Wind energy? Let’s talk hydrogen

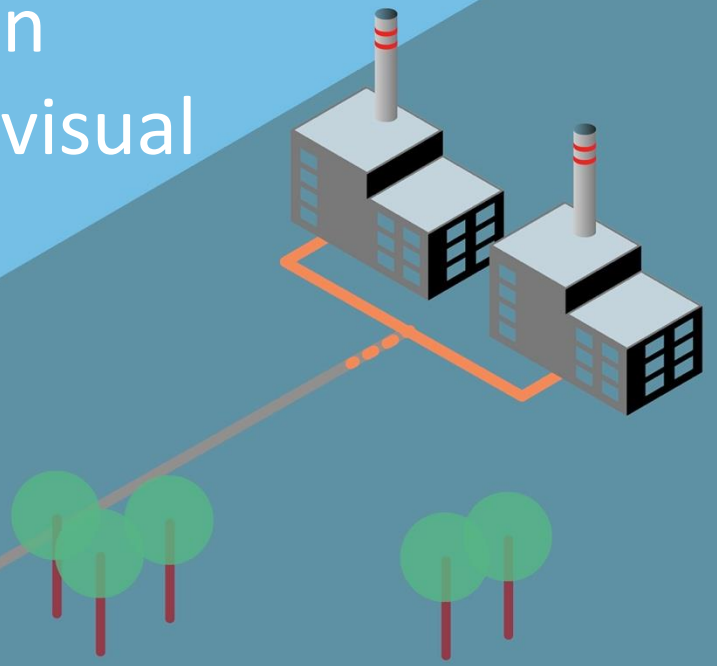
- Tata Steel IJmuiden
  - Switching from coal to Direct Reduced Iron (DRI) route
  - 10 million ton steel/year, thus:
  - 720.000 ton hydrogen/year required

- When will hydrogen be green?
  - 2026 /2035 /2050

- How much wind energy required?
  - 385 or 575 or 1.152 km^2 sea?

Hydrogen directly from wind

- Double energy per km^2
- 2,4 x more CO_2 reduction
- 3 x more hydrogen
- Limited spatial & visual impact



Cheaper than:

- Central electrolysis (40%)
- Electricity (5%)
- Diesel (30%)
- Blue hydrogen (15%)

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HYGRO: the green hydrogen energy company

Our vision

Synergy between wind, solar, direct electrolysis and pipelines will double the yield of wind at a lower cost per unit of energy compared to electricity.

Mission

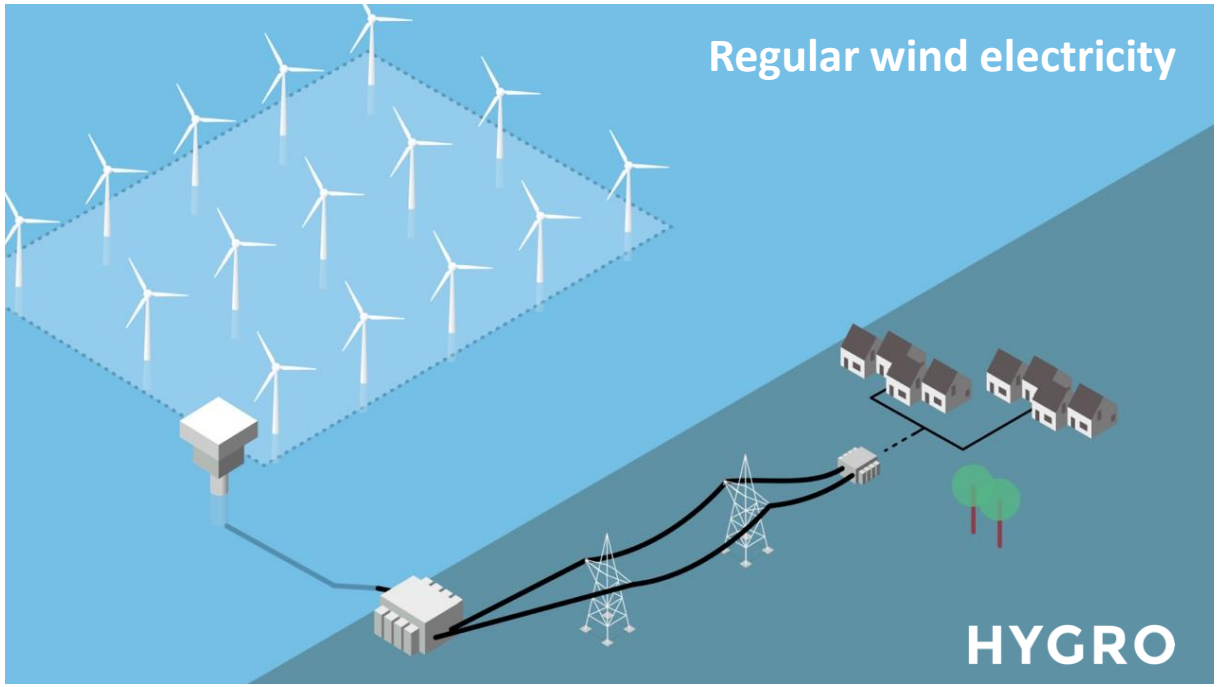
To develop, build and operate a sustainable and integrated supply chain with hydrogen as primary energy carrier.

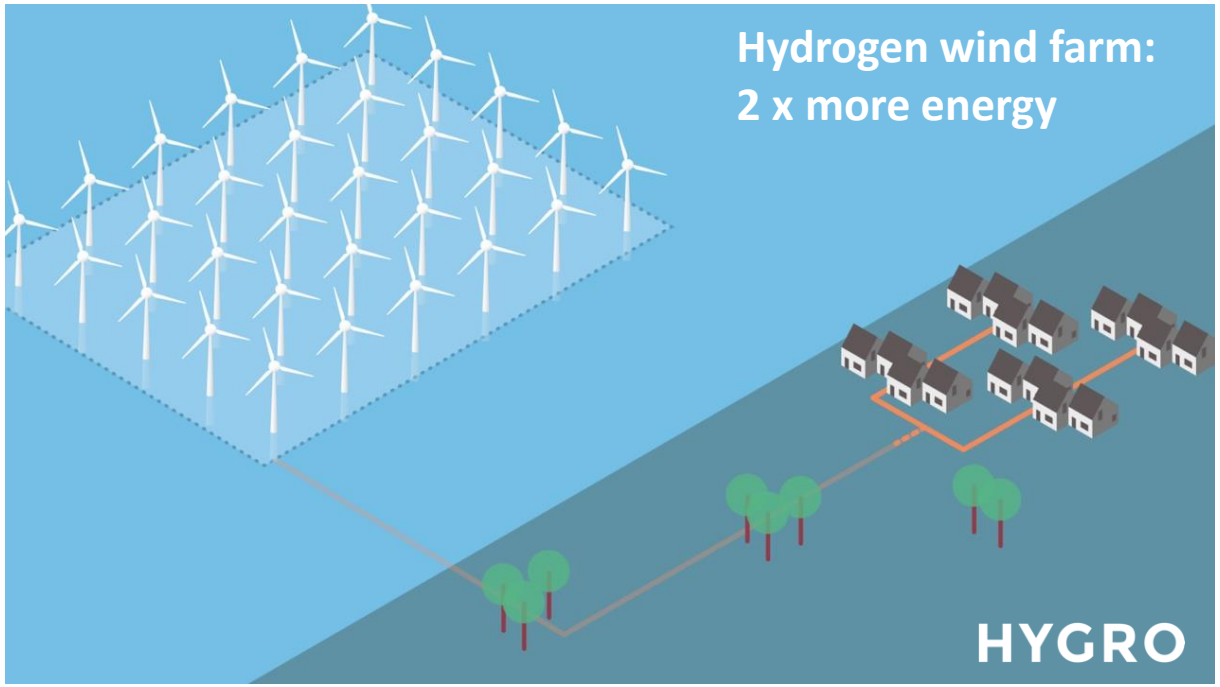
HYGRO current projects

- 1 x Demonstrator project
  - 4 MW wind (2021) + 2.5 MW electrolyser (2022)
- 3x new project under development
  - Total 36 MW wind 22 MW elx
- Research programs
  - Offshore Wind2wheel
    - 2017, HYGRO, TNO & partners
  - Power density & LCoH
    - 2020, HYGRO, TU Delft
  - Feasibility offshore demonstrator
    - 2020 MHI-Vestas, Boskalis, VS&H, Soluforce TNO
  - SBIR (USA) phase I & II
    - 2020/21/22 GINER, NREL, GE
  - Noth Sea wind II
    - to be awarded, 2022, TNO & many partners

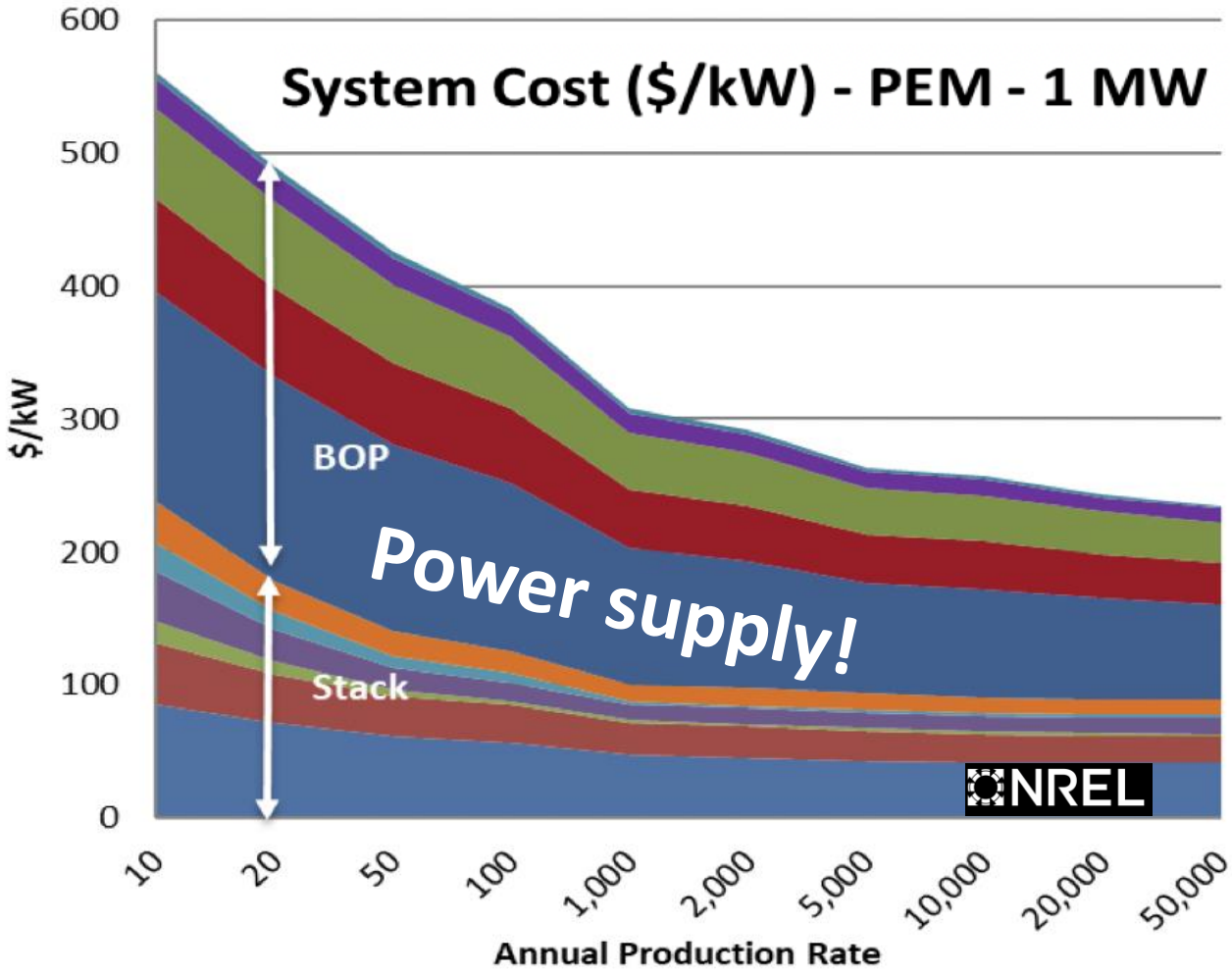
Twice the energy, delivered at lower cost

Synergy leading to new economic optimum for
1) farm design => 60% more energy
2) turbine design => 30% more energy

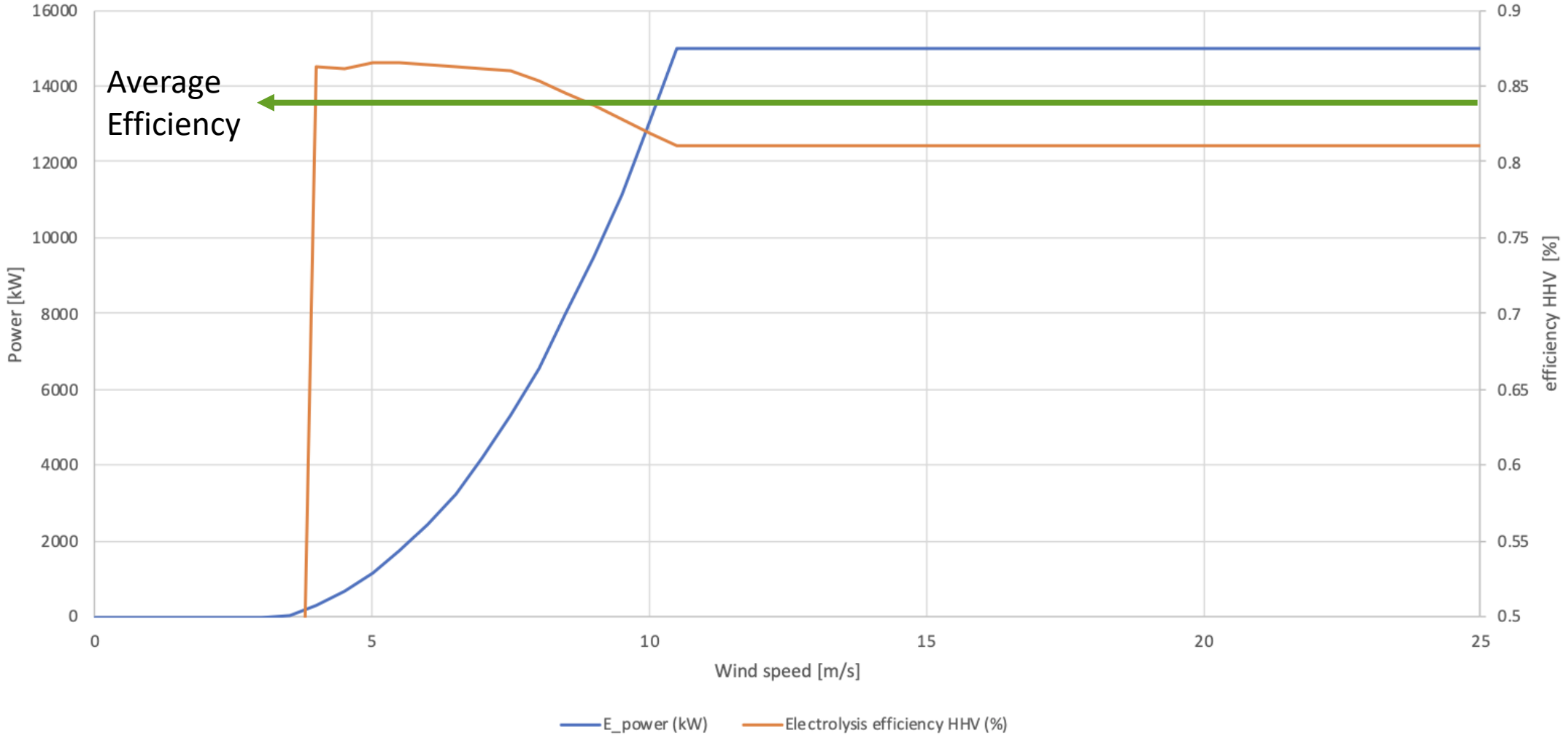




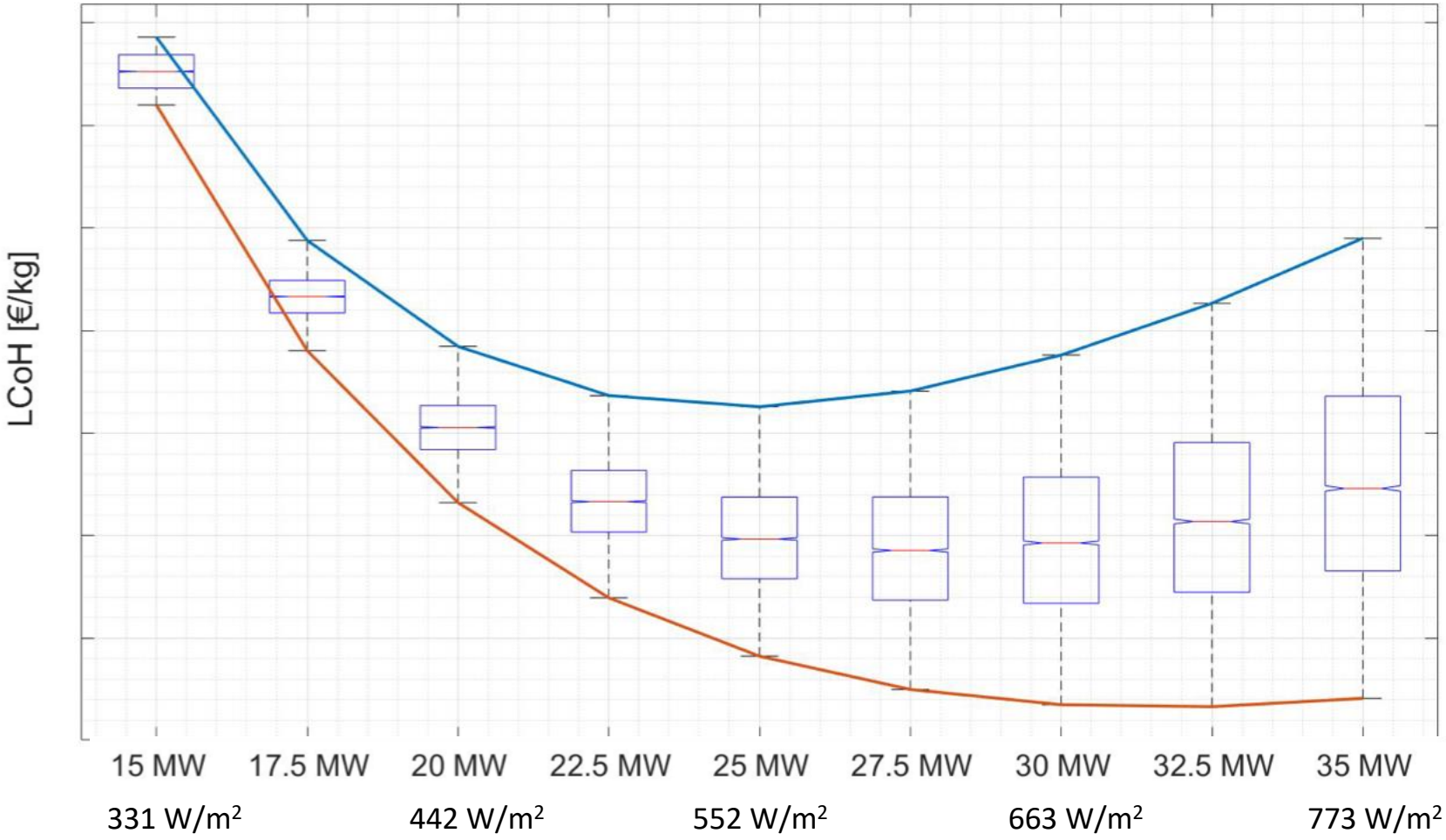
Dominant cost driver electrolyser



Wind power & electrolyser curve



LCoH vs Power density



- NREL Direct drive model
- Rotor 240 meter
- Scaling generator capacity
- Farm optimisation not included
- Joint research:

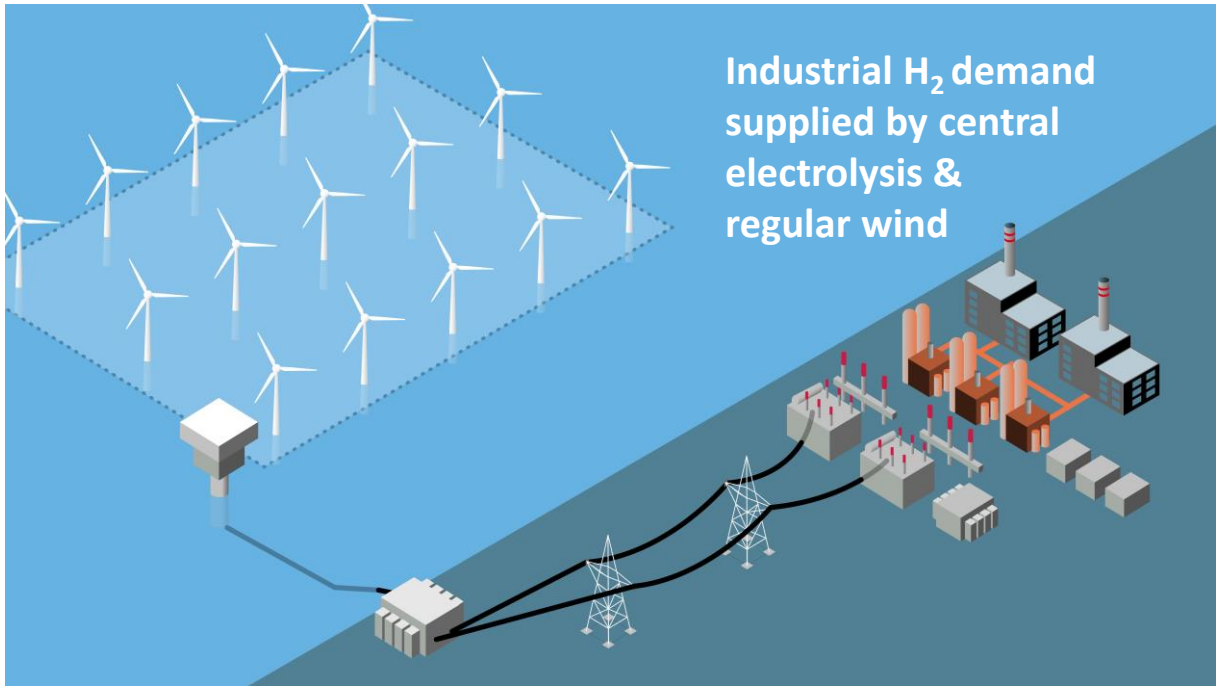
HYGRO

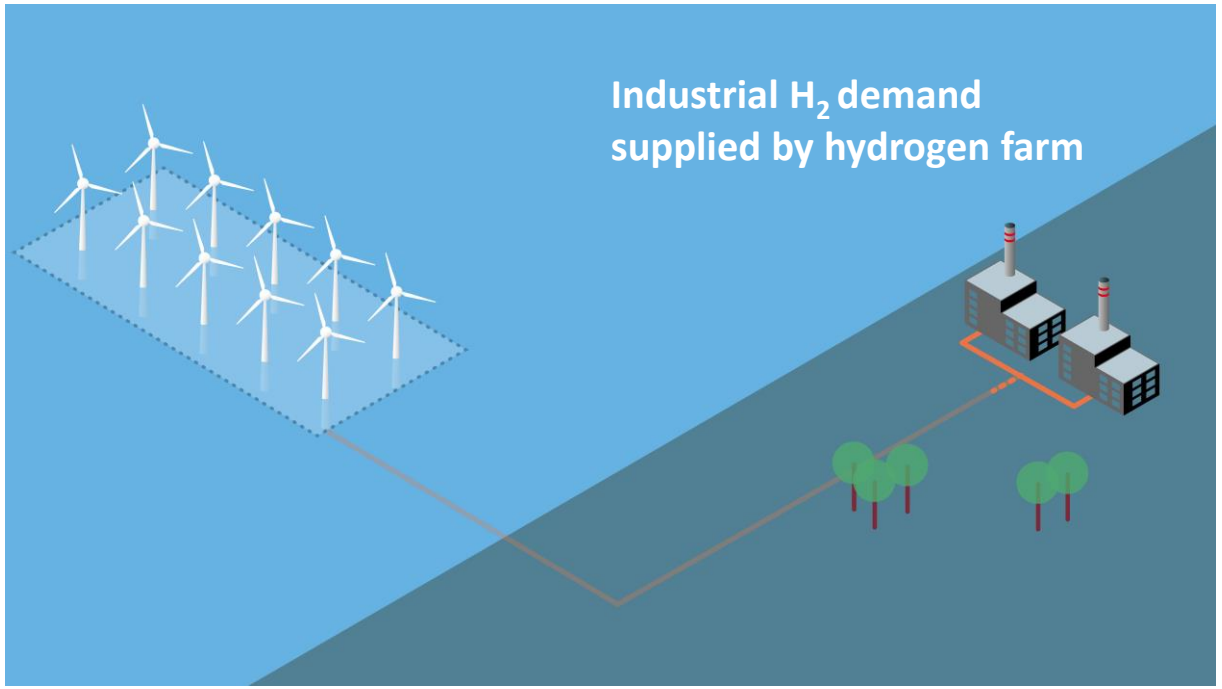
TU Delft

Centralized electrolysis vs hydrogen turbines

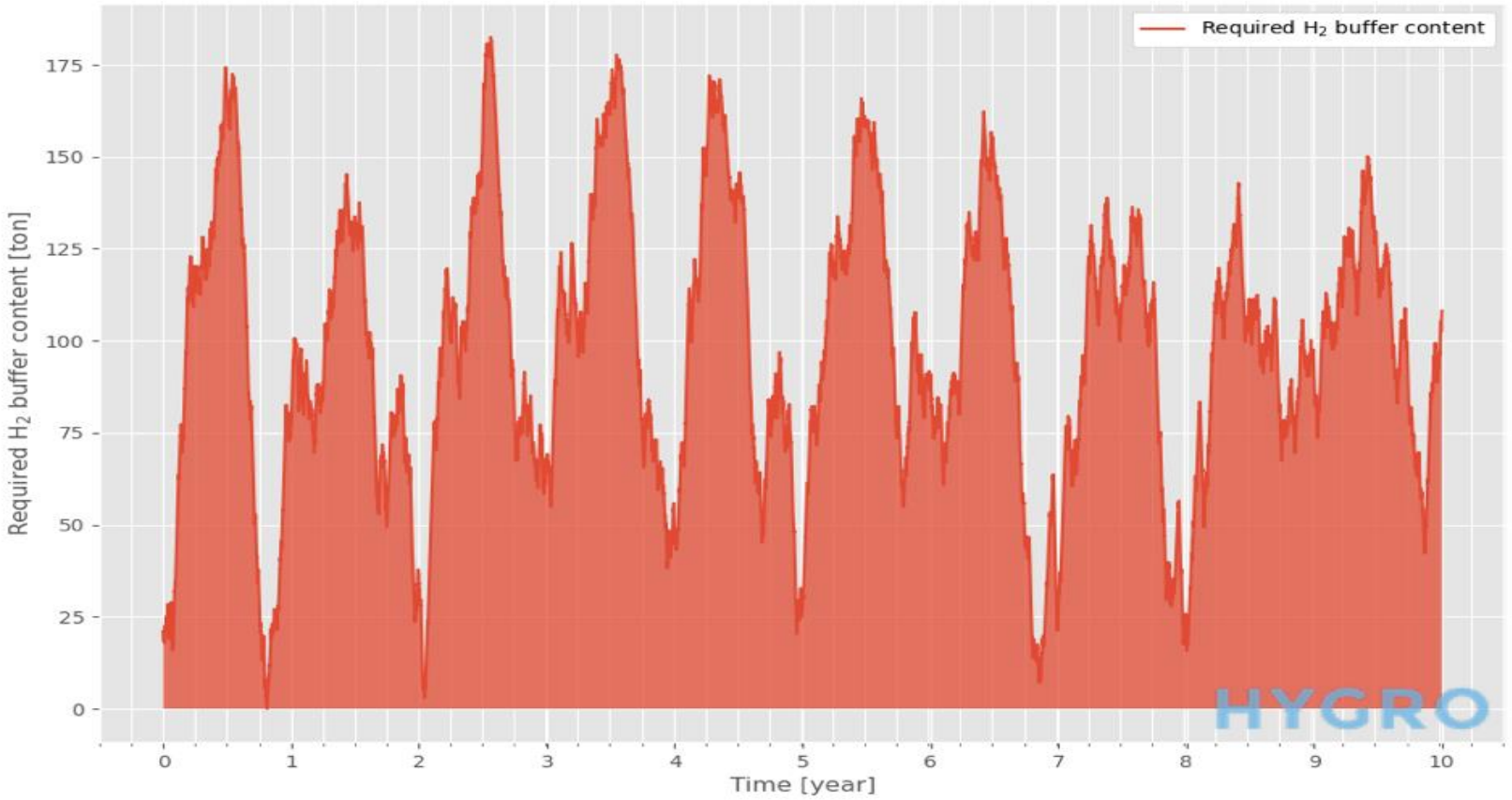
Central electrolysis = combining disadvantages of hydrogen and electricity

- By definition more costly per MWh than electricity from wind
- Split incentive / paradox between wind park and electrolysis
- No synergy possibilities between turbine, electrolysis & pipeline



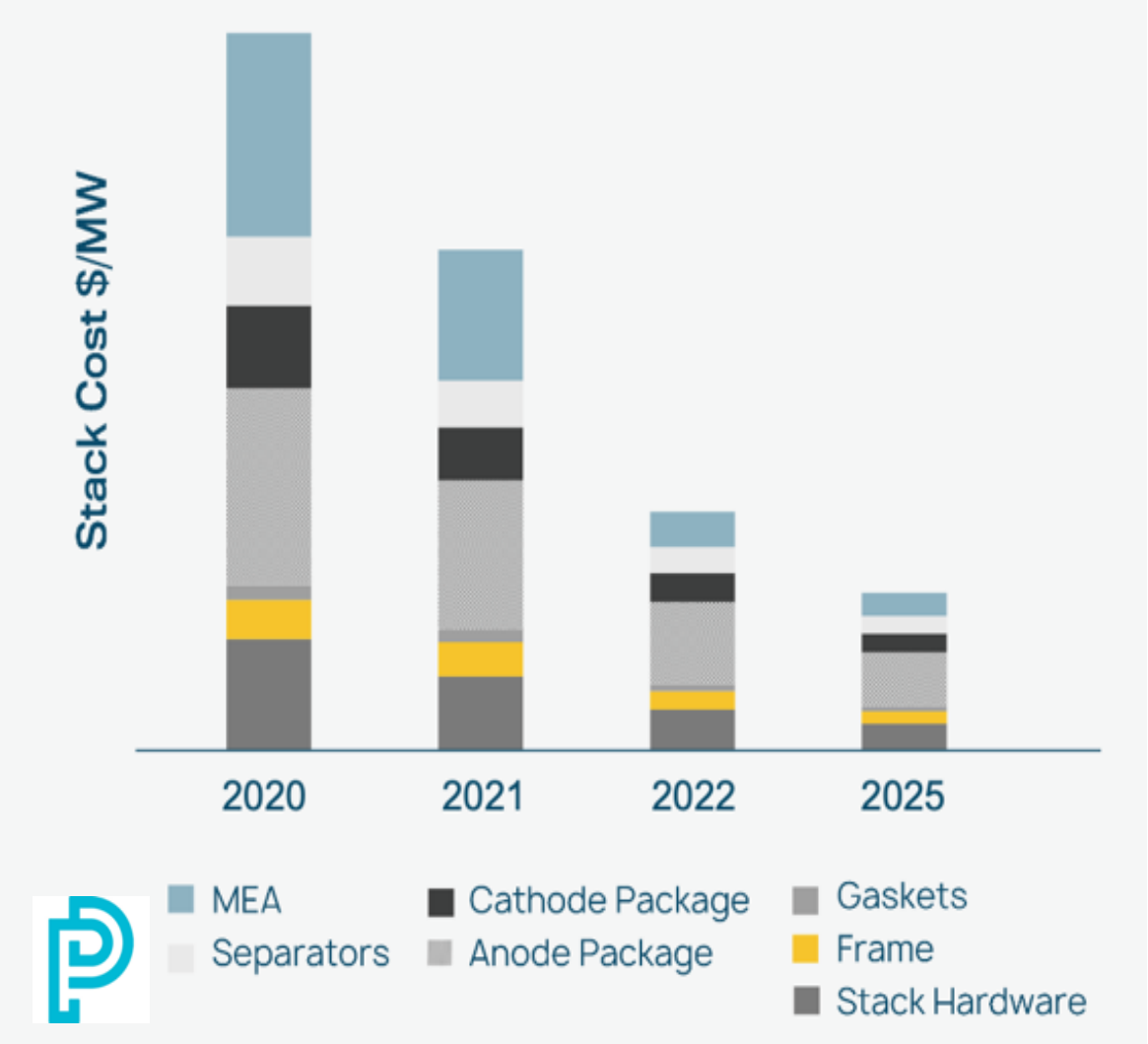


Produce more steel in winter?



Breaking cost barrier by 2025

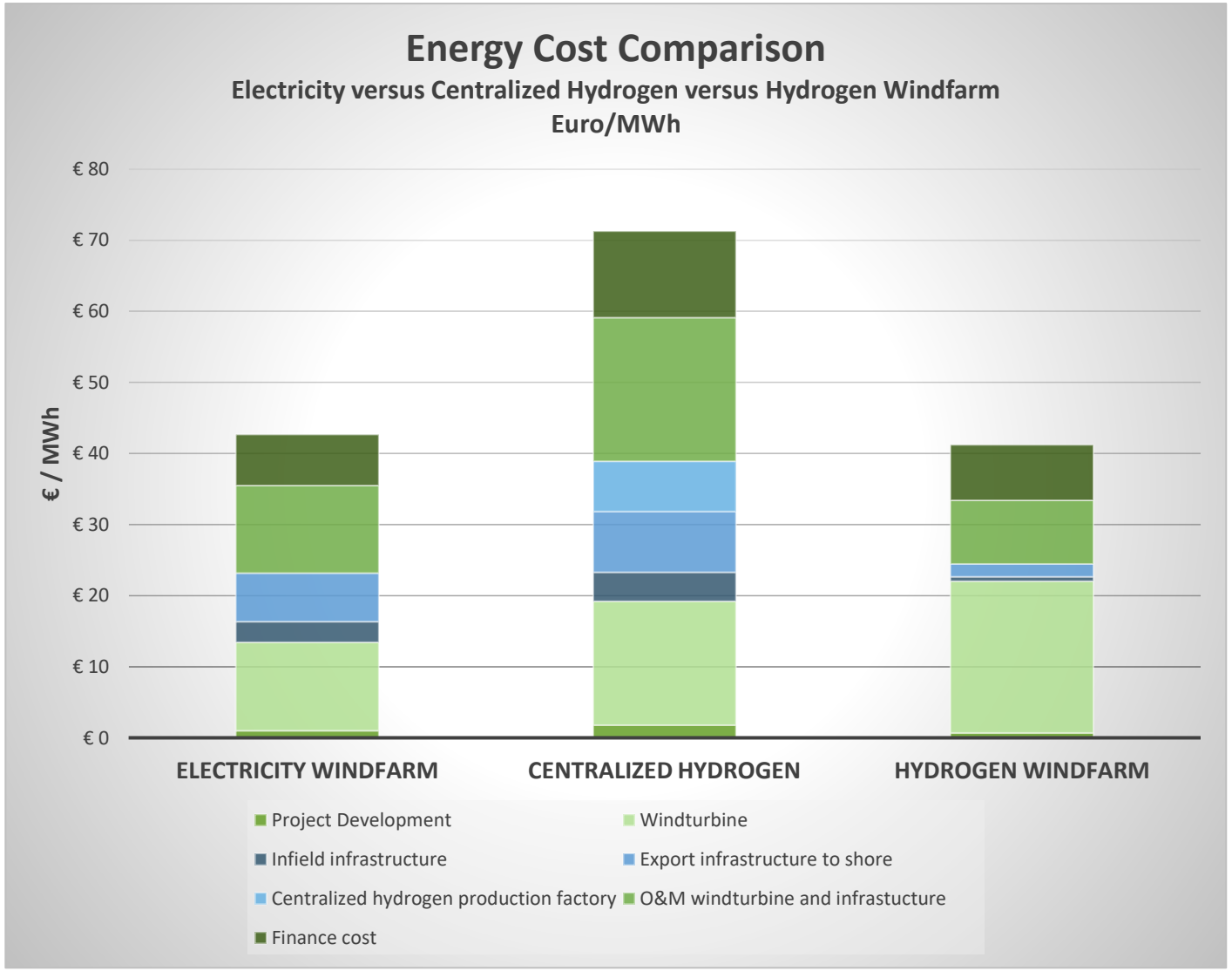
Stack << 8% of levelized cost of hydrogen (turbine)



Outcome Hollandse Kust West realisation 2026

- Based on existing technology
- Reference case assumptions as much as possible alike
- Two main drivers for this outcome
  1)Much lower cost infrastructure cost
  2)Much higher yield (±55%)

HKW Tender rules block hydrogen turbines….



Tender IJmuiden ver 2023/25: Next chance for Tata?