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An assessment of electrolyzer for offshore wind considering its key properties – efficiency, ramp rate and capacity

Agenda

- Background and motivation
- Methodology
- Scenarios of system set-up
- Electrolyser dynamics and their effects

Background and motivation

What is an Energy Island

An energy island serves as a hub for connecting and distributing power from the surrounding offshore wind farms (OWF).

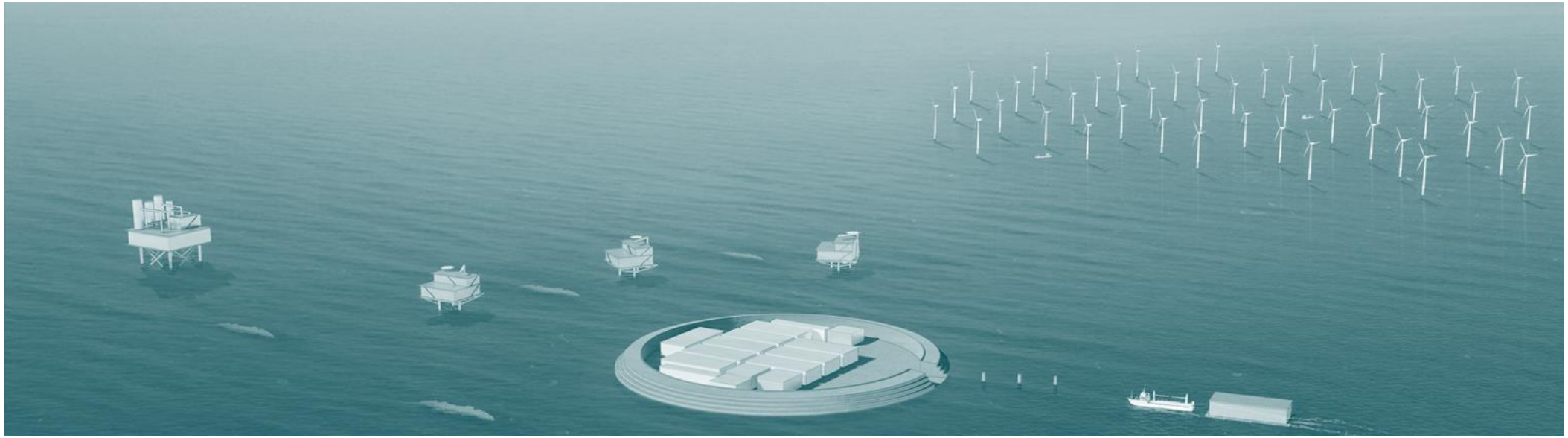
Power can be pooled from multiple OWF and transmitted directly to several countries.[1]

Power-to-X

The scale of production means some electricity can be used for Power-to-X (PtX), e.g. fueling ships and planes with green energy, and for other fuel/energy consumers.[1]

Scaling effect

Concentrating offshore wind around an island hub enables connection and interconnection capacity at scale.[1]



[1]Source: The Energy Island in the North Sea – Teaser for potential investors, EY and Danish Energy Agency, November 2022

Research question and methodology

How and how much will the inclusion of an electrolyser's operational details influence the estimated operational performance of a wind-electrolyser set-up?

Scope

Identify and dissect the difference in dynamic performance of a wind-electrolyser setup when modelling its dynamic properties at different granularity levels

Produce as much renewable hydrogen as possible with a given wind farm operating at various wind conditions

- Today's electrolyzers technology
- Centralised vs. Decentralised wind-electrolyser configurations

Focus on different properties for electrolyser

1. Efficiency
2. Ramping
3. Operation range
4. Capacity

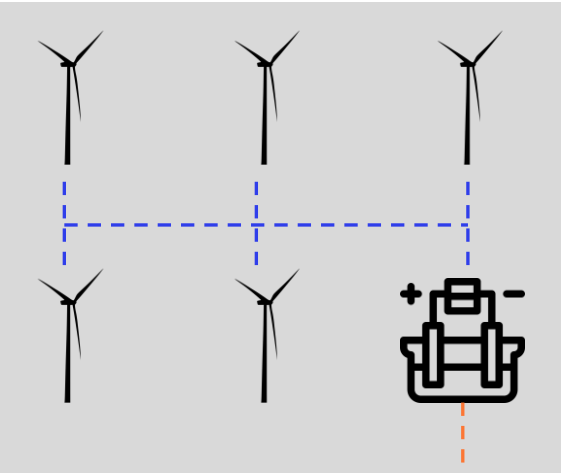
Scenarios for system set-up

Reference scenario

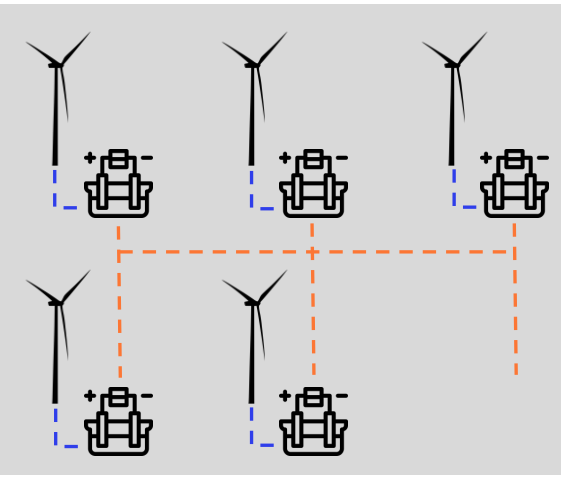
- Wind power profile for 30 MW wind fram consisting of 5 x 6 MW turbines
- Annual capacity factor of 0.56 for the wind farm

- **Centralised** set-up has a single location of green hydrogen production
- **Decentralised** set-up has multiple locations of green hydrogen production

Centralised



Decentralised

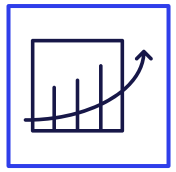


Electricity

Hydrogen

An electrolyser's key properties that are related to its operation performance

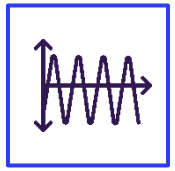
Varying efficiency



Variable power consumption at different loads

- The efficiency curve can be scaled linearly across electrolyser capacity
- Alkaline electrolyser

Ramping



Ramping electrolyser up and down

- 20% per second
- For demonstration purposes assumption of 20% per 10min

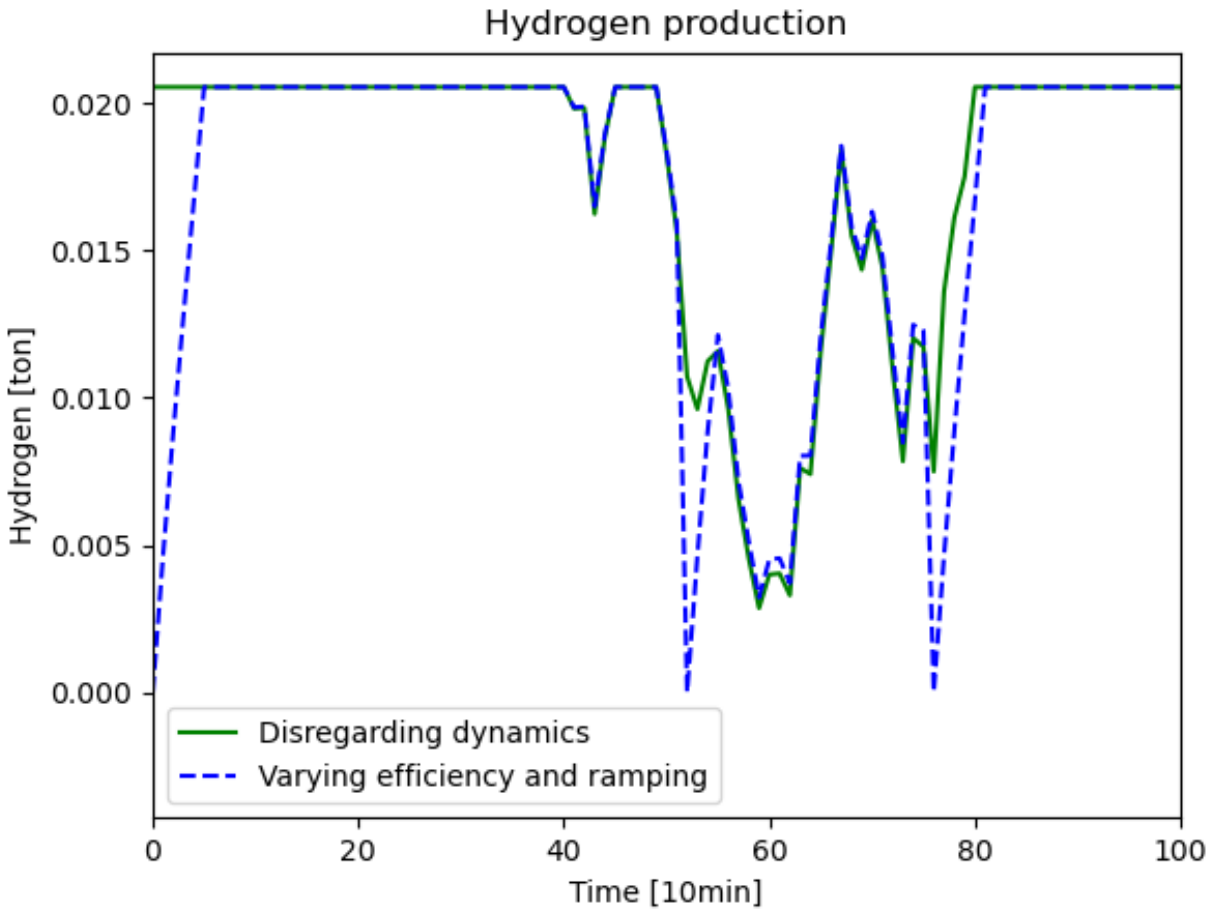
Variable size

Selection of electrolyser capacity

- Centralised versus decentralised set-up

The estimated operation performance depends on how these properties are modeled and included in the calculation

Effect of dynamics



- Wind profile (single turbine) with a representative electrolyser

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- Inclusion of ramping decreases the hydrogen production

  With varying efficiency (instead of using a constant efficiency) the available power can be utilised better, thus hydrogen production is increased slightly

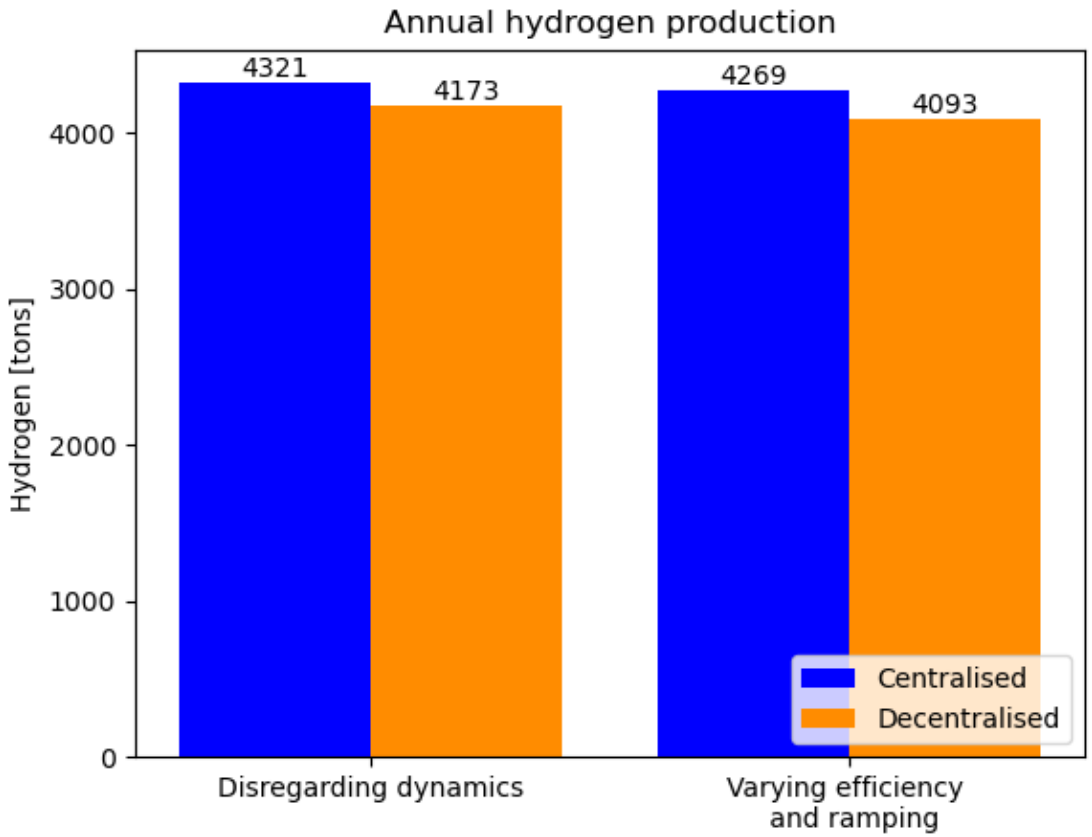
Effect of dynamics

System performance at different scales for 1-year simulation

- A 1 MW electrolyser connected to single turbine
- A 5 MW electrolyser connected to total wind farm
- A12 MW electrolyser connected to total wind farm
- 5 x 1 MW electrolysers connected to total wind farm (5 turbines)

- Decrease in hydrogen production from no dynamics to dynamics included
  - 1 MW ≈ 1.9 %
  - 5 MW ≈ 1.2 %
  - 12 MW ≈ 0.6 %
  - 5 x 1 MW ≈ 1.9 %

Centralised vs. decentralised system set-up



- Wind capacity: 30 MW
  Consisting of 5 x 6 MW turbines

- Electrolyser capacity: 5 MW
  Comparing **5 x 1 MW (decentralized)** and **1 x 5 MW (centralized)** solution

- ≈3.5% larger annual hydrogen production for centralised solution disregarding dynamics and ≈4.3% with dynamics

Future research

- ✔ **The impacts of electrolyser' dynamic properties on the operational performance of a wind-electrolyser setup are not the same for different configurations**
- **How to construct the electrolyser portfolio?**
- **How will the techno-economic assessment look like? Prioritise hydrogen production vs. electricity, grid-connected vs. off-grid, seasonality, pipelines vs. cables**
- **How will start – stop rates impact the optimal operation of an electrolyser?**
- **Will the conclusions change for a 1GW site?**

Thank you!

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