Innovations at Hollandse Kust Noord wind farm

CROSSWIND

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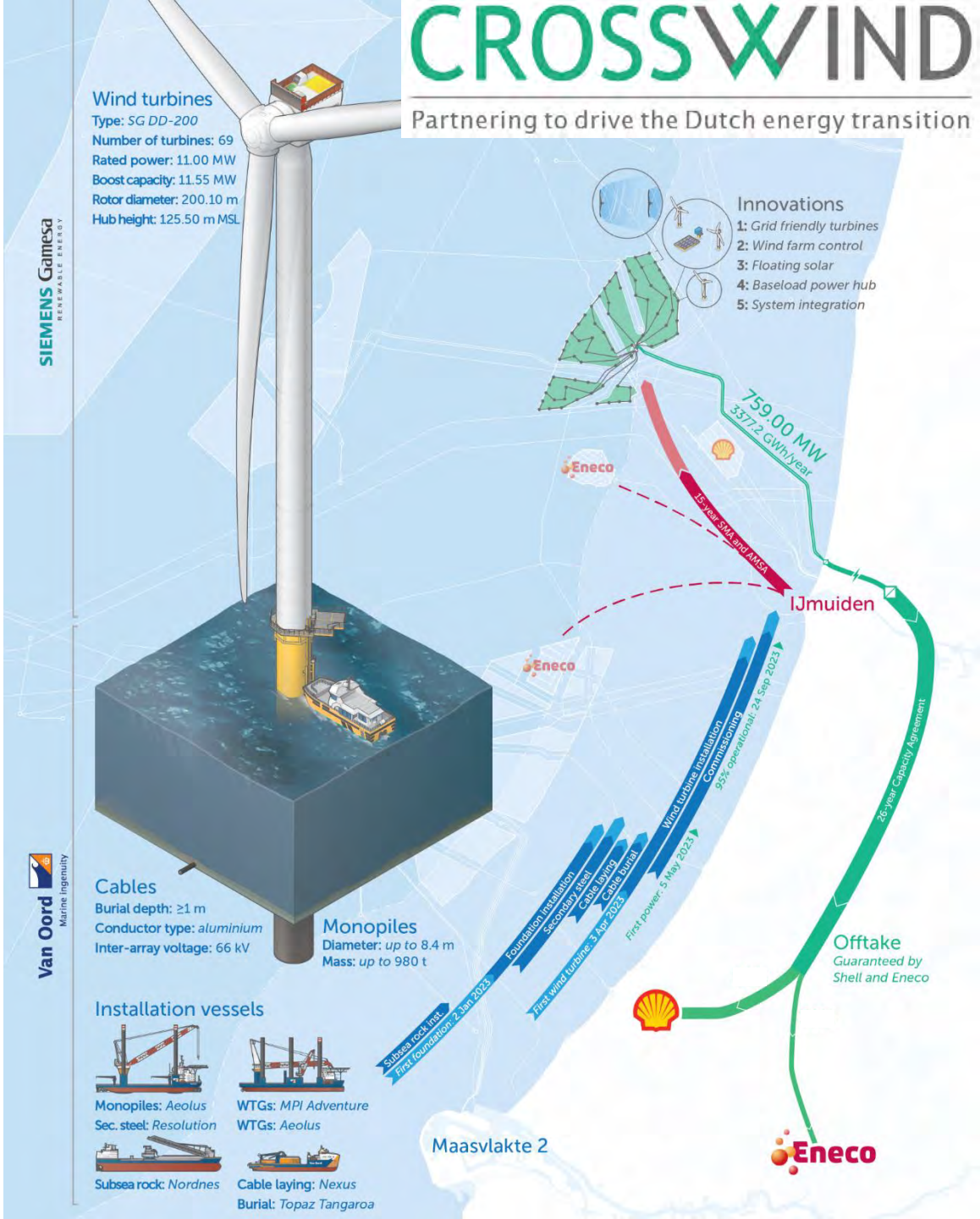
The Crosswind Joint Venture (JV)

- 20km of the coast of Egmond aan Zee
- 760 MW, 3.3 TWh/year
- Operational Q3 2023

- Crosswind JV (Shell (80%) & Eneco (20%) consortium)
- 69x 11MW SiemensGamesa turbines
- 1 monopile for innovation hub
- Van Oord as BOP contractor
- FID taken by both partners
- Power take-off by both partners

- Awarded 1 August 2020
- Operational Q4 2023
- Innovations demonstration Q4 2025



Tender criteria to stimulate innovation

- In NL there is no competition on price, because bid are subsidy-free for the past years. Tender rankings based on criteria.

- For the 2020 tender of the Hollandse Kust Noord (HKN) wind area three areas of innovation were identified
  - **Time shifting of electricity supply profile**
  - **Power to X**
  - **Overplanting renewables**

- Strong emphasis on data dissemination and knowledge sharing

- Innovation plan is enabler to build wind farm

- Offshore substation is provided by the government, so all innovations must be implemented upstream of the substation.

STAATSCOURANT

Nr. 68472

17 december 2019

Officiële uitgave van het Koninkrijk der Nederlanden sinds 1814.

Regeling van de Minister van Economische Zaken en Klimaat van 13 december 2019, nr. WJZ/ 19201387, houdende nadere regels tot vergunningverlening windenergie op zee voor het kavel V van het windenergiegebied Hollandse Kust (noord) (Regeling vergunningverlening windenergie op zee kavel V Hollandse Kust (noord))

De Minister van Economische Zaken en Klimaat,

Gelet op de artikelen 14, tweede lid, 23, eerste, derde en vierde lid, en 24, derde lid, van de Wet windenergie op zee;

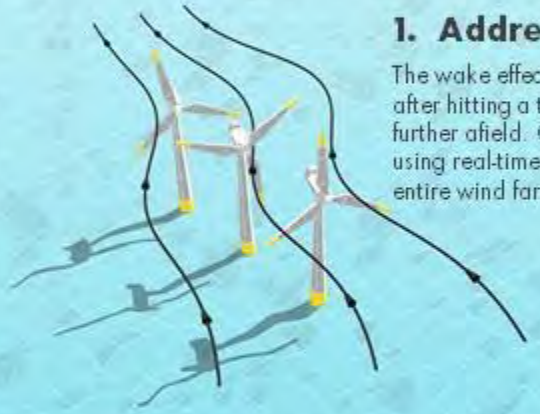
Besluit:

Artikel 1

In deze regeling wordt verstaan onder:
flexibiliteit van het leveringsprofiel van een windpark: mate waarin de levering van elektriciteit aan het net op zee in de tijd niet rechtstreeks afhankelijk is van de windcondities op het moment van de levering;
kavel V: kavel V van het windenergiegebied Hollandse Kust (noord) zoals aangewezen in Kavelbesluit V windenergiegebied Hollandse Kust (noord) (Stcrt. 2019, nr. 24545);
minister: Minister van Economische Zaken en Klimaat;

An intelligent wind farm

The wind doesn't always blow consistently. So how can a wind farm provide electricity when there is little wind? CrossWind and its partners are exploring five different innovations designed to address these challenges. Through these innovations an offshore wind farm is capable of providing electricity, no matter the wind conditions.



1. Addressing the wake effect

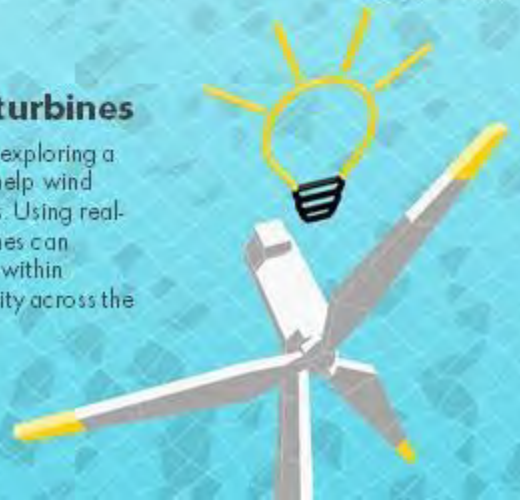
The wake effect describes how wind can slow after hitting a turbine, affecting those situated further afield. CrossWind is looking at ways of using real-time data to reduce this across the entire wind farm.

3. Floating solar energy

What about times when there is simply not enough wind to turn a turbine? CrossWind and its partners are experimenting with floating solar panels that could sit alongside the wind turbines and help to deliver more consistent energy.

5. Research and integration

CrossWind is looking at opportunities to integrate these innovations within the wind farm. We have commissioned further research to assess its feasibility. Our aim is to help the world build intelligent wind farms that can align supply with demand of renewable energy and to further power the transition into a lower-carbon future.



2. Intelligent wind turbines

CrossWind and its partners are exploring a range of technologies that can help wind turbines in a range of conditions. Using real-time data, intelligent wind turbines can respond to changing conditions within seconds and help to keep stability across the energy grid.

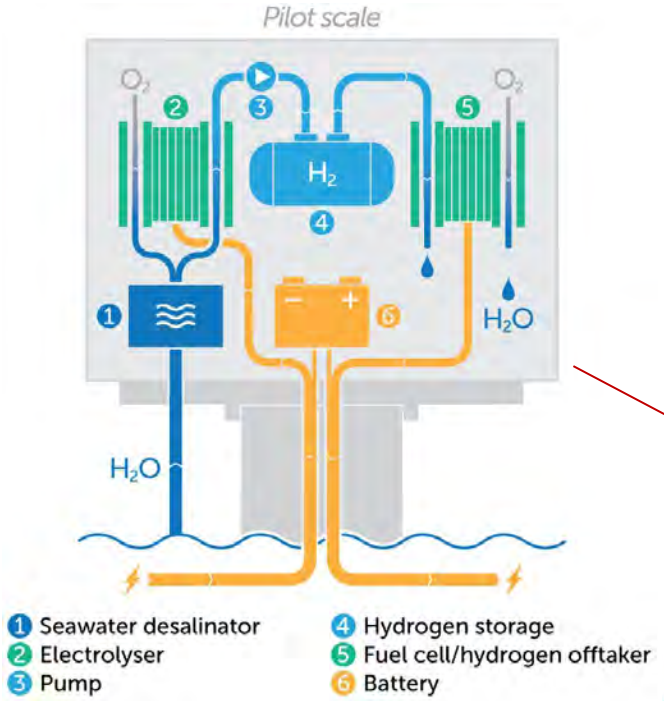
Baseload power hub

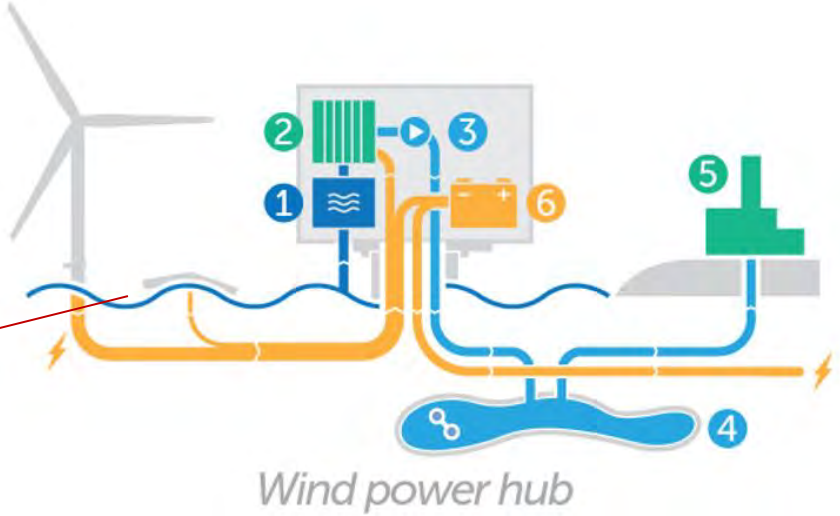
4. Storing energy

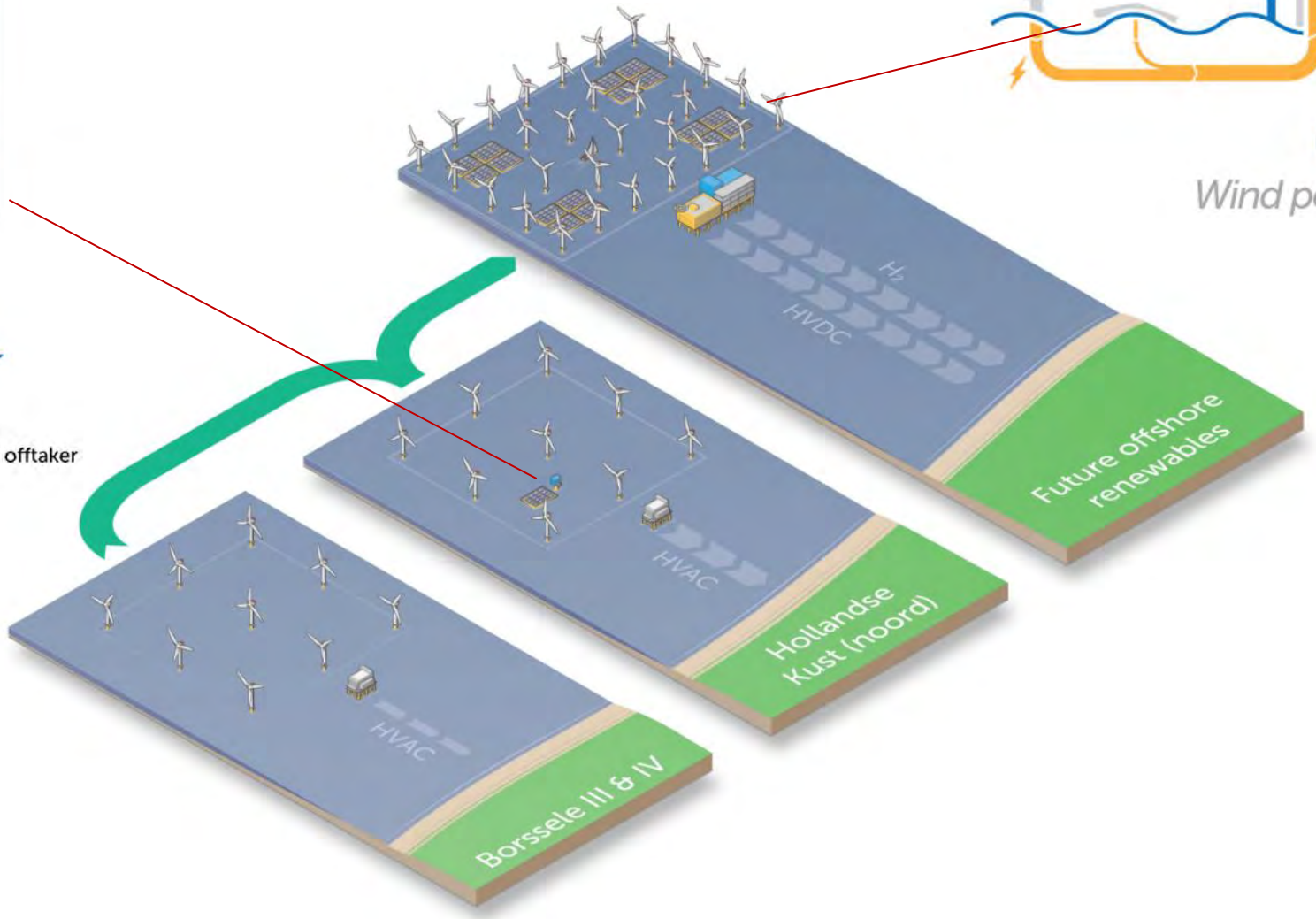
How can you store excess energy in times of low demand to supply it in times when demand is high? CrossWind and its partners are exploring energy storage solutions of batteries and even a hydrogen plant on site that produces, stores and converts hydrogen from electricity to power.

August 2022

From wind farm to integrated energy plant



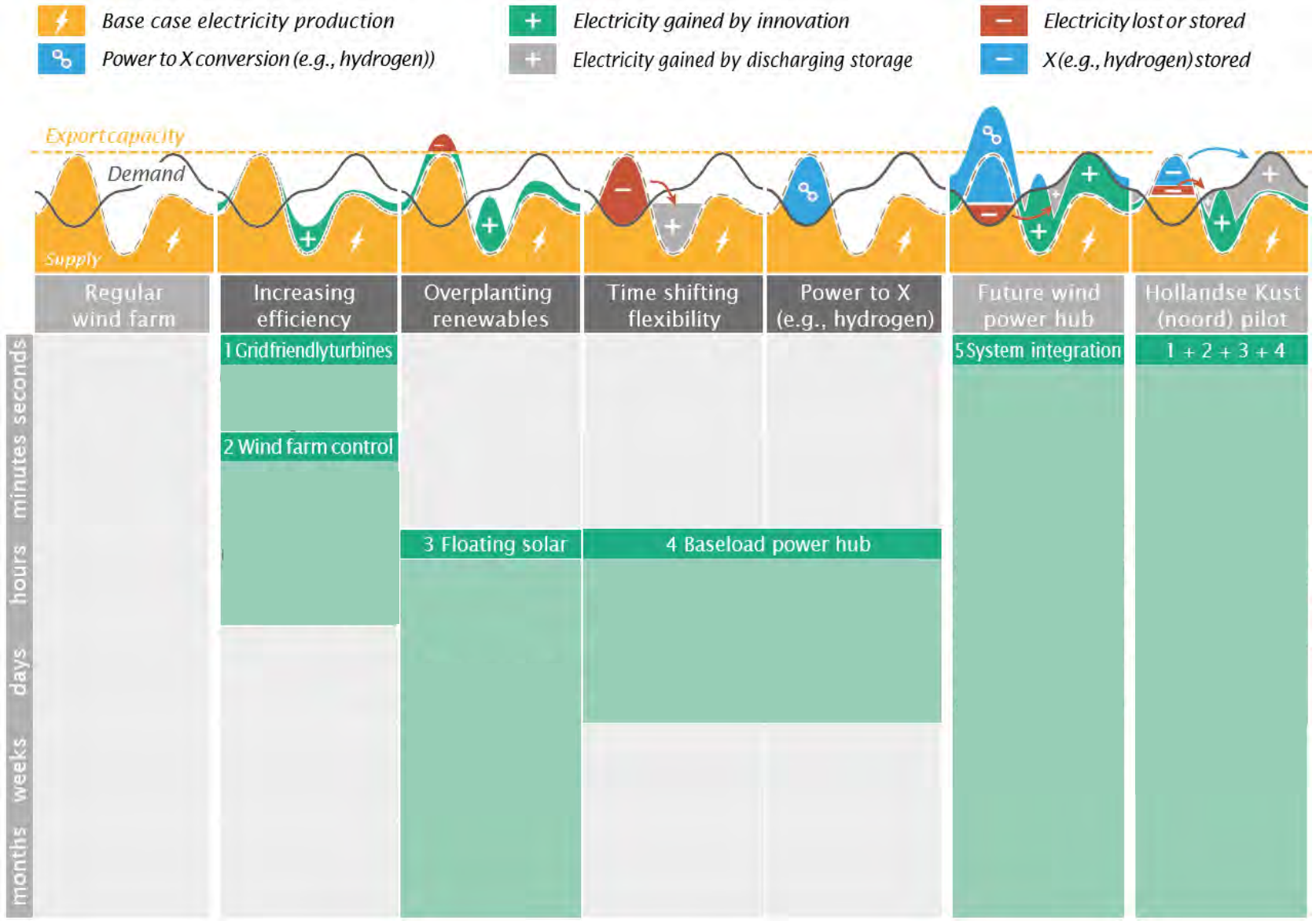




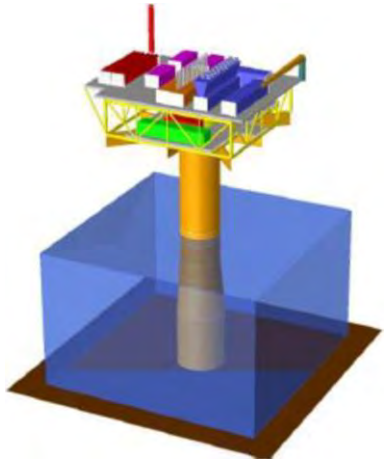
Our innovation plan

- Increasing flexibility can be done at **different time scales** with different technologies

1. Grid Friendly Turbines
2. Advanced Wind Farm Control
3. Floating Solar
4. Baseload Power Hub
5. System Integration



Baseload Power Hub

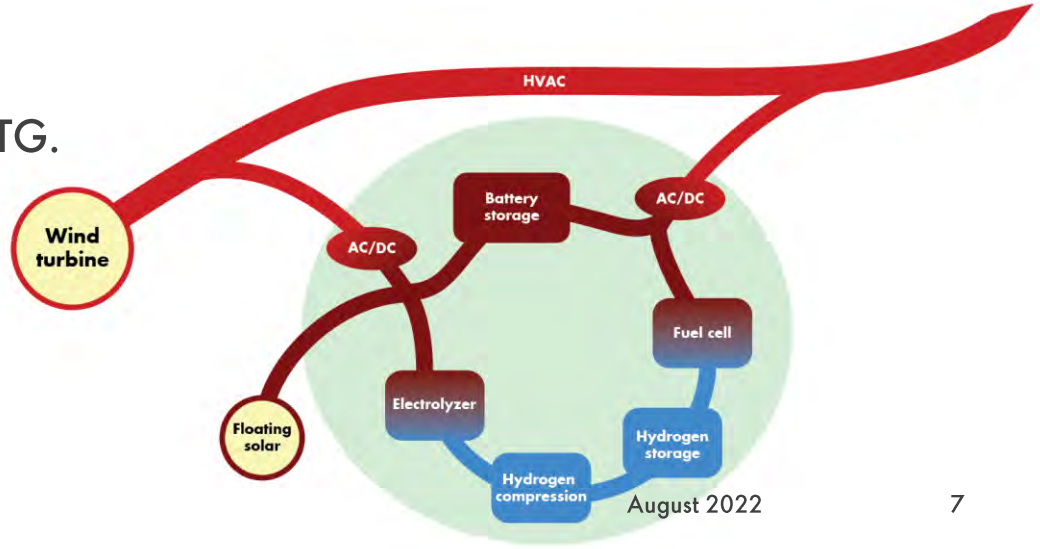


- Demonstration related to a single WTG instead of to the whole wind farm.
- Consider an 11MW WTG with capacity factor 45% produces on average 5MW.
- Demonstration scale project that has significant impact for a single WTG*:

To deliver 99% of the time at least 20% (i.e. 1MW) of the average electricity production of a single WTG independent of wind conditions

- 99% is significantly higher than the 85% that is achieved by a single WTG.
- Platform to be installed within the wind farm in 2025.
- Platform will at least operate for 2 years.

- **Indicative sizing:**
  - 1 MW / 5 MWh Li-Ion battery
  - 2.5 MW electrolyser
  - 1,200 kgH_2 hydrogen storage tubes
  - 1 MW fuel cell
  - 0.5 MW floating solar panels



* Assuming 100% availability

Baseload Power Hub

- *A pilot-scale wind power hub that creates time-shifting flexibility on the hours-to-days scale through a combination of battery and hydrogen storage.*

- The increase in flexibility and its more stable power output will be critical for the future electricity system.

- The baseload power hub will enable the wind farm to always deliver a certain minimum baseload power.

- The North Sea Wind Power Hub consortium in NL (TenneT, Gasunie & Energinet) foresees that the electrical export capacity of offshore wind farms will be supported by a power-to-gas (hydrogen) infrastructure, hence the inclusion of hydrogen in the pilot.

Addressing the wake effect

Dynamic wind farm flow control through:

- Active wake mixing using HELIX technology (individual pitch control)
- Closed-loop active wake steering (yaw control)

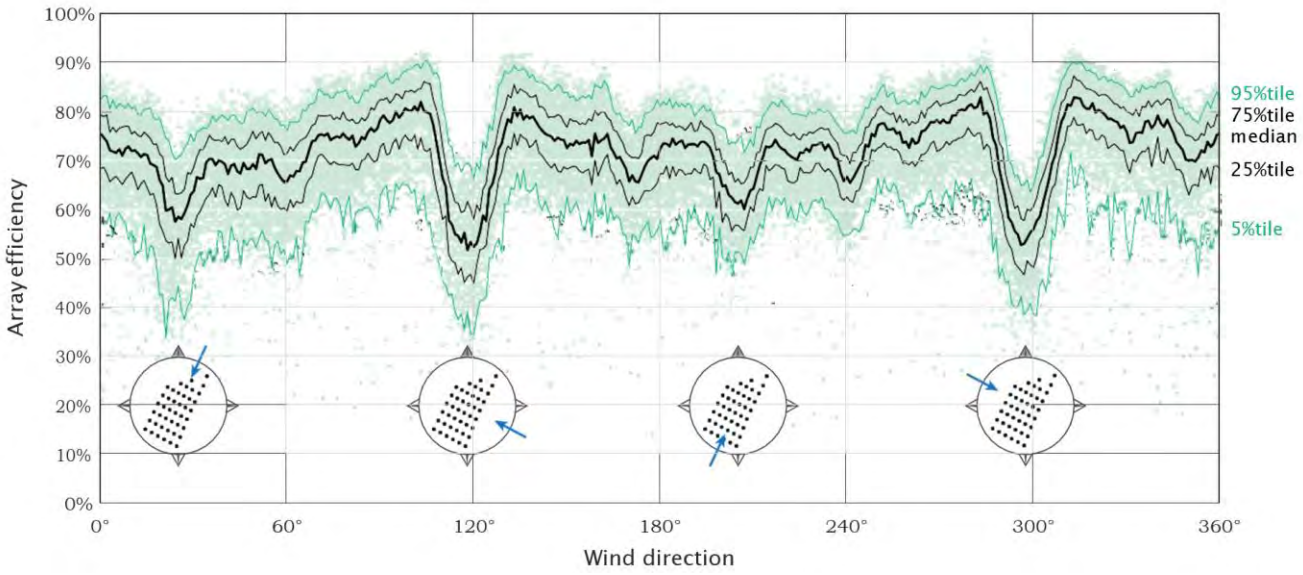
Objectives:

- Increased annual power output in the order of 3% based on current wind farm layouts
- More stable power output with decreased dependence on apparent wind speed that can be predicted and controlled
- Increased wind farm power density (GWh/km2) of utilized offshore space by a factor 2 as a resulted of decreased distances between turbines.

Project Lead: Prof. Jan-Willem van Wingerden (TU Delft)

- 7 PhDs, 2 post-docs and masters students

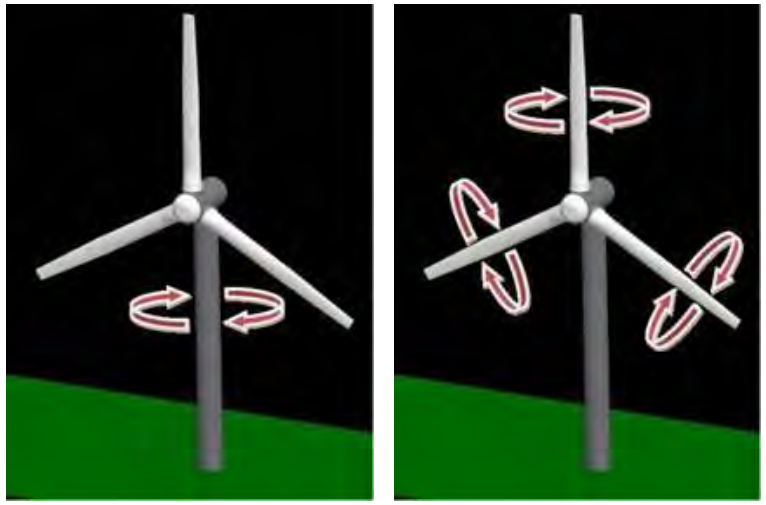
Wind Farm Flow Control



Significant drops in power production due to turbine alignment

Yaw control

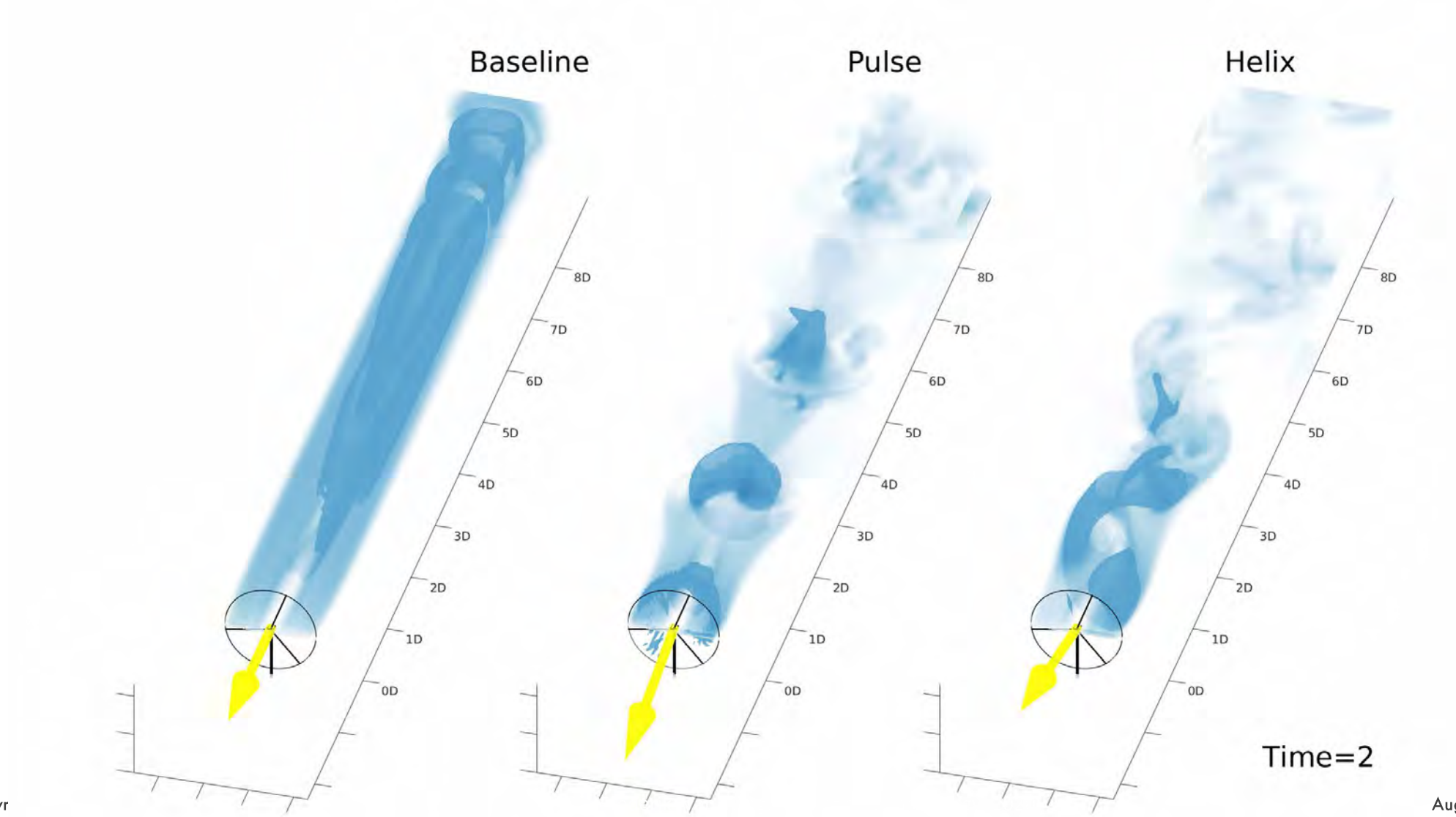
Pitch control



Flow control as mitigation

Frederik, Van Wingerden et al, Wind Energy, 2020

Wake mixing using HELIX individual pitch control



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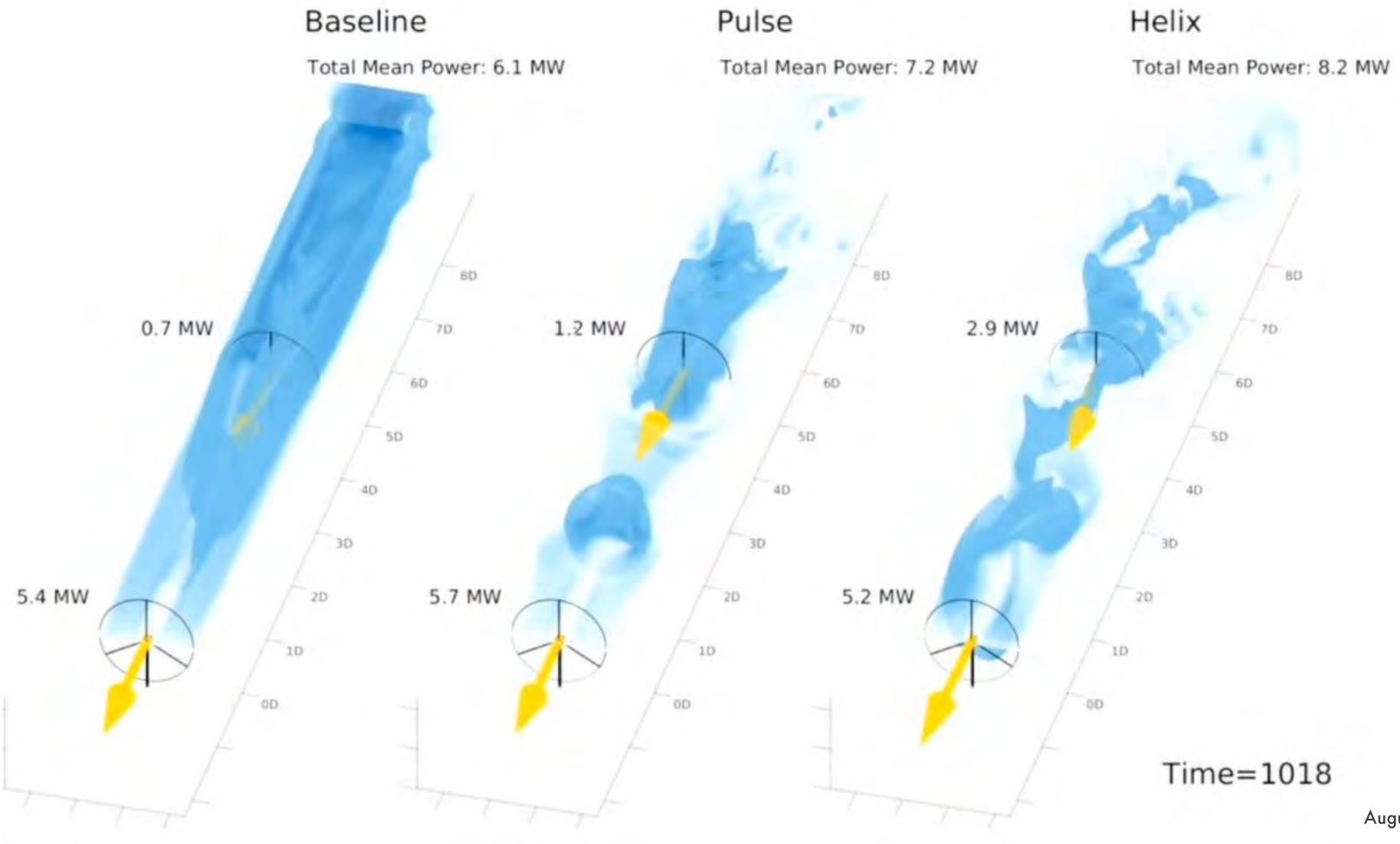
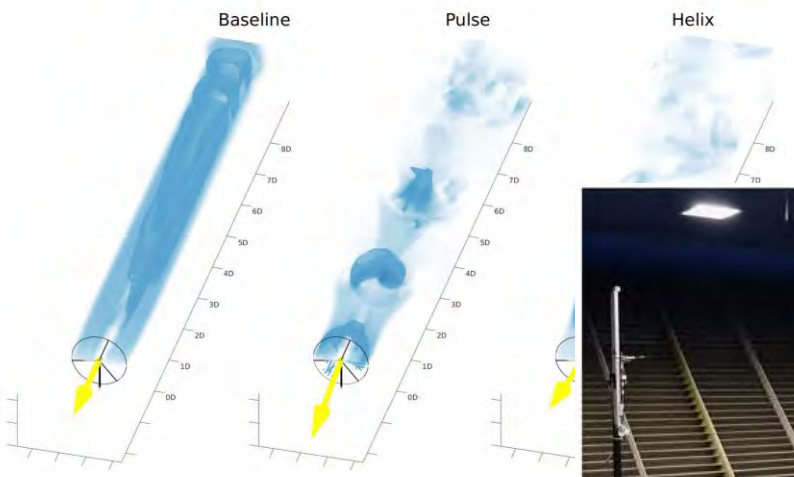
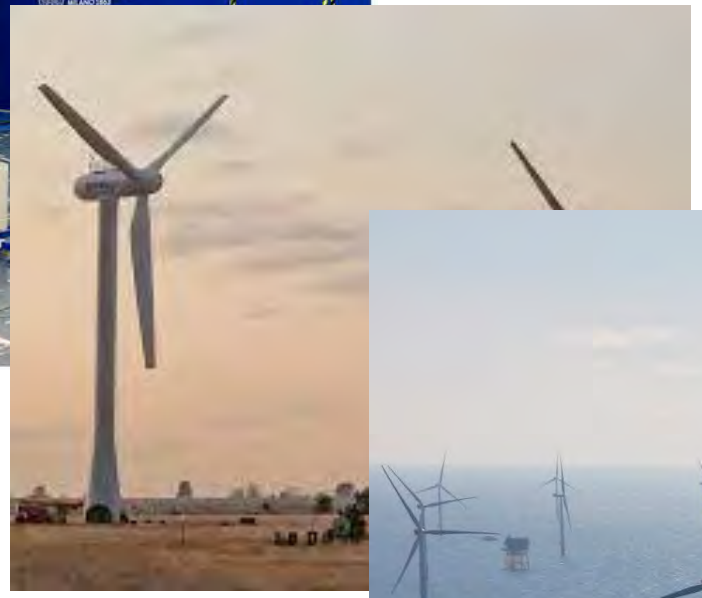


Roadmap to implementation (from TRL2 to TRL7)



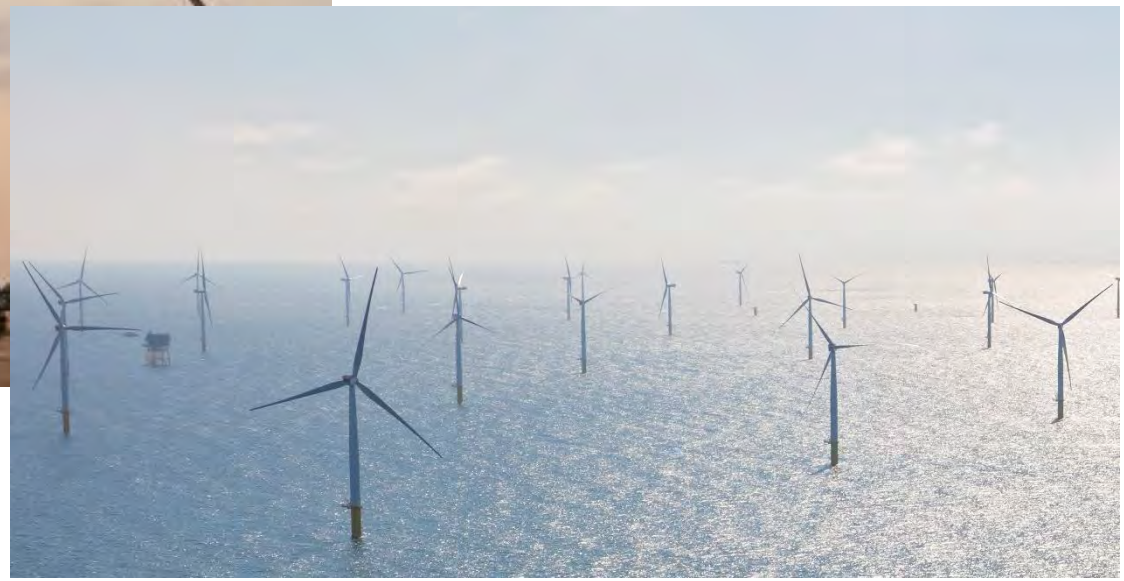
Computational study
(started in 2021)

Wind tunnel study (2022)



Onshore field study (2024)

Offshore demonstration
(late 2025)



HKW Tender Innovation Focus

Dutch tenders continue to emphasize innovation on topics that are critical to large scale development of offshore wind. The tender for the two Hollandse Kust West (HKW) blocks closed in May 2022 and innovation was again a key differentiator.

- HKW-A tender focused on ecological innovation
  - Mitigate negative impact on birds, bats, marine mammals, and benthic and fish
  - Create positive impact
- HKW-B tender focused on system integration to decouple supply and demand
  - Scalable flexible demand to match delivery profile
  - Onshore technologies are now within scope
- Separate categories for roll out of mature technologies (TRL 9) and innovations demonstrated on select turbines (>TRL 7)
- Continued emphasis on data dissemination and knowledge sharing. It is not enough just to do these measures