CIP
Copenhagen Infrastructure Partners

Offshore-Wasserstoffproduktion

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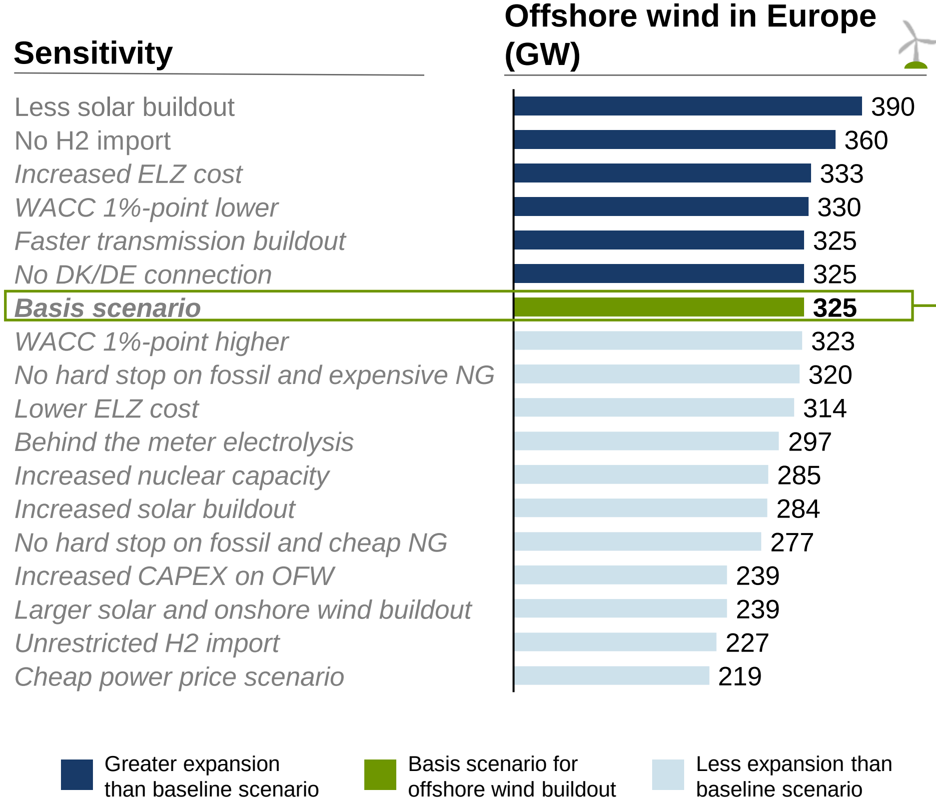
Europe's energy transition requires massive offshore wind expansion

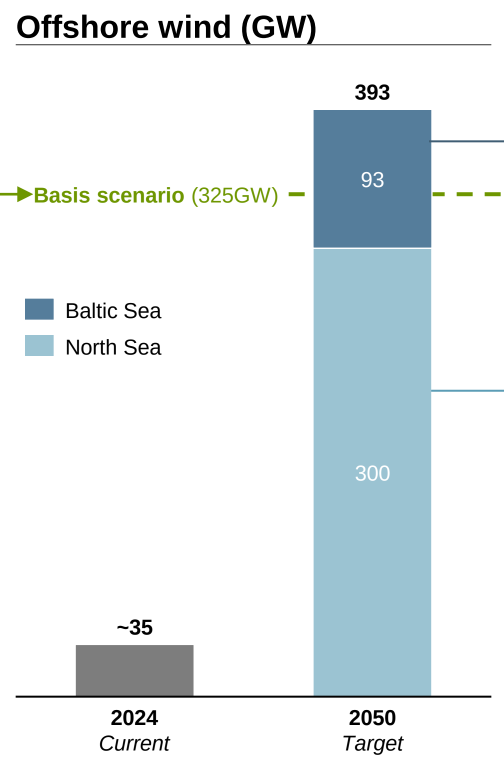
Assuming a green transition of Europe in 2050, Balmorel-model shows the optimal expansion of energy production in Europe[1]

Modelling by EA Energy Analyses shows a need for massive offshore wind deployment under a wide range of sensitivities...

Ea Energy Analyses



... which aligns with international targets of ~390GW offshore wind in the Baltic and North Sea by 2050



Aug 2022

Marienborg declaration
("Baltic Sea Summit")
✓ **93 GW before 2050**

Apr 2023

Ostende declaration
("North Sea Summit II")
✓ **300 GW before 2050**

Source: Analyses from EA Energi Analyses (2023)

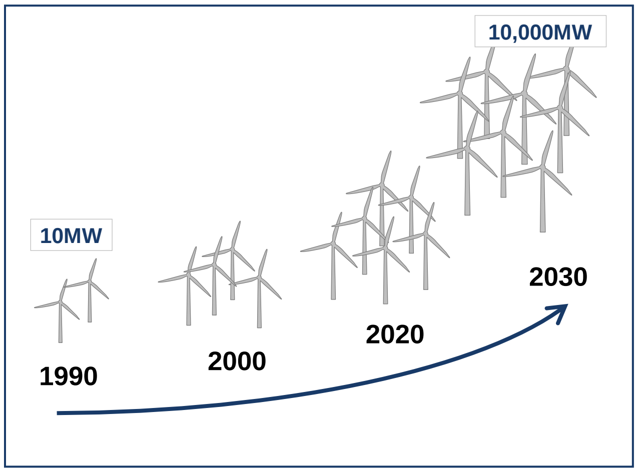
Notes: **1)** On behalf of CIP, EA Energy Analyses has modelled the expansion of offshore wind in the North Sea and the Baltic Sea. The analysis is based on Balmorel modeling of the European energy system, which models the optimal economic dispatch- and capacity expansion for the energy system across Europe.

Future offshore wind buildout requires a radically changed approach to deployment

Three main drivers for integrated energy hubs

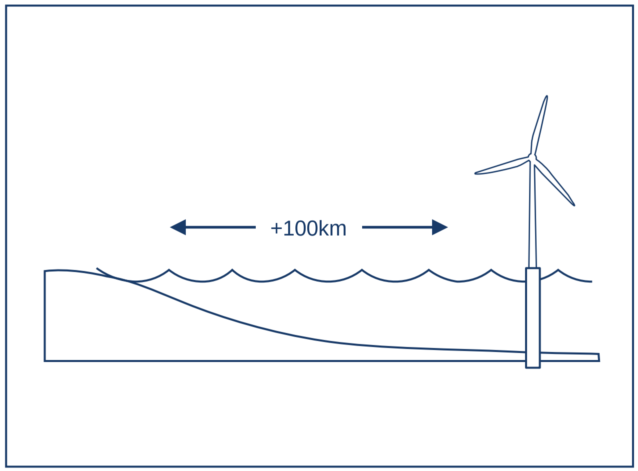
1

Offshore wind is rapidly developing towards larger and more integrated projects



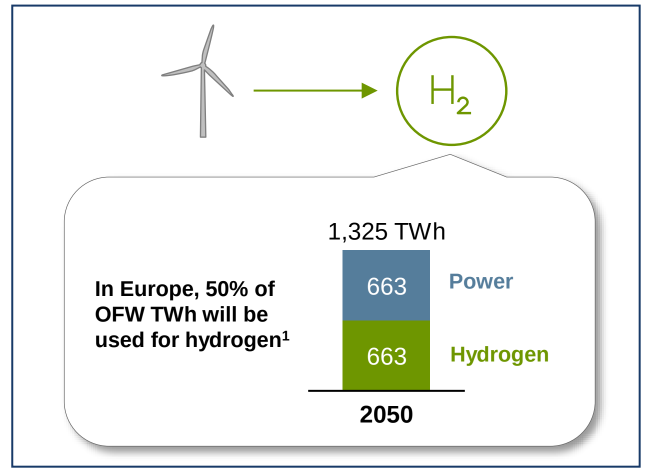
2

More than 70% of global offshore wind potential is located far from shore



3

Significant share of future offshore will be converted into hydrogen



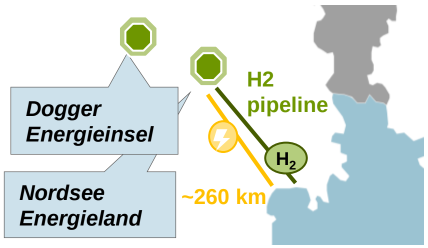
Traditional radial connections no longer fit for purpose - too costly, too slow, and do not enable system balancing synergies between power and hydrogen production → New approach needed

Notes: **1)** EA Energy Analyses

Benefits of offshore energy hubs

Significant societal and environmental benefits from offshore sector coupling in offshore energy hubs

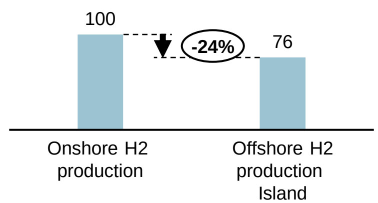
Lower cost buildout of electricity system and hydrogen



- **Energy hubs reduce cost to consumers by**
  – Reducing transmission buildout cost
  – Reducing curtailment
- **Fraunhofer: Up to EUR 4.3 bn systemwide cost savings annually[1]**
  – Avoided transmission capex investment
  – Reduced curtailment

Large-scale affordable domestic German hydrogen supply

LCoH using 10 GW offshore wind (indexed)



Domestic hydrogen production expected to be 5-8 mtpa in 2045[2]

- Domestic German hydrogen production increases energy resilience
- **Energy island offers 1mtpa of domestic hydrogen production from mid 2030s**

Offshore energy hubs enable 24% saving in hydrogen production costs (LCOH)

- Analysis by CIP and GASCADE based on detailed layout incl.:
  – Wind farm and PtX plant
  – HVDC and hydrogen transmission

Results driven by:

- Pipeline cheaper than cables and converter stations
- Lower power losses
- Higher capacity utilisation

Supply chain effects

More local production

- Large top-sides on platforms are mainly produced in Asian yards
- Modular HVDC and PtX for islands can be constructed in multiple German yards

Strengthen local supply chain

- Phased construction enable supplier to build up local supply chains, manufacturing capacity, jobs & skills

Fuel for German industry growth

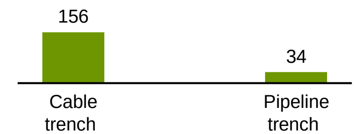
- Cost-competitive hydrogen supports growth of green industry transition

Local employment

- Estimated ~10,000 local FTE during construction of island

Environmental benefits from less cable trenching

Distance of trenching in protected areas in German waters (km)



Offshore hydrogen production:

- Reduce cable trenching in nature protected Wattenmeer
- No land taken up for hydrogen production
- Less pipelines onshore for extracting and discharging sea water for cooling and H2 production in the protected Wattenmeer

Nature inclusive design of artificial island

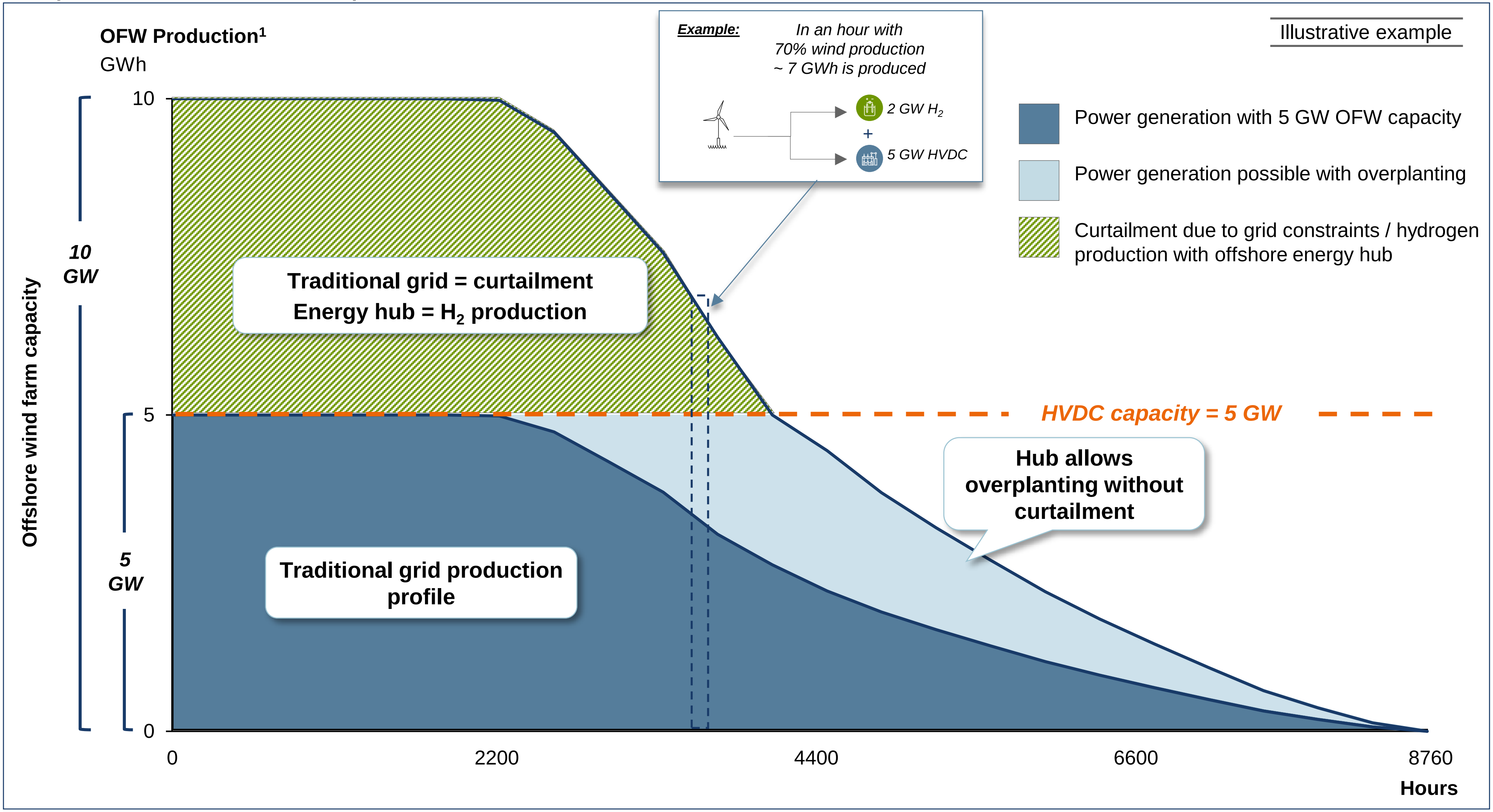
- Nature inclusive design enhance biodiversity by creating habitats for oyster, species of fishes, and nesting areas for birds and wildlife
- Draw on work by Princess Elisabeth energy island to enhance biodiversity

Notes: 1) Fraunhofer (2024) has for CIP conducted a study to examine the economic effects of producing green hydrogen at two artificial offshore energy islands connected to 10 GW offshore wind each. The study is compared against a 70 GW buildout of OFW with electricity transported onshore (link), **2)** BMWK (2024): Estimates of hydrogen demand in 2030 and 2045 expects 30-50% to come from domestic sources, based on "Import Strategy for hydrogen and hydrogen derivatives" (link).

Offshore energy hubs can be stabilising factors in the electricity grid

In addition, making it possible to integrate significantly more offshore wind energy production

Hourly distribution of offshore wind production

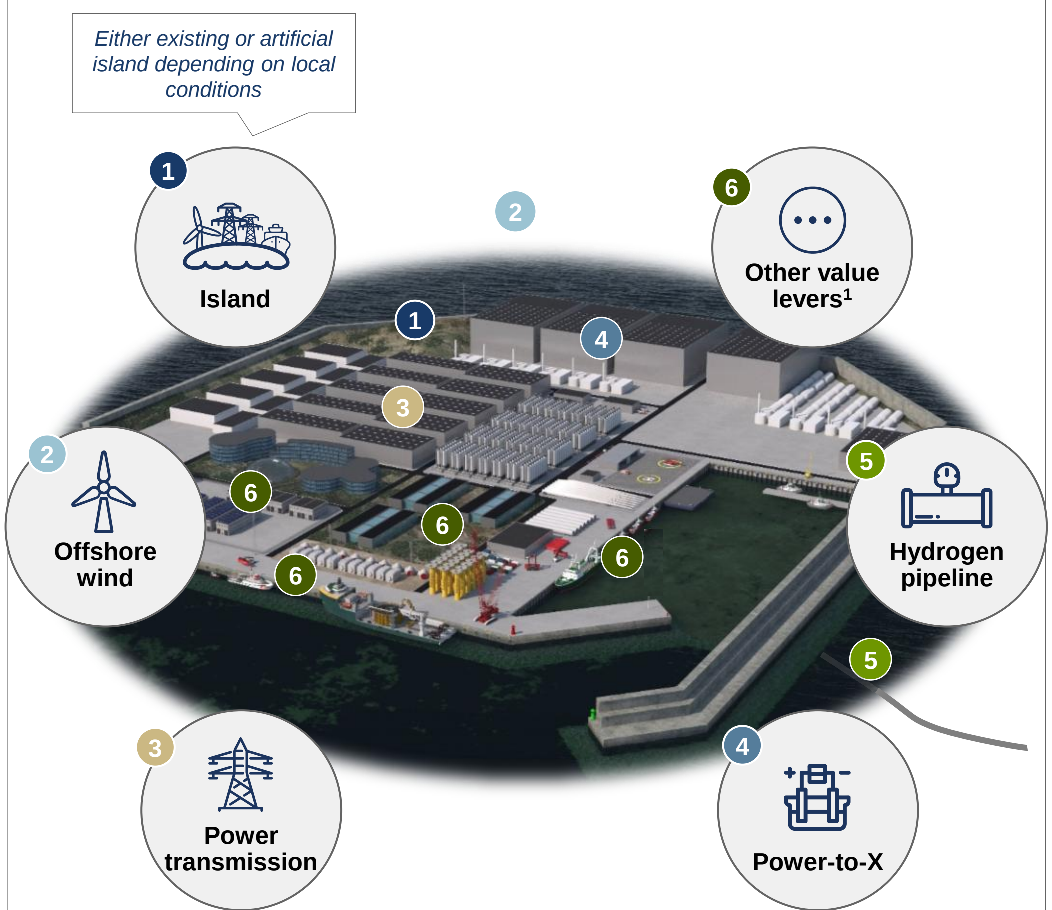


Notes: 1) Production based on profile from European offshore windfarm.

Rationale for energy islands/offshore hubs

Energy hubs are expected to become cornerstones in the development, deployment and integration of ultra large-scale offshore wind

Six building blocks

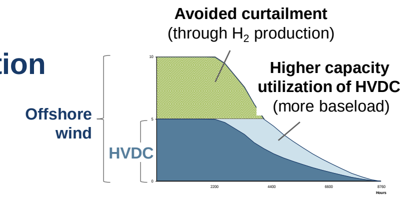


Value proposition

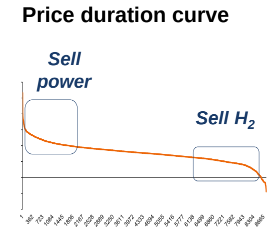
Hydrogen pipelines with significantly lower energy transport costs compared to HVDC
(~20% of HVDC cost)

vs

Higher HVDC cable utilisation and lower curtailment of offshore wind



Synergies from combining power and H_2 production
Producing power when power prices are high, and hydrogen when electricity prices are low



Local job creation and **economic growth**
Estimated +10,000 FTE during construction

Notes: 1) Potential value levers for the island include harbour for O&M and installation, defence, emergency response, storage, etc.

Regulatory changes required to enable offshore sector coupling and energy islands

Summary of proposed regulatory changes to WindSeeG (SoEnergieAnl, SoEnergieBe and FEP[1])

Topics	Actions	Current situation	Legislative proposal
Regulatory modifications	**1** **Expansionary targets**	• Law does not include targets for offshore H2 production • Only grid-connected turbines count towards current 70 GW target (H2 turbines are excluded)	• 10 GW offshore hydrogen production by 2040 • Offshore wind turbines (also) connected to offshore electrolyses count towards buildout target of 70 GW offshore wind buildout – Minimum volume of at least 6 GW to be allocated for first tender to ensure scalability
	2 **Technology-neutral infrastructure**	• Not allowed to produce hydrogen offshore and place HVDC systems on artificial islands (as is the case with e.g. platforms)	• Hydrogen production on artificial islands to be allowed to enable technology-neutral infrastructure solutions, in parallel with platforms and in-turbines
	3 **Sector coupling**	• Sector coupling is not allowed, i.e. offshore hydrogen production cannot be grid connected, acc. to SoEnergieBe	• Offshore wind tenders in zone 4 to allow for sector coupling, i.e. future offshore wind buildout can be connected to the electricity grid and to electrolysers offshore – Authorisation to apply grid connection entitlement of [1/3] of the OFW tender
Guidance to BSH	**FEP to include energy islands**	• FEP does not include areas for large-scale offshore hydrogen production in German EEZ	• FEP to mention option for energy islands in areas planned for offshore wind and hydrogen production

Notes: Flächenentwicklungsplan