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ENERGINET – TRANSMISSION AND FUTURE OSW CONNECTIONS

November 2022

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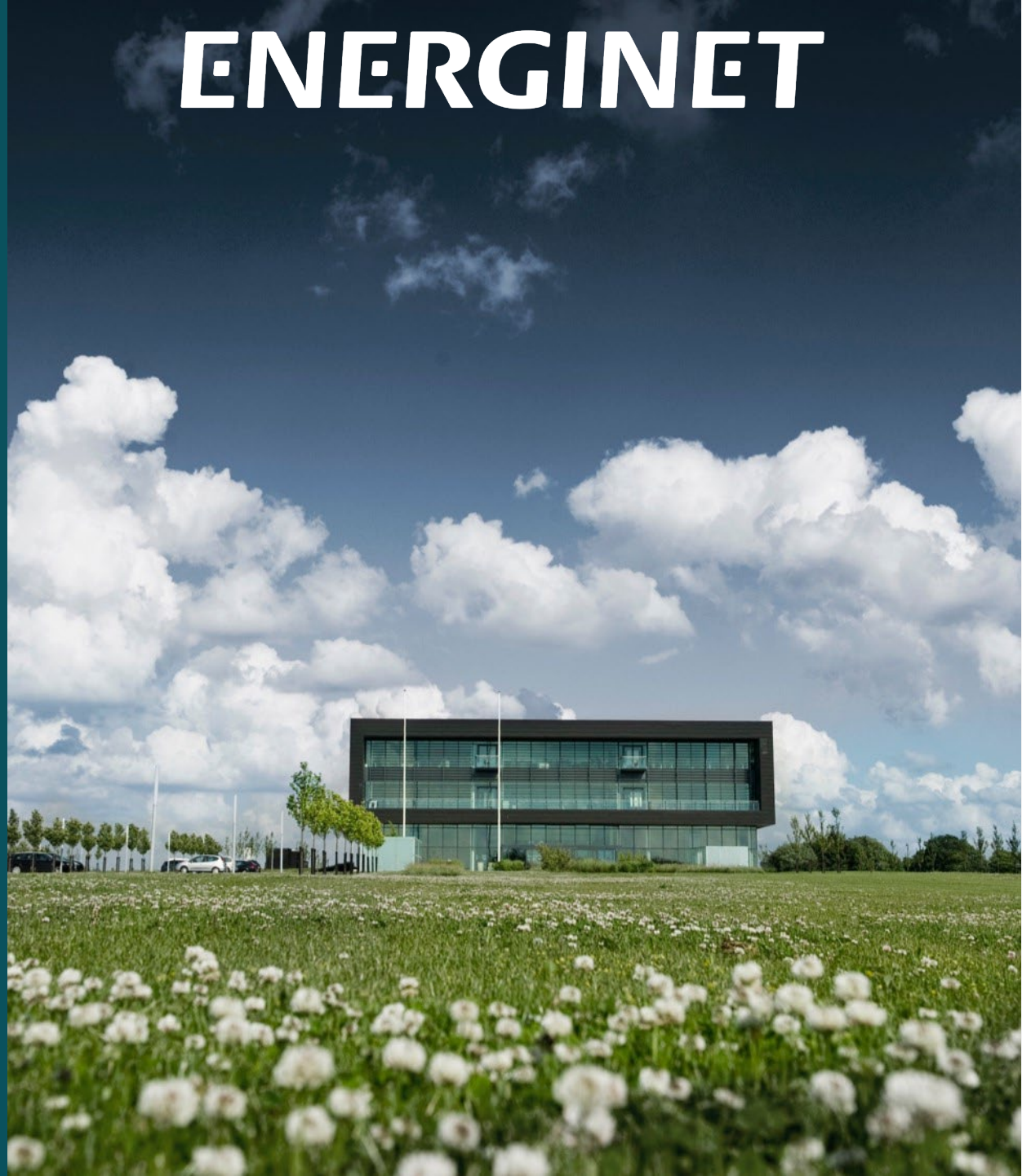


ENERGINET

THE ENERGY BACKBONE

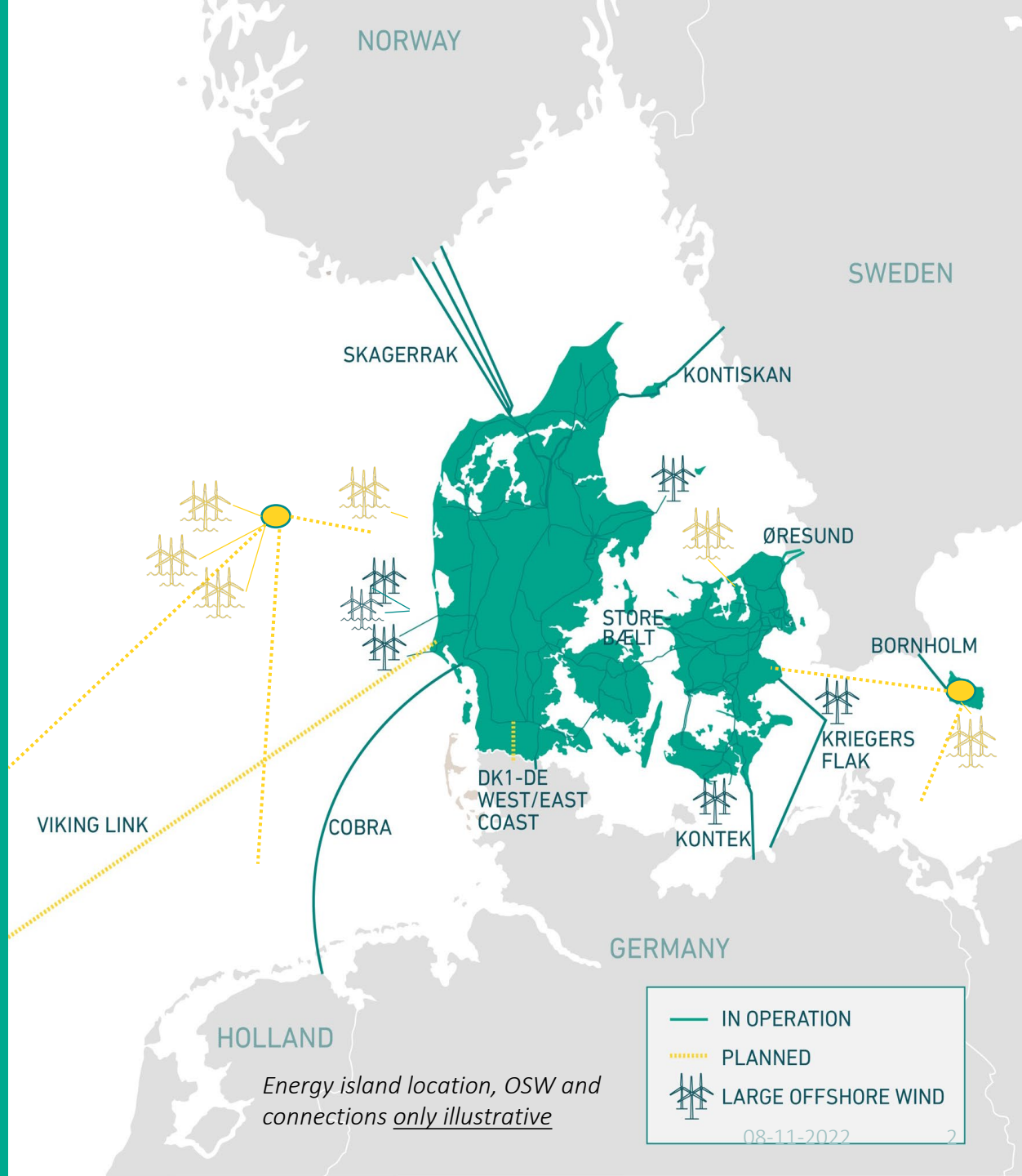
We operate and develop the transmission grids and gas pipelines in Denmark.

ENSURE BALANCE

We have the day-to-day and long-term responsibility for the overall electricity and gas system in Denmark.

WORKING FOR THE SOCIETY

Owned by the Danish Ministry of Climate, Energy and Utilities we safeguard society's interests as we move to a 100% green energy system.



Energy island location, OSW and connections only illustrative

FUTURE OSW BUILD OUT

Accelerate development and continue to reduce costs, risks and uncertainty

ACCELERATE DEVELOPMENT:

- Larger OSW tender size (from 200 MW to 3 GW)
- Speed up decision process (and proactive grid planning)
- Parallel build out of tenders and open door projects

REDUCE COSTS AND RISKS

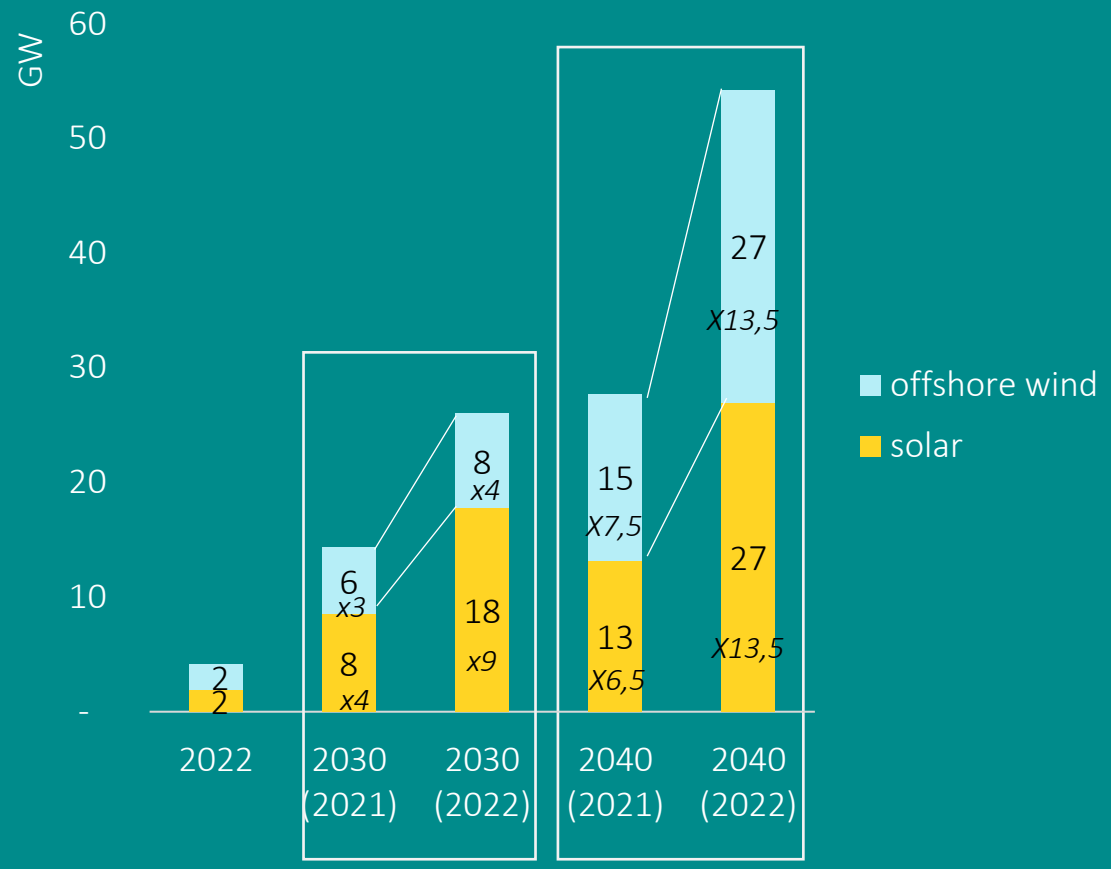
- Hybrid onshore grid connection
- Development of meshed offshore grid (backbone)
- Direct line from OSW to onshore Power to hydrogen

REDUCE UNCERTAINTY

- Market dialogue!
- New tarif and connection payment structure
- Take supply chain issues into account
- Cooperation on HVDC technology development

ACCELERATED DEVELOPMENT TO REDUCE USE OF FOSSIL FUELS AND FASTER GREEN TRANSITION

From 2021 to 2022 large change in DEA planning assumptions for solar and offshore wind capacity (GW)



Source: Danish Energy Agency, 2021 and 2022 public hearing version

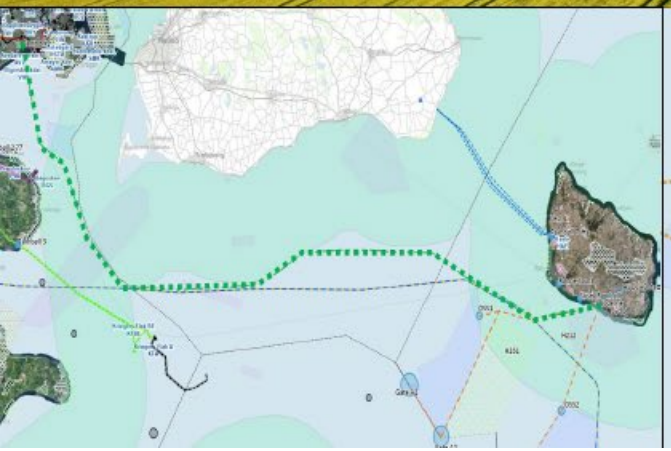
Energy island Bornholm

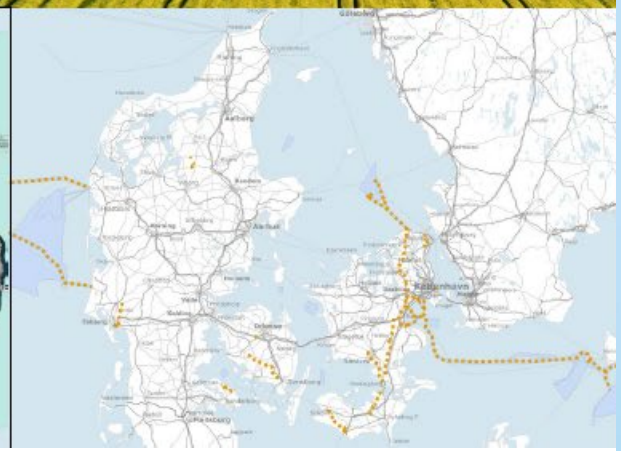
Climate Agreement

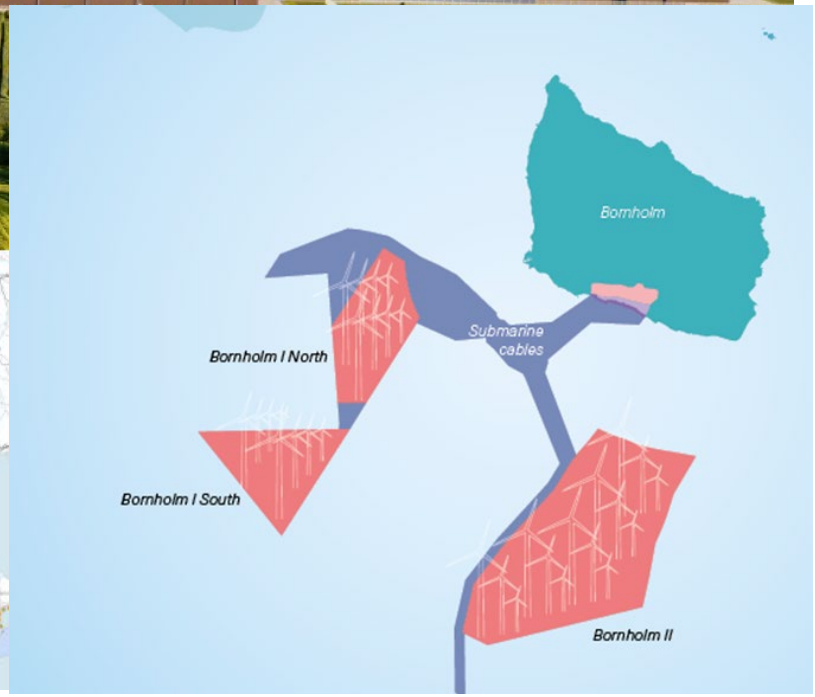
Add. August 2022

3 GW offshore wind
Operation 2030

Visualisation of HVDC and onshore connection







ENERGINET

[Energy Island Bornholm | Energistyrelsen (ens.dk)]

SOCIO ECONOMIC BUSINESS CASE- BORNHOLM

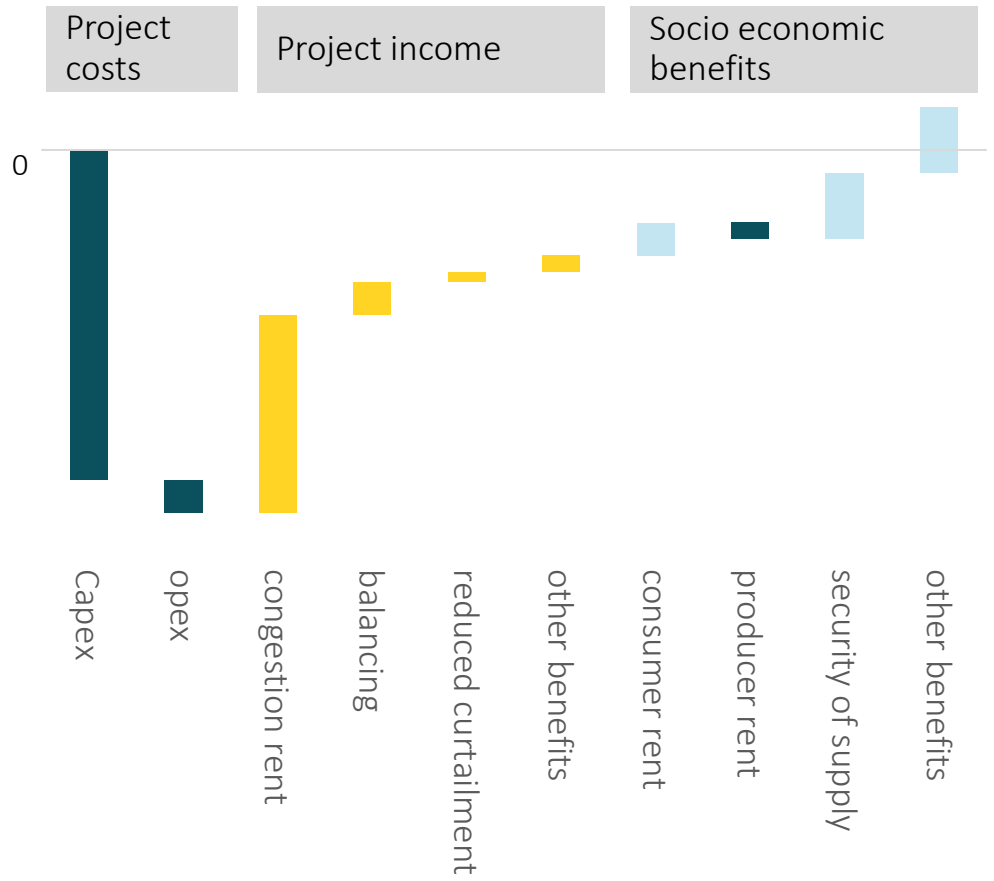
Business case for electricity infrastructure politically approved October 2022

Based on cost benefit analysis for most optimal connection of 3 GW:

- Estimated 67 bill DKK investment (infrastructure and wind turbines)
- Socio economic business case not positive and need for subsidies or other kind of support
- Electricity infrastructure be tarif neutral for consumers
- Large uncertainty on electricity prices and dependency on especially HVDC technology development !

[business case not public available due to confidentiality before tenders]

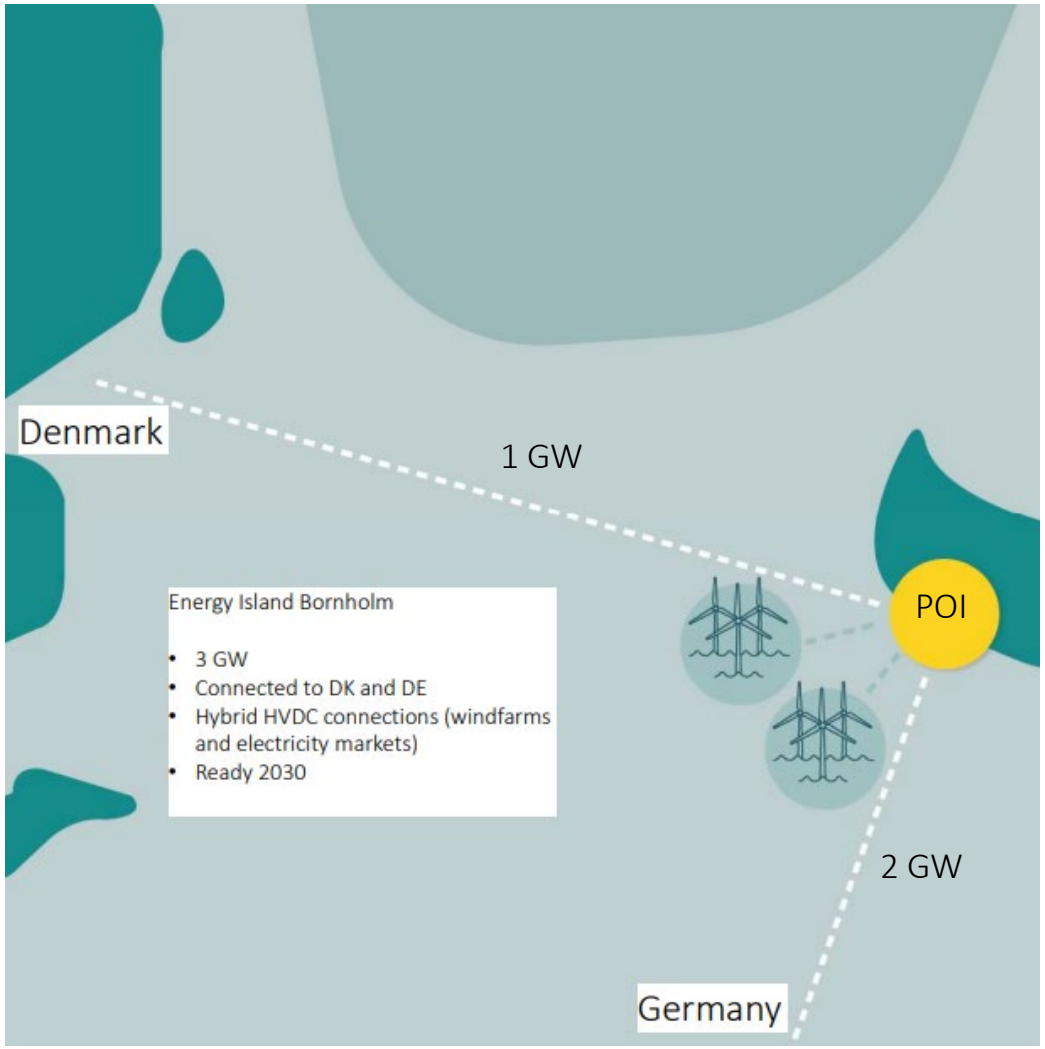
Illustration of NPV from business of HVDC infrastructure



POI FOR BORNHOLM ENERGY HUB

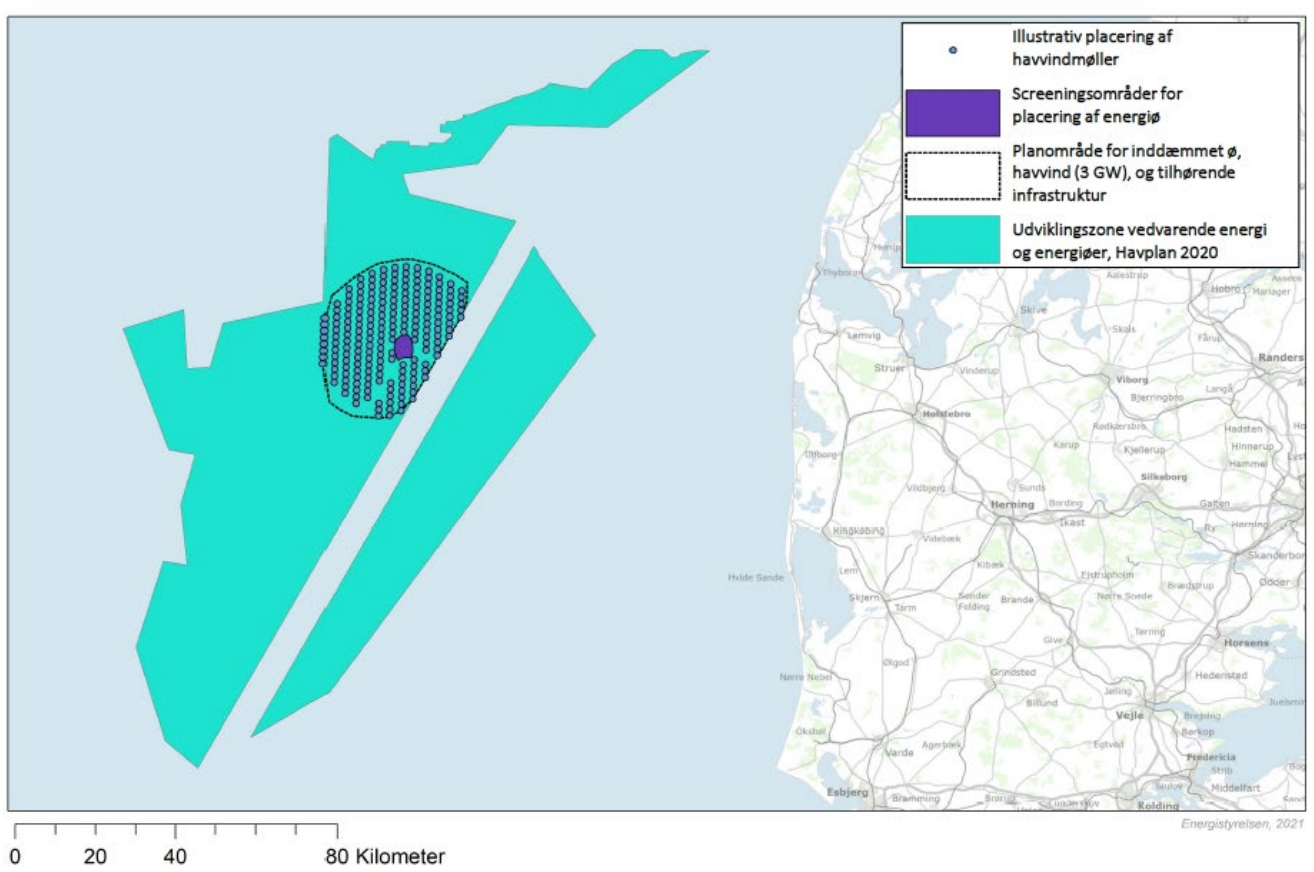
Change in responsibility and allocation of costs - again

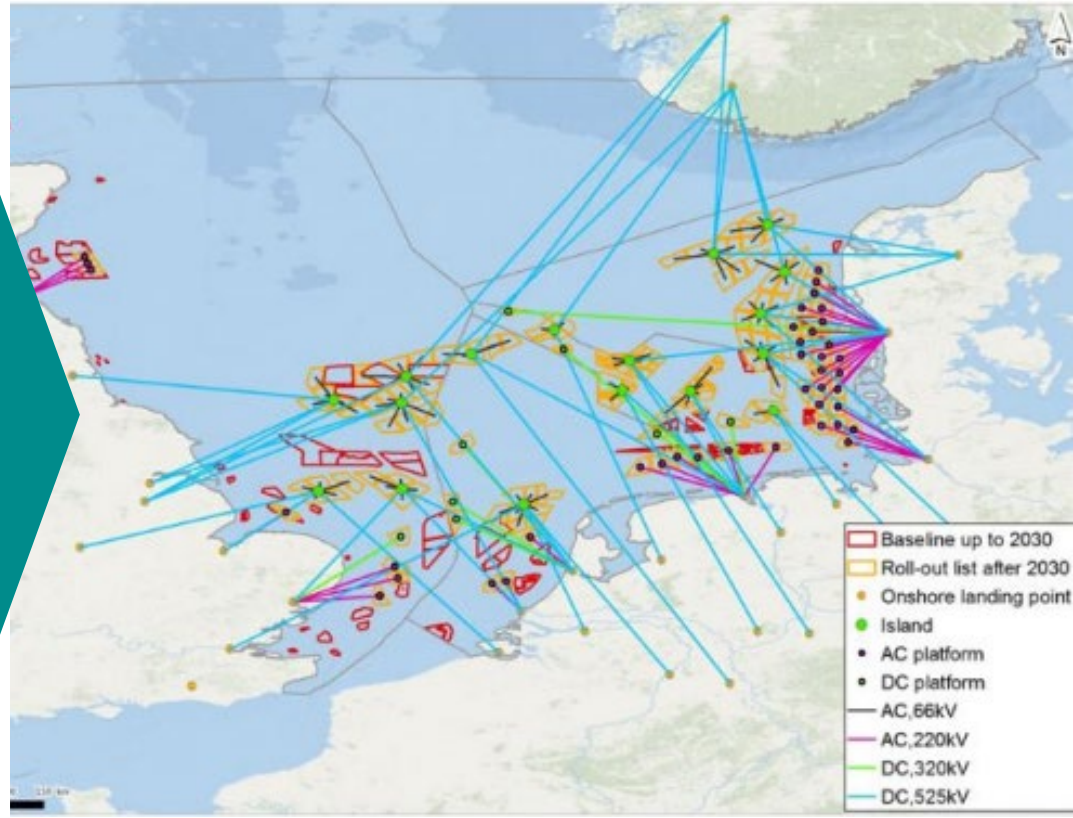
	Horns Rev 3	Thor/ Hesselø	Bornholm Energy hub
Offshore substation/ cables	Energinet (build/operate) Developer (pay)	Developer	Developer
Onshore connection	Energinet (build/operate) Developer (pay)	Developer	Developer
Internal grid extension	Energinet	Energinet	Energinet
HVDC grid	-	-	Energinet (build and operate) Developer (pay for use)



DANISH NORTH SEA Energy hub - 3 GW and up to 10 GW

Part of North Sea Wind Power Hub and +300 GW OSW potential



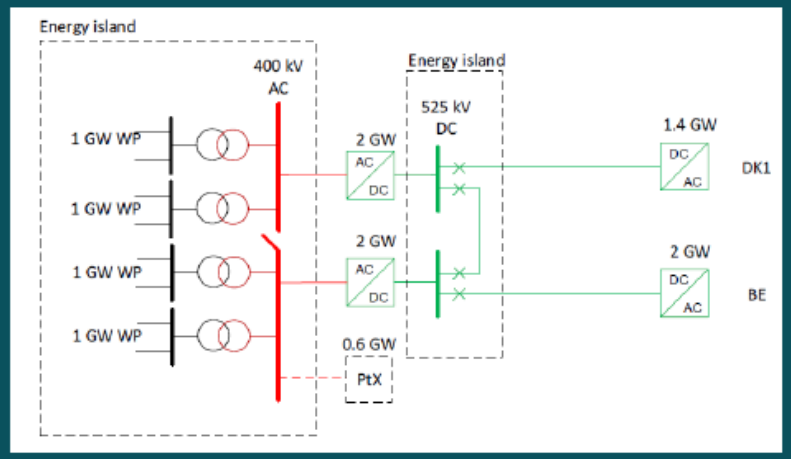


North Sea Wind Power Hub

PHASES FOR ENERGY ISLAND

Phase 1: (3GW OWF) + (3.4GW transmission) **2033**

- HVDC transmission to DK1 and BE
- HVAC (4GW) & HVDC switch gear on island
- Separate HVDC-platforms
- HVDC/HVAC onshore station DK1 (Revsing + land cable)



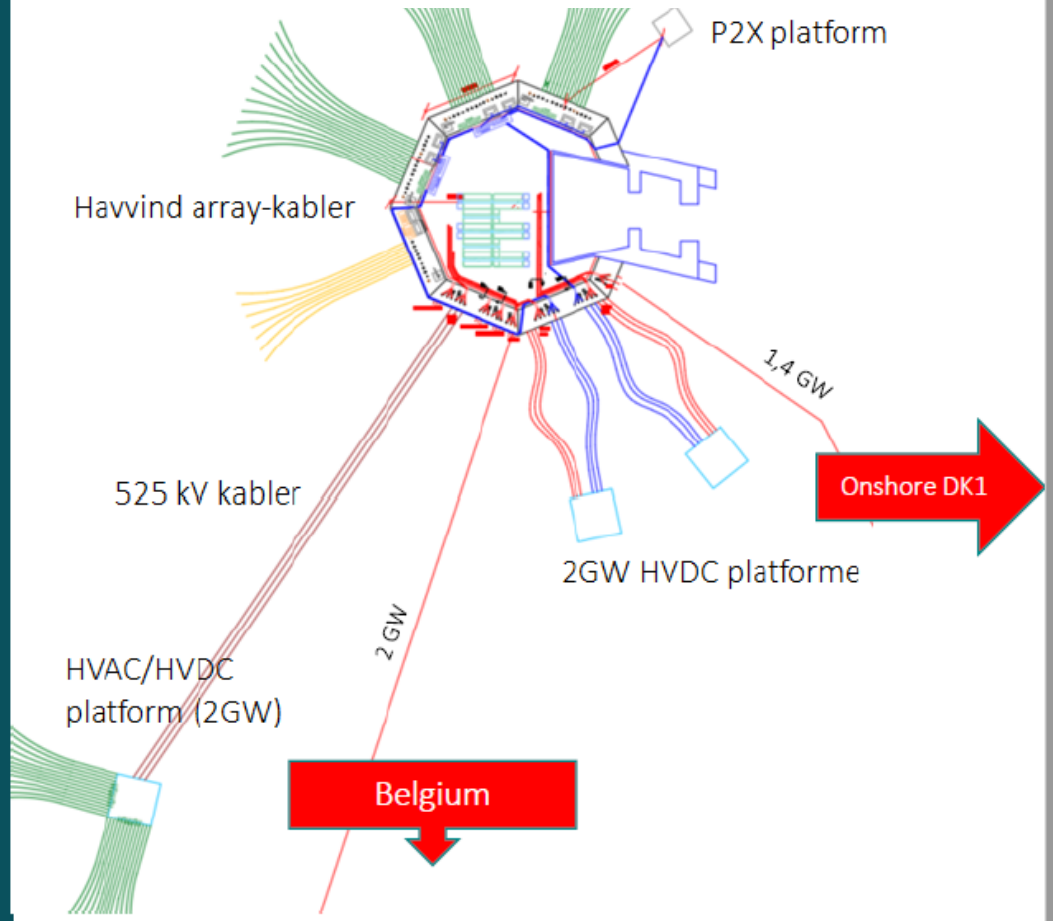
Phase 2: (+3GW OWF) + (x GW IC) **2035-37**

- 1GW OWF connected to island
- 2GW OWF connected to separate HVAC/HVDC platform
- HVDC switch gear on island

Phase 3: (+4GW OWF) + (x GW IC) **2040**

- 2 x 2GW platforms
- HVDC switch gear on island

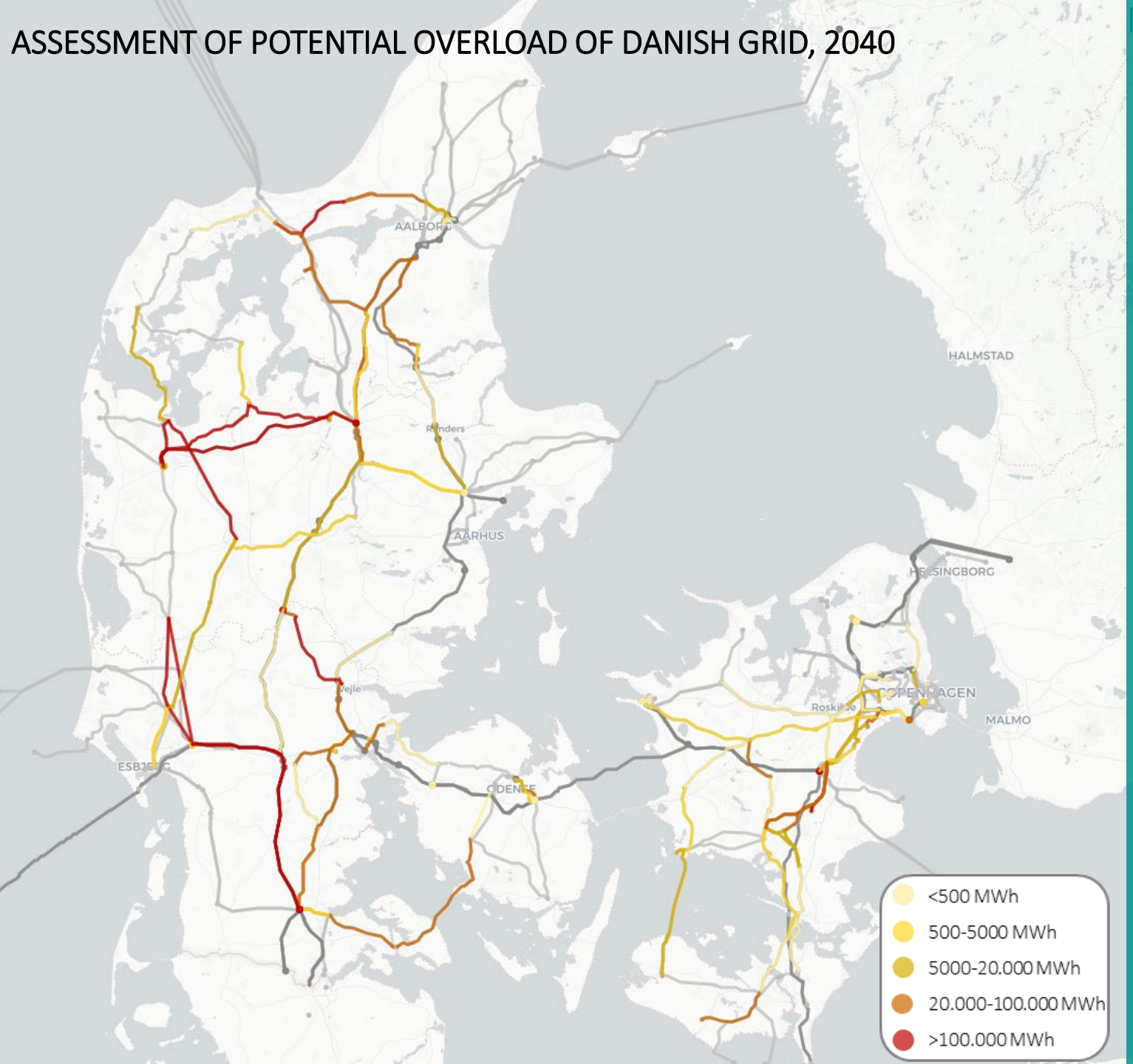
Illustration
Long term ttimeplan and concept not decided



Expected commissioning 2033
Tie lines operational from 2031
Expected positive socio economic business case

Mai

ASSESSMENT OF POTENTIAL OVERLOAD OF DANISH GRID, 2040



OSW AS PART OF ENERGINET LONG TERM GRID PLANNING

Large build out of OSW, onshore wind and solar

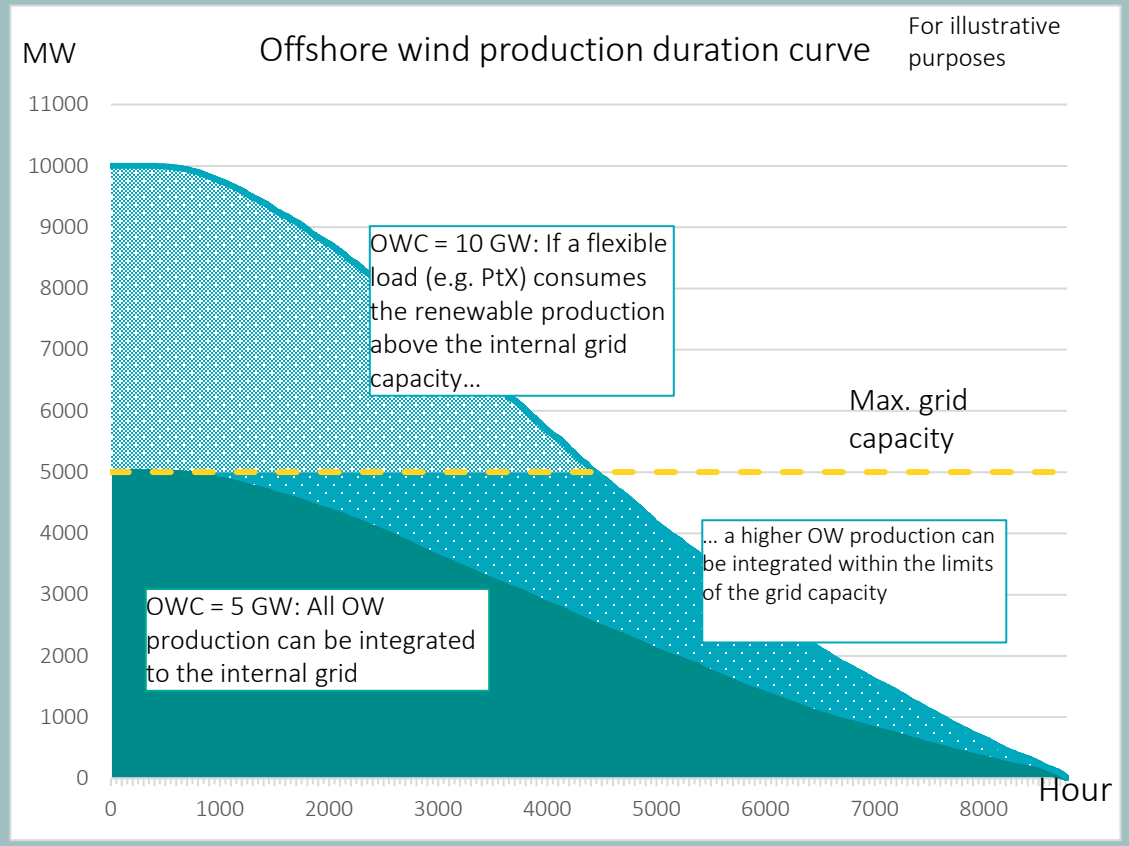
Maintain high Security of supply

Ageing grid and need for re-investments

- Grid development financed by tariff
- Reform of tarif - from consumer to user to pay (ie. capacity payment, increased connection fee, locational tarifs, direct lines)

POWER TO HYDROGEN AS FUTURE CONNECTION SOLUTION

Flexibility and efficient utilization of electricity with combination of hydrogen and electricity production



ENERGINET

DEVELOPMENT OF HYDROGEN PRODUCTION IN DENMARK

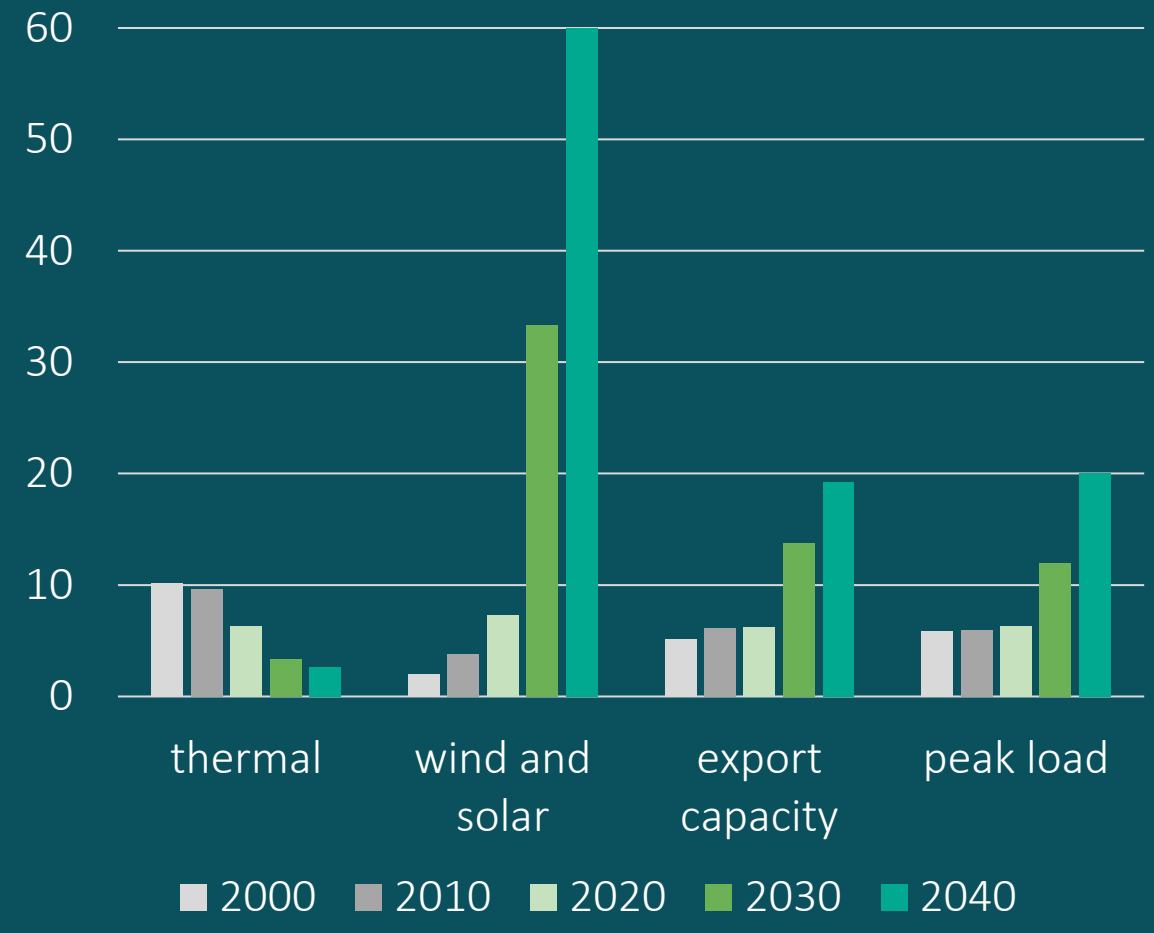
- 6-7 GW expected for 2030
- Hydrogen infrastructure needed


Thanks for your attention

BACK UP

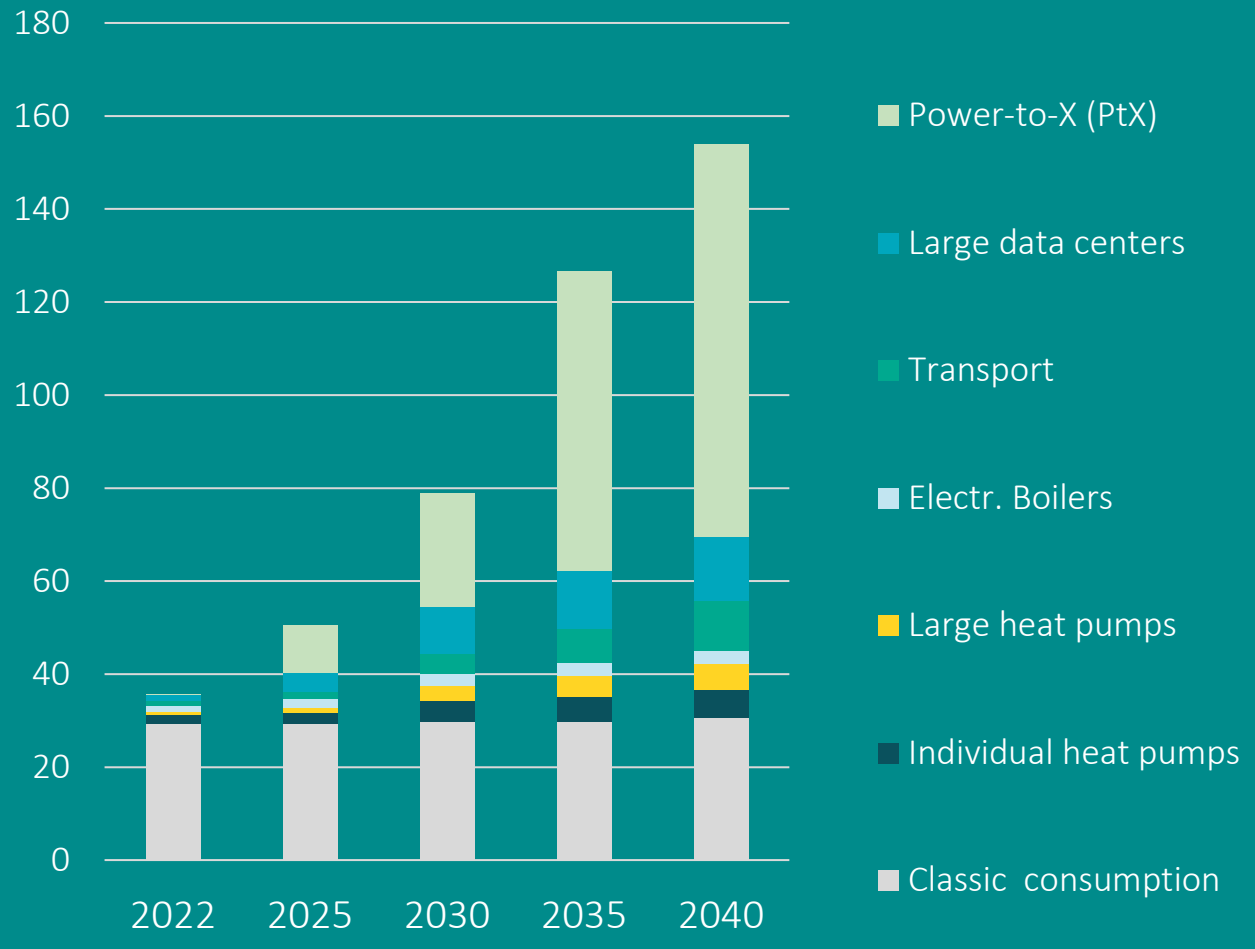
WHAT HAS BEEN ACHIEVED IN THE LAST 20 YEARS ACCELERATES TOWARD 2040

Electricity generation and peak capacity, GW



ELECTRIFICATION DRIVES THE CHANGE TO A CLIMATE NEUTRAL ENERGY SYSTEM

Electricity consumption, TWh



Source: Danish Energy Agency, draft assumptions 2022

ACCELERATE DEVELOPMENT

LARGER OSW PROJECTS

- Larger lease areas
- From fixed MW tender to capacity range based on lease area
- Both open door and tender solutions

DECISION PROCES

- Speed up environmental impact assessment process
- Early dialogue with stakeholders

INTERNAL GRID DEVELOPMENT

- Early dialogue DEA and Energinet on potential areas for OSW
- Grid planning include anticipated connection of VRE

REDUCE COSTS

HYBRID CONNECTION

- Freedom for developer to optmize connection with solar, battery, electrolyzer above connection capacity

DIRECT LINES

- Develop necessary regulation for direct lines (from OSW to hydrogen)
- Energinet only owner of transmission grid in Denmark today

DEVELOPMENT OFFSHORE GRID

- Political agreements on OSW development (By 2030 65 GW North Sea and 20GW in Baltic Sea)
- Energinet dialogue with other TSO on new tie lines

REDUCE UNCERTAINTY

SUPPLY CHAIN ISSUES

- Close market dialogue on development of supply chain issues
- Ensure balanced tender agreements between TSO and developer

CONNECTION COSTS

- Connection costs fixed in tender – budget risk on Energinet
- HVDC link is Energinet responsibility and tarif payment for use
- Open for future direct line and hydrogen connection

TECHNOLOGY DEVELOPMENT

- Developer freedom to choose technology
- Technical requirements at onshore connection
- TSO, developers and manufactures common R&D/standardization projects

ECONOMICS – THREE EXAMPLES

Budget for offshore and onshore connection very dependent on specific site and need for internal transmission grid upgrades

	Anholt, 2013	Horns Rev 3, 2019	Kriegers Flak (2021)	Thor (2024)	Bornholm Energy hub	North sea energy hub
Capacity	400 MW	407 MW	605 MW	1000 MW	2 GW	3-10 GW
Budget for connection*	170 mio. Euro	230 mio. Euro	386 mio. Euro**	92 mio. Euro***	2.4 bill Euro****	3.8-14.0 bill. Euro****
Planning time from approval (political agreement)	2010-2013 (2008)	2013-2016 (2012)	2014-2020/2021 (2012)	2018-2023 (2018)	2022-2030 (2021)	2022-2035 (2021)
Off/onshore cable Offshore Transformer Onshore cable station Extension onshore Extension internal grid	30/56 km Yes Yes Yes (220 kv) No	35/58 km Yes Yes Yes (220 kv/400 kv) Yes (29 km 400 kv)	85/105 km Yes Yes Yes (220/400kv) Yes (400 kv+ btb HVDC)	- - Yes Yes Yes	Ca. 1000 km yes Yes Yes Yes (HVDC)	Ca. 1700 – 7200 km yes Yes Yes Yes (HVDC)

*public available budgets from Energinet application for project

**Energinet part of investment and incl. 150 mio. Euro EU subsidy

*** only budget for onshore connection. Offshore cable and connection responsibility of developer

****based on report from consultant – business case and ownership model still being devoped, a209704-001_cost_benefit_analyse_endelig_version.pdf (ens.dk)

HOLISTIC ENERGY PLANNING – DENMARK CASE SCENARIE YEAR 2035