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Danish lessons learned on grid connection of offshore wind farms

CEC workshop on offshore wind transmission, 10 November 2022

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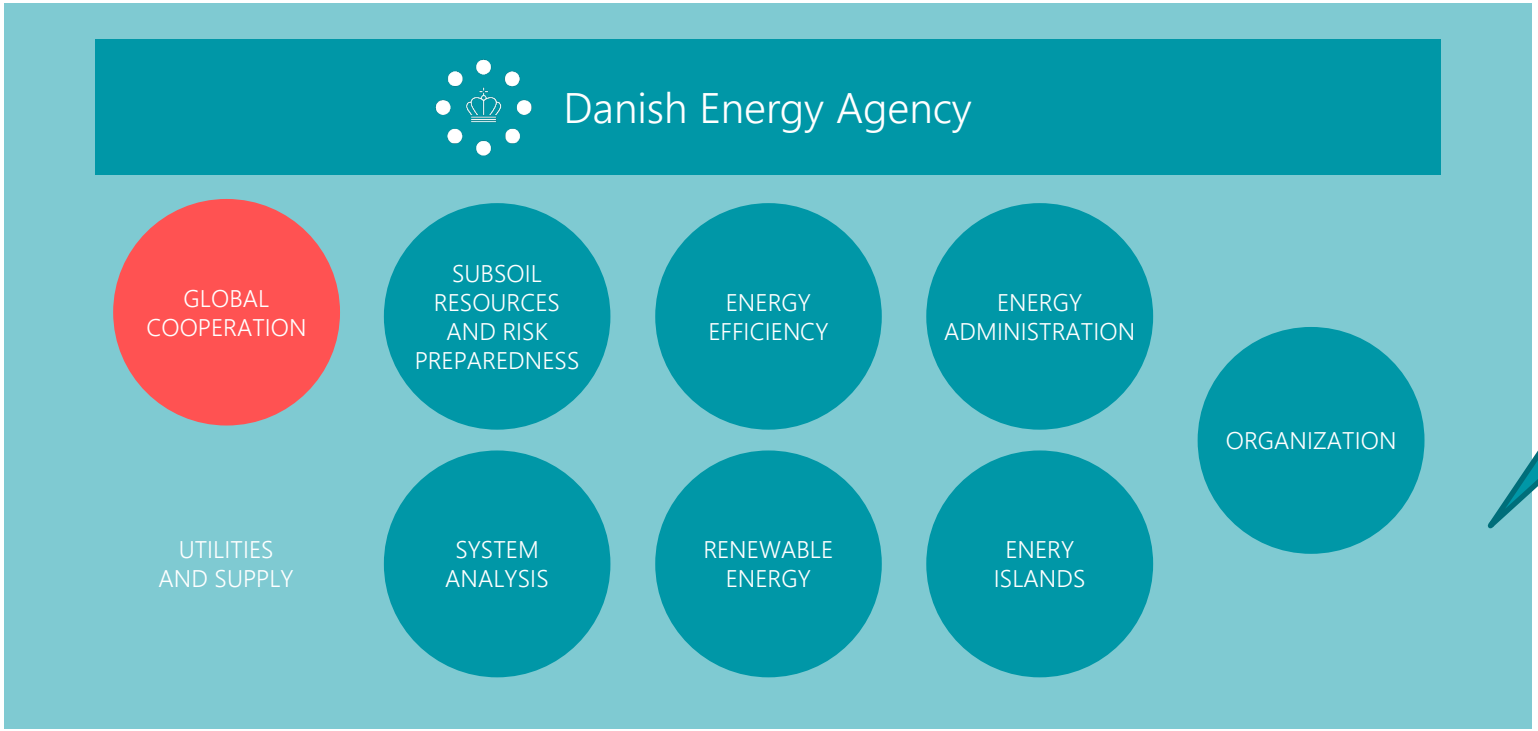
Danish Energy Agency

THE DANISH ENERGY AGENCY (DEA)

A government agency under the Ministry of Climate, Energy and Utilities



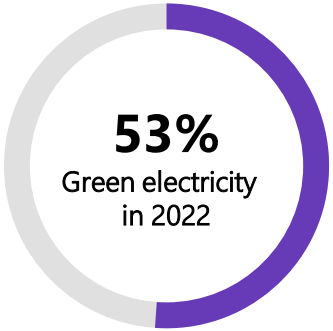
DEA (OSW):
- Regulation
- MSP
- Site selection
- Tender/solicitation
- Grid planning together with TSO
- Permitting

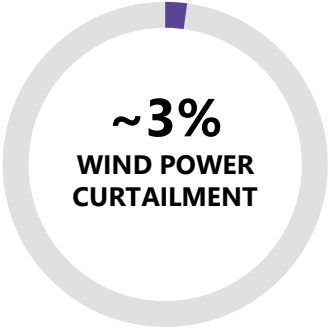
DK STATUS AND TARGETS – ENERGY AND CLIMATE POLICY

Vision of a climate neutral society in 2050

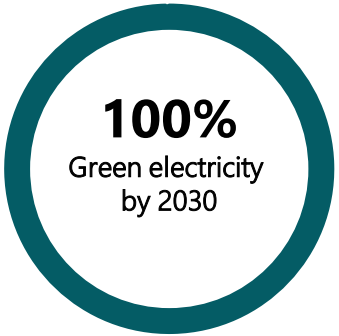
Denmark
- size of NH and VT combined
- population of MA

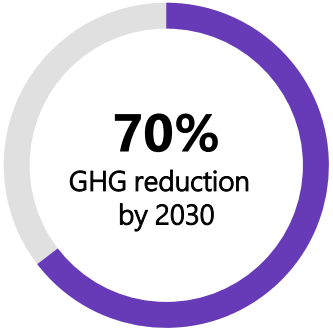
Status

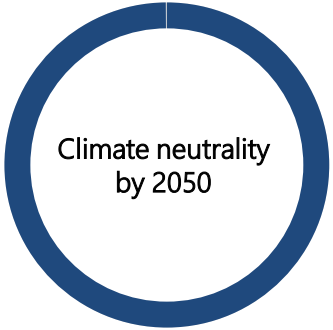




Targets







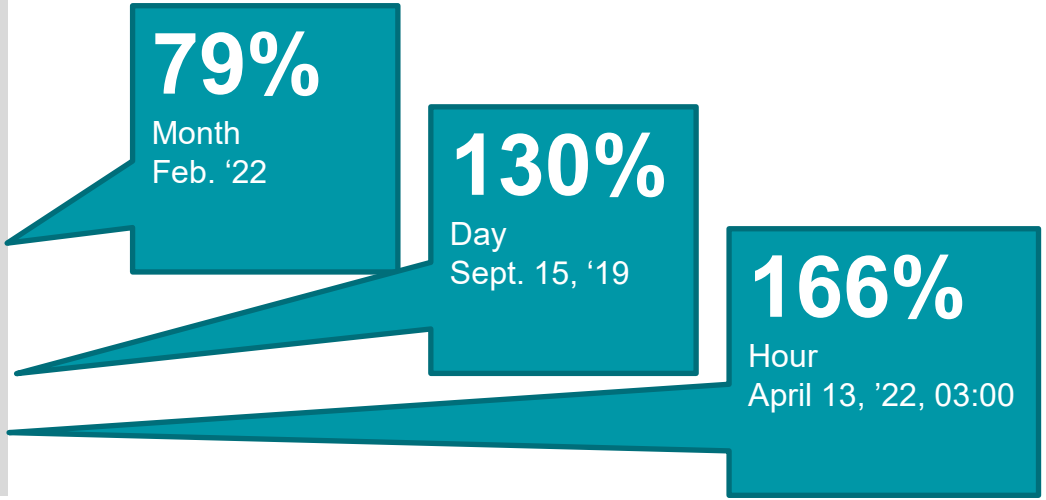
Source: Energinet

DK WIND AND SOLAR DRIVEN SYSTEM

Installed capacity, 2021

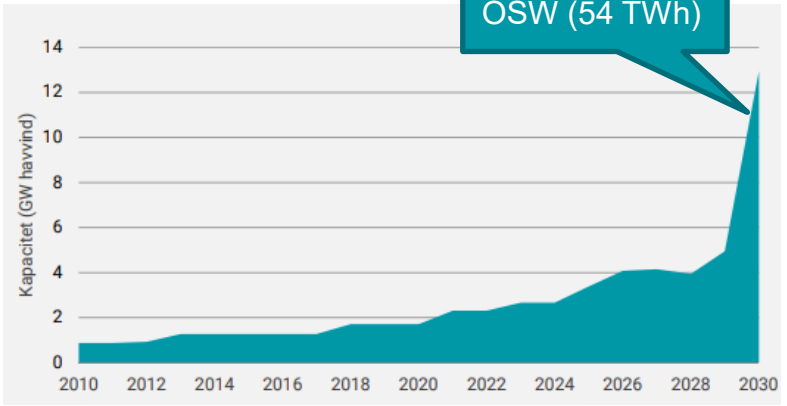
Onshore wind:	4.7 GW
Offshore wind:	2.3 GW
PV solar:	1.4 GW
Thermal:	6.0 GW
Interconnectors:	7.0 GW
Peak demand: (5.6 mill. people)	7.0 GW

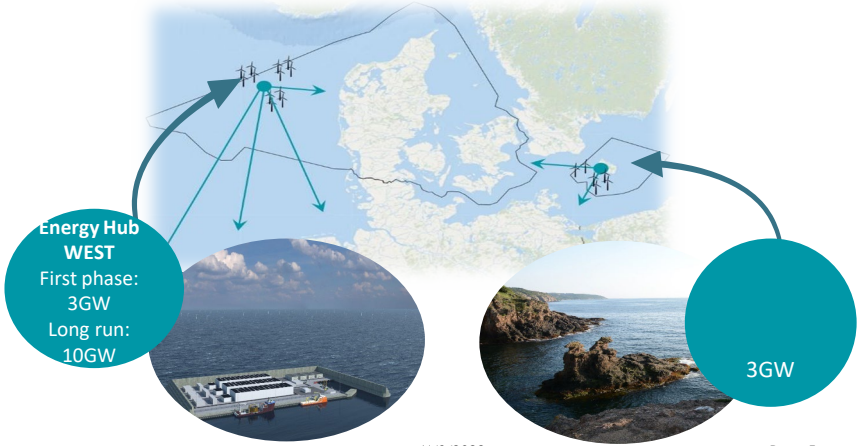
Danish power system records on wind and solar:



DK PLANS FOR BUILD OUT OF OFFSHORE WIND

- **OSW in operation:** 2,3 GW (split over 15 offshore wind farms over 30 years)
- **OSW under construction:** 1,4 GW
- **Before 2030:** planned: 9,2 GW
- **After 2030:** Energy islands
  North Sea (10 GW)
  Baltic sea (3GW)
- **Long term target**: >35 GW total capacity in 2050





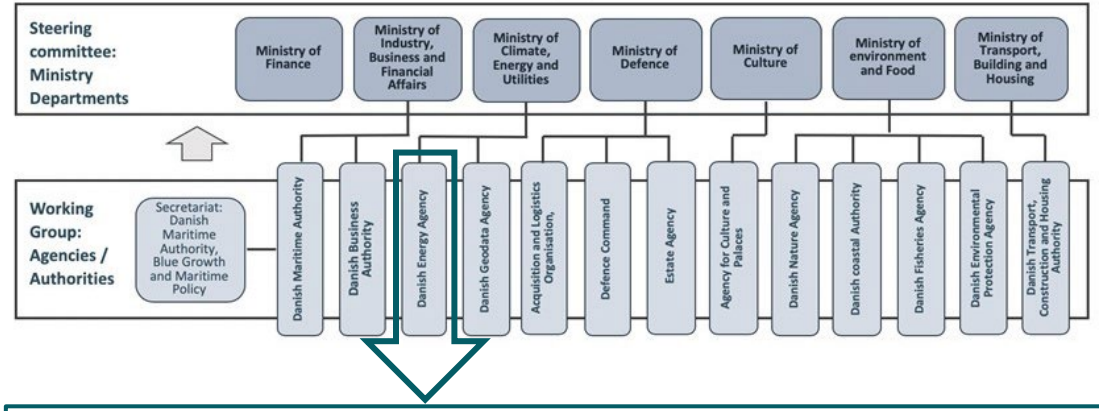
DK REGULATION FOR OSW AND GRID CONNECTION

DK process in a nutshell (centrally planned transmission for OSW):

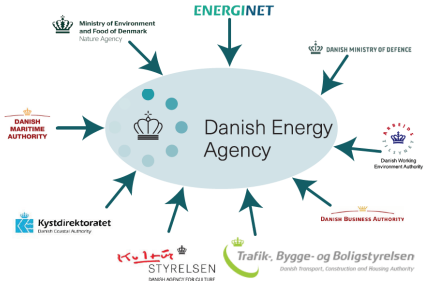
- Political agreement on building OSW farms
- DEA responsible for planning OSW
- DEA mandates TSO (Energinet) to plan required grid connection for the wind farm
  - Order by DEA/Ministry to TSO to start planning (beginning of tender process)
  - Order (§4) and business case approval by Ministry (end of tender process)
- Guaranteed grid access: as part of the tender process it is agreed between the bidders and TSO when the first power should be delivered (specified in the concession agreement)
- As part of the concession agreement it is specified that the concession winner will be compensated if the TSO delivers grid infrastructure too late
- Concession winner/developer subject to penalty, if wind farm is not build on time (this time is specified in the contract)

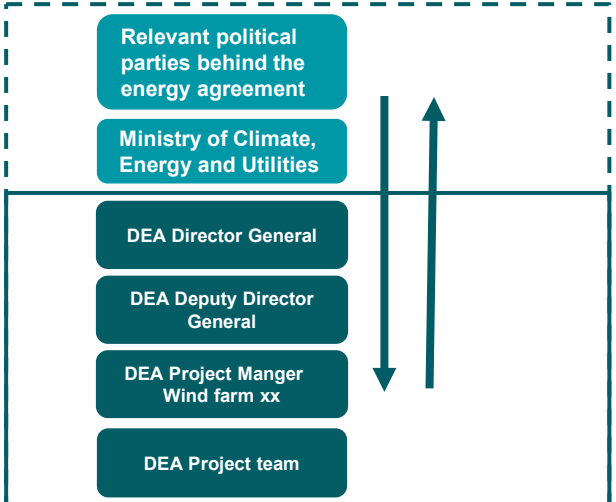
GOVERNANCE AND DECISION-MAKING – ONE-STOP-SHOP

Political parties/agreement



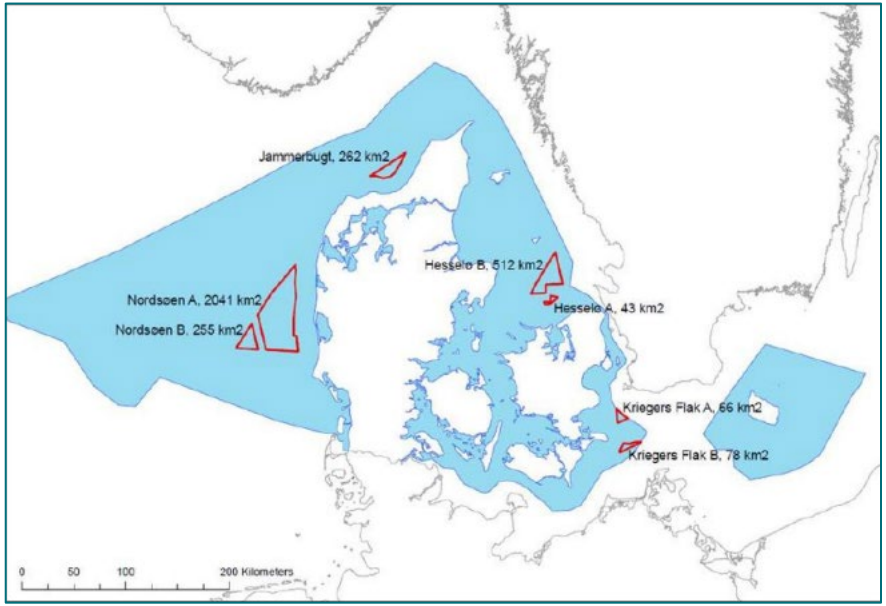
- In relation to planning and tendering for the development of offshore wind farms the Danish Energy Agency (DEA) is the authority in charge.
- The DEA coordinates with the relevant authorities, which provide input to the DEA on their respective and relevant regulations.





- Most topics and challenges are managed on the operational level within the DEA project team.
- It is rare the topics are escalated beyond the DEA.

EARLY ANALYSIS OF GRID – DEA AND TSO COORDINATE



Identifying best match between wind farm and onshore grid:

- Focus on less need for upgrades
- Focus on best onshore cable corridors (landowners, environment, planning issues)

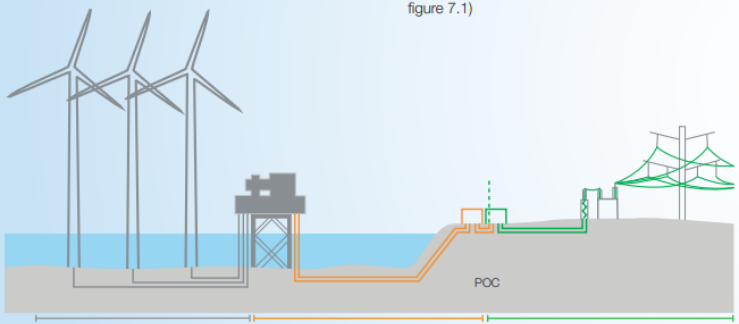
TENDER COMBINING WIND FARM AND GRID CONNECTION

7. Offshore grid connection, onshore facilities and Point of Connection

The offshore substation and the grid connection from the offshore substation to the Point of Connection (POC) at the nearshore substation will be included in the call for tender. Since this is a new and fundamentally different approach compared to earlier Danish call for tenders, it is relevant to describe more in detail how the environment- and planning process is being managed. It is also relevant to describe a number of technicalities, which the tenderer should be aware of early in the tendering process.

With the new approach, the tenderer should take the following into account:

- it will be the responsibility of the concession owner to decide on the voltage level at wind turbine generator terminals
- it will be the responsibility of the concession owner to decide on design, layout, construction and operation of the offshore and substation, the offsh... bles, the onsho... transmission cables up to the nearshore substation and connection to the POC provided by Energinet. In the following this is referred to as the export facility (see figure 7.1)



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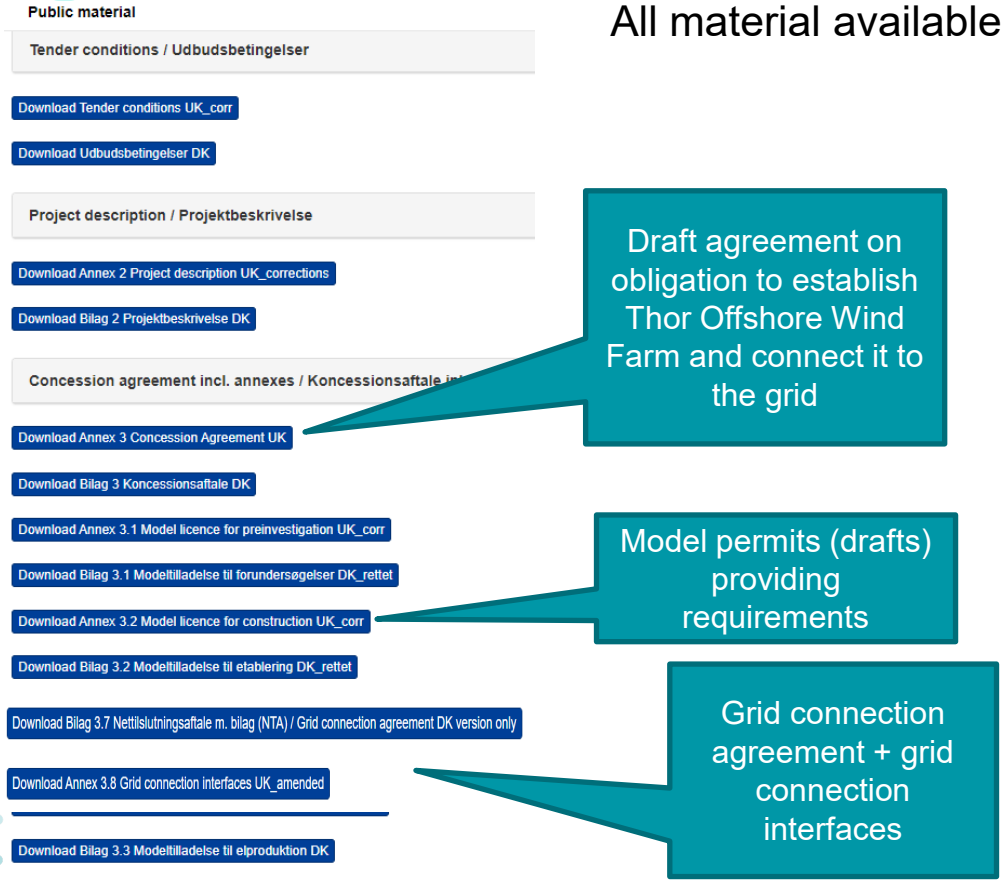
Robust market dialogue with developers ensures better informed project + less risk premiums

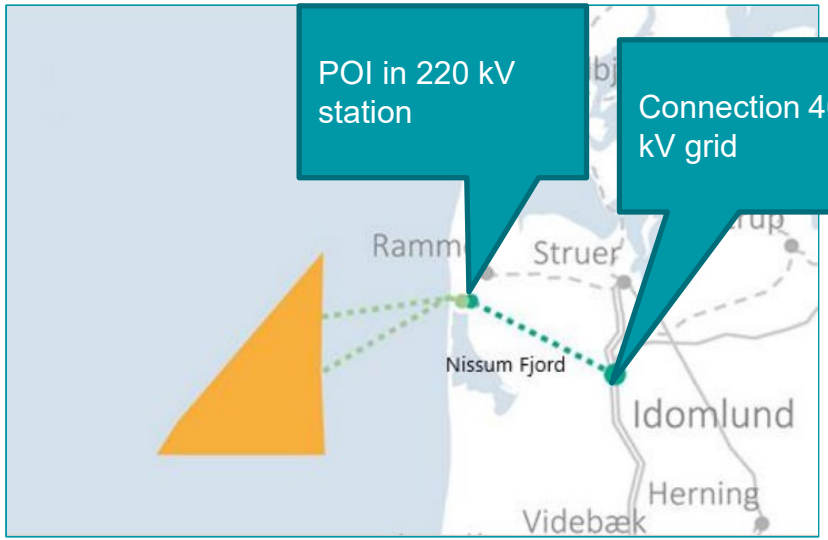
CASE: THOR TENDER – TENDER MATERIAL

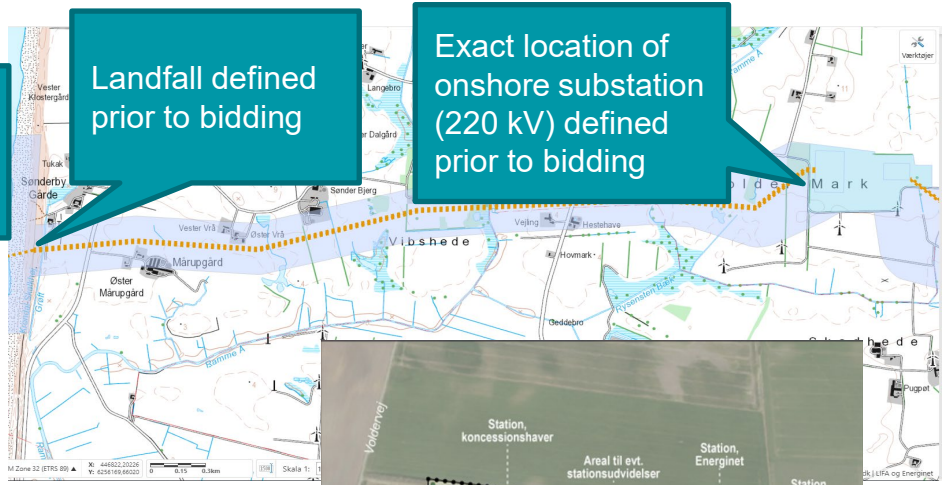
All material available in the [the electronic tendering system]



- Roughly a total of approx. 20 different documents
- The tendering material is subject to a Q&A process with pre-qualified bidders
- Potentially addressed modifications and comments from the Q&A process will be incorporated in the relevant documents
- This process strengthens the robustness of the tendering material, provides transparency, decreases risk, ultimately leading to lower risk premiums

LANDFALL, RIGHTS OF WAY, POI, SPECIFIED IN TENDER

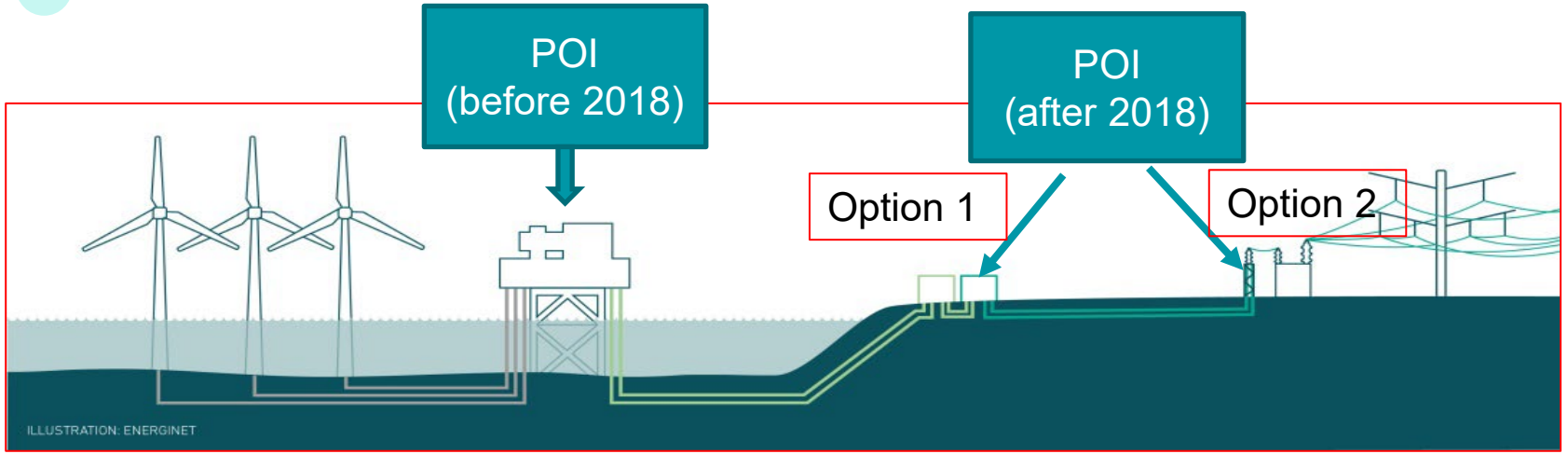




POI details defined prior to bidding:

- Ownership boundaries
- Max. MW connected
- Settlement metering

EVOLUTION IN LOCATION OF DK TRANSMISSION POI'S



Paradigm shift in location of POI:

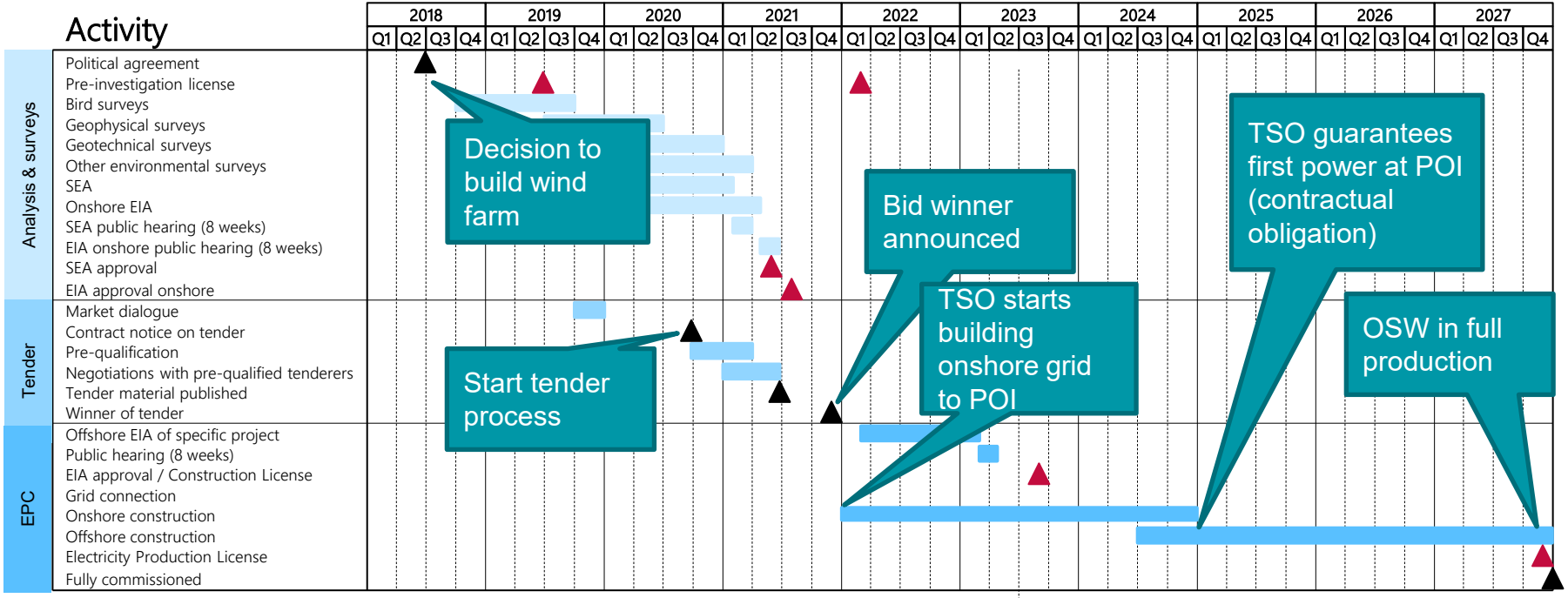
- Prior to 2018, TSO building offshore substation and export cables
- After 2018, developer to build offshore substation and export cables forward to POI onshore
- Rule of law: collective grid build and owned by TSO

Argument:

- Developer better at cost-optimizing offshore grid than TSO
- Possibilities of doing storage (ptx, batteries)

CASE: THOR OSW TIME TABLE

8-9 years from decision to fully operational wind farm



* The political agreement based on the rough and fine screening in 2017 and 2018.
Licensing duration from Political agreement to SEA: 35 months
Licensing duration from Political agreement to Construction License: expected 62 months

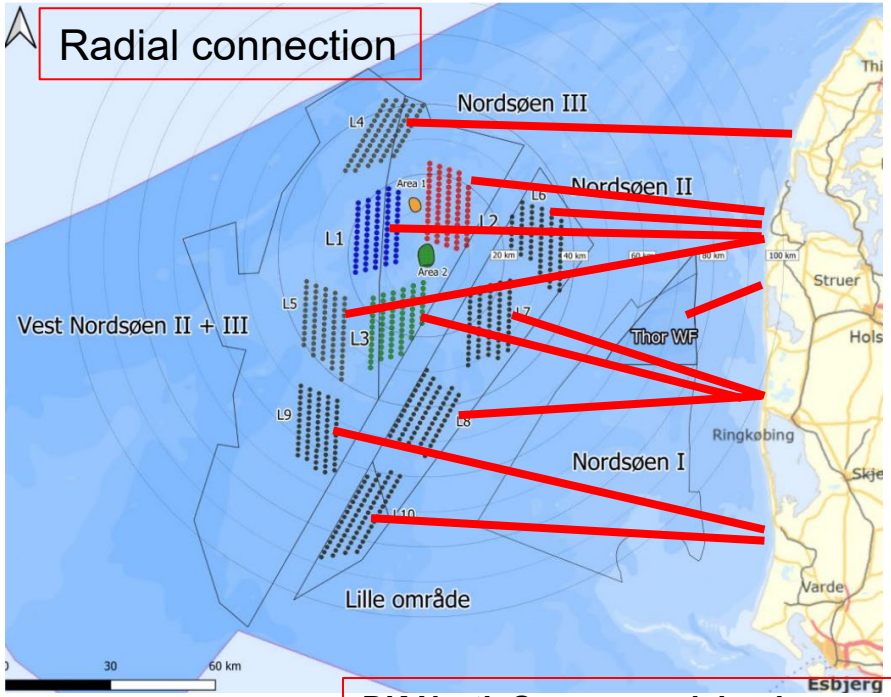
▲ General milestone
▲ Permit milestone (some expected)

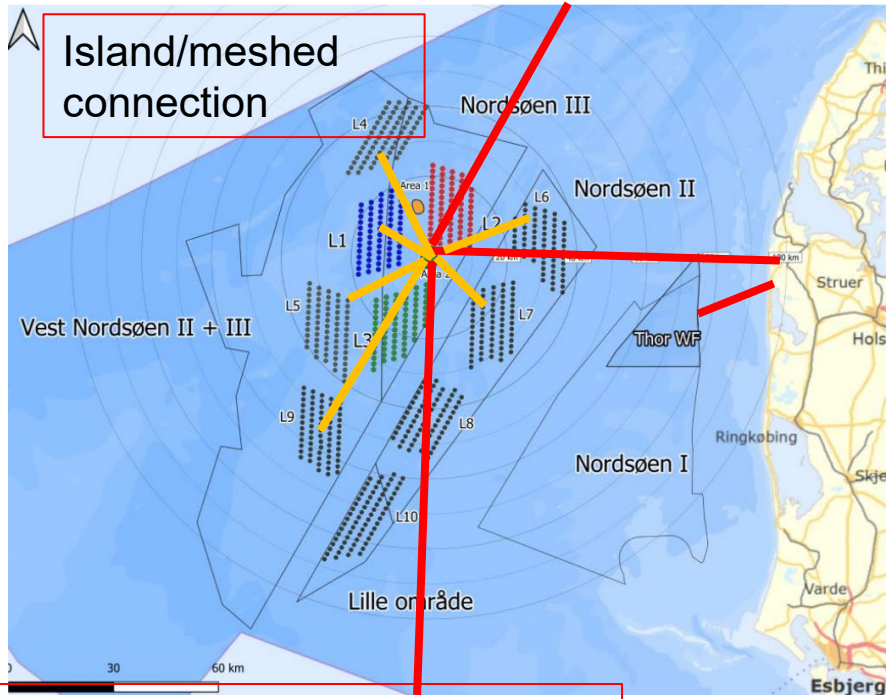
<Table. Thor Process>

'17~'18	'18	'19~'21	'21~'23	'27
Rough Screening → Fine Screening	Political Energy Agreement	Preliminary Surveys SEA, Tender process	EIA	Operation

Danish Energy Agency

RADIAL VS MESHED GRID / ENERGY ISLAND





DK North Sea energy island:

- Possible to source large wind resources in an optimal way
- Easier export of power to other markets
- Less cables going onshore = less trouble onshore with landowners
- Distance to shore and use of HVDC cables, fewer more economic

COSTS AND FINANCING

Tenders/solicitations as contract-for-difference for 50.000 full load hours (incl. on and offshore connection costs)

Winning bid:

- Horns Rev 3, 2015: 770 DKK/MWh (102 USD/MWh)
- Kriegers Flak, 2016: 372 DKK/MWh (50 USD/MWh)
- Thor, 2021: 0 DKK/MWh (0 USD/MWh)

Annual costs for Danish households (at time of tender) :

- Horns Rev 3 (400 MW): 45 DKK pr. year (6 USD pr. year)
- Kriegers Flak (600 MW): 10 DKK pr. year (1,4 USD pr. year)
- Thor (1000 MW): 0 DKK pr. year (0 USD pr. year)

Assumptions:
Based on expected lifetime of 25 years
Electricity market price of 300 DKK/MWh
33 TWh annual Danish consumption
Household 4 MWh of consumption
Current prices and not taking current energy crisis into account.

KEY TAKEAWAYS AND DANISH LESSONS LEARNED

Transparency and thus de-risking:

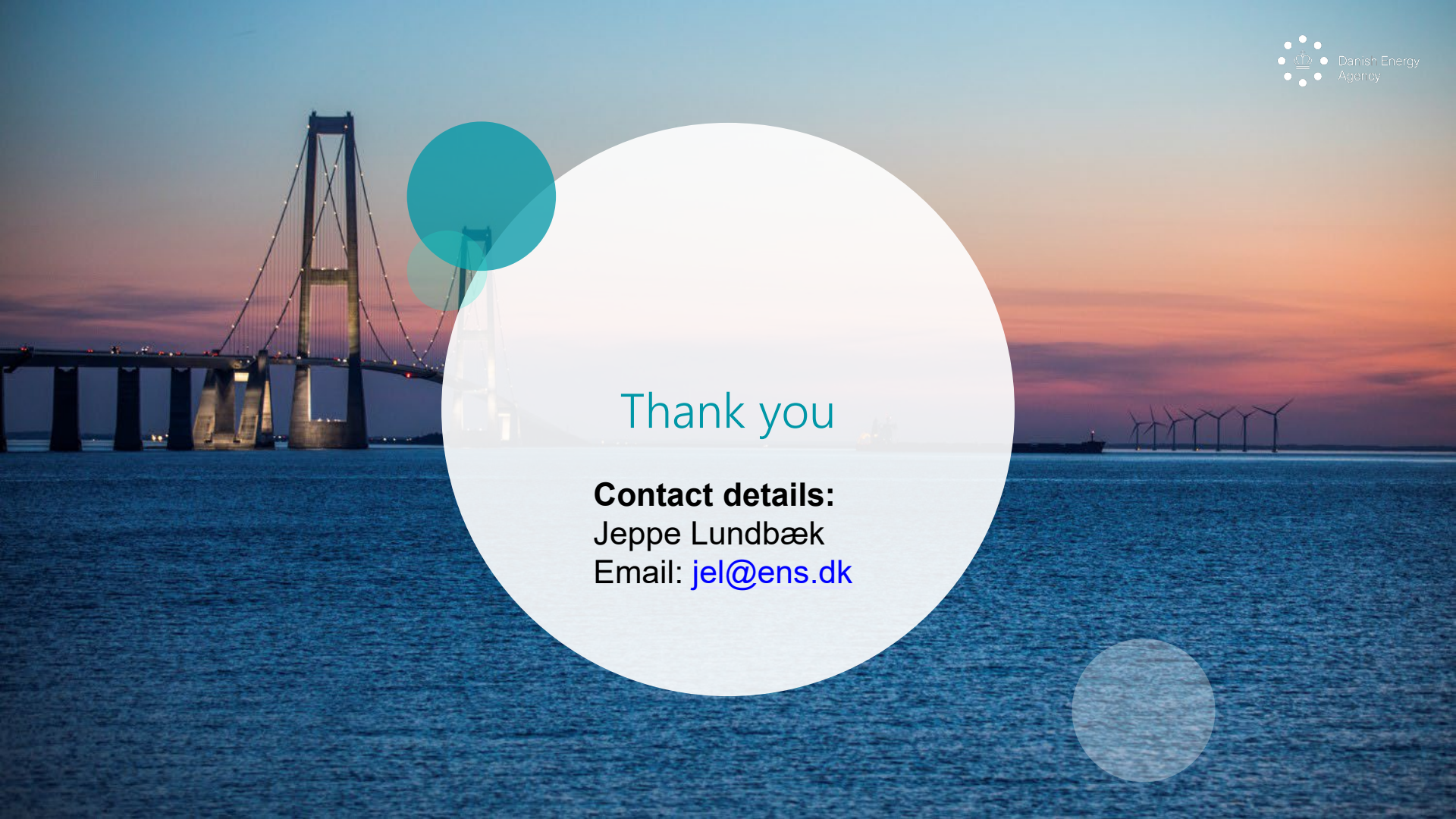
- Well planned and early identified POI's and ownership boundaries provides transparency for bidders, thus reducing risk premiums
- Well planned cable corridors being exposed to robust market dialogue and environmental processes builds up buy-in from developers, and helps reduce local resistance and possible appeal cases
- Guaranteed grid access: the TSO has identified when first power can be delivered, thus reducing risk premiums (compensation if TSO is late)
- A coordinated process bringing together key players (central procurement unit for wind farm, TSO/ISO, permitting authorities, etc.) ensures faster/smarter plan with less risk of failure

Saving time:

- Well planned tender processes tying in links between wind farm and onshore grid/POIs help reduce time by enabling working in parallel processes.

Saving costs:

- All the above results in less risk premiums = lower bid prices/rate payer costs.



Thank you

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