THOR OFFSHORE WIND FARM

Market dialog November 25, 2019
Grid connection

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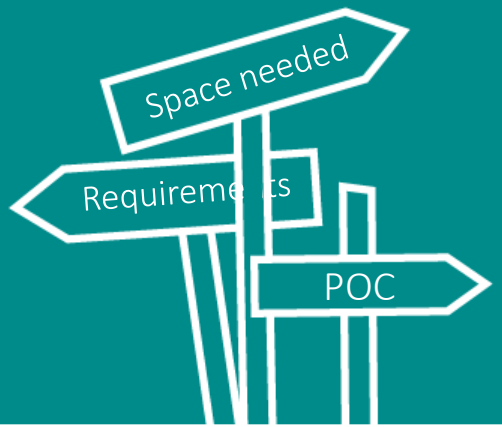
Agenda



- Background
- Requirements
- What to build and space needed
- Grid codes
- Follow-up on questions

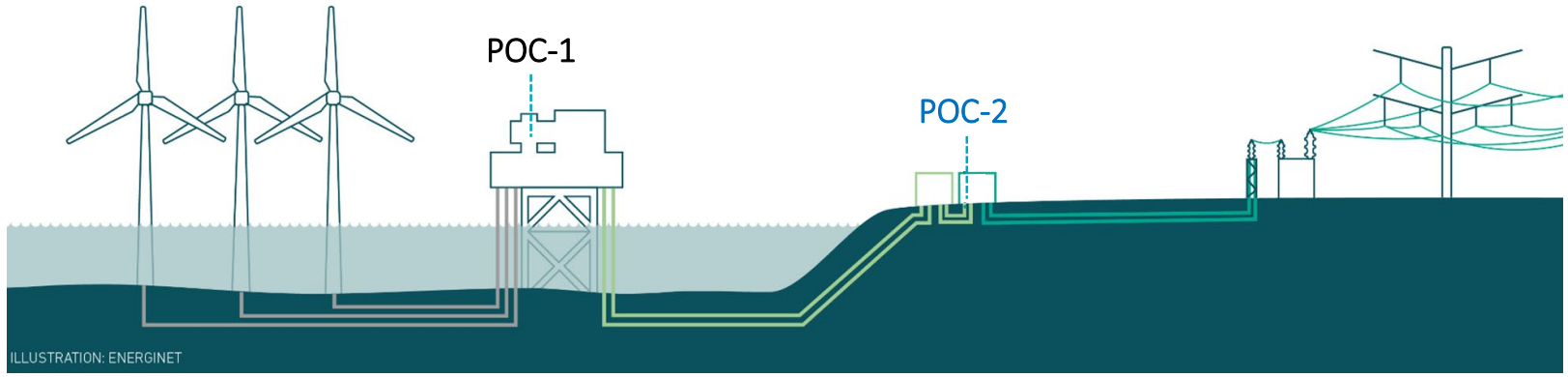
The following presentation is based on the material published by the DEA “Invitation to dialogue” chapter 7

BACKGROUND - NEW MODEL

As a part of the political decision to do the tender for a new offshore wind farm, it was also decided to try a new model for establishing the grid connection.

1. **Previous connections, TSO-model** -> Energinet provide POC and settlement on a offshore transformer platform (**POC-1**), by constructing, operating and own the grid connection from the platform to the existing transmission grid.

2. **Thor connection, new model** -> Energinet provide POC and settlement in a new 220 kV substation 2-5 km inland from shore (POC-2), by constructing, operating and own the part of the grid connection from a new nearshore substation to the existing transmission grid. The rest will be constructed, operated and owned by the concession winner.



1. TSO-model

2. New model

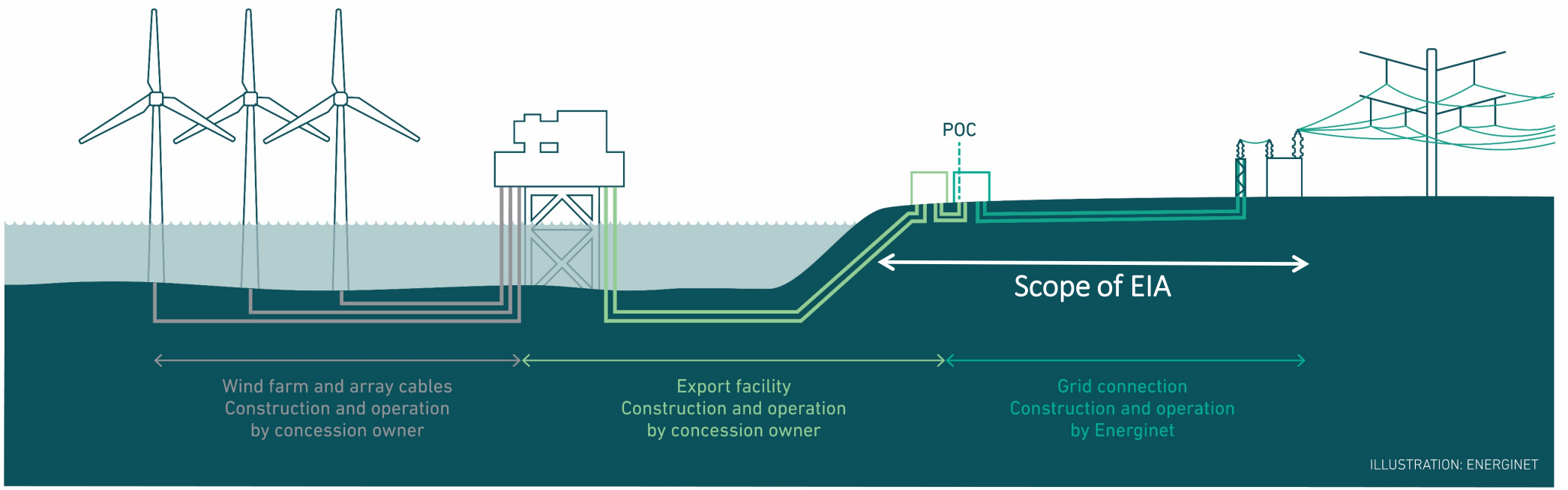
WHAT TO BUILD

ENERGINET

The onshore EIA will be carried out by Energinet, including the land based nearshore facility of the concession winner and will be carried out before the concession winner has been found.

- Any significantly discrepancies between scope proposed in the EIA and what concession winner whishes' to build can lead to the need for a supplementary EIA, including a new addendum to the municipality plan. Not impos-sible but will be time-consuming and effect the time schedule of the concession winner.

- Therefore it is important that the suggested scope in the EIA will be able to contain what is necessary to build.



REQUIREMENTS

1. The wind farm and the export facility must be **compliant with all grid code requirements** in POC.

2. Must be constructed and at all times operated in such a way, that **no incident can cause loss of more than what equals dimensioning fault** in the DK1-area – currently 682 MW.

3. Energinet will facilitate the EIA for all onshore activities. **The concession winner will be responsible for handling any adjustments needed on their part**.

4. **Purchase of land needed** for construction of concession winner facilities will be the responsibility of the concession winner.

5. **Other permits** than the EIA permit and the addendum to the municipal spatial plan needed for construction of concession winner facilities will be the responsibility of the concession winner.

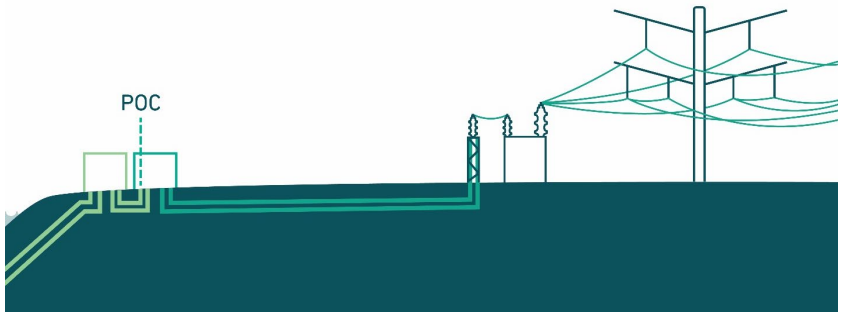
AIR INSULATED SWITCHGEAR
(AIS)

OR

GAS INSULATED SWITCHGEAR
(GIS)

Energinet has decided to use a housed GIS solution for the nearshore substations and that is the base for the EIA

WHAT TO BUILD



Estimate of maximum technical content of concession winner´s nearshore substation:

- Housed GIS
- Voltage level of 220 kV
- Double busbar with breaker divided busbar and one-breaker bays
- Busbar coupler in each of the two sections of the busbar – two bays wide each
- Two bays for concession winner´s cables coming from landfall
- Two bays for concession winner´s cables going to the POC
- Three bays for shunt reactors
- Two bays for STATCOM's / harmonic filters
- Three shunt reactors
- Two STATSCOM's / harmonic filters
- Auxiliary supply (10/04 kV and battery backup). No diesel generator included
- Protection, SCADA and communication housed in building together with auxiliary supply
- Fence and approx. 10 meter plant belt around the substation

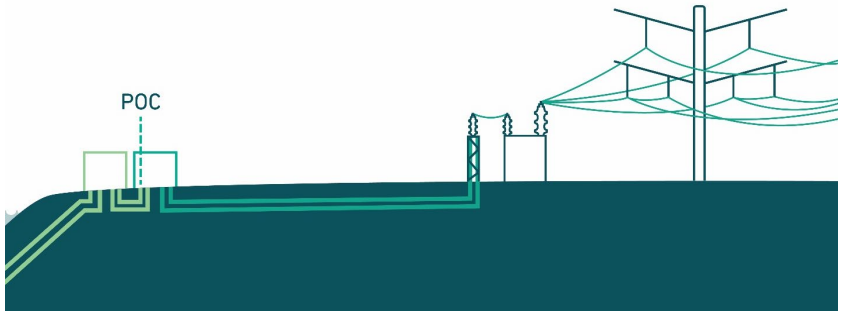
Housed 220 kV GIS

220 kV shunt reactor

Harmonic filter
?

STATCOM
?

WHAT TO BUILD



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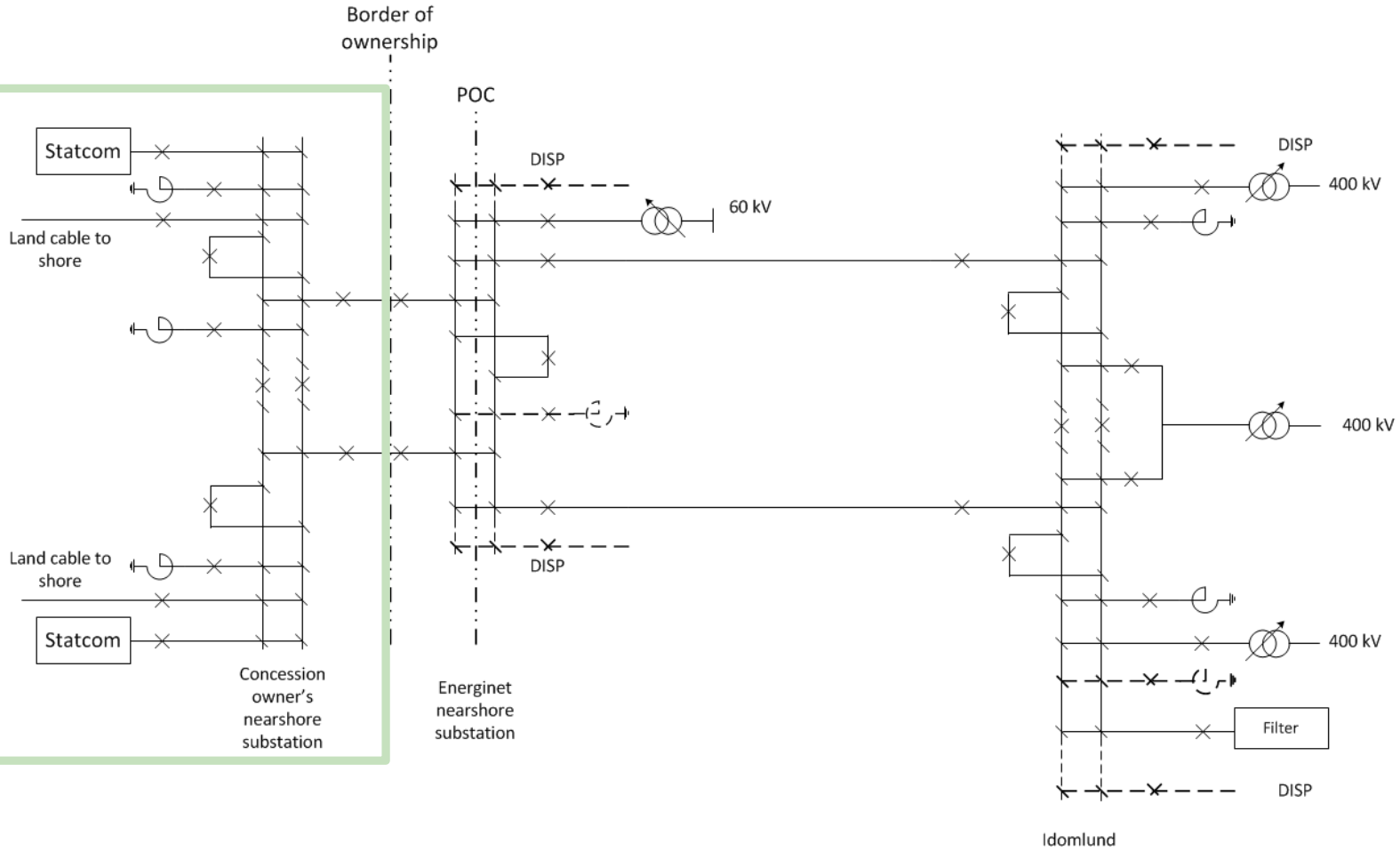

ASSUMPTIONS ABOUT DIMENSIONS

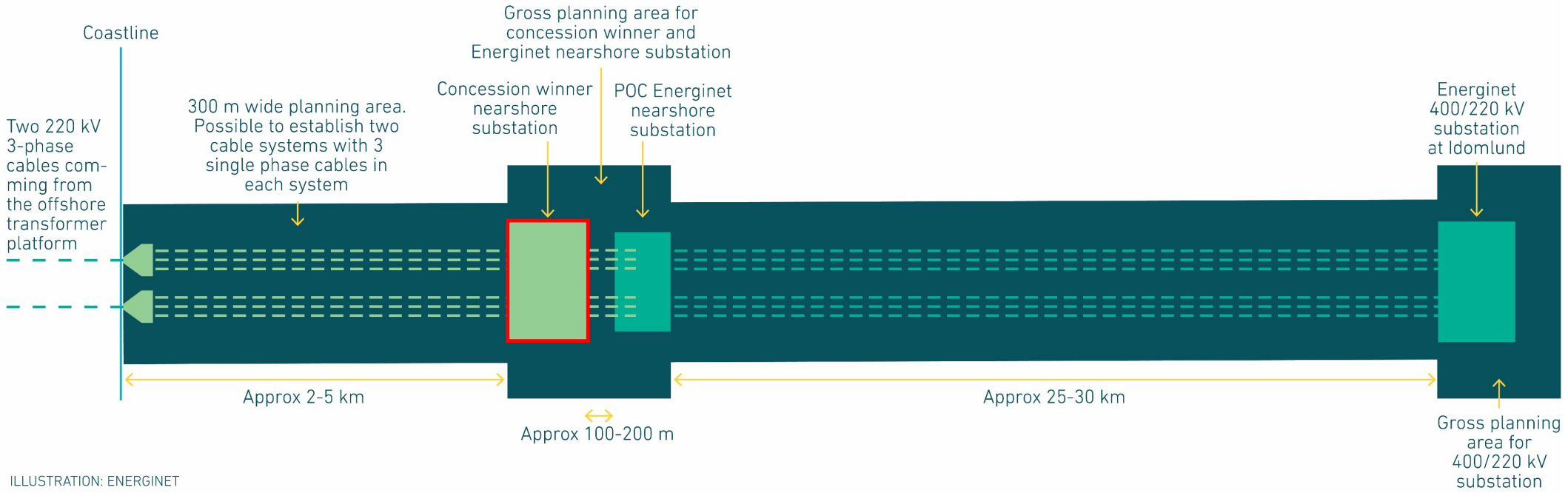

ILLUSTRATION: ENERGINET

Parameter	GIS	AIS
Total substation max. footprint incl. plant belt, m²*	22,000	65,000
Building max. height, m	12	7
Busbar max. height, m	-	11
Lightning protection max. height, m	-	30

*) Plant belt of 10 meters and a buffer of 20 % is included in the show estimate of the total substation footprint

GRID CODES

Regulation for grid connection

- COMMISSION REGULATION (EU) 2016/631 of 14 April 2016 establishing a network code on **R**equirements **f**or grid connection of **G**enerators (**RfG**)
  - and references included
- All relevant appendix, approved by Forsyningstilsynet, available on Energinet website.
- Technical regulation (TF 3.2.7) “Krav for spændingskvalitet for tilslutning af produktionsanlæg til transmissionsnettet”
- Connection agreement for site specific requirements

GRID CODES

Selected requirements/conditions from the RfG (1/2)

Link:

https://energinet.dk/El/Nettilslutning-og-drift/Netregler/Godkendte-krav-vilkaar-metoder-og-betingelser

- One POC at the 220 kV busbar. All requirements are referred to POC unless otherwise mentioned
- Voltage ranges, time period for operation – RfG ref. table 6.1 and A16(2)(a)
- Active power ramping limits – RfG ref. A15(6)(e)
- Thor – expected mandatory voltage control mode
- Supplementary reactive power – RfG ref. A21(3)(a)
- Simulation model - RfG ref. A15(6)(c)(i)

GRID CODES

Selected requirements/conditions from the RfG (2/2)

Link:

https://energinet.dk/El/Nettilslutning-og-drift/Netregler/Godkendte-krav-vilkaar-metoder-og-betingelser

- Quick re-synchronization after network disconnection – RfG ref. A15(5)(c)
- Power Oscillation Damping (POD) – RfG ref. A21(3)(f), Synthetic inertia – RfG ref. A21(2)(a), requirements are expected to be specified prior Thor connection agreement
- Offshore PPM – onshore requirements – RfG ref. A23(1)
- Operational notification procedure – RfG ref. A33 - A36
  - Energization operational notification (EON)
  - Interim operational notification (ION)
  - Final operational notification (FON)

- Is the described set-up for the solution onshore (dimensions for nearshore substation, **footprint (m^2), building height, HV-equipment** etc.) within the expectations of developers?

- If the tenderer decides to **use a voltage level different from 220 kV**, the tenderer will need to install transformers in the nearshore substation. Is that a plausible possibility?

- Is it likely, that the tenderer **will need STATCOM's** in the nearshore substation?

- Is it likely, that the tenderer **will need harmonic filters** in the nearshore substation?

- Any other question?