

DONG Energy Wind Power

The challenges of connecting offshore wind

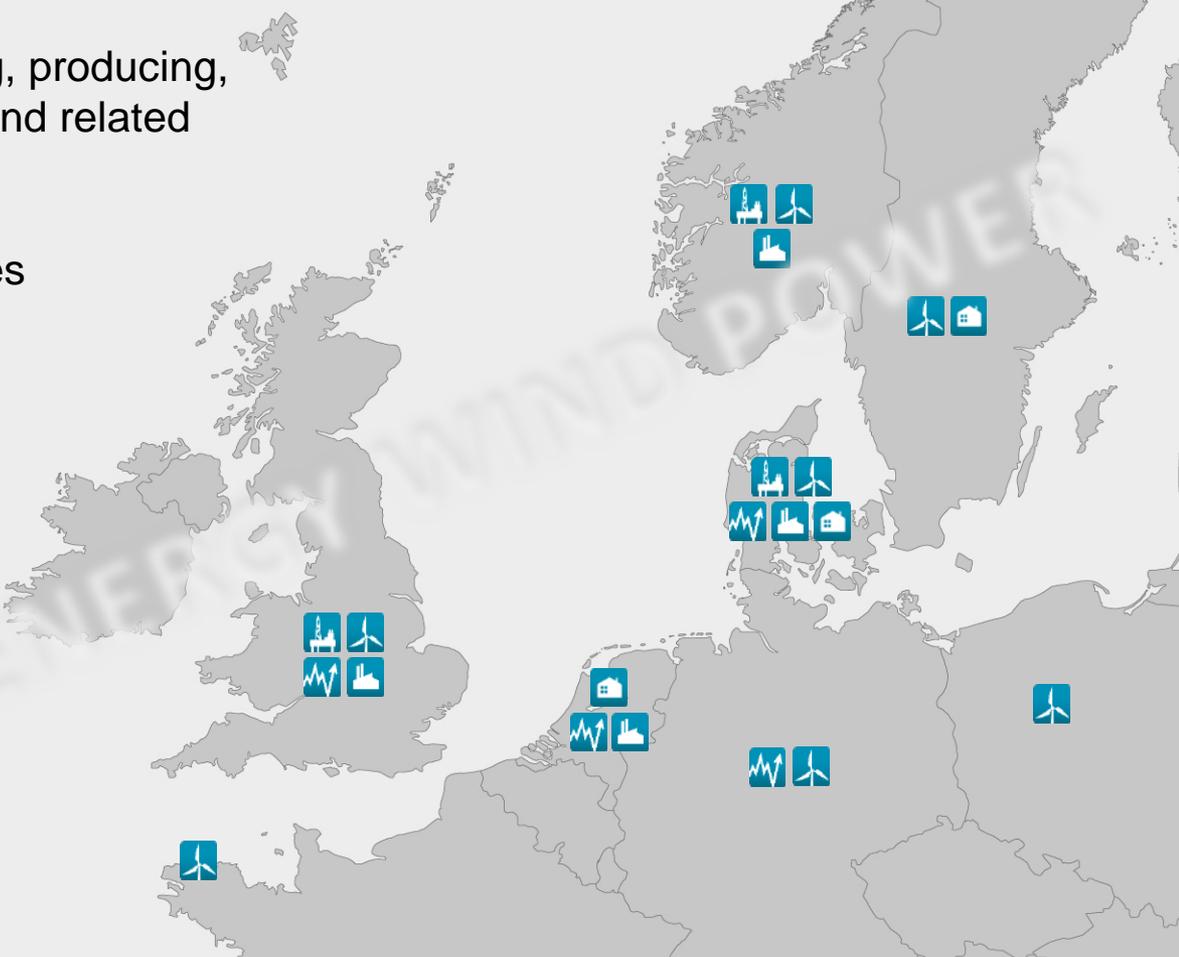
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DONG Energy Wind Power
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DONG Energy is one of the leading energy groups in Northern Europe

Our business is based on procuring, producing, distributing and trading in energy and related products in Northern Europe.

DONG Energy has 7,000 employees and is headquartered in Denmark.

-  Exploration & Production
-  Wind Power
-  Thermal Power
-  Energy Markets
-  Sales & Distribution



DONG Energy's strategy

WHERE TO

Doubling EBITDA, DKK billion



Halving CO₂ emissions, g CO₂ per kWh



Offshore Wind Power



Wind Power develops, constructs and operates wind farms in Northern Europe.

Under construction

Anholt Offshore	400
Demo projects	12
Lincs	270
London Array 1	630
West of Duddon Sands	389
Borkum Riffgrund 1	277
Total	1,978

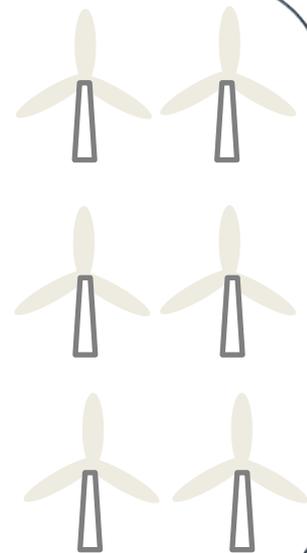
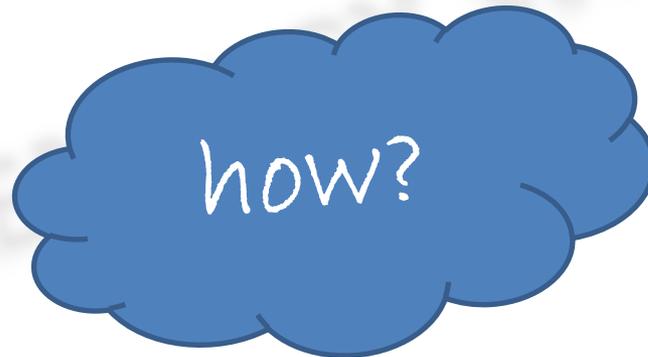
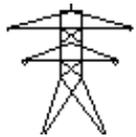
Target 2020: 6,5 GW

Projects completed with DONG Energy



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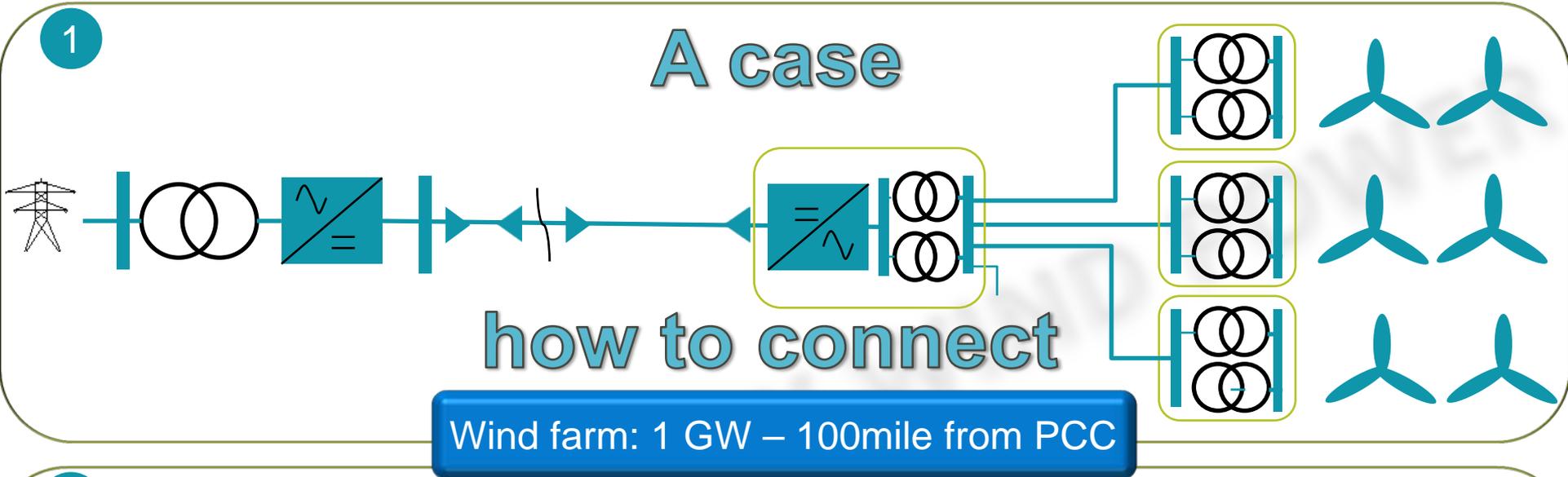
- Larger turbines
- Bigger wind farms
- Further from the power system



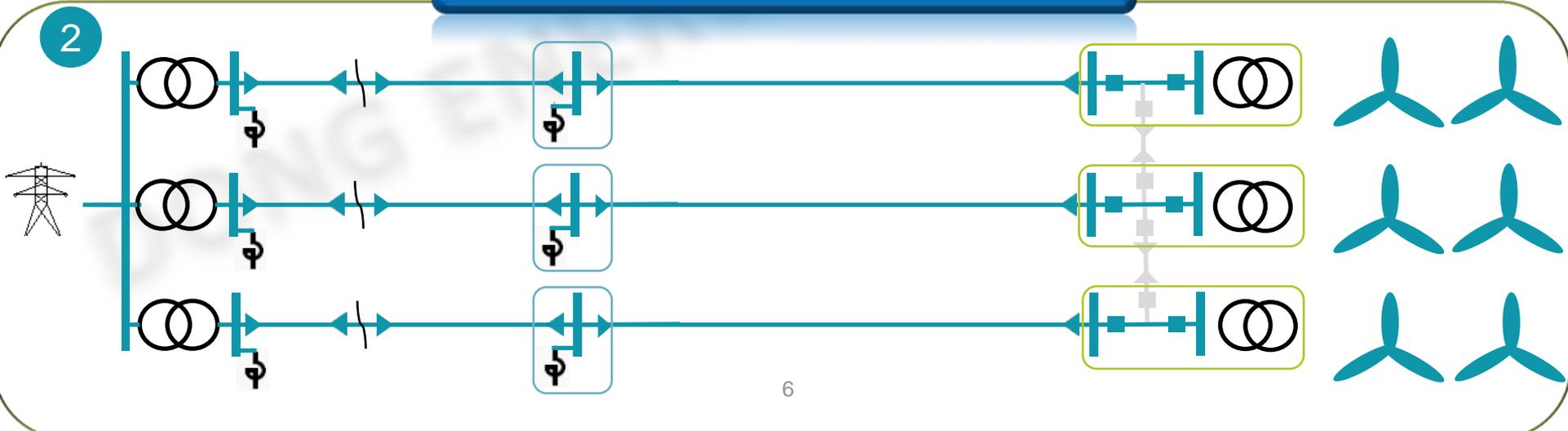
The challenges of connecting offshore wind

1

A case



2



The challenges of connecting offshore wind

The electrical challenges

- HVDC
- Long HVAC Cables

Harmonic resonance
Harmonic stability
Transient voltages
voltage control
Protection
Emission



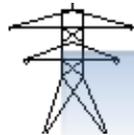
Cost of Energy



The grid code challenges

- New requirements
- Ancillary services

Black-start
Artificial inertia,
Stop-to-house-load,
High wind ride through,
High voltage ride through,
Power Oscillation Damping



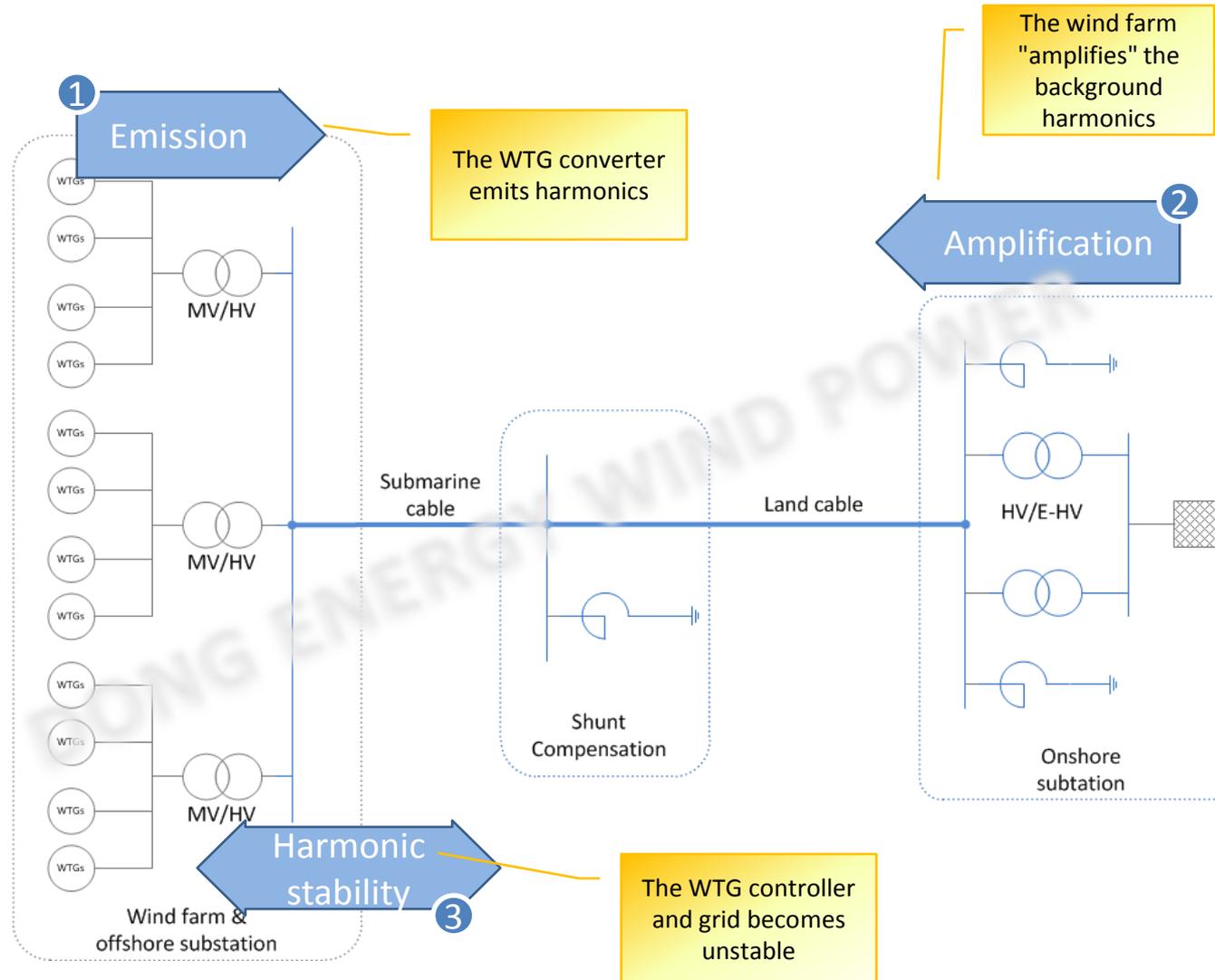
DONG ENERGY WIND POWER
– LONG HVAC CABLES

– ANCILLARY SERVICES

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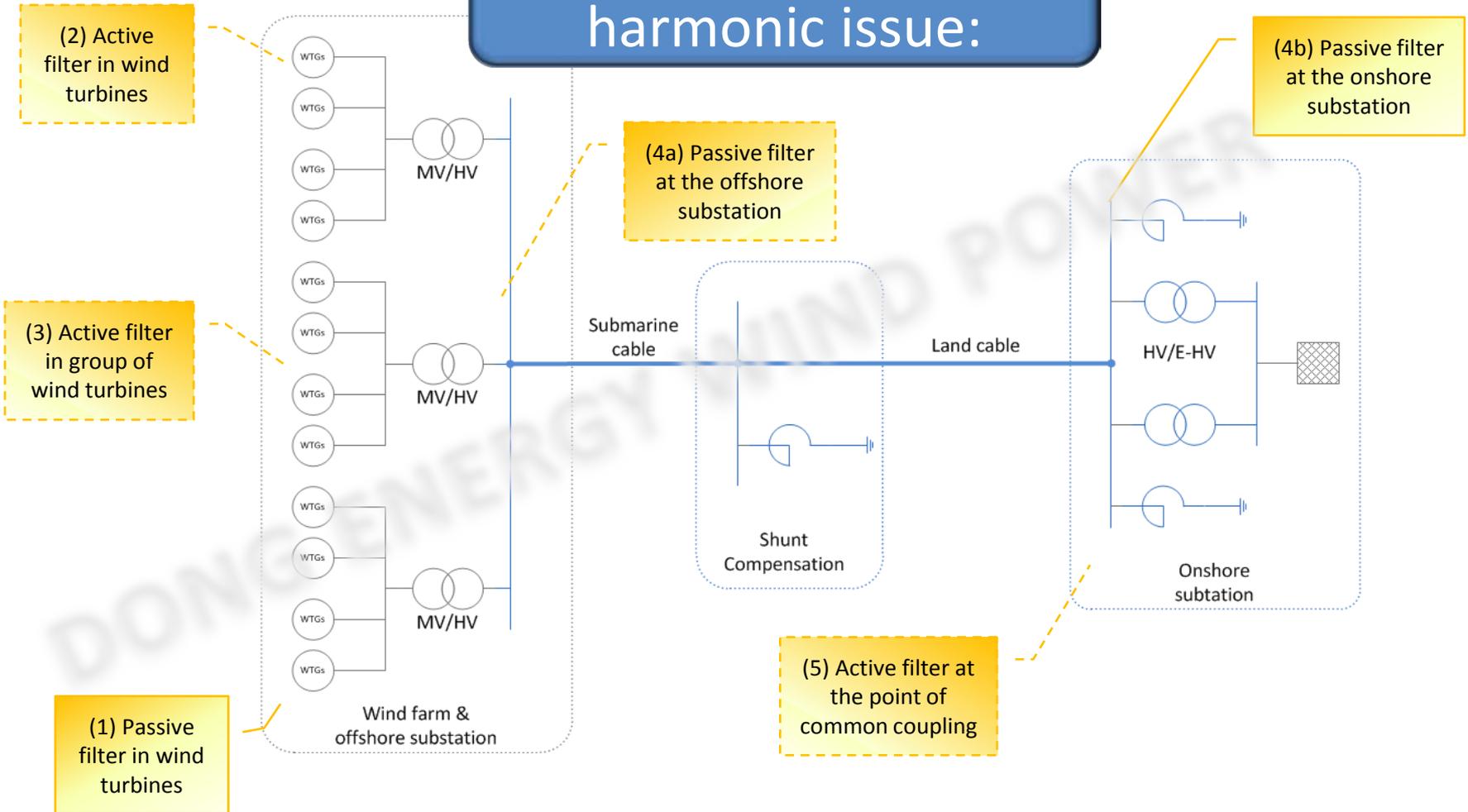
Harmonic issues

We need to understand:
WTG
converter
controller
array design
export cable
power system



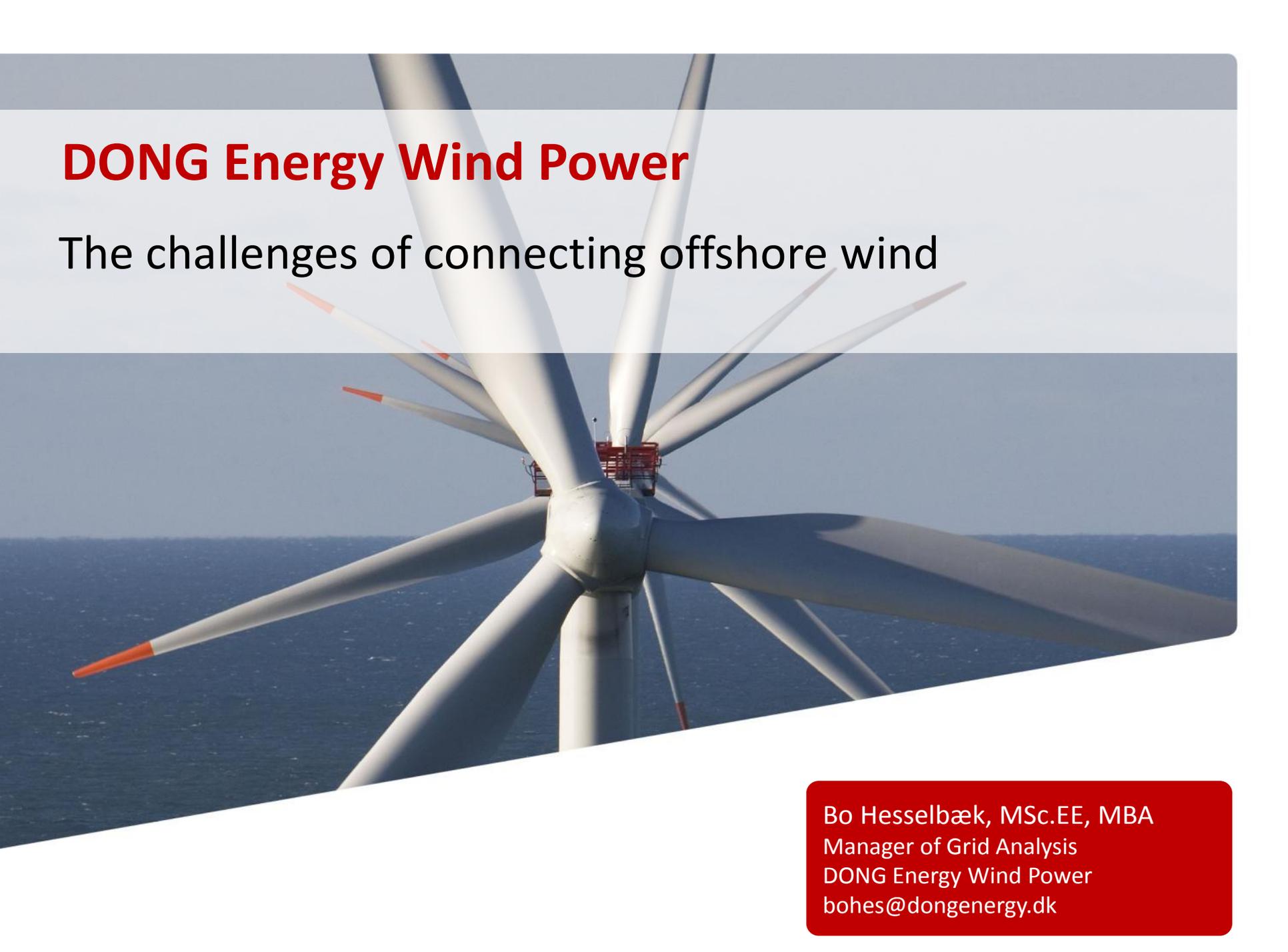
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Ideas to mitigate the harmonic issue:



The challenges of connecting offshore wind

- Areas of interest
 - Harmonic resonance and stability
 - Mitigation of harmonics
 - Wind Farms connected via long AC cables
 - HVDC connected wind farms
 - Multiple HVDC connected wind farms
 - Multi terminal HVDC



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