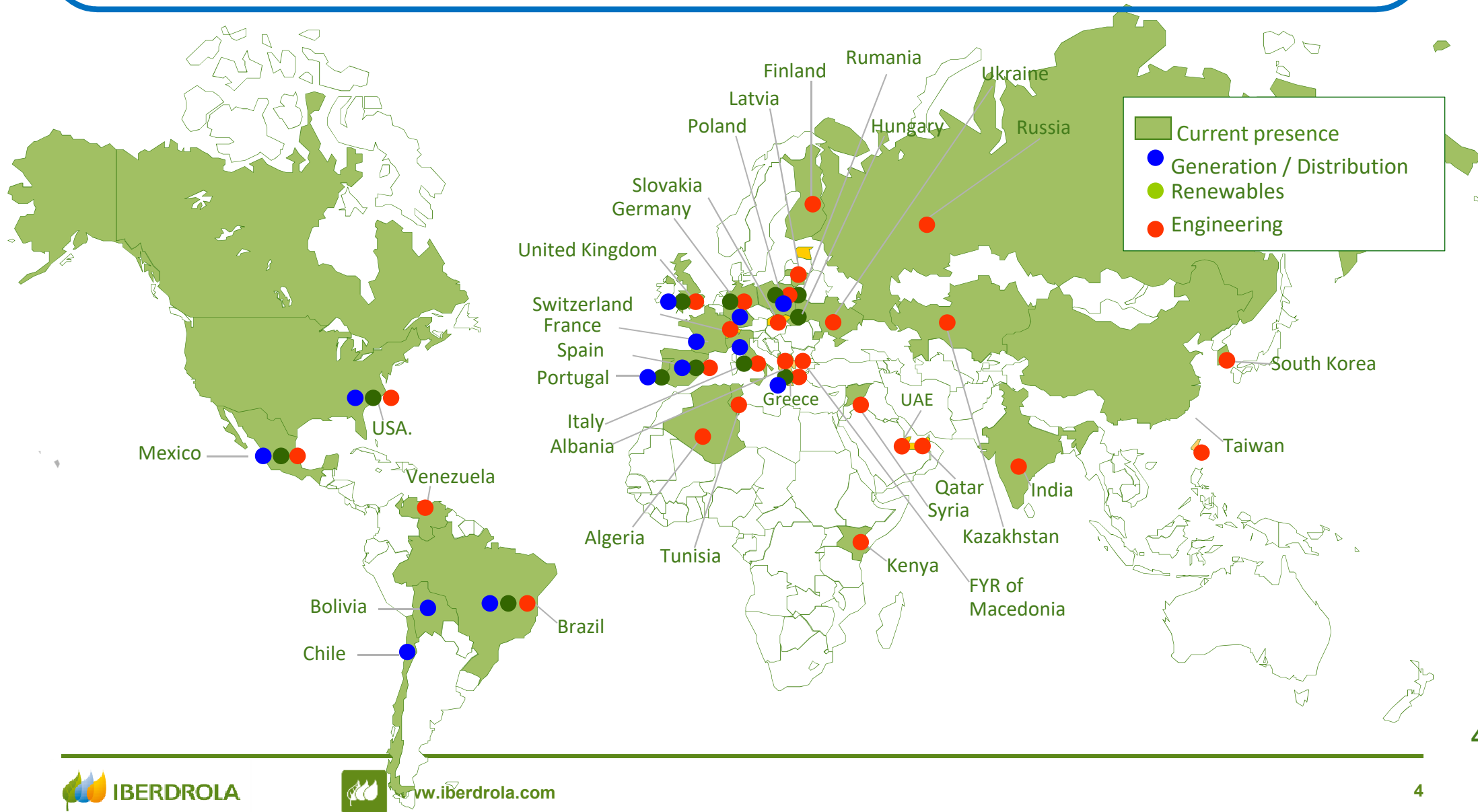


Technology from the Utility perspective

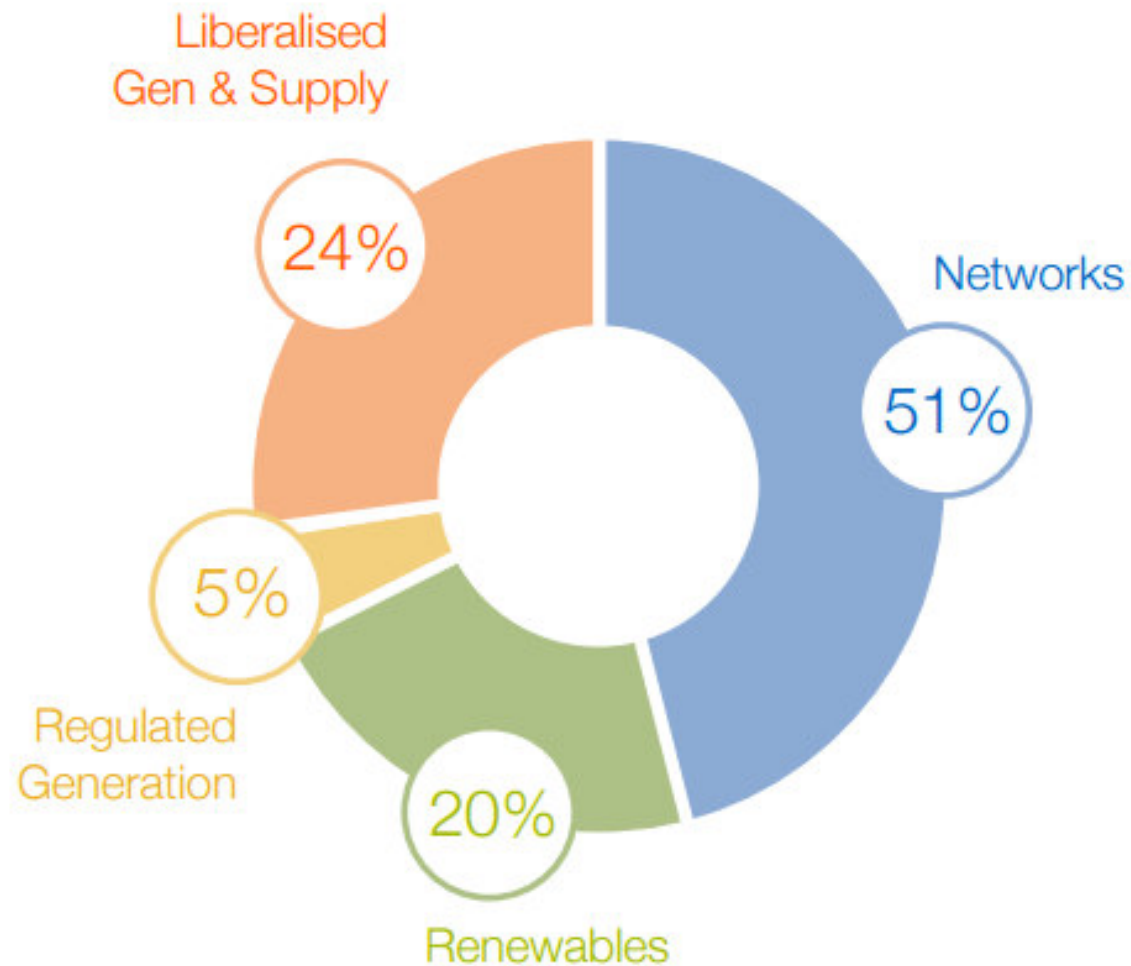
- General information about Iberdrola Renewables
- Wiker offshore wind farm
- East Anglia
- View on HVDC grids
- Questions for discussion

Iberdrola Renewables

Iberdrola Group: presence in more than 40 countries



2016 EBITDA 1st nine months: 5,730 M€



14.717 MW of Renewable generation



14.054 MW ONSHORE WIND



194 MW OFFSHORE WIND



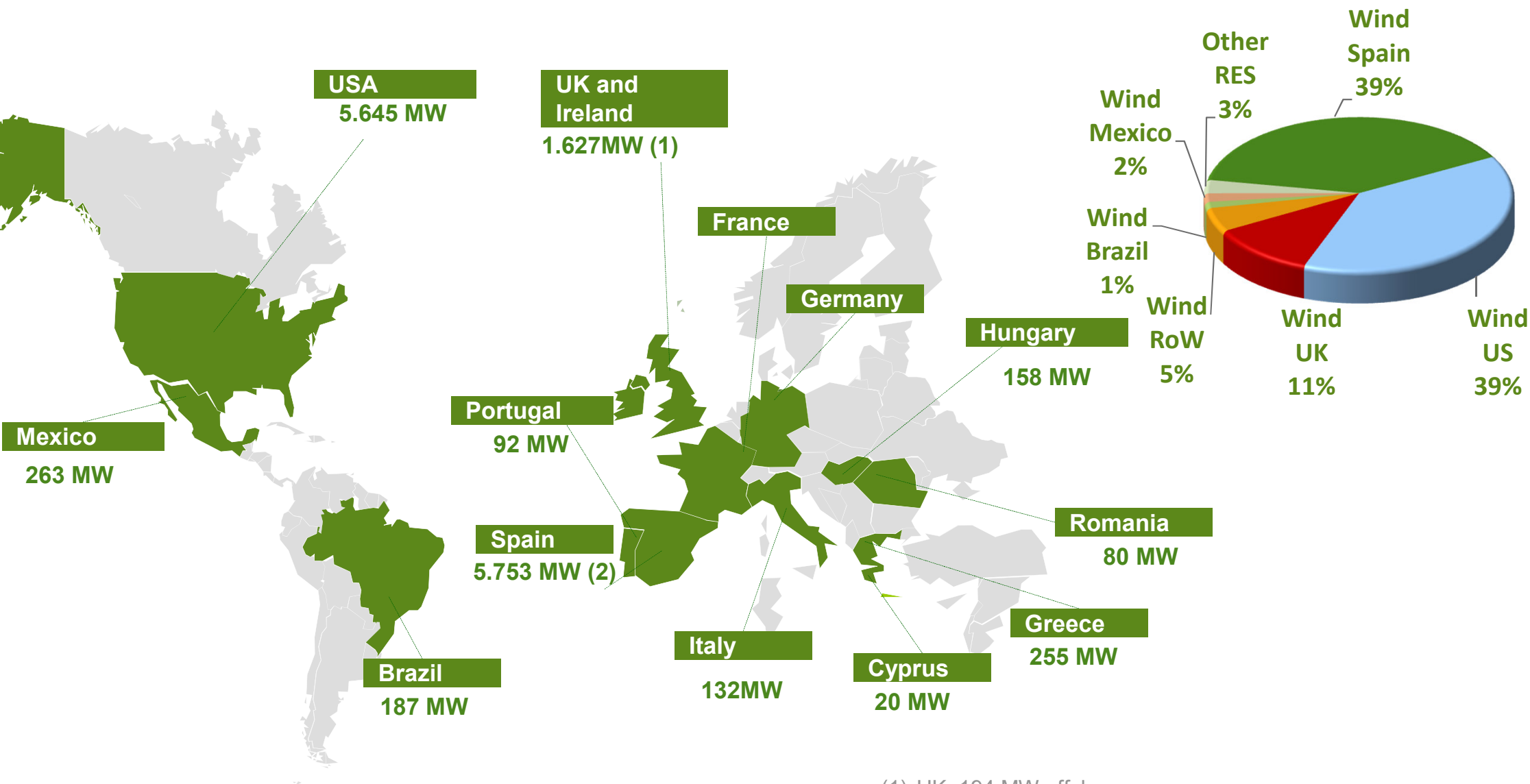
363 MW SMALL HYDRO



56 MW PV + 50 MW CSP

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Iberdrola Renewables

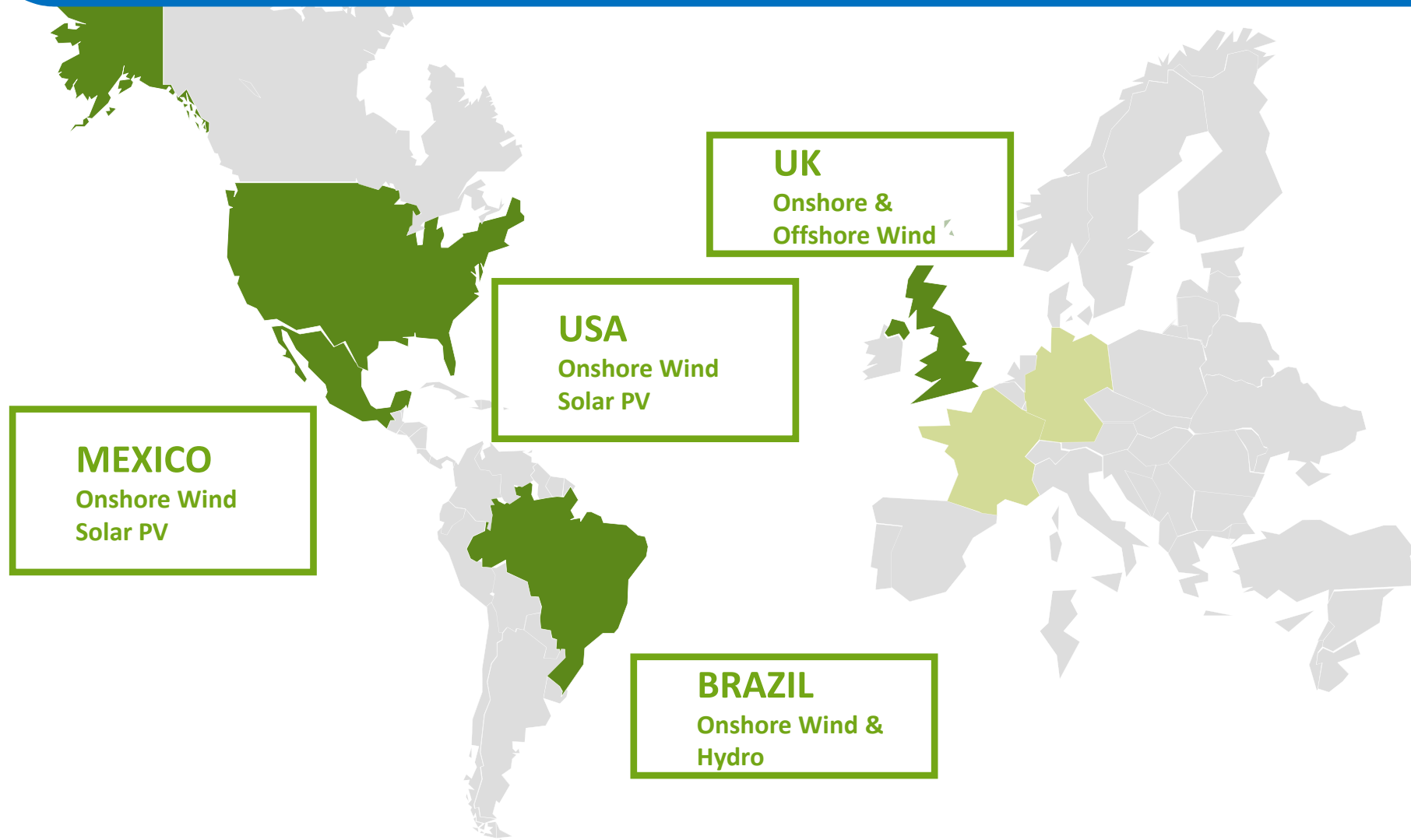


* As of 1H 2015

(1) UK: 194 MW offshore

(2) Spain: 413MW other renewables

MAIN GROWING POLES





Offshore

1,064MW
in construction

- **Wikinger (350MW)**, Germany
Initial output in 2017.
- **East Anglia 1 (714MW)**, UK.
70% of equipment and services contracted
Initial output in 2019.
- **St. Brieuc (496MW)**, France
Preliminary works - Initial output in 2022



Onshore

1,923MW
in construction

- **US (744MW)** commissioning 200MW in 2016, remaining 2017-2018.
- **UK (398MW)** commissioning in 2016.
- **Mexico (325MW)** commissioning in 2019.
- **Brazil (424MW)** commissioning 84MW in 2016, 340MW in 2017-2018.
- **Spain (32MW)** commissioning in 2017.



Solar PV

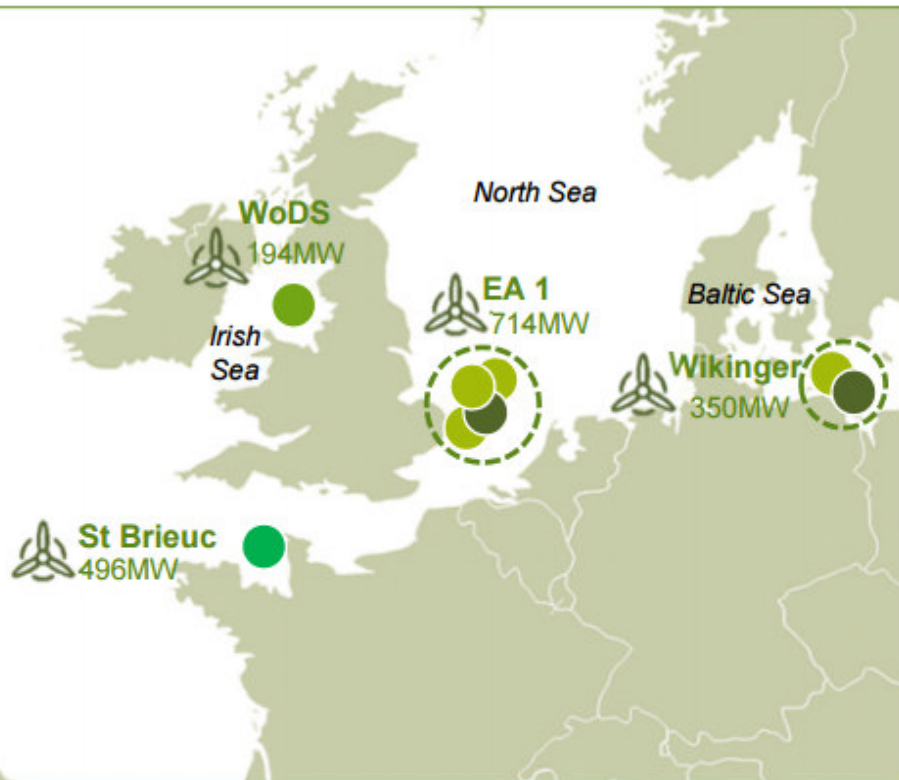
336MW
in construction

- **Mexico (270MW)** commissioning in 2018.
- **US (66MW)** commissioning in 2017.

**2,284 MW to be commissioned
between Q4 2016 and 2018**

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Iberdrola Renewables



Current projects: Total 1,754MW

- In operation (194MW)
- In construction (1,064MW)
- Preliminary works (496MW)

Future projects: Total 3,130MW

- East Anglia 3 (1,200MW)
- East Anglia 2 & 1N (1,600MW)
- Windanker/Wikingen Süd (330MW)

UK

West of Duddon Sands, 389 MW

Investment ~1600 MM £
Joint venture (JV) 50-50 with DONG
Grid connected 2014
108 Wind turbines

East Anglia I, 714 MW

100% Iberdrola
Investment ~ 2,650 MM £
Commercial operation by 2018

Germany

Wikingen 350 MW, Baltic Sea

100% Iberdrola
Investment ~ 1.350 MM € (+OFTO)
Commercial operation by Q3 2017

France

St. Brieuc, 496 MW

70% Iberdrola – 30 % Eole Res
Investment ~ 2.600 MM €
Commercial operation by 2022

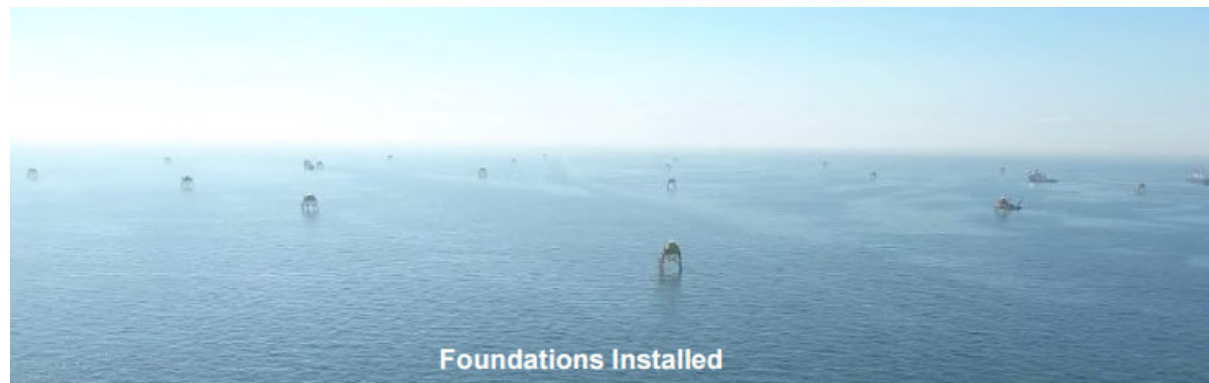
Wikinger

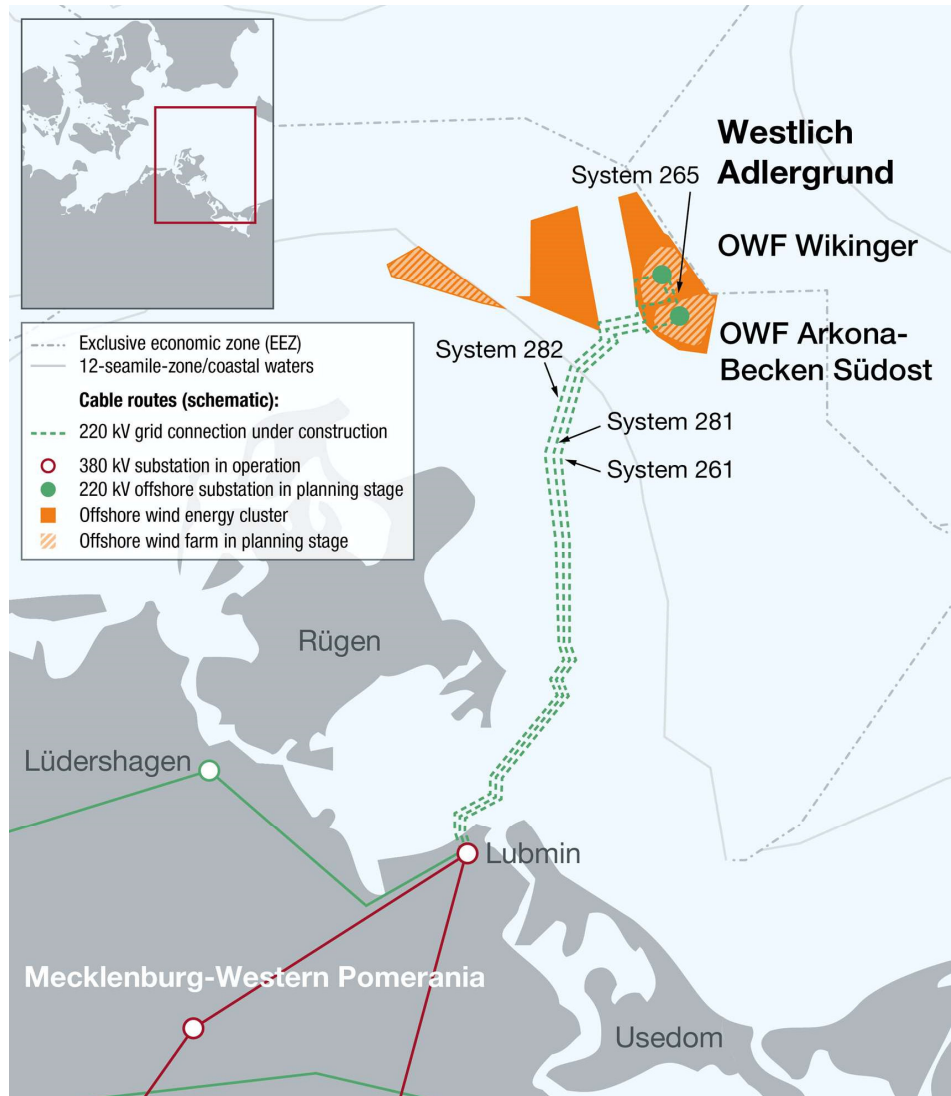
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Wikinger

KEY FIGURES

Nº of Turbines	70
Turbine Type	AREVA M5000-135 (5MW)
Total Capacity	350 MW
Distance to Shore	90 km
Water Depth	35 – 42 m
Project Area	German Baltic sea - 34 km ²
Foundation Type	4 legged Jacket

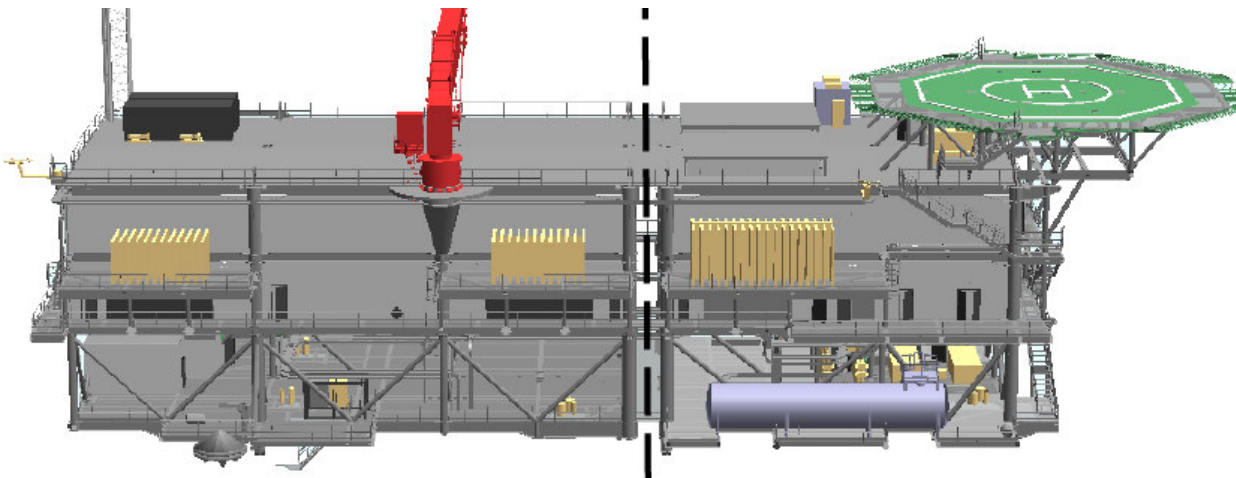




- **HVDC technology was considered at the time by the TSO (50Hertz):**
 - 750 MW cluster
 - Total cable route length 93 km
- **Reasons why HVAC was chosen instead:**
 - CBA showed that the traditional 90/100 km breakpoint was moving farther from shore
 - Change to auction process similar to the UK
 - Grid connection timescales too tight for large HVDC platform
 - Lack of clarity on the future cluster

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Wikinger



220kV Equipment

33kV Equipment



- **Lessons learned with the Wikinger substation**

- Sharing topside with TSO, not only the foundation, resulted in more realistic programme.
- Larger and heavier substation → Separated into two topsides and installed with heavy lifting vessel.
Challenges to coordinate:
 - Engineering
 - Procurement
 - Construction
 - O&M requirements
 - Allocation of costs

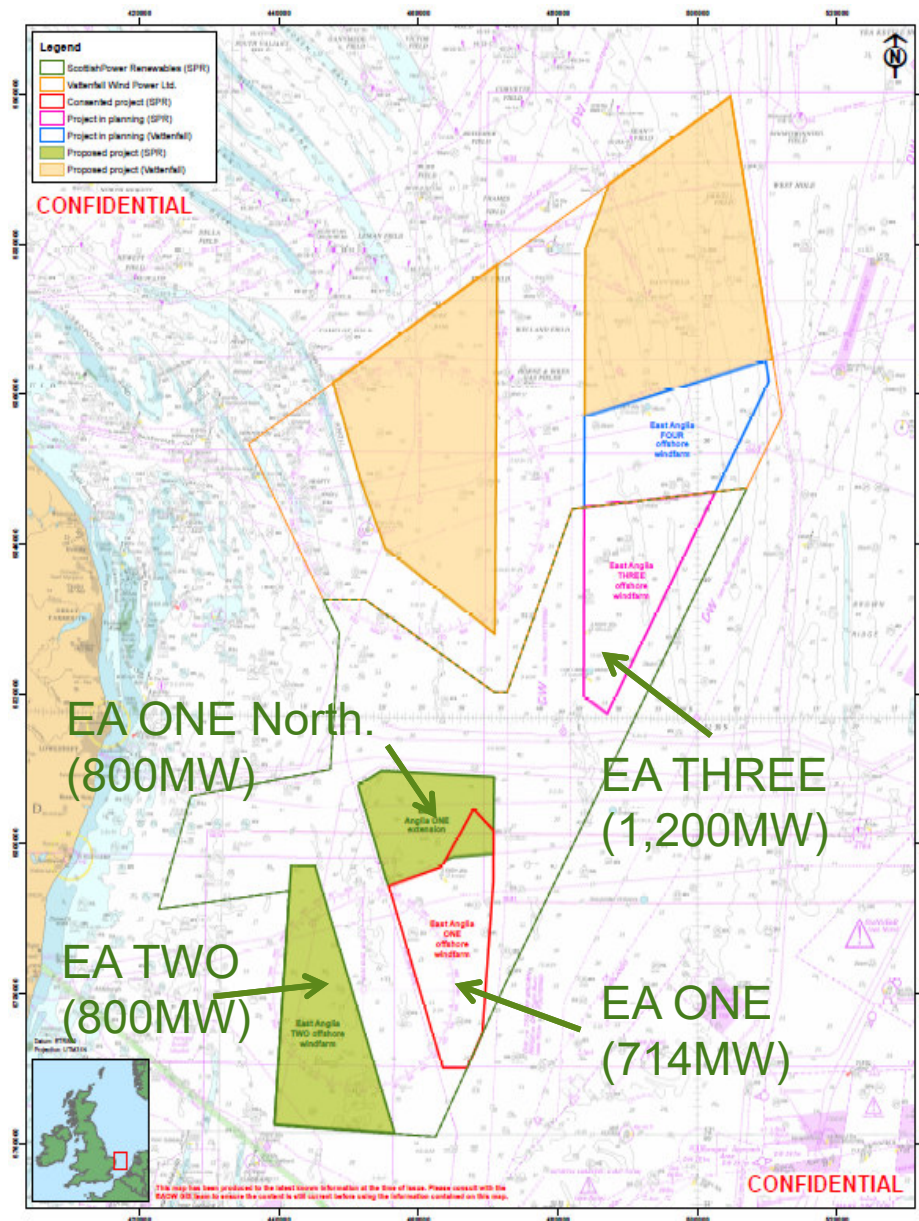
Can lead to some additional costs and inefficiencies
- Additional hook-up works compensated by the reduction of steel costs
- Few installation vessels in the world:
 - Very busy
 - For the same reason, they are very efficient
 - Require similar level of efficiency from developer's side
- Our experience shows that this was a good solution in comparison with self-installing platforms
- Cultural differences among different countries should not be dismissed as they can lead to delays in the project

East Anglia

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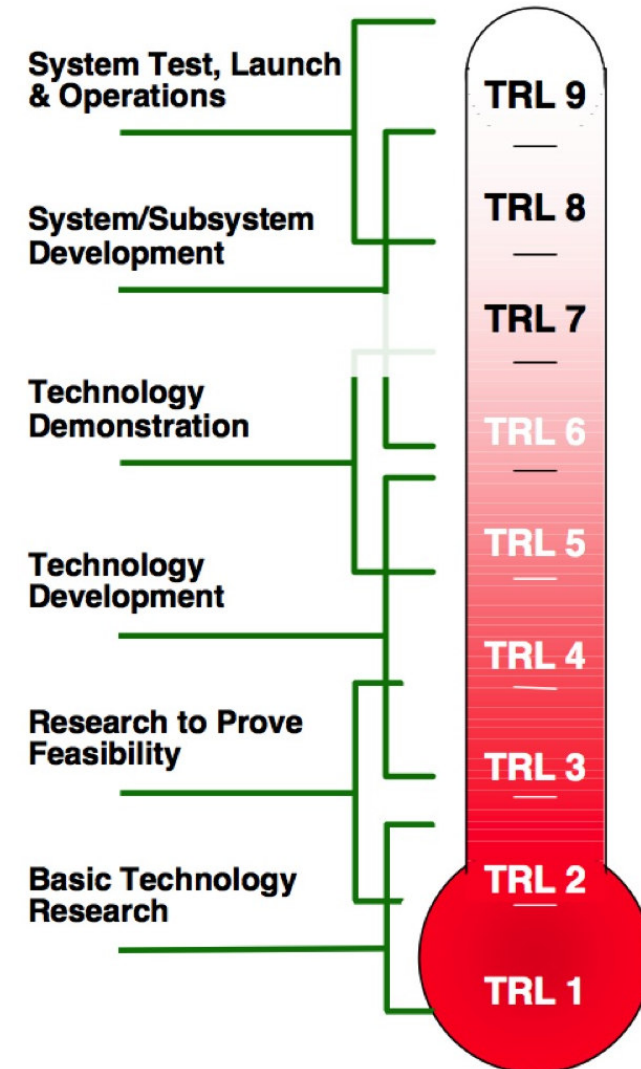
East Anglia

- ScottishPower Renewables is promoting four projects in the southern half of the East Anglia Zone:
 - East Anglia ONE (starting March 2017)
 - East Anglia THREE (consenting)
 - East Anglia ONE North (pre-consent)
 - East Anglia TWO (pre-consent)
- EA1 initially planned as HVDC project:
 - 1,2 GW
 - 78km offshore + 37km onshore
 - **Changed to HVAC due to:**
 - Change to auction process (CfD instead of ROC)
 - Not enough for 1,2 GW → reduced to 718 MW)
 - Need to reduce cost for auction
 - Larger number of suppliers



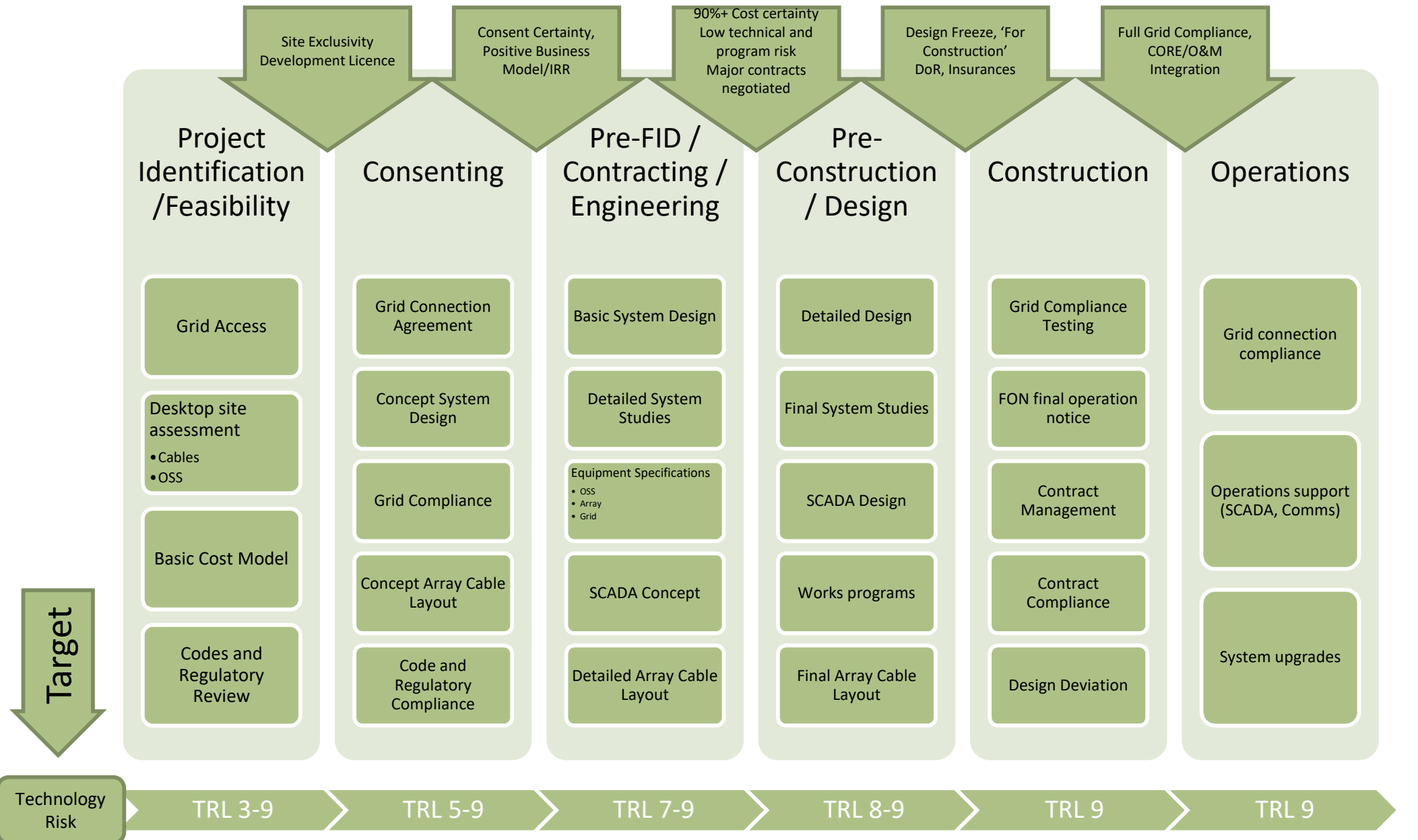
EA2 Iberdrola's first HVDC project

- 1,2 GW
- 155 km offshore + 37 km onshore
- Possible technologies
 - MMC VSC
 - DRU → Single manufacturer, TRL?
- Excluded technologies due to CBA, technical feasibility & constant risk
 - Low Frequency AC (16.7 Hz)
 - “Classic” HVAC (50 Hz)



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East Anglia



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East Anglia

IOTP-E(Integrated Offshore Trensmmission Project – East)

National Grid Led Project

Project Established in 2012,
Involved Vattenfall, Forewind,
Smart Wind and SPR

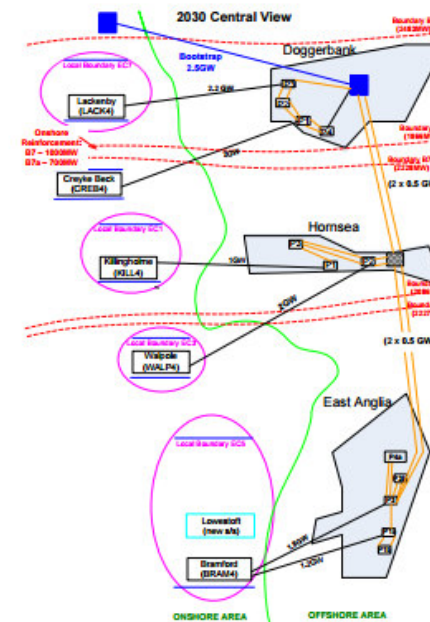
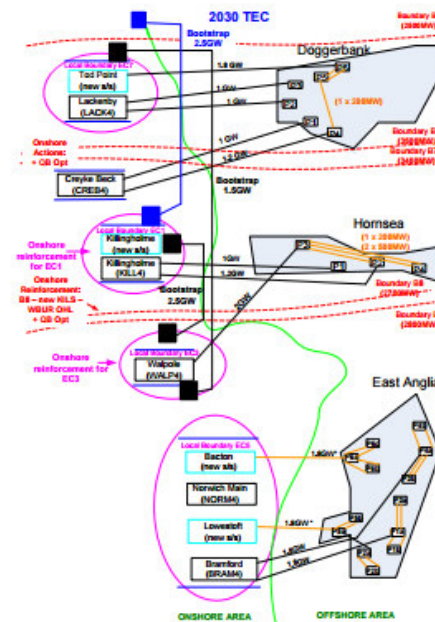
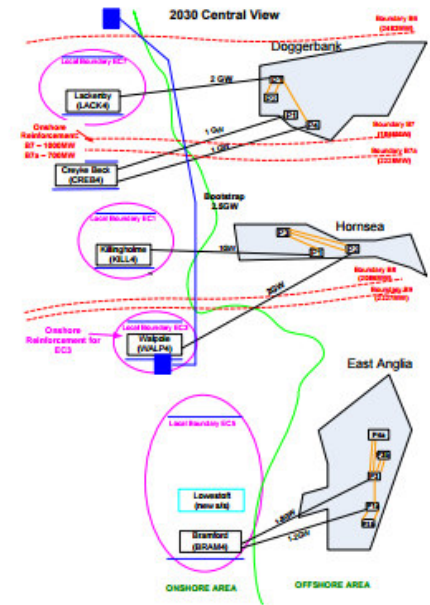
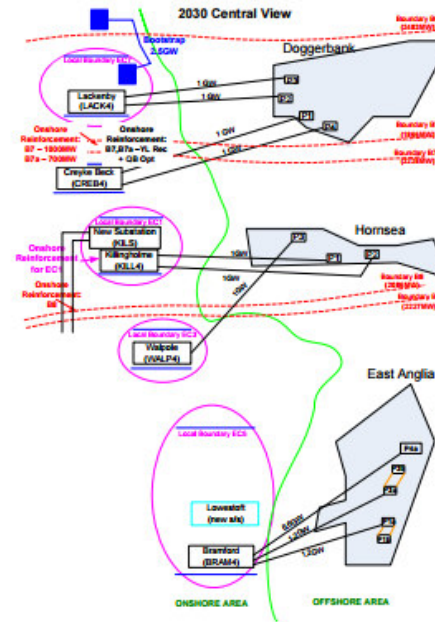
Objective:

Study benefits of interconnecting Dogger Bank,
Hornsea and East Anglia

Conclusion:

As a result the project team does not believe it would be economic and efficient to progress with the development of an integrated design philosophy or delivery of anticipatory assets at this time.

Final report, August 2015,
<http://www2.nationalgrid.com/uk/industry-information/future-of-energy/>



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East Anglia

CONSENTING

- Design options
 - Routeing alternatives
 - Environmental Impact Assessment
 - Stakeholder engagement
 - Landowner Agreements
-
- Contributes 3-5% of wind farm costs
 - Managed by different parties in different regulatory regimes
 - Timescales vary from country to country

Issues: New technologies

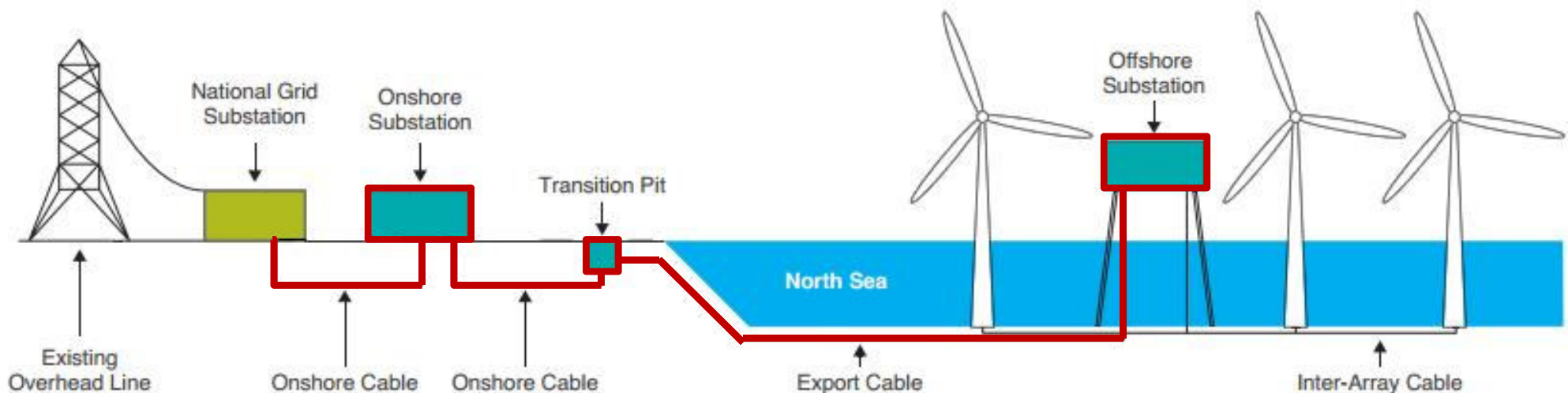
- Limited experience across industry
- Limited consultants/contractors

Risks:

- Changing regulatory regime
- Failure /delay in securing consents



- To achieve low carbon targets, the Government established a policy framework to support investment in offshore renewable generation.
- Offshore Transmission Owner (**OFTO**).
- Developer typically constructs OFTO assets with the obligation to divest to a 3rd party.
- Typical offshore wind farm OFTO assets:



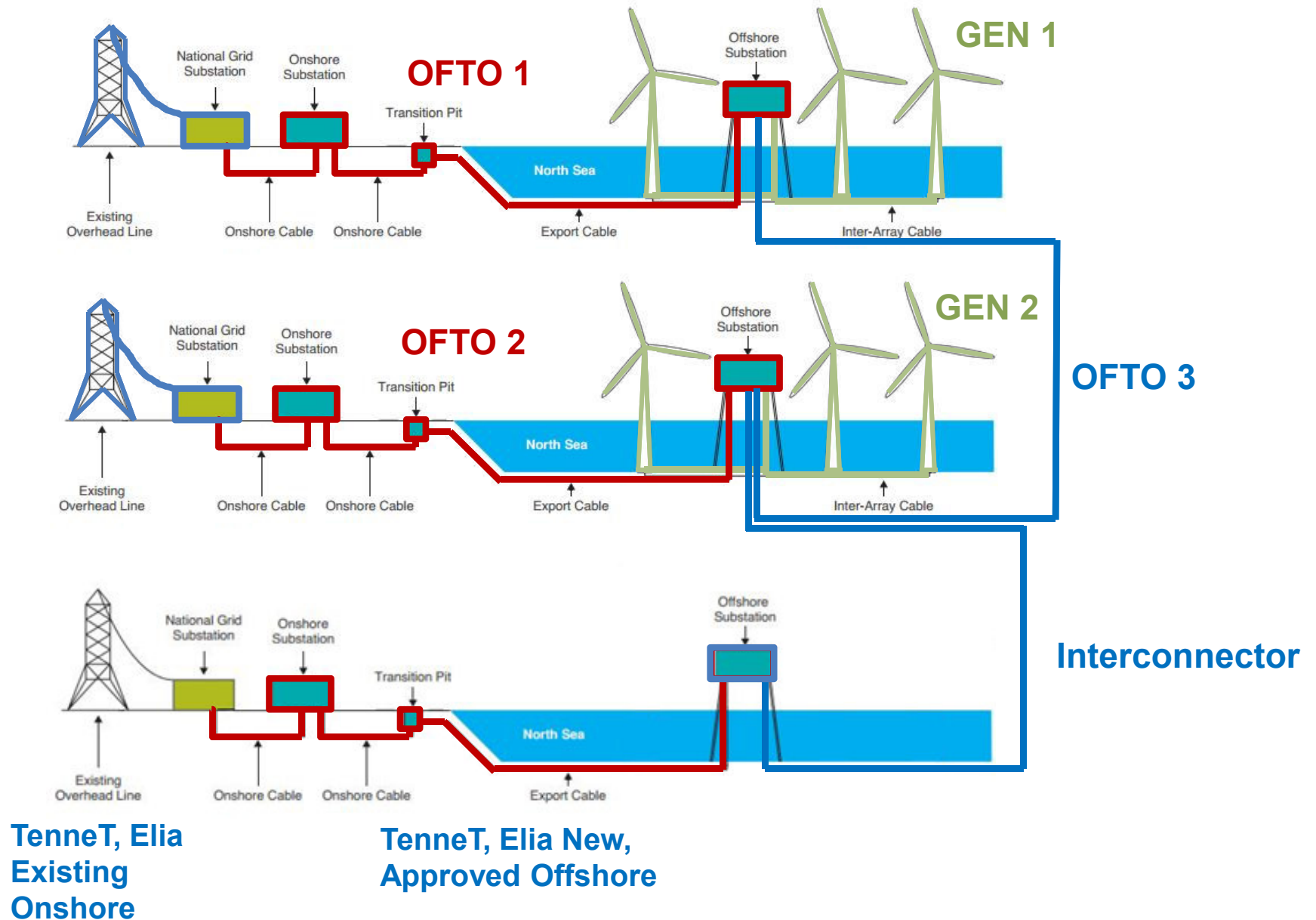
View on HVDC grids

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View on HVDC grids

UK

Belgium/
Germany/
Netherlands



- We are “technology agnostics”. We choose the technologies that are most cost-effective and better suited for each project
- HVDC grids will provide great benefits to developers in terms of availability, redundancy, but...
- It is not clear how they will implemented (phases, technologies, regulation...) or who will determine this
- A detailed planning will be required for meshed HVDC grids
- Developers will have to consider future upgrades
 - Additional transformers and switchgear?
 - Increase in volume of platform
 - Increase in foundation size
 - Increase in costs
 - What if plans are not fulfilled?

- There are technical difficulties to overcome, but can be solved. Regulatory aspects are most important
- Interoperability is vital → converters from different manufacturers should be able to work seamlessly with each other
- Future technologies:
 - Diode-based converters should reach high TRL levels in the very short term
 - If diode rectifiers are adopted, will all the wind turbine manufacturers be able to adapt their controls?
- We hope PROMOTioN will answer some of these questions

Open questions

1. Who should own and operate the HVDC grid?
2. Will the developers build the HVDC assets (similar to OFTO in UK)? How will these assets be paid?
3. How will be the generators charged for accessing the grid?
4. How do different renewable energy subsidy schemes apply to generators connected to two or more jurisdictions?
5. How should interoperability be ensured?