



# Meeting the challenge of “Net Zero” by 2050

**IEEE Workshop on Representations of Power  
Electronics for Grid Dynamic (PEGD) Studies**

5th December 2019

# Today's presentation

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- Who we are
- Public & third party acceptance challenges
- Congestion challenges
- Market challenges

# National Grid overview

UK



**nationalgrid**

- UK Core regulated business
- Electric system operator
- Electric and gas transmission network owner

US



**nationalgrid**

- US Core regulated business
- Electric distribution service
- Gas distribution service
- 7M customers: MA, NY, RI

Ventures



**nationalgrid ventures**

VikingLink New York Transco. IFA2

Nemo Link GERONIMO sunrun

DEEPWATERWIND NorthSeaLink



**nationalgrid**  
partners

ENERGY IMPACT PARTNERS

CARBON LIGHTHOUSE OMNIDIAN DRAGOS copperleaf

JVP IQ CAPITAL

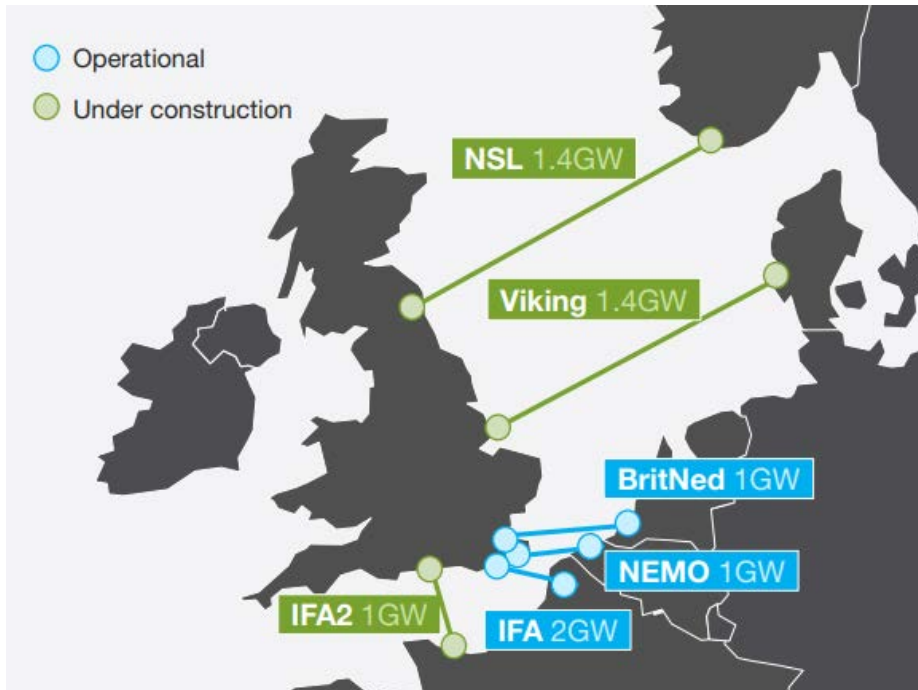
# Global Transmission

## Interconnectors

## LNG

## US Transmission

- Interconnectors allow electricity to flow between countries and markets
- 3 operational interconnectors (4GW) between the UK & Europe;  
3 more under construction (3.8GW)
- We sell capacity to energy traders and provide services for transmission system operators in the UK and mainland Europe



- Grain LNG is the largest importation terminal in Europe
- Importation services of ship berthing, temporary storage, ship reloading and re-gasification into the NTS
- Can supply 20% of UK gas demand
- Customers include BP, Centrica, and Uniper, among others



- Revolution Wind: 400MW RI and 300MW CT OSW
- NERL: 600MW NY renewable energy to MA via new 23 mile, 345kV overhead line
- VT Green Line: 400MW NY renewable energy to VT via new 70 mile under lake and underground line
- GSPL: Scalable Canadian renewable energy to NH via new 52 mile overhead HVDC line (US) and additional mileage in Canada

# Market leader in subsea HVDC interconnectors

|                         | IFA  | BritNed  | Nemo Link   | IFA 2                                    | NSL                                     | Viking Link                                  |
|-------------------------|--|--|---|--|---|--|
| Capacity                | 2GW  | 1GW  | 1GW   | 1GW                                      | 1.4GW                                   | 1.4GW  |
| Total length            | 70km   | 260km  | 140km   | 240km                                    | 720km                                   | 760km  |
| Converter stations      | UK:<br>Sellindge<br><br>France:<br>Les Mandarins | UK:<br>Isle of Grain<br><br>Netherlands:<br>Maasvlakte | UK:<br>Richborough<br><br>Belgium:<br>Herdersbrug | UK:<br>Chilling<br><br>France:<br>Tourbe | UK:<br>Blyth<br><br>Norway:<br>Kvilldal | UK:<br>Bicker Fen<br><br>Denmark:<br>Revsing |
| Commissioned            | 1986   | 2011   | 2019  | FY21 est                                 | FY22 est                                | FY24 est                                     |
| Ownership               | Partnership with RTE                             | Joint venture NG & TenneT                              | Joint venture NG & Elia                           | Partnership with RTE                     | Partnership with Statnett               | Partnership with Energinet                   |
| Exp. Capex <sup>1</sup> |  |  |   | c.£340m                                  | c.£660m                                 | c.£850m                                      |
| Regulatory construct    | Phased sharing of profits with customers         | Subject to a cap                                       | Cap and floor                                     | Cap and floor                            | Cap and floor                           | Cap and floor                                |

- 6 projects with ~2200km total cable route distance
- Largest capacity subsea HVDC link (IFA)
- Longest subsea HVDC link (NSL)
- Longest overall HVDC cable link (Viking)
- Partnerships in different markets & regulatory frameworks
- State of the art technology: LCC & VSC (to 525kV) converters and MI (to 525kV) & XLPE (to 400kV) cables
- Experienced with complex asset management issues, both on & offshore





# Climate & infrastructure challenge



## ■ Climate neutral economy by 2050

- UK Gov first major economy to legislate for net zero emissions
- European Commission's strategic vision

## ■ Cross-border interconnection targets increased

- >15% of installed generation capacity by 2030 - almost double the 2023 position for the UK

## ■ >75GW of OSW for UK to achieve 2050 net zero

- OSW Sector Deal anticipates 30GW by 2030 - double the 2023 position

## ■ Estimated 450GW OSW in the North Seas regions

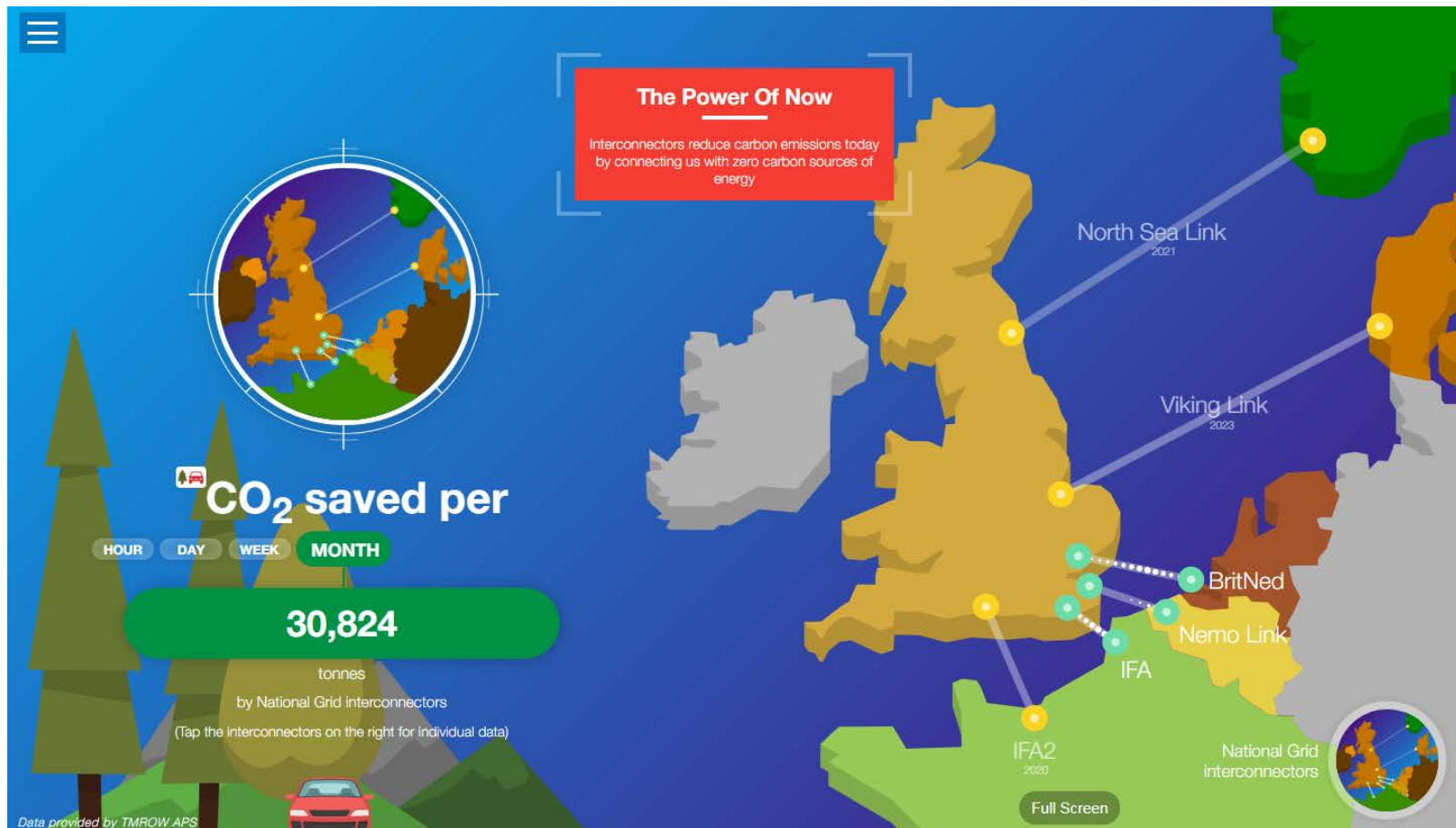
## ■ Continuing as we are would require 10-20 times more offshore infrastructure

- Hundreds of discrete projects, landfalls, routes, grid connections, planning processes – *and onshore transmission*

## ■ We need to find a better way **#greenergrid**

# Market modelling

<https://www.nationalgridcleanenergy.com/powerofnow/>



# Congestion and public acceptance challenges

- Single-purpose projects are increasingly difficult propositions in the UK
- Coordination will be key going forward

## FROM

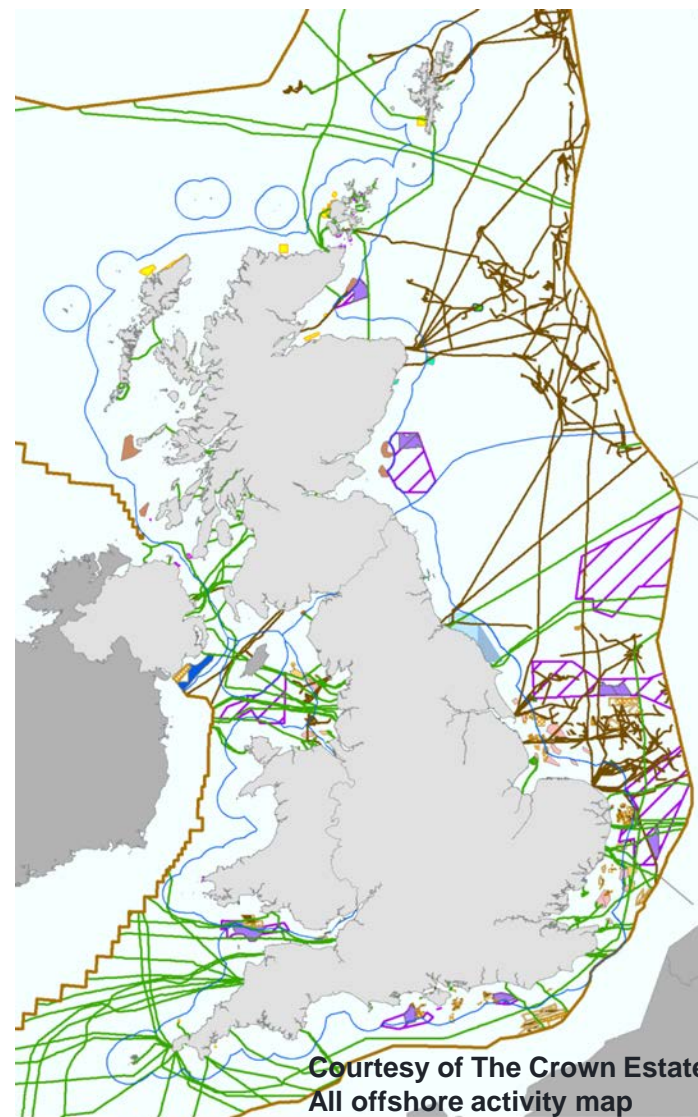
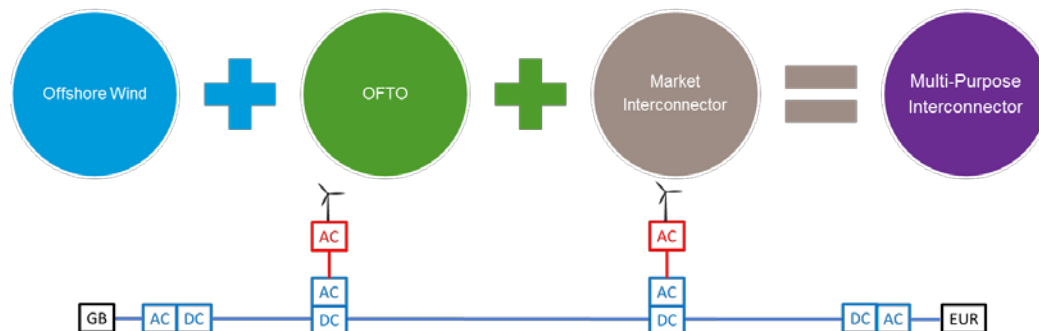
### Fragmented, single-purpose infrastructure

- Congested permitting processes & land use
- Grid connection congestion
- Cumulative environmental impact challenges
- Growing public objection

## TO

### Coordinated, multi-purpose infrastructure

- Switch to hub & spoke and cross-border approach
- Boosting OSW sector deployment using HVDC technology
- Coordinated permitting & land use
- Coordinated grid reinforcement
- Improved public buy-in





# Public acceptance

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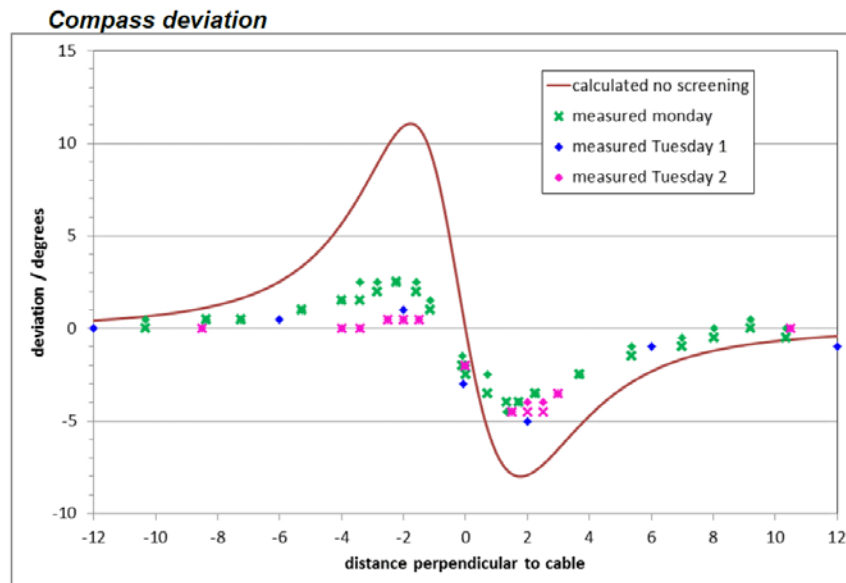
- Very large construction activities
- Impact on local economies



# Public Acceptance

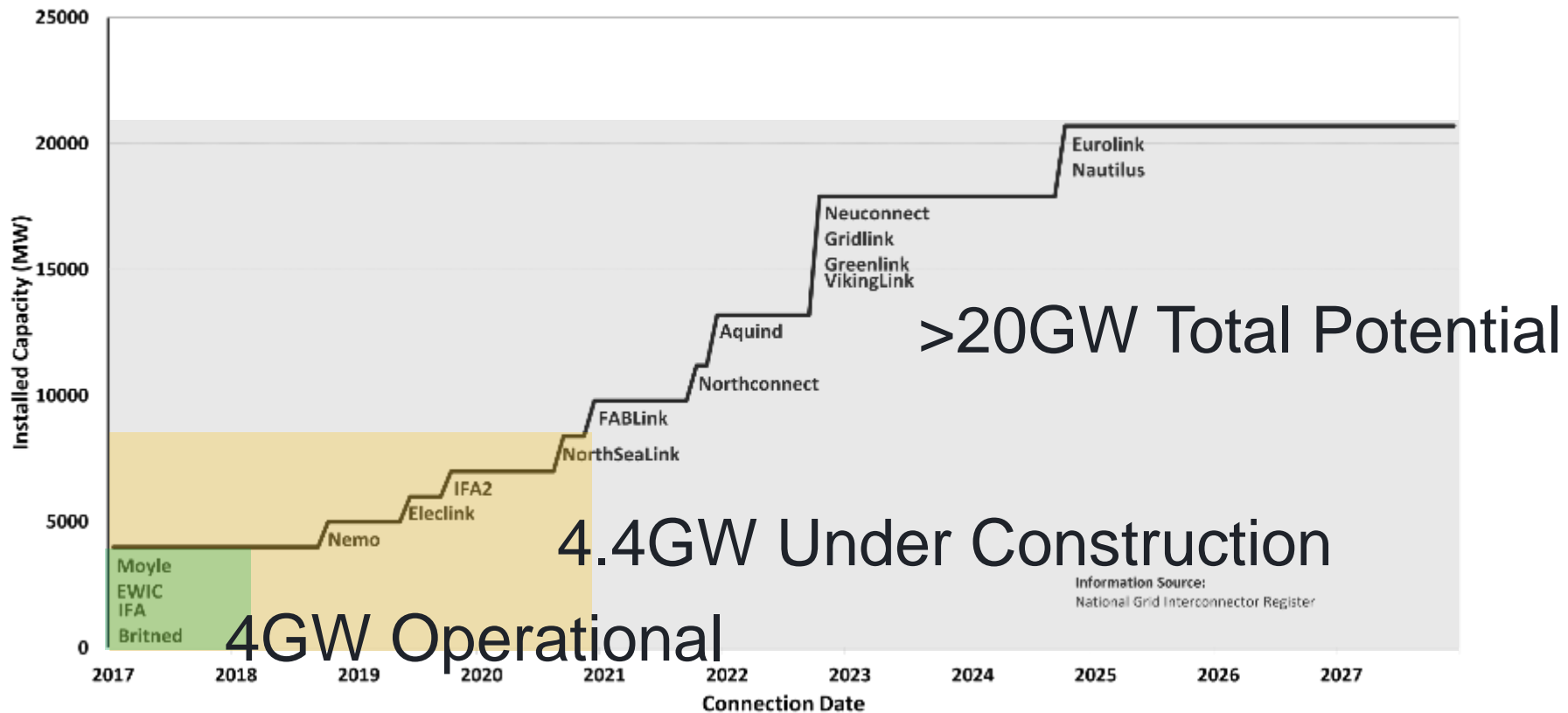
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# Impact of Power Electronics on Third Parties

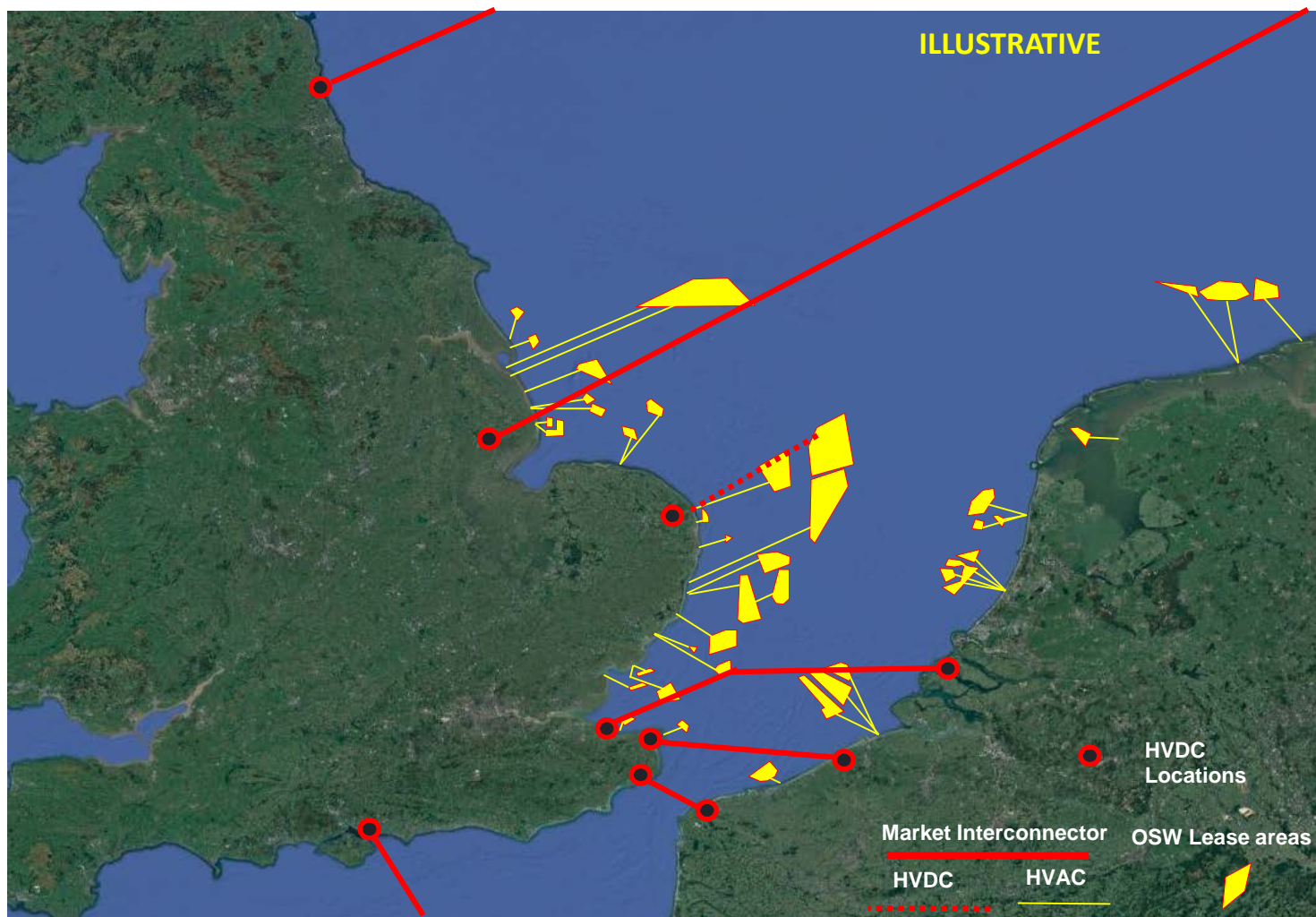


# GB interconnector capacity by connection date

## Potential to quadruple in 10 years



# Congestion: Current situation

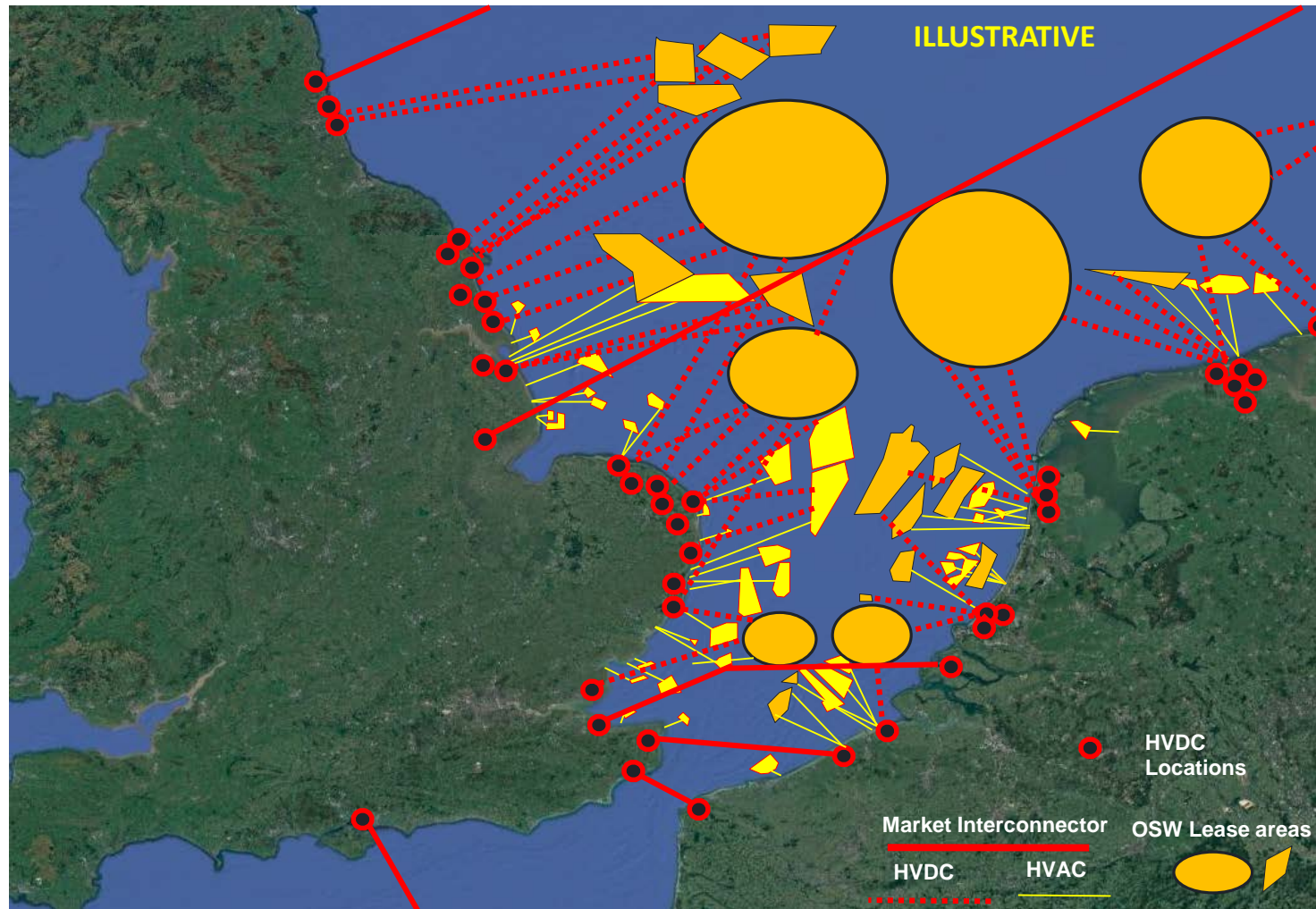


- Single-purpose HVAC & HVDC connections per project
- ~13GW offshore wind operational in North Sea basin



# A potential future...

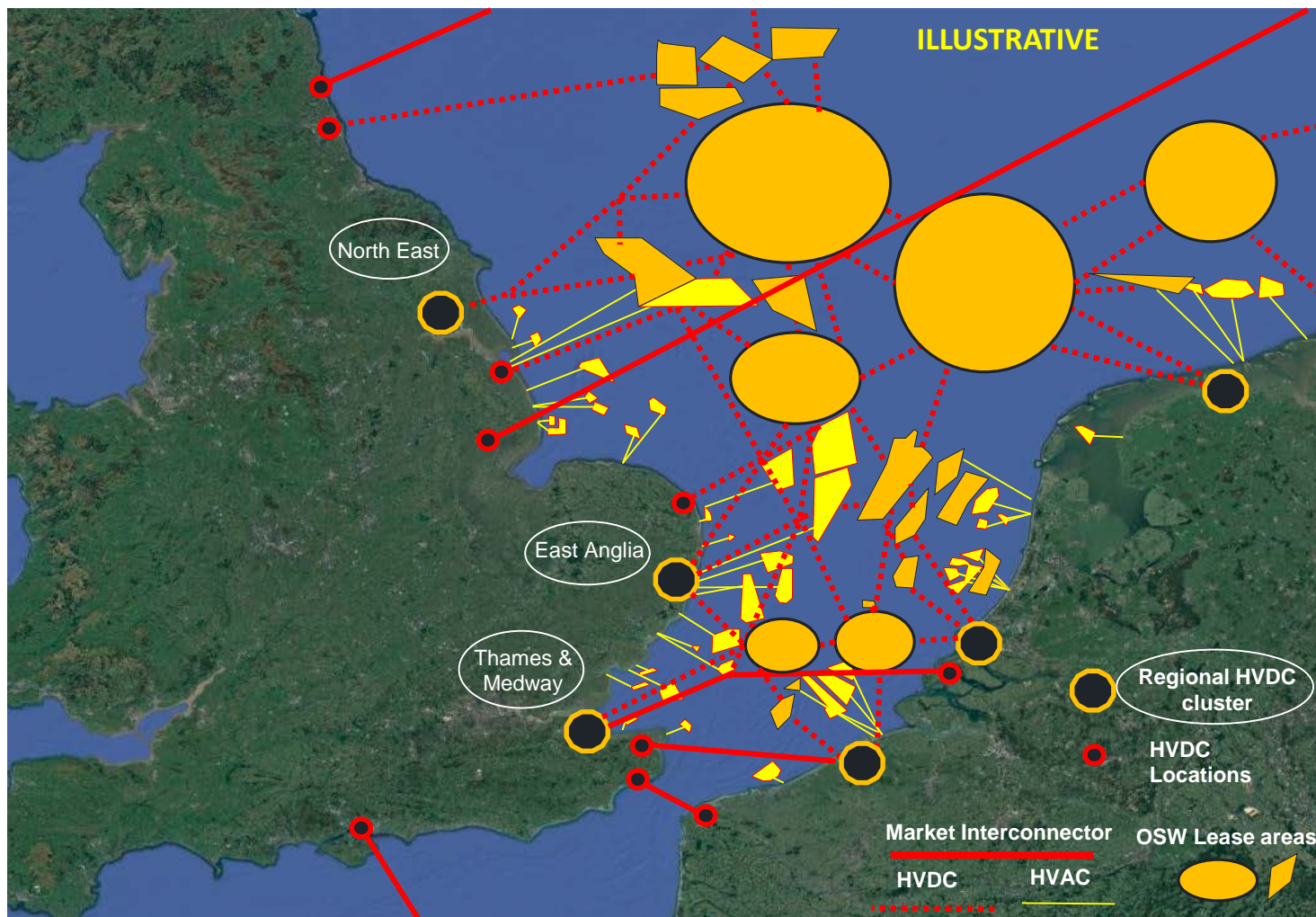
## With business as usual connections



- Significant expansion of OSW seabed leasing
- Unprecedented competition for grid and coastal access
- Single-purpose connections per project - mainly HVDC due to distance
- Significant barriers to public acceptance

# A potential future...

## With multi-purpose HVDC interconnections & clusters

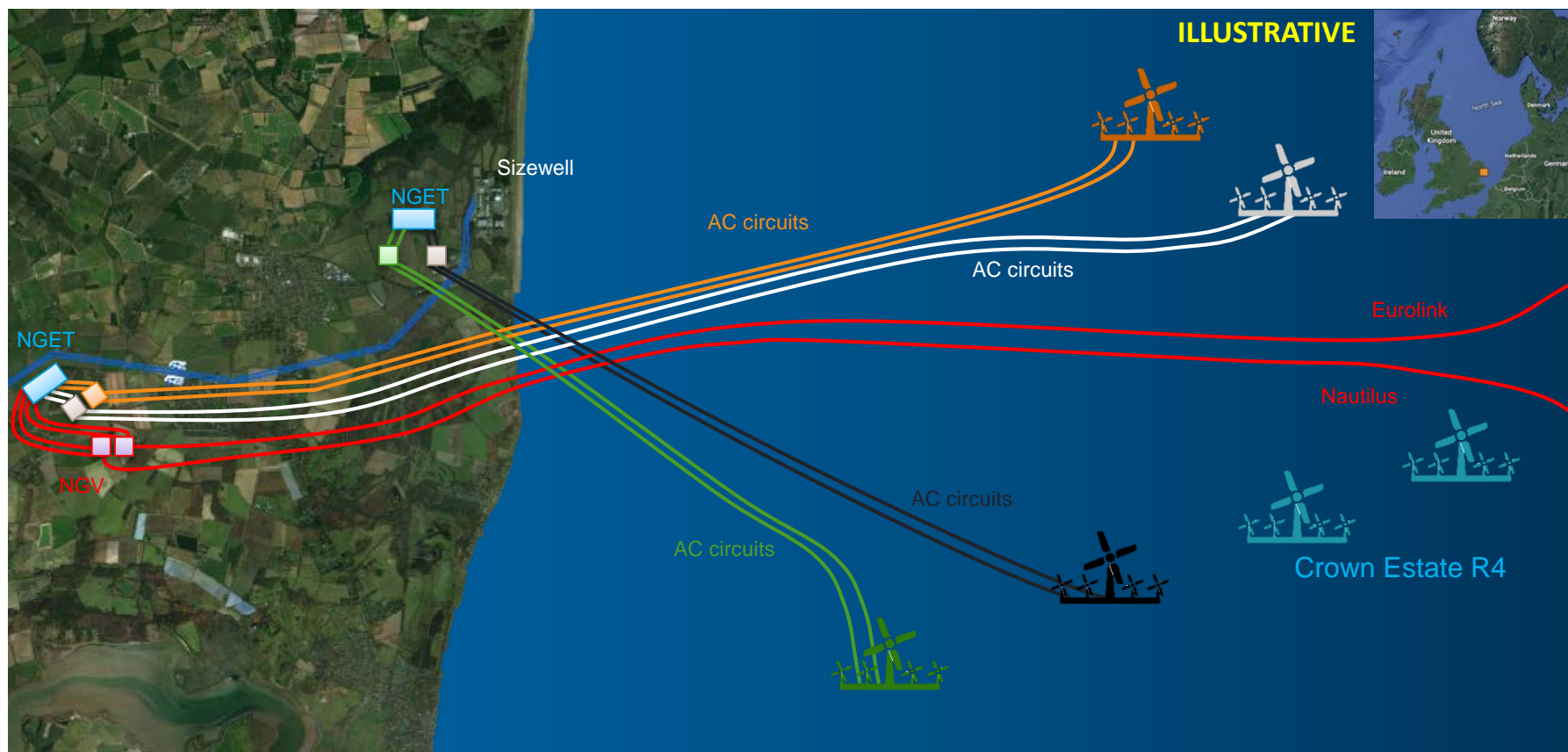


- Multi-purpose HVDC linking markets *and* offshore wind
- Regional onshore HVDC clusters
- Significant potential to coordinate and reduce onshore & coastal development & onshore grid reinforcement



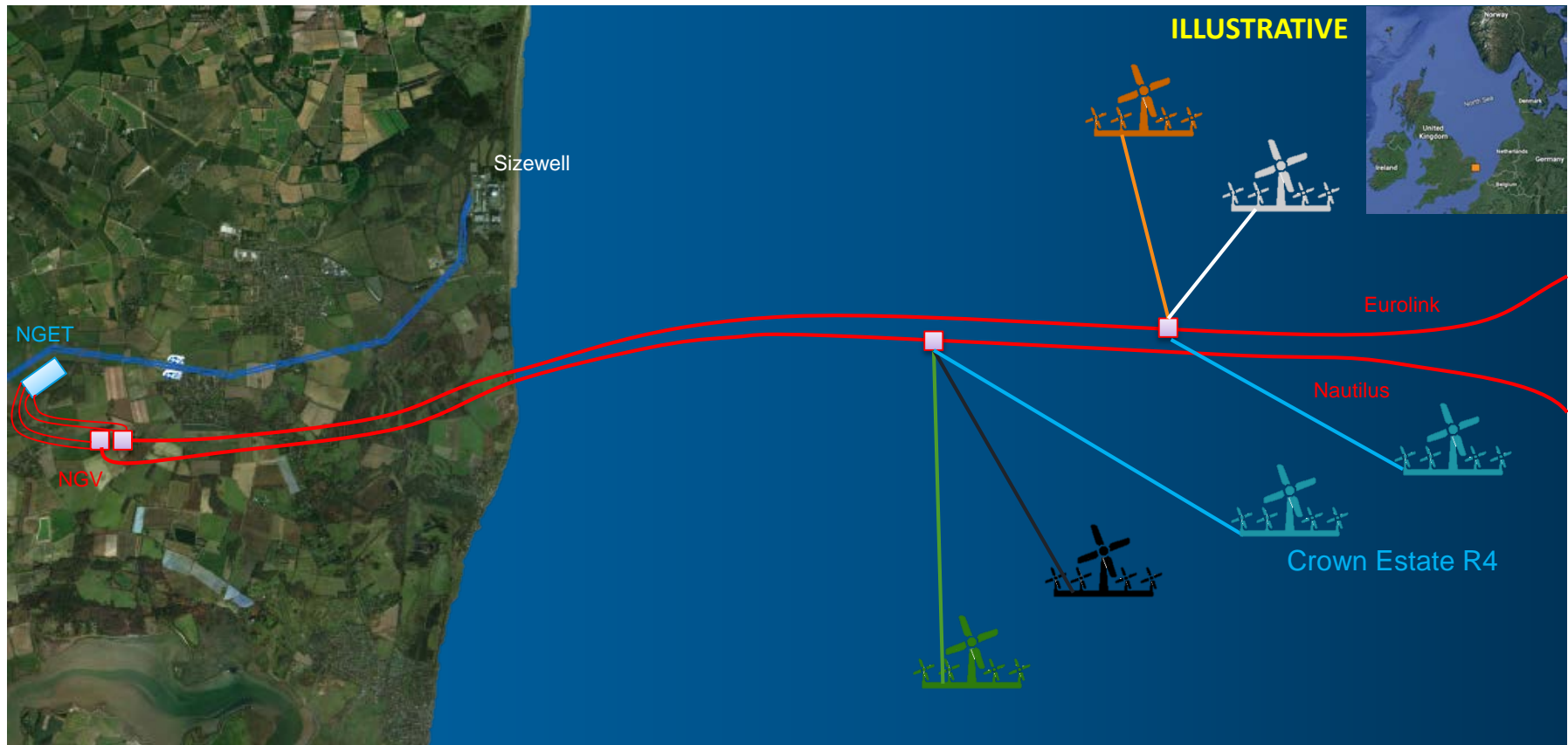
# Real example & potential catalyst in UK

**FROM: Multiple, single purpose projects**



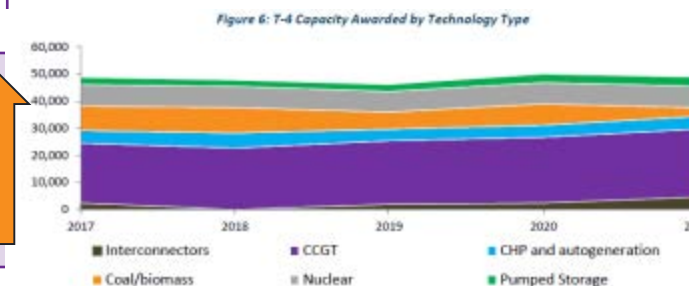
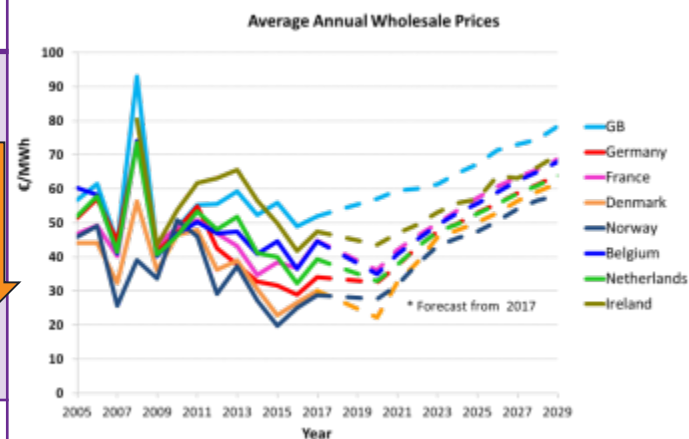
# Real example & potential catalyst in UK

## TO: Multi-purpose interconnector



# Market Challenges: Interconnector Revenue

| Market                       | Description   | Product   | Value    |
|------------------------------|---|---|----------|
| <b>Wholesale electricity</b> | Customers capture value from underlying structural arbitrage between markets and from market volatility | Long term auctions – annual, seasonal<br><br>Short term auctions - day ahead, intra-day | ~70-85 % |
| <b>Capacity</b>              | Reliable technology providing capacity availability   | Capacity Market Auction   | ~10–20 % |
| <b>Ancillary services</b>    | Providing flexible performance to System Operators  | Fast Ramping<br>Frequency Response<br>Reactive Power<br>Black Start                     | ~5-10 %  |



Source: Provisional Auction Results, T-4 CMA for 2021/22



# Unplanned outage risk

## Managing imbalance risk from asset trips

- Interconnectors may suffer unplanned outages
  - Unplanned outages due to cable faults or at the converter stations will result in a 'long' or 'short' position in each market they connect
  - If position is not resolved by trading, position will be subject to imbalance price
- Imbalance prices can move to very extreme levels
  - When system is undersupplied, prices can get very high
  - If supply > demand then prices can fall below zero – ie anyone who is long needs to pay to export power to grid
- High financial risk
  - Potential for big financial hit– eg Storm Angus in Nov'16
  - Trading in the within-day market provides a way to manage this risk

## Storm Angus – Nov 2016

- Violent storm in the North Sea resulted in a ship's anchor striking the IFA cables on the seabed
- Capacity on IFA dropped to zero causing a 'short' position against the commercial flow
- Unplanned outages at power stations and low wind output exacerbated system tightness resulting in imbalance price peaking at £1011/MWh
- Loss for IFA on the day was c.£6m



# Challenges

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- Optimisation of system and individual design to minimise impact on public and third parties
- Grid Congestion will need further coordination
- The market is changing with greater focus on ancillary services