# ML-Powered De-risking of Multi-vendor HVDC Transmission Systems

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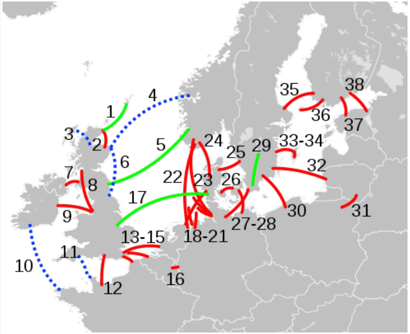
# Overview

1. The Status of Large-scale Offshore Renewable Energy for Net Zero Economy
2. The Current Challenge of Multi-terminal HVDC Transmission Networks
3. ML-powered De-risking of Multi-vendor HVDC Systems

# Large-scale Power Transmission for Net Zero Economy

## What is the current status and outlook?

- Significant large-scale wind park development are ongoing and planned in the European North sea.
- In addition to strong political will to interconnect countries.
- Given the distances and power levels, HVDC is the only credible technology to transmit power.
- 95% of current HVDC projects are point-to-point links:
  - A tightly integrated pair of converters at each end and a connecting cable.
  - It's costly, reliability issues, poor economics, lack of wider interconnectivity.
- Simply put, a DC **network** is desired.
- Importantly, how to interconnect these existing and planned links to multi-terminal networks?




Source: Wikiland

# The Current Challenge of Multi-terminal HVDC Transmission Networks

## Multi-terminal HVDC Networks, So What?

- The current business model for HVDC projects is an entire link—pairs of converter from a vendor.
- Each vendor has its own **intellectually protected** method of design, control, and integration:
  - Systems from different vendors don't "play-well" with others—**interoperability issues, interactions that are often quite detrimental.**
  - Significant difficulty in connecting the links from different vendors.
- However, vendors are willing to share black-boxed models or systems (e.g. replicas).
- The big challenge is you need 1000s of simulations to identify potential risks of interaction:
  - Tedious, time consuming and increases project timeline, expensive, and rarely exhaustive.
- The big question:
  - How to make efficient use of black-boxed data of individual components from each vendor to de-risk projects?

# ML-powered De-risking of Multi-vendor HVDC Systems

## How? Physics-informed ML Surrogate Models

- Based on supplied black-boxed models:
  - Identify/construct valid surrogate models using physics-informed ML (in the broadest of sense).
  - This model identifies the **parameter space** of each active components.
  - At network-level, we interconnect these models in the desired network structure and identify the **network space**.
  - The network space quantifies the risks of interactions and potential interoperability issues.
- Very fast, very efficient and insightful, and scales neatly.
- Final step is the design of advanced data-driven control structures for mitigation of control-related issues.