SP Energy Networks

Why high voltage engineering is critical to meeting Net Zero – a British transmission utility perspective

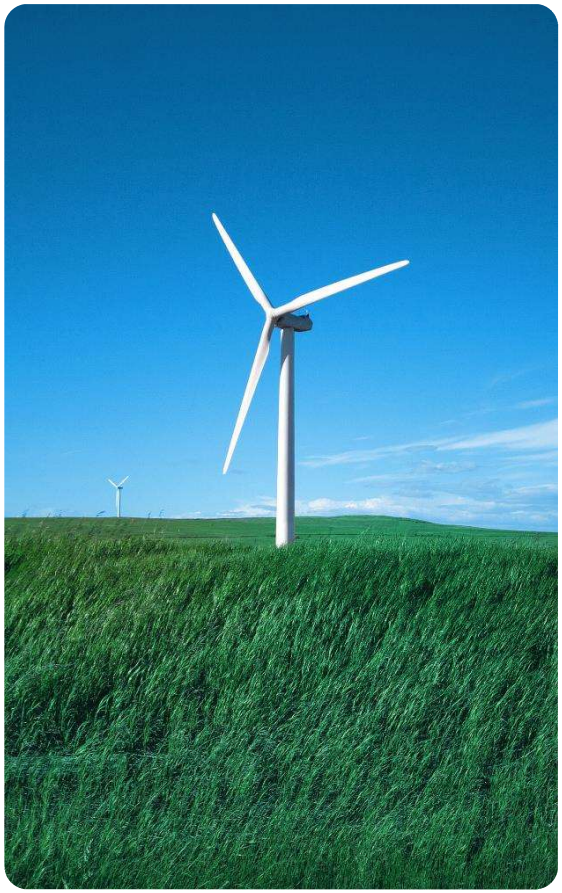
Dr. Cornel Brozio

The Transmission Network and Net Zero

- **Scotland plans to reach Net Zero by 2045 (UK target is 2050)**
- **ESO has zero carbon operation ambition by 2025**
- **Scottish wind generation**
  - 11 GW already connected
  - More than 60 GW by 2040
- **Scotland – England network capacity**
  - Presently 6.6 GW
  - 40 GW required by 2040

- **SP Energy Networks committed to**
  - Delivering a sustainable network
  - Reducing SF_6 where possible

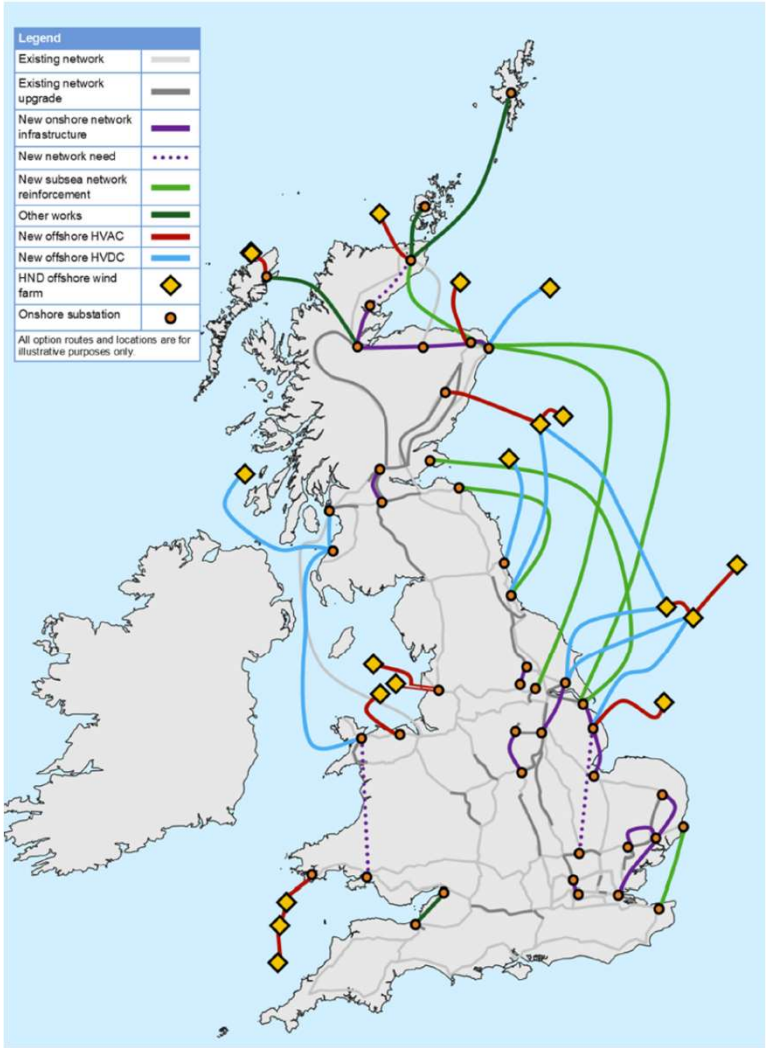
- **High voltage technology and engineering is vital for success**



How is the Transmission Network Changing?

- **Significant expansion in the next decade**
- **Network characteristics are evolving**
  - More shunt and series reactors
  - Longer cables
  - Shunt capacitors (MSCDN) and harmonic filters
  - Lower losses, reduced damping
- **HVDC, including multi-terminal systems**
- **More use of GIS**
  - Smaller footprint
  - Allows off-line reconstruction of existing substations

- **What are the high voltage issues?**



National Grid ESO – Pathway to 2030, Holistic Network Design

Circuit Breakers

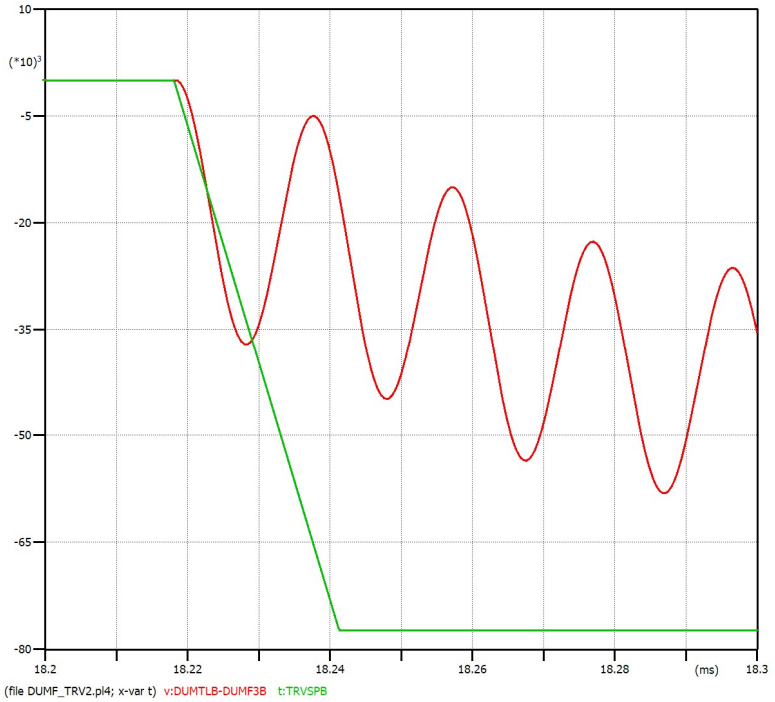
- **Standard ratings are insufficient in an increasing number of cases**
- **DC time constant**
  - High X/R ratios
  - IEC62271-100 standard DC time constant is 45 ms
  - SPEN specification is at least 60 ms
  - Transformer-fed faults are a particular problem
    - 90 ms for 132 kV
    - 135 ms for 33 kV
- **Increased circuit breaker operations**
  - Shunt reactors
- **More application of point on wave switching**

Circuit Breakers

- **Standard ratings are insufficient in an increasing number of cases**
- **Transient recovery voltage**
  - High prospective RRRV and peak TRV
  - Transformer-fed faults are a particular problem
    - Increased T30 requirement for 145 kV and 300 kV breakers
  - More discussions with manufacturers
  - Grading capacitors with multiple interrupters

- **Very challenging requirements:**
  - Increased DC time constant and TRV capability
  - Cost effective
  - Reliable
  - SF_6 free

  - DC circuit breakers?



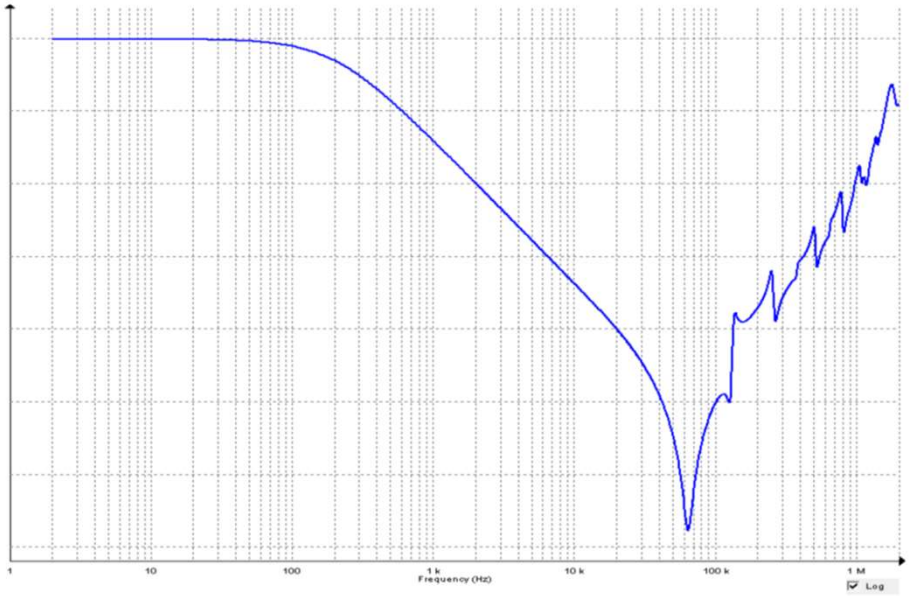
High Voltage Cables

- **New overhead lines problematic in the UK**
  - Visual impact and planning permission
  - Public concerns about noise and electromagnetic fields
- **Increased use of cables**
- **HVDC links**
  - Offshore cable routes
  - Western Link (LCC, DC polarity reverses)
    - 2250 MW
    - ±600 kV DC, paper polypropylene laminate cable
  - Eastern Green Link EGL1 (VSC)
    - 2000 MW
    - ±525 kV DC, XLPE
- **Higher voltage cables?**
  - Cables are often a limiting component

High Voltage Measurements and Testing

- **Instrument transformers**
  - Harmonics up to at least 100 (5 kHz)
  - Transient events and resonant conditions
  - More phasor measurement units (PMU)
  - SPEN slow to embrace new developments

- **Use of frequency response analysis (FRA) measurements**
  - Very useful for estimating model parameters
  - Available very late
  - More design studies now required for TRV and insulation coordination
  - Better models from manufacturers?



High Voltage Technology and Engineering

- **Net Zero is not possible without high voltage engineering**
- **Manufacturers**
  - Continue to enhance equipment ratings
  - New developments
- **Network Designers**
  - Need to be aware of issues
  - Often better to design in mitigation (e.g. capacitance to manage TRV)
- **Education and development of skills**
- **Should utilities be less risk averse?**
- **Close cooperation**
  - Network companies
  - Manufacturers
  - Researchers and universities