Electricity
Transmission

Energy Innovation Summit, Oct 29-30, 2024

VoltXpanse: Ultra High Voltage Onshore Energy Highway

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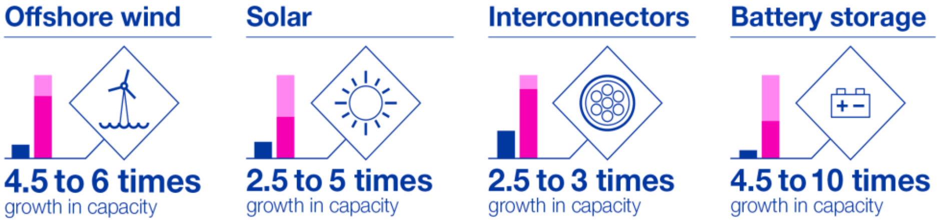
nationalgrid

Introduction

Energy transition to Net Zero

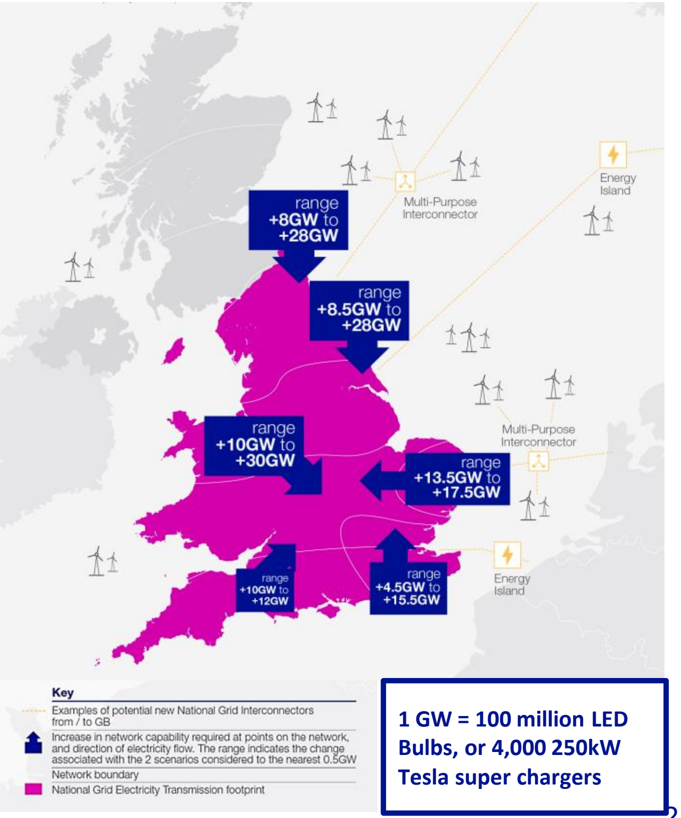


At the same time cross sector electrification is expected to increase total electricity demand by around 50%.[5]

Need to substantially increase the network capacity

Ultra High Voltage (UHV) transmission technologies

- Lower transmission losses
- Significant Increased capacity
- Reduced environmental impact
- Better power flow control capability (for UHVDC)



1 GW = 100 million LED Bulbs, or 4,000 250kW Tesla super chargers

What is VoltXpanse?

VoltXpanse (NIA project) aims to investigate innovative UHV transmission solutions that significantly increase the network capacity needed while also reducing environmental impacts.

- Identifying strategic UHV solutions for GB network onshore reinforcement
- Understanding the impacts of UHV circuits on system stability, protection, and control.
- Assessing the feasibility of an innovative compact tower design for UHV overhead line (OHL) circuits
- Investigating alternative technological and routing solutions required to ensure the deliverability of UHV circuits
- Recommending an optimal strategy to deliver the UHV circuits in an economic, efficient, and environmentally friendly way

Collaboration with SPEN, SSEN and HVDC centre

Scope of work

Work Package 1

Strategic UHV Solutions

- Identifying locations and capacities of UHV circuits
- Assessing UHV circuits' impact on system stability
- Simulating and evaluating the system's protection performance

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Work Package 2

Compact Tower Design

- Reviewing overhead line and tower design criteria adopted worldwide
- Recommending compact tower design options
- Assessing audible noise and electromagnetic field implications of different overhead line and tower systems

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Work Package 3

Technological Feasibility

- Investigating the cutting-edge technologies that are alternative to overhead lines, e.g. UHV cables, gas-insulated lines, etc.
- Investigating HVDC technology and fractional frequency transmission systems
- Assessing routing and consenting implications

Work Package 4

Optimal Delivery Strategy

- Evaluating each of the identified UHV solutions with regards to their technical deliverability, life cycle costs, reliability, network operability, carbon footprints, etc.
- Developing an optimal strategy for UHV delivery

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Progress Update – Work Package 1

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Task 1: strategic locations and capacities of UHV circuits

Current progress

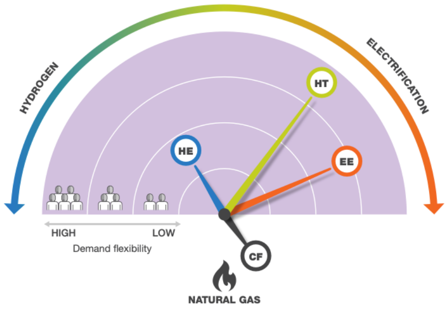
1. Credible set of future operation conditions → **2. Development of Representative GB transmission system** → **3. Assessment of UHVDC transmission needs**

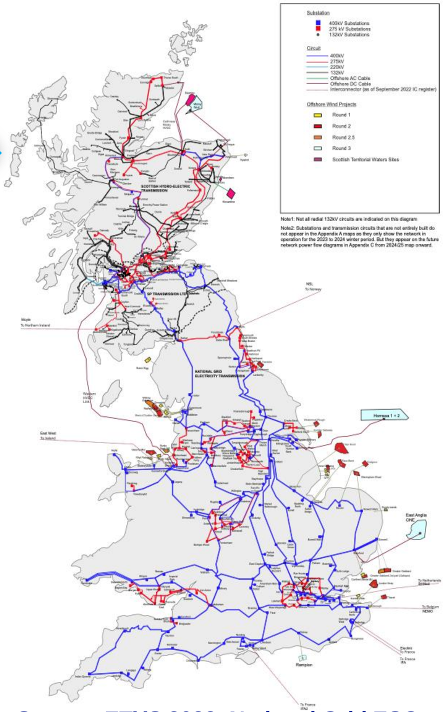
- Credible operating conditions for years up to 2050
- Development of a method to generate future operational conditions

- Development of a network model that includes the 275 kV and above transmission lines in England and Wales, and 132 kV and above lines in Scotland

- Identify the stratigic location and capacities of UHV transmission lines

Pathways framework 2024





Source: ETYS 2023, National Grid ESO

Progress Update – Work Package 1

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Task 2 & 3 Progress: Studies of UHV Stability and Protection

Task 2: Assessment of UHV Stability

Current progress (steps 1–2)

1. Review of global UHV-OHL projects
- Global UHV OHL projects
- Technologies adopted in existing projects, e.g. converter technology

2. Review of UHV control
- UHV control (e.g. UHVDC systems)
- Select representative control strategy for the UHVDC system

3. Development of UHV link models
- Develop UHV link models.
- Integrate the UHV link models with the wider network model

4. Frequency stability assessment
- Evaluate frequency stability in contingency events

5. Voltage stability assessment
- Evaluate the voltage stability in both steady state condition (e.g., terminal voltage limitation) and fault conditions.

Task 3: Assessment of UHV Protection Performance

Current progress (steps 1–2)

1. Review of UHV-OHL protection practice
- Protection schemes for UHV systems (both AC and DC)
- Protection arrangements applied in existing projects

2. Select suitable protection solutions
- Select appropriate UHV protection solutions from the literature review

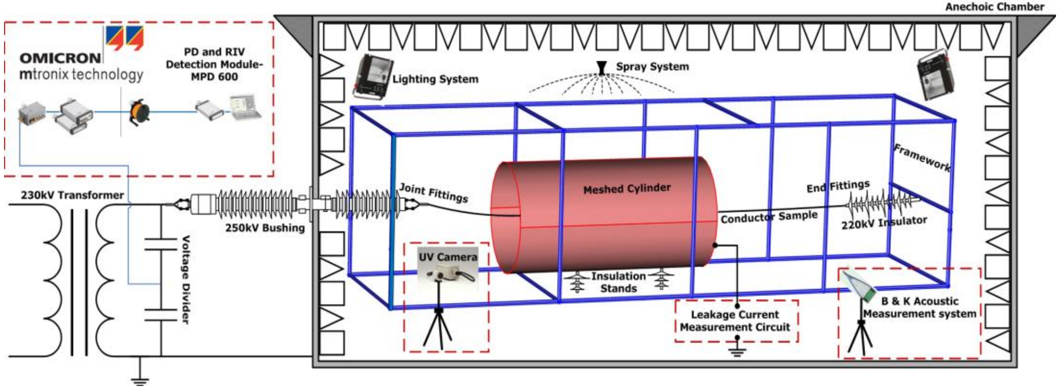
3. Replicate and validate protection solutions
- Develop and validate selected protection solutions in software

4. Systematic tests
- Systematic tests of overall protection performance under a range of system conditions

5. Detailed tests
- Detailed analysis of representative test cases

Progress Update – Work Package 2

- **Literature Review on UHV OHL Design Criteria**
  - Design practices implemented for UHV systems
  - Existing UHV OHL Systems with defined/specified design criteria
  - Tower Design Criteria



- **Audible Noise Experimentation on Single Conductors**
  - Test 3 type of conductors for both UHV AC & DC under dry and wet conditions.
  - AN level of DC is generally lower than AC systems

Progress Update – Work Package 2

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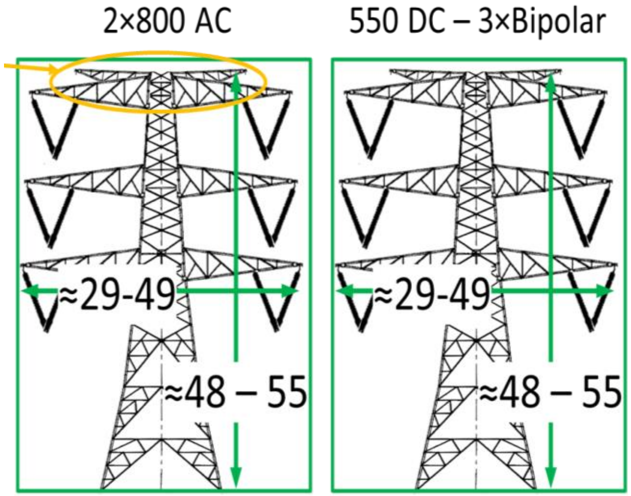
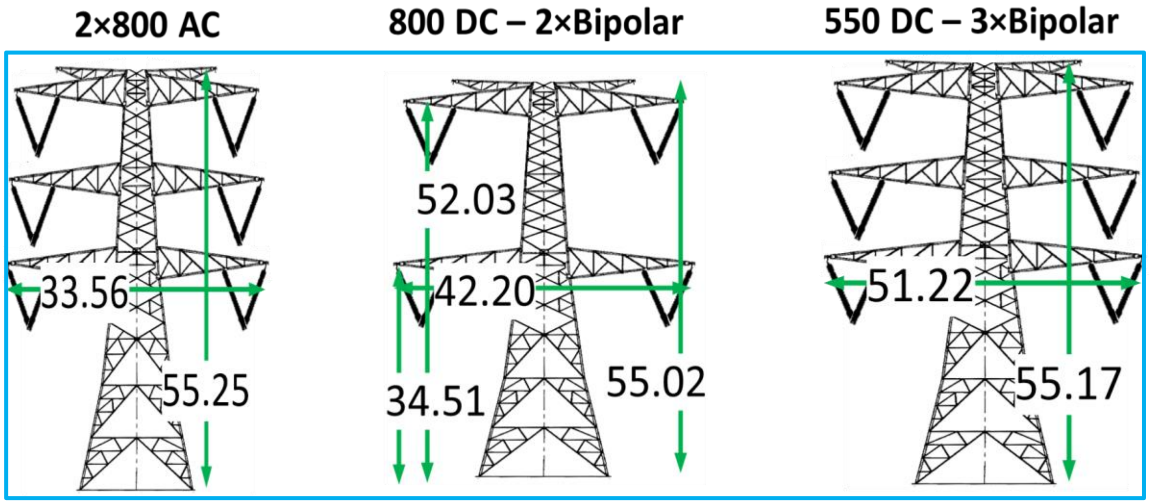
Preliminary Tower Design



Modifying the shield design



Preliminary design considering Emf & Audible noises limits

Progress Update – Work Package 3

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Investigate UHV cable section solutions

Cable :

- Strong incentives in increasing DC cable voltage, but not for AC cable.
- DC cables up to 640kV achieved.
- No CIGRE or IEC specifications > 500kV for AC cable; CIGRE recommendations up to 800kV available for DC cable.
- More choices for DC cable solutions (XLPE, XLPEn, HTPE, etc.) than AC cables (XLPE)
- Substantial amount of installation engineering feasibility would have to be carried out.

- First 400kV g3 installation in Sellindge, UK
- In service >5 years
- Leak rate marginally higher than equivalent SF6 leak rate

Gas-insulated lines:

- Maximum capacity: 2850 MVA (at 500 kV)
- Maximum current rating: up to 4,500A
- Typical voltages: 245 kV-500 kV
- Longest distance: 3.3 km (realised, 275 kV)
- Energy losses: 0.0015% km at 500 kV and 260 MW
- Standard definition: IEEE Std C37.122.4-2016
- Expected lifetime: > 60 years

Progress Update – Work Package 3

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UHVDC technology:

- Choices of DC technologies (LCC, VSC or hybrid)
- Different DC configurations: monopole, bi-pole, multi-terminal
- Challenges such as overloading capability, overvoltage stress, control and protection, DC fault clearing, etc.
- Highest VSC rating: ±800kV, 3kA, circa 5GW
- Highest LCC rating: ±1100kV, 5.5kA, 12GW
- VSC converter rating is limited by the rating of IGBT

HVDC VSC (diagram source: ABB)

Low frequency transmission (LFT):

- Increase power transmission capability
- Can use existing HVAC lines, circuit breakers, and protection relays (with adapted settings).
- Real and reactive power flow and voltage control
- Potential to form multi-terminal meshed configurations using existing AC circuit breakers

- Voltage 220kV
- Maximum Power Capacity 300MW
- Distance:13.2 km
- Commissioning date: June 2023

Look Ahead

VoltXpanse will work closely with all key stakeholders to advance investigations within each work package. The primary areas of focus include :

- Identifying strategic locations of UHV circuits in the GB network while comprehending their potential impacts.
- Designing compact tower in detail
- Developing an optimal delivery strategy for UHV solutions in the UK

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Q&A

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