Power system technical performance issues related to the application of long HVAC cables

This Technical Insight from CIGRE UK is based on the 2013 publication of CIGRE Technical Brochure (TB) 556.

Background

There is a significant need to reinforce and extend the high voltage transmission network in the UK to connect a number of new sources of electricity, including wind farms and nuclear power stations as well as provide interconnectors to other European networks.

Some of these works will necessitate the use of long High Voltage Alternating Current (HVAC) cables due to technical constraints, such as for offshore wind farms where submarine cables will be required. Additionally despite typically being significantly more expensive than overhead lines (OHL), the advantages of underground cables from a planning legislation, public perception and environmental impact perspective have resulted in underground cables becoming an increasingly attractive option within the UK and globally.

Although the fundamental issues associated with the design of transmission systems utilising long HVAC cables are well known, there is limited practical experience amongst some network planners and network operators of the performance of transmission systems with long HVAC cables given that most transmission networks are based primarily on OHL.

The objective of the recent CIGRE publication is to provide a practical guide for the preparation of models and studies necessary when planning the addition of long HVAC cables to transmission systems. The target audience is transmission network operators, developers, regulators, consultants, contractors, and anyone else who may be engaged in the future development of the UK transmission system.

Issues Associated with Long HVAC Cables

For the purpose of this work, long cables as being those that require reactive power compensation and are therefore typically 20 km and longer.

Some of the technical system performance issues identified and discussed in the TB include:

- Impact on AC Voltage Control in the network
- Potential to create a new system resonance point
- Changes to the current in the network following system faults
- Changes to the magnitude of over-voltages in the network, potentially requiring changes to over-voltage protection equipment or the need for replacement of equipment.
- Impact on the short and long term stability of the network
- The requirement to review and potentially change protective relay settings

System studies are described together with weighting factors, so that a view can be taken as to the relative importance of the various studies. Critical phenomena considering the above bullet points are identified.

Appropriate HVDC cable and network models are suggested for the different types of study from planning, system impact through to detail design and forensic studies.

Methods to verify models are also covered within the scope of the work, with an example of measurements made on a 100 km long 150 kV HVAC cable system in Denmark.

Relevance to the UK

Multiple HVAC long cable connections have already been made to offshore wind farms in the UK and more are expected in addition to anticipated HVDC connections.

On the Beauly-Denny project, some sections of OHL are to be replaced with underground cables. Whilst at the moment such cable sections are relatively short (up to 10 km) these lengths could increase on future projects.

In other parts of the world, examples of long HVAC cable projects include:

- Japan, where a length of 40 km at 500 kV is installed
- Connecticut, where Northeast Utilities and United Illuminating have installed 37 km and 15 km double-circuit 345 kV cables into a relatively weak system
- Denmark, where a 150kV connection to the offshore wind farm Horns Rev 2 is installed and has a length of 100km. Indeed Denmark has an ambition to replace their existing 132 kV and 150 kV network as well as some of the existing 400kV lines with underground cable. Their planned development of the grid includes both overhead line and underground cable.

Other Relevant Publications

CIGRE has produced a number of Technical Brochures which will be relevant to those interested in the application of HVAC cable systems.

- CIGRE TB Technical Brochure 268 Transient Voltages affecting Long Cables
- CIGRE TB Technical Brochure 490 Recommendations for testing of long AC submarine cables with extruded insulation for system voltage above 30 (36) to 500 (550) kV
- CIGRE TB Technical Brochure 504 Voltage and VAr Support in System Operation
- CIGRE TB Technical Brochure 531 Cable System Electrical Characteristics
- CIGRE TB Technical Brochure 247 Optimization of Power Transmission Capability of Underground Cable Systems using Thermal Monitoring
- CIGRE TB Technical Brochure 303 Revision of Qualification Procedures for high voltage and extra high voltage AC extruded underground cable systems

Find out more...

Founded in 1921, CIGRE, the Council on Large Electric Systems, is an international non-profit association for promoting collaboration with experts from all around the world by sharing knowledge and joining forces to improve the electric power systems of today and tomorrow.

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