HVDC Grids for the European Transmission System: Accelerating the Large-Scale Integration of Renewables

An IEEE European Public Policy Initiative Position Statement

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The IEEE[1] European Public Policy Initiative (EPPI) calls on European Union policy makers to prepare the network for a large-scale integration of renewable energy and to enable a fully integrated internal European energy market[2] by unlocking the full potential of Direct Current (DC) transmission. The technology can play a key role in the ongoing efforts to strengthen the energy cooperation between countries, such as for instance the one between the North Seas Countries[3].

An increasing need for system interconnections, the use of long-distance cables and increased energy efficiency[4] are amongst the most prominent trends and arguments why HVDC (High-Voltage Direct Current) has started to play an increasingly important role in our transmission systems. HVDC is used to reinforce the existing electric power system and the connection of offshore wind parks is increasingly being met through HVDC links, connecting the wind farm with the onshore grid. All existing HVDC connections in Europe connect two nodes in the grid, so-called point-to-point systems. To improve the system security, increase the efficiency and lower the overall system costs, a move towards HVDC grids represents major opportunities to the European power system, in particular to harvest offshore wind energy onshore and deliver it to consumers throughout the continent. Such a HVDC grid would serve as the basic transmission technology for the envisioned European "supergrid", a key component in securing a stable, cost-effective and reliable energy supply.

1 www.ieee.org

2 DIRECTIVE 2009/72/ - http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0055:0093:en:PDF and DIRECTIVE 2009/73/ - http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0073&from=EN

3 Political declaration on energy cooperation between the North Seas Countries. https://ec.europa.eu/energy/sites/ener/files/documents/Political%20Declaration%20on%20Energy%20Cooperation%20between%20the%20North%20Seas%20Countries%20FINAL.pdf

4 DIRECTIVE 2012/27/ - http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1399375464230&uri=CELEX:32012L0027

The appropriate policy decisions to unlock the potential of HVDC grids, will

- Facilitate creating a truly European internal energy market by removing congestion in the transmission system;
- Enable the move towards a low carbon energy supply through the increased access to renewable energy sources;
- Increase the security of the electricity supply in a system dominated by renewable energy;
- Strengthen European industry as global leaders in this important field.

Europe holds all the cards to be at the forefront of these developments, and action is needed. Specifically, the EU policy should:

1. Act to enable technology by facilitating turn-key projects involving all stakeholders such as Transmission System Operators (TSOs), R&D institutions, and Original Equipment Manufacturers.
2. Provide a robust legislative framework to overcome long-term investment uncertainty in order to unlock long-term opportunities that HVDC grids bring for social welfare.
3. Ensure the compatibility of short-term investment decisions with long-term system development.
4. Continue to emphasize R&D to accelerate crucial technological developments, through the creation of a JTI on DC technology;
5. Ensure the development of internationally recognised standards on HVDC grids, leading to interoperable and multi-vendor HVDC technology;
6. Incentivise European transmission system operators to proactively conceive new control and operation guidelines for the power system of the future. This includes a continued emphasis on cross-border coordination and requires national regulations and rules to target social welfare at a European, rather than national level.

Background

The electricity system is evolving to a hybrid system, integrating both contemporary systems that are largely based on AC technology, and DC systems. Remote offshore wind farms can often only be connected to onshore power systems through HVDC cables, rendering DC technology the preferential candidate for building offshore grids to strengthen the European transmission system. In the mid to long term, these developments can give rise to a European HVDC "supergrid", interconnecting the power generated by wind in the North Sea with solar power generated in the South of Europe. HVDC grids will not only allow **integration of renewable energy sources**, but will also reinforce the European system to better serve the **Pan-European electricity market** by increasing the transfer capacity between the different member states. With the vast majority of the HVDC technology providers based in Europe (both for converters and cables), a stable investment framework in Europe for building this future power system will enable job creation within the EU and create export opportunities to other world regions.

Europe holds all the cards to play this leading role. Now that first significant steps towards a practical realisation of HVDC grids are being made in China, however, Europe risks losing not only its pioneering role, but also risks missing out on the crucial learning process in the practical realisation of such a system.

At present, manufacturers are waiting for a robust demand from the market to speed up the development of new products and components and lack a strong incentive to move towards multi-vendor systems. Meanwhile, a strong incentive for transmission system operators to effectively plan multi-terminal HVDC systems is lacking under the current regulatory framework, causing a multiplication of point-to-point connections.

What are the next steps?

With the current VSC (Voltage Source Converter) HVDC converter technology and the current limits of DC cables, we can already build 'smaller' multi-terminal systems. However, addressing a number of challenges is key to enable the development of reliable and affordable meshed HVDC grids:

- There is a need for speeding up the **development of the building blocks** of the HVDC grid, by increasing their ratings and achieving cost reductions:
    - HVDC circuit breakers will be essential to establish a reliable system. The development of the first prototypes by different manufacturers is encouraging, but further developments and improvements are needed.

- Offshore platforms, including converter and breakers, will make up a large share of the system cost. New converter and breaker designs should aim at substantially reducing the platform size to achieve important cost reductions.
- Voltage and power ratings for breakers, converters and cables need to increase further to build a 'supergrid' with ratings that exceed current-day levels.
- If existing point-to-point links are to be connected to the future HVDC grids, new building blocks such as DC/DC converters need to be developed.

We therefore recommend that the EU continue to put an emphasis in R&D in these specific areas to accelerate these crucial technological developments. In particular, we recommend that the EU consider grouping the R&D efforts around HVDC grids through the creation of a JTI (Joint Technology Initiative) around HVDC technology, particularly to identify the gaps in standards that define the electrical characteristics and associated components of HVDC grids.

- **Interoperability guidelines and standards** for combining the building blocks from different manufacturers are needed and should depend on system-based functionality requirements. These are essential for a stepwise development of an HVDC grid. Such standards are still missing since no meshed HVDC grid has been built up to now, while the existing point-to-point links have generally been designed and developed as single products by different manufacturers.

We therefore recommend that the EU support the development of internationally recognised standards on HVDC grids. Legislation should encourage system-based functionality requirements.

- **Procedures to control and operate** the building blocks need to be developed by considering the system as a whole:
  - A reliable HVDC grid protection scheme that balances reliability and costs is of utmost importance. This requires the development of new approaches to system protection as faults need to be isolated much faster than in AC systems. At the same time, these approaches need to be coordinated with existing AC grid operational practices.
  - Operation and control actions in future HVDC grids will have major impacts on the AC systems they are connected to and vice versa. Therefore, future operational procedures (network codes) need to be updated to include HVDC grids as a system layer that interacts with the rest of the system, rather than as mere injections into existing AC power systems. Moreover, the HVDC system can become the new backbone of electrical energy transmission, thus even a so-called"demeshing" the

existing AC transmission system by splitting it in several zones connected through an HVDC backbone becomes possible.

We therefore recommend that the EU incentivise European transmission system operators to proactively adjust the control and operational guidelines (network codes) for the combined future power system, whilst facilitating the market.

- **Definition of HVDC system responsibility** for widespread HVDC grids connecting multiple TSOs and possibly also non-synchronised AC systems is critical.
    - This responsibility should define who invests in, develops, maintains and operates such a system.
    - With regards to such grids, each TSO would have a very limited number of converters within its responsibility area, since the size of meshes within the grid is much larger compared to the AC transmission system. Thus, it is reasonable to define a separate HVDC grid responsibility (control area) for large future HVDC grids with cross-border dimensions in order to reduce coordination effort among different responsible organizations.

We therefore recommend that the EU ensure a robust legislative framework to overcome long-term investment uncertainty in order to unlock long-term opportunities that HVDC grids bring for social welfare.

Summary

The EU can and should be at the forefront of the international HVDC grid technological developments by fostering research and prioritizing turn-key demonstration projects involving all different stakeholders.

In particular, the **EU should provide a legislative framework for a stepwise development of an HVDC grid**. This will give rise to **accelerating the HVDC technology developments in Europe.** In this regard, standardisation is key to guarantee interoperability in multi-vendor systems. Legislation should thus encourage system-based functionality requirements.

At the same time, the legislative framework should define the system responsibility and incentivise system operators to proactively adjust networks codes for a future power system including HVDC grids.

Further reading*:*

D. Van Hertem, O. Gomis-Bellmunt, and J. Liang, Eds, *HVDC Grids: For Offshore and Supergrid of the Future*. Wiley-IEEE Press Series on Power Engineering, 2016, 528 pages.

This statement was developed by the IEEE European Public Policy Initiative and represents the considered judgment of a broad group of European IEEE members with expertise in the subject field. IEEE has nearly 60,000 members in Europe. The positions taken in this statement do not necessarily reflect the views of IEEE or its other organizational units.

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