Network code on HVDC connections:
a progressive framework for tomorrow's grid

High Voltage Direct Current (HVDC) technology is playing an important role in the European energy grid system. It has proved increasingly viable in a number of cases providing very long distance connections, which can transport large volumes of electricity and can be built within a relatively short time frame.

HVDC technology is used to construct interconnectors between countries (e.g. the East-West Interconnector between Ireland and Great Britain) and to connect offshore wind farms to the grid. In the future, HVDC technology could form part of a "supergrid" or provide long distance onshore connections, although it is unlikely to completely replace Alternating Current (AC) onshore.

The prevalence of HVDC technologies in Europe is of high strategic importance. By increasing interconnections between European countries and facilitating the growth of renewable energies, HVDC lines are seen as important building blocks of the European internal electricity market. These lines increase competition and ensure optimal use of generation capacities, therefore reinforcing Europe's sustainability, competitiveness and security of supply.

The network code on HVDC connections and DC-connected Power Park Modules (NC HVDC) sets out the rules and requirements that will cover HVDC technology. The network code covers HVDC connections between different areas of Europe, as well as specifying the connection rules applying to the generators, which are connected to the main electricity systems via HVDC lines.

Few countries currently have a HVDC grid code, with most setting connection requirements on a per project basis. NC HVDC will establish a European frame for rules on HVDC technology for the first time.

What are the objectives of NC HVDC?

Cable used in the Britned HVDC link between Great-Britain and the Netherlands.

NC HVDC will set out the rules for managing HVDC lines and connections to these lines. The objective of NC HVDC is threefold:

- To ensure that HVDC technology contributes to system security and promotes the integration of renewable energy sources (RES);
- To promote the coordinated development of HVDC infrastructure as its use becomes more prevalent and;
- To facilitate competition in the provision of HVDC technology.

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Why is the code needed now?

Investment decisions taken now will affect the power system in the years and decades to come. The European energy system of 2020 is already being constructed and the foundations of the European energy system of 2050 are being laid. As such, there is a need to make sure that all users are aware of the capabilities which their facilities will be required to provide – recognising both the need for all parties to make a contribution to security of supply and, the high cost of imposing requirements retrospectively.

The grid connection codes therefore seek to set proportionate connection requirements for all parties connecting to transmission and distribution networks (including generators, demand customers and HVDC connections). A stable set of connection rules also provides a framework within which operational and market rules can be developed.

NC HVDC is a progressive code, addressing the potential high scale dissemination of innovative technologies. It is inherently adapted to today's technological context, within which it was developed. As innovations go forward and new technologies are developed, NC HVDC will also need to evolve.

Why are offshore requirements included?

As Europe progresses towards its energy target deadlines, more elements are being connected to the European grid. Large offshore power park modules (PPM) clusters, currently wind turbines for the most part, are developed and increasingly connected to the main (onshore) electricity system via Direct Current (DC) link.

Currently these clusters and the transmission links which connect them are not designed to be complementary. When defining the design of a new HVDC link, the offshore PPMs are often not final designs. For example, a final decision may not be made on which of the PPMs will be connected to a specific hub. This development strategy, which is necessary for the emergence and progression of these technologies, can only be realised if both the offshore PPM and the HVDC system are designed according to common rules and standards.

Having requirements at the offshore connection point also provides clarity in case ownership of DC links or wind parks changes over time. In addition it ensures equitable treatment with other actors of the power system, in particular onshore generation plants.

Why are there no separate requirements for radial connections with no view of further integration?

Some organisations argue that there is no prospect of their particular planned offshore links ever becoming part of a widely integrated offshore network, or even becoming part of a cluster of PPMs. Thus, they expressed concerns that some of the code's requirements may be disproportionate for these types of projects. They asked that in these cases, an option for reduced requirements should be foreseen within the code.

ENTSO-E firmly believes that such an option would lead to reduced resilience through lower voltage and frequency ranges. This could have a significant impact during disturbed conditions, when there is a greater risk of loss of links as well as lower readiness to restore the network quickly.

NC HVDC sets rules and requirements which will make it possible to interconnect all HVDC links in the future, and create a new European DC network. An optional application of these requirements would contradict the long term multi-national intent for offshore integration. It would also go against the equitable treatment of all developers (comparing different offshore projects, as well as comparing onshore to offshore).

Trencher used by Eirgrid for burying the cable of the East-West Interconnector

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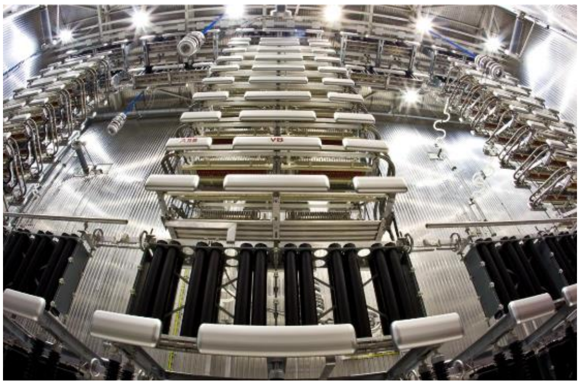
What costs will the requirements add to new projects?

Particular care has been taken to fully explore options with manufacturers, project developers and other impacted parties. In the interest of all energy consumers, discussions and work focussed on finding the right balance of equitable treatment and lowest cost for society.

ENTSO-E requested some key HVDC equipment manufacturers provide their (confidential) views on the cost implications of NC HVDC requirements. Based on this feedback and with some requirement improvements, ENTSO-E concludes that NC HVDC in itself is not a driver for additional costs. Costs for most HVDC connections and offshore development projects are still due to case-specific technical needs. Adequate implementation of the NC HVDC into national codes or project requirements will be key. NC HVDC ensures that a non-discriminatory and future-proof approach is taken for all new connections.

Main benefits of HVDC common rules to operate a fast changing power system

- The European grid is divided into synchronous areas, which are operated as one system and maintain the same frequency at all times. NC HVDC will enhance frequency management with reduced inertia in synchronous areas, by creating the conditions for new inter-area links to be developed;
- Traditionally, conventional generation has been used to maintain voltage management in the system. HVDC links will be able to provide this service in areas located remotely from main centres of RES installations during times of high RES production when conventional plants are not operating;
- In the case of rapid increase of renewable generation level, traditional plants can be switched off and system strength (fault level) quickly decreases to extreme low level. The network code creates the conditions for HVDC links to participate in the fault level management;
- Future fast changes in power flows resulting from the change in generation pattern will be handled more securely by the operator;
- The controllable active power flow can be used to minimise wider system losses and to overcome bottlenecks by distributing the power flow in an optimal way, making full use of all circuits;
- In emergency situations, e.g. partial black outs or islanding of networks, the HVDC scheme could increase stability margins or re-energise or stabilise an island.
- The code sets out clear processes how unwanted interactions between HVDC stations and other grid users are to be mitigated.



While converting AC electricity to DC (and vice versa) the valves pictured above switch 1,650 times per second and are controlled via fibre optic cables.

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