Best
TRANSMISSION FOR SUSTAINABILITY
Paths

RECOMMENDATIONS FROM THE EU PROJECT BEST PATHS

The European grid has to be fit for the **fast evolving energy system**, both as (inter)- connecting capacity and to provide operational flexibility. But how can we ensure electricity from remote and/or dispersed solar and wind sources reaches European consumers through a high performing transmission grid? The EU project Best Paths has tackled this challenge. In a timeframe of four years (Oct. 2014 – Sept. 2018), Best Paths has gathered the expertise from 38 industry and research partners, and successfully developed new network technologies organised in five demonstration projects. This set of recommendations suggests how these experiences can be replicated and to how to overcome the barriers for their wide deployment.

Power transfers driven by the **European Single Electricity Market** require sufficient grid capacity to attain their optimal dispatching. Modern and smart performing grids are also one of the flexibility means necessary to face the system unsteadiness introduced by intermittent renewable energy, so act as a fundamental pillar of a resilient energy system and of a secure supply. Transmission grids will represent the backbone of this electricity system, while the local level will be characterised by decentralised energy patterns including self-consumption and prosumers: both layers will contribute to the overarching aim of **maximising the efficient use of all primary resources** and will be pivotal for the energy transition.

New transmission lines based on High Voltage Direct Current (HVDC) technology are indispensable for **the future European transmission network**, as they allow efficient transport of large amounts of energy. At the same time, reinforcements of the existing Alternating Current (AC) grid are necessary to accommodate more power flows with minimal social impact. Thus, a coordinated upgrade of both AC and DC networks is essential, which can both take advantage, in specific cases, of superconducting links, characterised by very high efficiency, compact size, and **reduced environmental impact**.

BEST PATHS stands for "BEyond State-of-the-art Technologies for rePowering Ac corridors and multi-Terminal HVDC Systems". It is co-funded by the European Commission under the Seventh Framework Programme for Research, Technological Development and Demonstration under the grant agreement no. 612748.

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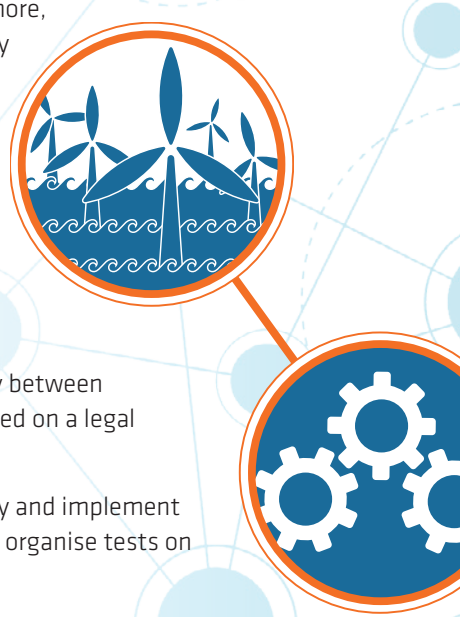
HVDC GRIDS AND INTEROPERABILITY

HVDC has become an **efficient and reliable technology** for new grid developments, and Best Paths engineered a full range of **innovative and high performing components** up to deployment stage. With leading research institutions and major industry partners, it is paramount that Europe maintains its technical and knowledge excellence in this key technology.

In order to build **a future transnational HVDC grid**, smooth operation with equipment provided by different suppliers is needed. This capability (called interoperability) had never been investigated before Best Paths and requires the development of specific technical standards.

Thanks to the project, **interoperability issues were demonstrated for the first time** for the HVDC converter technology needed to build multi-terminal HVDC structures. A high degree of specification and standardisation is required but it is unlikely to guarantee "plug'n'play" solutions which can readily be connected to the DC grid. Furthermore, intellectual property, necessarily owned by the individual manufacturers, hinders a fully featured multi-vendor DC grid. Finally, accurate simulation tools are needed at different points in time: generic models in the preliminary stage can provide a good indication of the HVDC grid feasibility and possible operation, but accurate HVDC converter models and control cubicles from the suppliers are mandatory to ensure final interoperability.



Recommendations:

- In HVDC projects, there should be a vendor-independent stakeholder acting as "DC grid integrator" (typically a TSO) to solve interoperability issues and to ensure confidentiality between competitors. Common procedures should be defined at the design stage and agreed based on a legal statement by owners, suppliers and grid operators.
- For faster and smoother development of the grid, the "DC grid integrator" should specify and implement directly the high-level control and protection algorithms for the different converters and organise tests on reference scenarios.
- Industrial manufacturers should be incentivised to share a common pool of patents and techniques, while still protecting their intellectual property and respecting competition rules; this would greatly contribute to technical progress and standardisation.

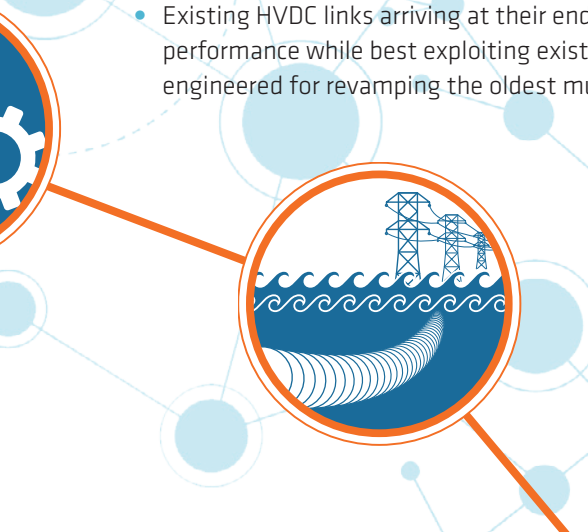
OPTIMAL USE AND MODERNISATION OF EXISTING AC & DC NETWORKS

HVAC overhead lines are and will remain the backbone of the European transmission network. The majority of these lines is ageing and given the difficulty of building new ones, they require **optimisation, upgrading or retrofitting**.

In particular, with the expected increase in offshore wind generation in Northern Europe, the HVAC electricity system and especially its **high level of flexibility and availability** will be a crucial factor for a secure electricity system.

Recommendations:

- In order to increase the utilisation factor of overhead lines and therefore improve the availability rate of the whole grid, smart working methods should be regularly incorporated into operation and maintenance schemes, such as those successfully implemented in Best Paths: Live-Line Working (LLW), aircraft warning marker, and mounting robots.
- To increase the acceptance and minimise the environmental impact of new HVAC line projects, they should be implemented along existing overhead line routes and be optimised and enhanced with regard to their visibility, footprint and capacity; several options have been investigated thoroughly under the umbrella of Best Paths. Examples for these solutions are: dynamic line rating, high-temperature low sag conductors, insulated cross-arms, and composite overhead line towers.
- Existing HVDC links arriving at their end-of-life should be revamped to state-of-the-art technologies, maximising their performance while best exploiting existing corridors and permits; within Best Paths, a fully-fledged hypothesis has been engineered for revamping the oldest multi-terminal HVDC link still in operation.



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TECHNOLOGICAL BREAKTHROUGH: SUPERCONDUCTING LINKS

In Best Paths, gigawatt-scale superconducting cables have been investigated and shown to be **technologically mature and cost-competitive** for the transmission of large amounts of electricity. Thanks to their high efficiency, compact size, and reduced environmental impact, superconducting cables are likely to find higher public acceptance than overhead lines and conventional cables.

In the long term, superconducting links could transport large amounts of electricity over long distances. In the short term, the most suitable applications are areas where civil work is expensive, but also urban areas where space is limited. Here, a short superconducting cable could serve as a 'bridge' connected to resistive cables or overhead lines.

Recommendations:

- In order to deploy this new technology, appropriate de-risking instruments should be put in place within the framework of European energy-climate policies.
- For feasibility studies and tenders of new transmission projects, it is recommended to take the superconducting option into due consideration.

More information about Best Paths and its results is available here:

www.bestpaths-project.eu

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