WHEN TRUST MATTERS



Multi-terminal HVDC Grid: Current status and next steps

Power Systems Advisory

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What is HVDC?

- High voltage direct current
- Cost-effective and low-impact technology for high capacity and long-distance transmission
- Fully controllable
- Grid integration of remote large-scale renewables
 - Hydro
 - Offshore wind
 - Solar
- Energy trade between countries / continents
- Reinforcement of existing onshore grids



When does it make sense to use HVDC?



How can HVDC systems be used?

Α



Point-point systems

- Bespoke projects
- Easier project development
 - Single vendor procurement
 - Single purpose
- Mature and widely applied

Radial multi-terminal system

В

- Multi-purpose
- Fewer converters
 - Lower cost
 - Lower footprint
 - Lower losses
- Requires compatibility



Meshed multi-terminal system

- Redundant paths
 - Increased availability
 - Reduced impact on AC grids
- Requires DC protection system

What is the difference?

Multiple point-point links

- Allows different technologies and voltage levels for each link
 - Optimize design & operation of each link
- Avoids project dependencies
 - Schedule
 - Terminal locations
 - Anticipatory investments for expandability
- Simplifies multi-vendor interoperability
 - Systems from different vendors coupled at AC side guided by AC grid codes
- Proven, accepted technology

Multi-terminal grid

- Better utilization
 - Multi-purpose use
- Fewer converters
 - Lower losses
 - Lower footprint
 - Lower socio-environmental impact
 - Lower permitting burden
 - Higher availability
- Fewer cables (for meshed systems)
 - Use redundant paths to satisfy most severe single contingency constraints

Multi-terminal HVDC grid benefits

•UK Example



- 18% lower lifetime costs
- Significantly lower
 environmental impact
- Significantly lower local and social impact
- Improved security of supply

Multi-terminal HVDC grid benefits

•US Example



- Benefits of networking comes from:
 - Reduced curtailment
 - Reduced usage of higher-cost generations
 - Contribution to reliability
- Benefits outweighs Cost, often by ratio of 2:1

Deck stacking in favor of multi-terminal HVDC grids





HVDC grids in operation > 30 years



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Where are we now?

- Strong global growth expected
 - Both onshore & offshore
- First multi-terminal (radial) VSC-HVDC grids
- Multi-purpose HVDC infrastructure appearing
- Policy moving towards multi-terminal HVDC grids

What are the main barriers?

- Inadequate cross-jurisdiction coordination
- Between states
- Between ISOs and non-ISOs
- Between countries
- Incompatible regulatory frameworks
- Insufficient operational and planning experience
- Proven protection and control strategy
- Lack of standardization
- Unsolved vendor interoperability issues
- Limited supply chain
- Onshore AC grid constraints

Pilot projects

Full scale demonstrators of feasibility and benefits

Seven levels of compatibility

Coordination: Unlock project synergies and realize societal benefits

Standardization: Enable technical compatibility

Future developments

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Conclusions

Multi-terminal HVDC transmission grids:

Have significant benefits over multiple point-point links Already exist \rightarrow the technology is ready Are a key enabler of the energy transition

North American **pilot projects** needed to demonstrate technical feasibility and project benefits

Cooperation and collaboration across Standardization to enable technical compatibility and interoperability all stakeholder levels needed to achieve: Coordination to unlock project synergies and realize societal benefits

Questions?

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