

Ancillary Services and Operation of Multi-terminal HVDC Systems

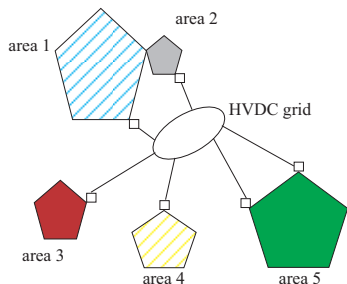
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Motivation

Multi-terminal HVDC systems are a promising alternative to :

- Connect offshore wind power
- Interconnect non-synchronous areas systems
- Transmit high power at continental scale



Motivation

- Technology providers tend to develop converters that
 - Offer flexibility in real/reactive power injections
 - Apply settings with a short time response
- Hierarchical control considers :
 - Setting : the input for controllable devices
(typically changes in less than a second)
 - Reference value : the setting under steady-state operation
(typically changes every 15-60 seconds)
 - Set point : the expected average of reference value
during a 15-60 min period of time
(corresponds to market outcomes)

Problem

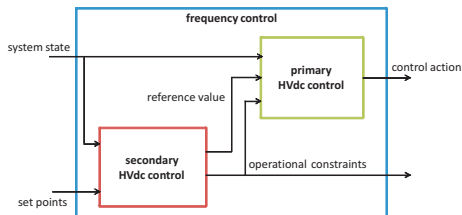
The paper provides an analysis of :

- alternatives in multi-terminal HVDC system control to provide ancillary services
- alternatives in multi-TSO coordination and its impact on the management of the infrastructure

Frequency control

Organization :

- hierarchical
- time-space delineation



Frequency control

Primary HVDC control :

- Acting in a few seconds to restore balance
- Two strategies to share reserves :
 - Share reserves only in case of significant disturbances
 - Share reserves at all time
- Issue of delays \Rightarrow avoid remote communications
- Requires strong commitments between system operators
- Reduces the magnitude of frequency variations

Frequency control

Secondary HVDC control :

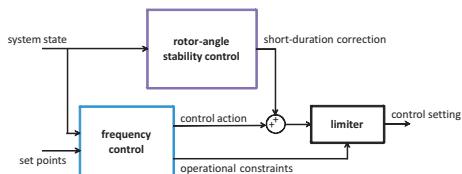
- Adapts reference value in case of configuration change
⇒ Particularly necessary with offshore wind power
- Smooth changes from a set point to another
- Sets operational constraints for primary HVDC control

Stability-related control

Fast control capabilities of VSCs can be used to :

- Avoid loss of synchronism
 - Relying on local information only ?
- Mitigate electromechanical oscillations

Challenges in coordinating actions Vs impacts



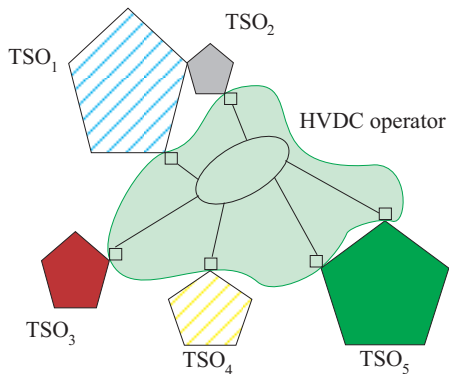
Voltage control

- Reactive power control
- Dynamic functionalities
 - Fault ride-through capabilities
 - Emergency voltage support
- Providing services may reduce the range of operation of the converters

Coordinated operation

System managed by an entity whose practices are decided by consensus

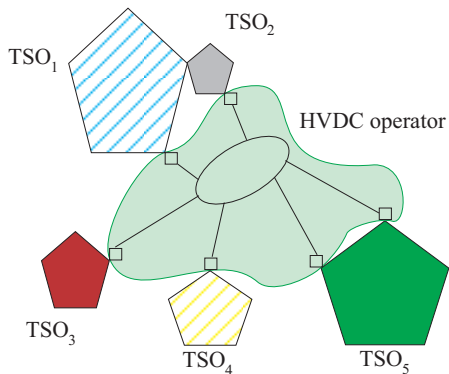
- Control actions must benefit every TSO
- Requires a common definition of reserves
- Needs also an agreement between TSOs on stability-related control



Independent operation

System managed by an entity aiming at maximizing its economic benefits

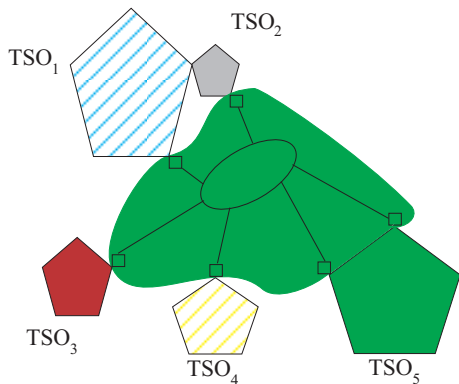
- Control actions depend on TSO regulations
- Sharing of reserves possible between TSOs with similar rules
- Stability-related control if required/valued



Integrated operation

System managed by one of the interconnected TSOs

- Operating the HVDC grid as an extension of its area
- Rely on bilateral agreements with TSOs to exchange services
- Difficulty to assess network access rules and tariffs for offshore wind



Contributions

- A MT-HVDC network can provide/exchange ancillary services
- It might be difficult to consider it as a VPP in practice, in particular for services it exchanges
- Several conditions determine the provision of services :
 - Type of MT-HVDC system operator
 - Network access rules and tariffs
 - Agreements between TSOs
- The implementation of such services in the context of multi-national systems requires strong commitments between TSOs