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Planning and Operation Aspects of Offshore Power Systems Incorporating HVDC Technology and Related Ancillary Services

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Abstract

The authors will present specific problem examples and plausible technical solutions for planning and operation of offshore power systems in the context of integrating large-scale offshore wind farms. The article is intended to give an overview on how state-of-the-art research activities regarding this topic are contributing to the success of future offshore grids and will inform in a comprehensive way. In particular, the issue of set-point allocation for an interconnected offshore power system considering technical capabilities of modern HVDC systems as well as market influence of possible schedules is discussed and a management system addressing this problem is proposed.

Methodology

The starting point for the analysis is a description of the findings regarding technical capabilities of HVDC systems with focus on ancillary services provision that was one aspect of the research project REserviceS coordinated by EWEA and supported by research and industrial partners. In addition, based on detailed study cases including one offshore case, several recommendations were stated at the final stage of this project also regarding HVDC research and technical developments on hardware and software level. However, for operating an offshore power system also energy market implications need to be taken into account that are investigated within the research project NSON recently started and funded by German ministries. As an outlook, the authors propose the concept of an superordinate management system that coordinates the offshore wind power plants as well as the controllable HVDC converter stations to fulfill the power systems' demand of system operation and services. This system will be developed within the integrated research programme IRPWIND carried out by the EERA partners and funded by the European commission.

Technical Capabilities of Modern HVDC Technology – Research and Technical Developments

Findings of the Offshore Case Study [1]

- DC connected offshore wind plants can provide frequency response and active power with provision of communication
- For DC connected offshore wind plants voltage and reactive power ancillary services can be provided by the onshore HVDC converter
- The speed of provision of reactive power ancillary service can be adjustable subject to system needs
- Voltage and reactive power ancillary service can be provided even at the time when there is no wind

FCR: frequency curtailment reserve
RR: replacement reserve
FRR: frequency restoration reserve
RM: ramping margin

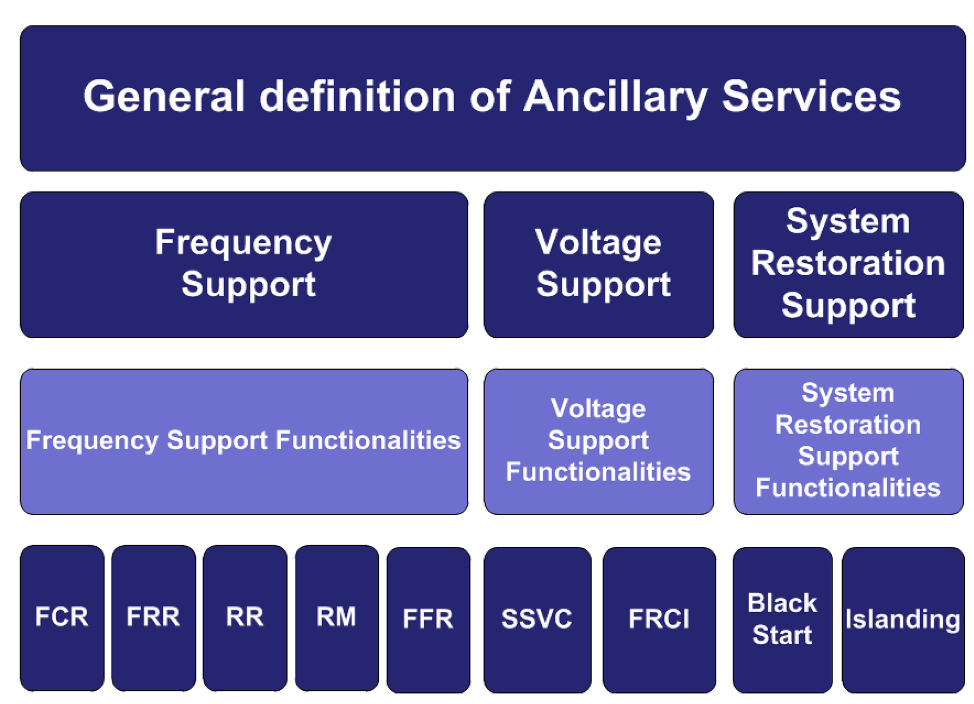

Fig. 1: categories of ancillary services and Technical capabilities investigated in REserviceS

Research recommendations of REserviceS [2]

- Fig. 1 shows the ancillary services framework that was treated in the project
- **Monitoring systems** to enable HVDC connected wind farms and/or clusters to provide frequency support (Hardware)
- **Control and coordination methods** to enable HVDC connected wind farms and/or clusters to provide frequency support (Software)
- **Better understanding** of technical requirements and control strategies for wind power operating in **hybrid AC and DC multi-terminal networks**

FFR: fast frequency response
SSVC: steady-state voltage control
FRCI: fast reactive current injection

Market Considerations of Offshore Power System Operation Using Extensive Multi-Terminal HVDC

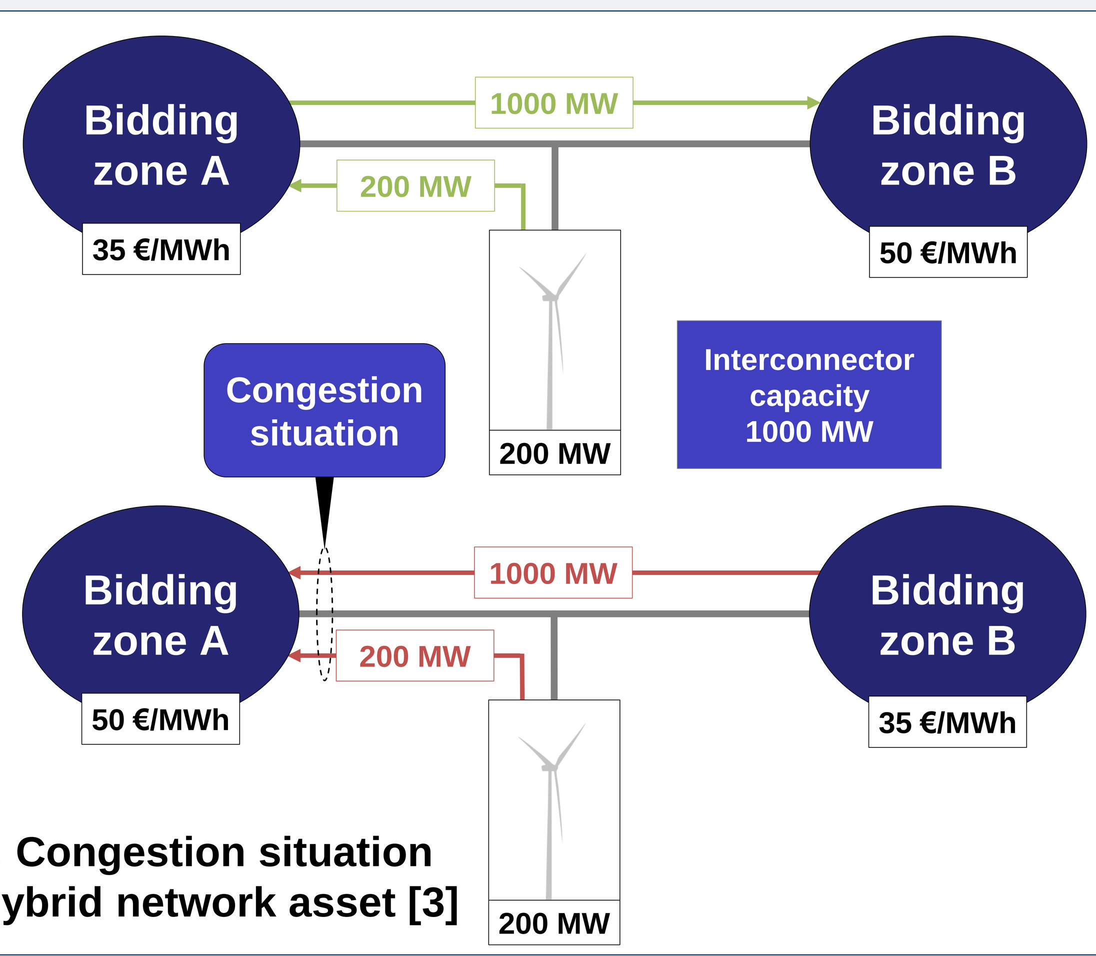

Fig. 2: Congestion situation in a hybrid network asset [3]

Impact of market arrangements and congestion management on set-points in a meshed offshore grid

- Hybrid network asset is used both for transporting offshore renewable generation and cross-border trade (Fig. 2)
- Priority Access and Priority Dispatch for Renewable energy sources [4] as well as the Congestion Management Guidelines [5] and EU Target Model can lead to conflicting targets in congestion situations
- Interactions of cross-border trade and integration of renewable energy from offshore generators can strongly influence set-point allocation of hybrid assets in a potential meshed offshore grid
- Ongoing research topic in the framework of the NSON (North Sea Offshore Network) project

Set-Point Allocation and Offshore Management System

Proposed supervisory offshore management system (Fig. 3)

- HVDC converter schedules and wind farm in-feed can be monitored and coordinated
- Offshore wind power forecast can be incorporated for anticipating congestion situations
- The full range of controllability and technical capabilities can be used
- Possible system interactions between AC and DC systems can be handled
- Ongoing development in the framework of EERA-IRPWIND

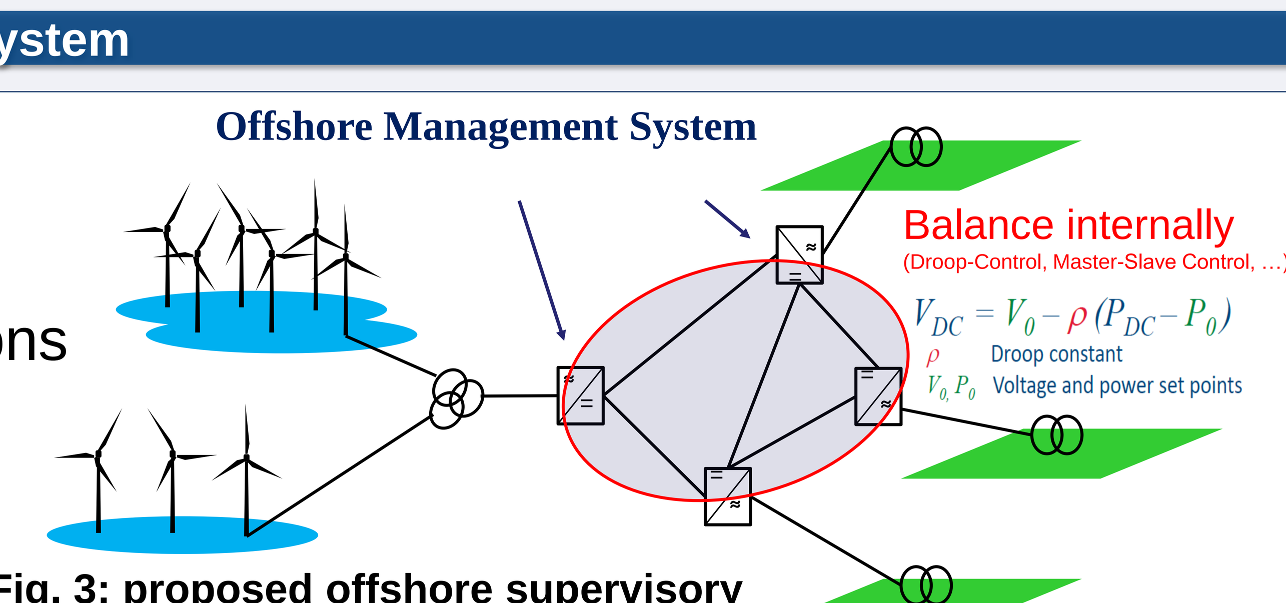

Fig. 3: proposed offshore supervisory management system

Conclusions

Ongoing research projects address offshore power system operational issues considering market implifications as well as technical capabilities of modern power transmission assets. Management systems can support offshore power system operation by anticipating and reacting to critical system conditions and can coordinate necessary system services provided by wind farms and HVDC systems.

References

[1] REserviceS, Offshore Wind Supporting the Grid, Deliverable D5.2, Offshore Case Study Report, January 2014
[2] REserviceS, Recommendations compiled by Frans Van Hulle, Version 2, July 2014
[3] NSCOGI (2013): Discussion Paper: Possible Market Arrangements for Integrated Offshore Networks.
[4] European Parliament, Council of the European Union (2009): Directive 2009/28/EC
[5] European Parliament, Council of the European Union (2009): Regulation (EC) No 714/2009

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