A TECHNOLOGY RANKING METHODOLOGY FOR THE COST-BENEFIT ANALYSIS OF TRANSMISSION INVESTMENTS IN EUROPE

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Overview

According to the IEA World Energy Outlook 2008 [1], the world primary energy use will rise by 45% and the electricity share should increase accordingly, if no new government policies and measures are taken by 2030. In the European Union (EU), constant pressures on security of supply, sustainability and competitiveness have brought the EU Member States to lay down a first set of ambitious targets to be reached by 2020: 20% greenhouse gases emissions reduction (compared to 1990 level); 20% overall energy demand covered by renewables (it was 8.5% in 2005); 20% savings in energy consumption (compared to 2020 projections).

Within this background, the European electricity grids – currently consisting of some 230,000 km High Voltage lines and 1,500,000 km Medium/Low Voltage lines - are on the critical path to meet the EU's climate change and energy policy objectives [2]. In fact, the challenge for the EU electricity networks will be the integration of very large amounts of variable renewable energy sources into the European power system, while keeping its security and reliability within an electricity market context. Also, active demand is foreseen to play an increasing role, for instance via Demand Response programs at peak conditions. Overall, times when generation was considered as fully predictable and consumption fully stochastic are changing to ones in which part of generation becomes stochastic and some of the consumption becomes controllable. The need for evolution in the design and operation of transmission and distribution networks emerges in Europe. This requires a technical and market re-engineering process, which will last tens of years and will have to be supported by different measures. Among them, a crucial role will be played by the utilisation of innovative network technologies to be integrated into the existing power system.

Concerning transmission, several technology options are currently available and have to be validated for transmission planning purposes: the goal is to detect the most promising solutions for the re-engineering of the pan-European transmission network.

The present work, carried out within the FP7 REALISEGRID project [3], focuses on a methodology developed to appraise the barriers or catalysts that could respectively slow down or accelerate the adoption of such innovative technologies by European TSOs. This appraisal will contribute to identifying those transmission technologies with the highest potential in terms of technical system integration and performance, as seen from the electric system perspective. The proposed methodology, validated by different European TSOs, will serve as a basis for an integrated cost-benefit analysis of grid expansion options, which represents a crucial stage of the transmission planning process.

This methodology has been applied to appraise the following advanced transmission technology families scanned within the REALISEGRID project:

- Superconducting cables;
- High Temperature conductors;
- Gas Insulated Lines (GIL) ;
- Phase Shifting Transformers (PST);
- Real Time Thermal Rating (RTTR)-based lines/cables;
- Wide Area Monitoring Systems (WAMS)/Phasor Measurement Units (PMU);
- Flexible Alternating Current Transmission System (FACTS): SVC (Static VAR Compensator); STATCOM (Static Compensator); TCSC (Thyristor Controlled Series Capacitor); SSSC (Static Synchronous Series Compensator); UPFC (Unified Power Flow Controller); DFC (Dynamic Flow Controller); TCPST (Thyristor Controlled Phase Shifting Transformer);
- High Voltage Direct Current (HVDC): Voltage Source Converter (VSC)-based HVDC (VSC-HVDC); Current Source Converter (CSC)-based HVDC (CSC-HVDC);
- Power Storage (possibly operated by TSOs): Flywheel; Supercapacitor; and Superconducting Magnetic Energy Storage (SMES).

In particular, this work pays attention to High Voltage Direct Current (HVDC). This technology exhibits characteristics that have already made it widely attractive over High Voltage Alternating Current (HVAC) transmission for specific applications, such as long distance power transmission, long submarine cable links and interconnection of asynchronous systems. Currently, recent advances in power electronics, coupled with traditional features of HVDC, should help further deploying this technology with the aim of improving operation and supporting the development of onshore and, possibly, offshore European transmission grids. This is the case of the promising Voltage Source Converter (VSC)-based HVDC [4], whose application may provide the

European power system with generally enhanced system security and controllability. The latter properties are especially important in a deregulated environment, where VSC-HVDC can be an attractive option to efficiently and timely relieve network constraints, thus reducing the need for building new HVAC lines. In addition, VSC-HVDC gives the possibility to feed reactive power into a network node and provide voltage support. Moreover, VSC-HVDC may offer a lower environmental impact and a smaller territorial footprint respect to HVAC (and also to HVDC lines due to a more compact station design). Also, both HVDC and VSC-HVDC offer undergrounding possibilities by using cables as a transmission medium.

Methods

The proposed methodology, aiming at assessing power transmission technologies, requires addressing two dimensions: the barriers to system integration and the potential performances, once integrated.

The barriers to system integration for a given technology combine two factors:

- The maturity of the technology, which measures the vision of system operators about the state of development of the studied technology
- The accessibility of the technology, which measures the capacity of system operators to integrate the technology within their own operations.

The potential performance of an innovative technology is defined by two factors:

- Security improvement
- Stability improvement.

The improvement is defined by means of a comparison between the transmission system having the scanned technology implemented and the current system without the integration of the studied technology. The ranking of a combined use of several technologies is, therefore, excluded from the present approach.

This methodology has been applied to all the above mentioned scanned technologies; the present work focuses on the assessment results related to the emerging VSC-HVDC technology.

Results

Despite all the above described advantages provided by the utilisation of VSC-HVDC, features such as converter losses and technology costs may still make VSC-HVDC less competitive than classic HVDC. Then, more accurate cost-benefit analyses can help to better understand the impact that VSC-HVDC technologies will have on the power system. All these elements are also taken into account while applying the above described approach of assessing the barriers and the potential performance towards system integration of VSC-HVDC. The results, validated by some European TSOs, even with some differences (also due to the different network configurations the involved TSOs have to deal with), show that a more widespread application of the VSC-HVDC technology, for which there is presently an increasing interest also in conjunction with some multi-national pilot projects, may be possible in the mid-term, when the present barriers could be overcome by the technological advance.

Conclusions

The present work introduces a methodology used as a basis for the techno-economic assessment of transmission technologies, validated by some European TSOs. This will allow :

- developing a 2020 and 2030 roadmap for the integration of innovative transmission technologies
- filtering out the set of key technologies that will have to be further analysed
- performing a cost-benefit analysis, key stage of the transmission planning process, which takes also account of the candidate technologies.

References

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