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ASSESSING AND IMPROVING POWER SYSTEM SECURITY, RELIABILITY AND PERFORMANCE IN LIGHT OF CHANGING ENERGY SOURCES

SPECIAL REPORT FOR SESSION II
Integration of Renewables in Power Systems

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INTRODUCTION

The need to realize a low carbon energy future is becoming accepted across the world. This puts the electricity society in a whole new perspective and gives room for new ideas and solutions which are needed. The volatility and the non-dispatchable nature of many renewable energy sources poses a challenge for planning a future proof transmission grid while at the same time maintaining or even improving our current reliability and performance standards.

The bridge between policy makers and applicants and on the other hand long term planning to ensure reliable day to day operations, seems bigger than ever. Also the effect of the smaller scale renewable distributed generation acting as if it was a bigger production unit, challenges our creativity.

The effect of not only having technical issues to deal with, but also the need to comply with regulatory and commercial pressures, enhances the complexity and favours different solutions. This can be witnessed in the presented papers.

The 8 papers presented give insights on the above mentioned topics. For structure purposes these have been joined in the following clusters.

a) **Reliability and penetration of renewable sources** – methodologies from a theoretical or a TSO point of view on how to assess or plan the grid to facilitate the maximum power to be connected (papers 21, 23 and 24).

b) **Interaction and transparency with applicants** – methods to meet the applicants' expectations, given the reliability constraints. (papers 25 and 26).

c) **Experiences and possibilities in the grid** – new insights to deal with new phenomena imposed by large penetration of renewable sources (papers 22, 27 and 28).

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Reliability and Penetration of Renewable Sources

Paper 21 shows how to improve computation performance by a factor of 5, without increasing the uncertainty margin beyond 5%. The usage of sequential Monte Carlo is explained. With this methodology an assessment was made for the penetration level needed based upon the standard IEEE network configuration while maintaining the current performance with respect to Loss of Load indicators. To realize a similar reliability from a generation point of view, 2.2 times more RES is needed than conventional (thermal) units. If the network is also taken into account this figure increases to 3.5 times. Diversity of RES in the different nodes of the network can lower this figure.

Paper 23 describes the background of different penetration levels in the EU for distributed generation. Also an insight is given into how all constraints can be taken into account when planning and designing a grid with high penetration of distributed generation. A study case in Italy is presented on how numerous RES connection requests are dealt with. High penetration of this distributed generation is often related to relatively small areas. By using "Power Collectors" the generation is combined and transferred from 150 kV to the 380 kV network. The bottlenecks described in the paper for the 150 and 220 kV network can be relieved by using these Power Collectors while facilitating RES and limiting the need for reinforcement of the 150 kV network.

Paper 24 presents a simple method to determine the penetration limit of photo voltaic distributed generation (PVDG) using the IEEE test network. Given the constraints on the load factor of the branches and the voltage levels an analysis is presented showing the possibility to connect up to 201% of the current load in the whole network. If the transformer within this network would be used as limiting factor only 169% could be reached. This study is conducted with an equality approach to increase the penetration of PVDG.

Question 1: While Loss of Load is a common indicator for assessing ex-post performance, the business is usually organized to maintain an N-1 principle during day to day operation on the high voltage networks. Focus on only the "tip of the iceberg" might pose future problems. What kind of indicators would be practical to take into account the "rest of the iceberg" in the planning phase?

Question 2: The papers showed different approaches to assess a maximum penetration of renewable resources in a network. Some of these approaches have used the maximum power in their assessment. Would utilising the broader duration curve for renewable generation allow even more penetration on the existing network, particularly if the peak was only available for a very short duration and the renewable resource could be switched to match load profiles?

Question 3: Are the more static constraints which were used in these papers indeed the limiting constraints if the system is evolving towards a high penetration of renewable resources?

Interaction and Transparency with Applicants

Paper 25 addresses the challenge EirGrid faced with the implementation of the policy to reach the target of 40% renewable electricity consumption by 2020. The process was organized in batches (at this moment 3) with each a gate closure time. Experience from the two first batches and the knowledge of a much higher amount in the third batch challenged the TSO to achieve an efficient and timely process to assess security issues and show a great amount of transparency towards market parties. One of the objectives was to take into account the network reinforcements planned and needed due to the new applications. The solution has been found in an automated process to check the application against the network constraints year by year. With this automated method it was possible to process 199 applicants and maximize the usage of the network in the planning horizon till 2023 for each year in a timely and transparent method.

Paper 26 describes the combined methodology between neighbouring TSO's with different legislation constraints to achieve a reliable network assessment with the high RES integration. The paper explains the change from an individual process for each single application and interaction with neighbouring networks towards a yearly overall view on the whole network with the mutual influence taken into account for all relevant TSO's. The different legislation in the Iberian systems is mentioned in relation to the application of generation capacity. Given the current trend a concern is presented on the availability of conventional generation for maintaining system stability.

Question 4: The papers have shown an approach with respect to the existing grid and forecast plans. In a meshed network the interaction of the first applicant with the remaining possibilities can be great. How can the risks of deviations of infrastructure projects and/or withdrawals of applicants be minimized?

Question 5: System stability with large penetration of non-dispatchable renewable resources is mentioned as a concern. What measures are taken to mitigate this risk and is it possible to have a simple indicator to assess the limit in an application process?

Question 6: To automate a process has big advantages on accuracy, time, consistencies, etc. On the other hand useful output is dependent on correct input. Understanding of the process and results can diminish if it is treated as a black box. What minimum measures are necessary to maintain appropriate control when planning a reliable network?

EXPERIENCES AND POSSIBILITIES IN THE GRID

Paper 22 elaborates on the possibilities of HVDC usage to cope with the challenges Europe is facing due to the political will towards a low carbon society. Taking redispatch costs into account an analysis is made of the usefulness for HVDC connectors between North of Germany (Diele) and Paris and/or Switzerland. These connections have been selected due to the different characteristics. Diele is in the neighbourhood of massive wind production, Paris is a high load area and Switzerland is the middle of the southern Germany load centre and the northern Italian load centre. The analysis shows a decrease in redispatch volume and also shows that both HVDC connections from North to South would have a high usage rate. The last option analysed was a triangle configuration, connecting Paris with Switzerland. This last HVDC line would have a very low usage rate.

Paper 27 shares a practical case in Brazil on protection issues. The wind farm configuration on a 345 kV network is connected by a single feeder to a 230 kV network. While not expected, the loss of the feeder imposed a significant overvoltage of 36% on the HV equipment (including the transformer) for a long time. The wind farms are connected through an inverter which needs the net frequency to trigger the thiristor gates. On losing the connection to the grid, it was expected to shut down the wind farms within seconds. Instead of this action a rise in voltage and frequency was observed by the inverter control system as was programmed for normal operation to react on normal deviations of the grid. A solution could not be found with the installed inverter control system, therefore an additional overvoltage protection scheme was implemented.

Paper 28 recalls the large disturbance in Europe in 2006 to emphasize the need for adapting the grid codes when providing grid access to large renewable resources. Using DC technology to relieve stress on the AC system could be one of the options and is presented in this paper. Dynamic behaviour could be supported by usage of FACTS and examples are given. Changes in our surroundings challenges us for new methodologies where the use of power electronics cannot be neglected.

Question 7: The drive to use power electronics is also driving us towards an active controlled system. Which KIS (Keep It Simple) principles should not be neglected in our goal to maintain our reliability?

Question 8: What new business case factors are emerging in assessing new infrastructure projects, given the fact that a "simple" overhead line is still one of the cheapest solutions?

Question 9: How can we gain experience with the new technologies needed for the huge powerflows that occur when integrating large amounts of renewable resources without jeopardizing the back-bone system?