institut d'études avancées
université de Cergy-Pontoise

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A. PROJET DE COLLABORATION SCIENTIFIQUE (maximum une page)

En français et en anglais.

Titre du projet/Title of the project :

Performance analysis of a Double Excitation Synchronous Generator in a Mini-grid with contribution of renewable energy resources.

Résumé/Abstract :

In the context that traditional fossil fuel are running out and pollution problems are on the rise in all countries across the world, renewable energies and solutions to energy saving are gaining more and more attention through years. Researches in the smart grid domain have been actively done to target the aforementioned issues. The smart grid (shown in Fig. 1) not only incorporates renewable energy resources (wind and solar energies, for instance) into the traditional electric system but also uses digital technology to improve reliability, security, and efficiency of the electric system from large generation, through the delivery system to electricity consumers and a growing number of distributed-generation and storage resources [1].

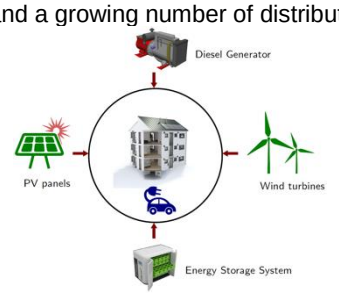

Fig. 1. System with contribution of various energy sources

Wind and solar energy are two important resources to be integrated into the smart grid. Traditionally, double-fed induction and permanent magnet synchronous generators (PMSG) are often employed for the wind turbine generator. The latter one, PMSG, tends to be dominant in the future due to the high power density, compact design, the decreasing trend of the permanent magnet (PM) price. However, due to the fact that field flux created by the PMs is hard to control, controlling the output voltage of the PMSG is, therefore, challenging. The double excitation principle idea is to inherit the advantages of the PMSG as mentioned above but the flux controlling capability is improved by using addition field windings [2,3].

Unfortunately, researches regarding the performances of the double excitation synchronous generator (DESG) in the smart grid are scarce. Sedrine *et al.* did a research to control a DESG for a wind turbine application [4], but the operation of the DESG in the context of a grid with other sources was not considered. Various DESG topologies for direct drive wind turbine were investigated and compared in [5]. The grid performances were not, however, taken into account. This research analyses the performance of the DESG in various operating conditions of the grid. This helps to provide an overall and comprehensive picture of a grid with the contribution from different power supply sources. More importantly, the elaborate evaluation of a DESG in the power grid application will be targeted. This is hoped to serve as a proof to justify the use of DESG in the smart grid. Key findings of the research is expected as follows:

- Controlling strategy of the DESG in the normal working condition of the grid with/without the ESS in the islanded mode to minimize the operating cost.
- Contribution of DESG in keeping the grid's power qualities within theirs limit in the scenario where there is a loss of PV energy. Significant impact of DESG expected where there is no ESS..
- It is expected to propose penetration levels for wind and solar energy.

References:

[1] U.S. Department of Energy, "Smart grid system report", July 2009.
[2] L. Vido, M. Gabsi, M. Lecrivain, Y. Amara, and F. Chabot, "Homopolar and bipolar hybrid excitation synchronous machines", in IEEE International Conference on Electrical Machines and Drives, pp. 1212 – 1218, May 2005.
[3] J. Tapia, F. Leonardi, and T. Lipo, "Consequence-pole permanent-magnet machine with extended field-weakening capability", IEEE Transactions on Industry Applications, vol. 39, no. 6, pp. 1704 – 1709, Nov. 2003.
[4] E. B. Sedrine, L. Vido, I. Slama-Belkhodja, and M. Gabsi, "Control of a hybrid excitation synchronous generator for a wind energy application", in Proceeding of the 2011 14th European Conference on Power Electronics and Applications, pp. 1 – 9, Aug. 2011.
[5] M. Ployard, F. Gillon, A. Ammar, D. Laloy, and L. Vido, "Hybrid excitation topologies of synchronous generator for direct drive wind turbine", in 2016 IEEE Energy Conversion Congress and Exposition (ECCE), pp. 1 – 7, Sept. 2016.

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B. PROJET DE CONFÉRENCE INVITÉE ou *GUEST LECTURE*

Rappel : A la faveur de la venue d'un chercheur international réputé, l'objectif de ces conférences invitées est de favoriser, dans le cadre de l'Institut d'Études Avancées, une ouverture disciplinaire et des échanges entre collègues de laboratoires différents mais qui partagent des intérêts scientifiques congruents.
L'IEA établira un agenda des guest lecture en fonction des propositions et prendra contact avec les chercheurs invitants pour leur organisation.

Titre de la conférence : Design of a 20 MW Fully Superconducting Wind Turbine Generator to Minimize the Levelized Cost of Energy

Date proposée : 16/05/2019 (prévisionnelle)

Résumé :
Superconducting machines are promising candidates for direct-drive multi-megawatt offshore wind turbines. Here, we designed a 20 MW fully superconducting synchronous wind turbine generator using magnesium diboride (MgB2) superconductors for both rotor and stator windings. MgB2 tapes operating at 10 K are used for the rotor windings in order to improve the packing factor. A Rutherford cable made of 91-filament MgB2 wires operating at 20 K is used for the stator windings in order to limit the AC losses. Two separate cryostats are considered for the stator and the rotor to increase the system reliability. Besides, to reduce the machine weight and to simplify the cryogenic system, a toothless magnetic circuit is adopted. The goal of the 2-D finite element method based optimization was to minimize the levelized cost of energy (LCOE). Numerical results show that the adopted topology is lightweight enabling to reduce the cost of the nacelle, tower and foundation, and therefore the LCOE in comparison to a conventional generator. But the AC losses are significant, requiring at this stage of the study an impractical number of cryocoolers.