PhD Proposal 2019-2020

Efficiency and Reliability Enhancement of a Multi-Source DC Microgrid by Integrating Advanced Energy Management Strategies

Duration: 36 months
Deadline for application: November 1st, 2019
Starting date: January 6th, 2020

School - Location: University of Lorraine (Thionville) and Centrale Supélec (Metz)	
Laboratory: LMOPS	**Web site:** http://www.lmops.supelec.fr
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Duration: 36 months (January 2020-December 2022)	
Scientific field: Electrical engineering	
Key words: DC microgrid, energy management, multi-level control, hybrid storage, artificial intelligence, power converter	

Scientific context:

Microgrid provides a promising and efficient solution by integrating various distributed renewable energy sources (RES) (e.g. photovoltaic panels, wind turbines and fuel cells), energy storage systems (e.g. batteries, supercapacitors and flywheels), and interconnected loads that acts as a single controllable entity with respect to the utility grid [1]. Over the last decade, remarkable progress has been made in increasing the penetration of RES, with a majority in AC microgrid due to the dominant AC-based electrical power systems. Nevertheless, DC microgrid has demonstrated more advantages for numerous usages due to the factors: (1) natural interface to DC type RES, storage systems and loads (e.g., lighting systems, computers, electrical vehicles, ventilation and air-conditioning systems); (2) higher efficiency and reliability due to the reduction of conversion stages (eliminating unnecessary dc-ac and ac-dc conversion); (3) simpler control system with no issues of skin effects, harmonics, synchronization and reactive power flow [2]. With the significant growing ratio of DC type RES and DC loads, DC microgrid provide potentially viable and economic solutions for future energy needs [3]. It is hence becoming an attractive solution for both residential and industrial applications, such as DC households, renewable energy parks, electric vehicle charging stations and hybrid energy storage systems [4].

Despite of its numerous advantages and extensive applications, DC microgrid is still relatively a novel technology and its grid architectures, control strategies, stabilization techniques and so on deserve tremendous research efforts. In both European and French scales, as more and more renewable DC microgrids being and to be installed, the efficiency, the monitoring and maintenance, the durability of those systems are becoming more and more important concerns [5].

Research subject and work plan:

In this research work, a typical DC microgrid prototype with multi-source (Photovoltaic /Wind) and a hybrid storage system (Batteries/ Supercapacitors) dedicated to residential applications is principally targeted. The research subject consists mainly in the design and realization of a multi-objective energy

management strategy (EMS) based on artificial intelligence methods, considering both the actual and future RES availability, demand side management and the electricity market. Fundamentally, a real-time EIS could be formulated as a stochastic multi-objective optimal power flow problem [6]. The decision-making module which deals with the RES generation, the load demand, the electricity market, as well as the forecasting information is highly necessary. One of the major difficulties for real-time realization is the computational complexity considering the hierarchical control layers involving the multiple different sources, loads and time-varying operating conditions. In this thesis, an advanced EMS with less computational complexity, uncertainty-dealing capability and good generation capability will be developed and further implemented for the target DC microgrid.

As illustrated in Fig. 1, the research plan includes: 1) system architecture, sizing, modeling and characterization; 2) DC/DC and AC/DC converter design and local control; 3) Design and implementation of the EMS; 4) Interaction between energy management and health management strategies (research subject of another parallel thesis).

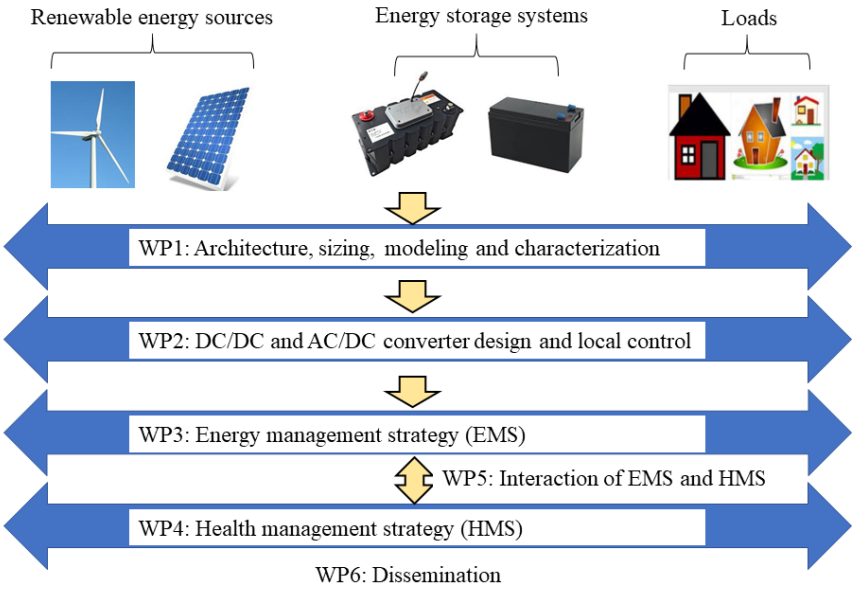

Fig.1 Research plan of the thesis

References:

[1] D. T. Ton and M. A. Smith, "The U.S. Department of Energy's Microgrid Initiative", *Electr. J.*, vol. 25, nº 8, p. 84-94, 2012.

[2] E. Rodriguez-Diaz, J. C. Vasquez, and J. M. Guerrero, "Intelligent DC Homes in Future Sustainable Energy Systems: When efficiency and intelligence work together", *IEEE Consum. Electron. Mag.*, vol. 5, nº 1, p. 74-80, 2016.

[3] J. J. Justo, F. Mwasilu, J. Lee, and J.-W. Jung, "AC-microgrids versus DC-microgrids with distributed energy resources: A review", *Renew. Sustain. Energy Rev.*, vol. 24, p. 387-405, 2013.

[4] T. Dragičević, X. Lu, J. C. Vasquez, and J. M. Guerrero, "DC Microgrids—Part II: A Review of Power Architectures, Applications, and Standardization Issues", *IEEE Trans. Power Electron.*, vol. 31, nº 5, p. 3528-3549, 2016.

[5] A. Kavousi-Fard, A. Khodaei, et S. Bahramirad, " Improved efficiency, enhanced reliability and reduced cost: The transition from static microgrids to reconfigurable microgrids", *Electr. J.*, vol. 10, nº 29, p. 22-27, 2016.

[6] W. Shi, N. Li, C. Chu, and R. Gadh, "Real-Time Energy Management in Microgrids", IEEE Trans. Smart Grid, vol. 8, no 1, p. 228-238, janv. 2017.

Expected skills:

- Solid background in electrical engineering, and automation background is a plus;
- Great interest for renewable energy generations and artificial intelligence;
- Good master of Matlab, dSPACE, Labview, or equivalent;
- Solid skills on experimental manipulations
- Fluent English; At least intermediate in French;
- Oral and written communications (meetings, seminars, conferences)
- Self-learning ability, autonomy, initiative.

Schedule for selection and PhD funding:

Friday, 01/11/2019: deadline for application
From Monday 04/11/2019 to Friday 08/11/2019: Selection of candidates
From Monday 11/11/2019 to Friday 15/11/2019: Interviews
Monday 18/11/2019: Finial decision
Monday 06/01/2020: Starting date

Research teams :

LMOPS	University of Lorraine
Group "Materials, Components and Systems"	IUT of Thionville-Yutz/Department of GIM
2 Rue Edouard Belin, 57070 **Metz**	Impasse Alfred Kastler, 57970 **Yutz**

Application procedure:

Motivated candidates are invited to send a detailed **curriculum vitae** and a **motivation letter** by e-mail by specifying [Thesis EREMITE] as an object before the to: Dr. Zheng (zhixue.zheng@univ-lorraine.fr)