Hybrid AC/DC MicroGrids for the integration of Renewable Energy Sources, Electric Vehicles and Smart Buildings

Supervisors:

Université Gustave Eiffel, France

- Mariana Netto, PICS L-COSYS, Université Gustave Eiffel, mariana.netto@univ-eiffel.fr
- Gilney Damm, IMSE-COSYS, Université Gustave Eiffel, gilney.damm@univ-eiffel.fr

Karlsruhe Institute of Technology (KIT), Germany

- Veit Hagenmeyer, Institute for Automation and Applied Informatics, KIT
- Ömer Ekin, Institute for Automation and Applied Informatics, KIT

Context and description

Context. The electrical network is at the core of the European energy system transformation and is currently going through a deep structural change in the production, transmission, distribution, and consumption modes. It requires the integration of Renewable Energy Sources (RES), with the intrinsic variability and intermittency it produces. At the same time, Electric Vehicles (EVs) have become a reality, and represent around 20% of new cars every year in Europe. Those EVs, in particular bidirectional ones, bring even more variability and intermittency to the grid. Finally, Smart Buildings are arriving on the grid. They include stationary batteries and controllable loads, and bring a flexibility tool to the grid, in addition to other stationary storage units that may be included in large charging stations and in strategic points in the electric grid. All these elements, if properly controlled, will improve flexibility, i.e., the system's ability to maintain continuous service amid production or consumption fluctuations. Nevertheless, implementing suitable control strategies without communication is complex, and the number of elements and the distributed nature of urban grids make such communication nearly impossible.

Thesis proposal. Hybrid Alternating Current (AC) and Direct Current (DC) MicroGrids are a promising architecture for integrating photovoltaic generation, battery energy storage, Electric Vehicle (EV) charging, and converter-interfaced loads while reducing conversion stages and losses. Yet, practical deployment remains constrained by a control gap: robust coordination of multiple storage units and interface converters, cross-domain balancing between DC and AC subsystems, and fast grid-supportive behavior are difficult to achieve without relying on communication infrastructure and supervisory dispatch. Building on the concept of MicroGrids, the interaction among AC and DC systems, and in particular the State-of-Grid (SoG) concept, this thesis subject proposes a coherent, measurement-driven control framework that enables easy integration of renewables, EVs, Supportive Loads like Smart Buildings, autonomous energy coordination and ancillary services among MicroGrids and the main electric grid, using only local voltage and frequency measurements. The project advances MicroGrids operation and SoG theory toward grid-code aligned operation, formal robustness guarantees, and reproducible experimental validation on a power-hardware MicroGrid platform in the KIT partner.

Thesis environment - The two groups involved in this thesis topic, UGE and KIT, have been working on these themes for several years and have just completed their first thesis in collaboration. This first thesis laid the foundations for this new work with a systems approach, in which the different elements already studied can now be integrated and their interactions analyzed in a coherent way.

This global approach, based on a "control systems" vision, will allow consolidating the first results and will constitute the starting point of this Ph.D. work. The thesis will be conducted in the framework of a partnership between a group of experts in nonlinear control applied to electric systems and a group of experts in electric systems with a strong experimental component. This complementarity is decisive in achieving the ambitious scientific objectives of this project.

The thesis will be carried out firstly in France, Marne-la-Vallée (Paris outskirts), with several periods in Germany, Karlsruhe, followed by a period mostly in Germany where the experimental setup is hosted.

Required Skills – The successful candidate is a highly motivated and scientifically excellent student with a master's degree, an engineering school diploma, or any equivalent degree in one of the main fields of this work: control, applied mathematics, power systems, or power electronics. Expertise in numerical tools like MATLAB/Simulink/Simscape will be much appreciated. The theoretical results will be systematically verified on the experimental setup, which is based on real-time power-in-the-loop implementation of the Matlab/Simulink schemes. The student will have full support from the experimental team to help with this process. The work will be conducted in English, but French notions will be necessary, and a willingness to learn some more French during the thesis.

Other information

Location: Université Gustave Eiffel - Marne-la-Vallée Campus and Karlsruhe Institute of Technology.
Start of the PhD: October 2025 (subject to the approval of the scholarship)
Application: Please send an email with your Engineering and Master's transcripts together with your CV to mariana.netto@univ-eiffel.fr and gilney.damm@univ-eiffel.fr. **Application deadline:** 25 April 2026.

References

Y. O. Cota, M. Netto, G. Damm, J. S. Costa, E. E. Okpo and A. J. Sguarezi Filho, "Lyapunov-Based of Finite Control Set Applied to DFIG Operating Under Distorted Voltage and Parametric Uncertainties," in IEEE Open Access Journal of Power and Energy, doi: 10.1109/OAJPE.2026.3666003, 2026.

Ö. Ekin, M. Ghadrdan, G. De Carne, and V. Hagenmeyer, "Communication-Free Grid-Supportive Control of Converter-Based ZIP Loads in DC Microgrids," IEEE J. Emerg. Sel. Topics Power Electron., doi: 10.1109/JESTPE.2026.3651885, 2026.

Ö. Ekin, G. De Carne, and V. Hagenmeyer, "Decentralized Control of DC Microgrids: Introducing the State-of-Grid Concept: How the Principles of Communicating Vessels Could Be Used in DC Microgrid Control," IEEE Industrial Electronics Magazine, doi: 10.1109/MIE.2025.3607070, 2025.

Ö. Ekin, M. Leuthäußer, G. De Carne, and V. Hagenmeyer, "State-of-Grid Based SoC Balancing and AC Coupling Control for DC Microgrids," IEEE Trans. Ind. Electron., doi: 10.1109/TIE.2025.3639739, Dec. 2025.

Erico Gurski, Roman Kuiava, Gilney Damm, ``A Novel VSG Control Strategy with Droop Compensation for Improved Oscillation Damping and Guaranteed Steady-state Performance in Microgrids", IEEE Access, DOI: 10.1109/ACCESS.2025.3615391, 2025.

Otremba, L., Monaro, R., Damm, G., Verrelli, C., ``Reduced-Order Model for Parameter Tuning of Virtual Synchronous Generator for Desired Frequency Dynamics in Isolated Hybrid Microgrid", Journal of Modern Power Systems and Clean Energy, DOI: 10.35833/MPCE.2024.000824, 2025.

Filipe Perez, Gilney Damm, Cristiano Maria Verrelli, Paulo Ribeiro, ``Adaptive Virtual Inertia Control for Stable Microgrid Operation including Ancillary Services Support", IEEE Transactions on Control Systems Technology, doi: 10.1109/TCST.2023.3234282, vol. 31, no. 4, pp. 1552-1564, July, 2023.