Research theme title:
Optimization and control techniques for energy management systems

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Curriculum of DAUSY:
AS for Automation

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Tutors:
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Description:
The effectiveness, efficiency, and economy of public action depend on the degree of knowledge of complex systems that the public administration manages and governs. In particular, electric energy distribution systems are a fundamental aspect of a country's economy; therefore, the related management of these systems is crucial.
Often, these systems are distributed and have complex dynamics, with mixed signals with continuous and discrete time nature. Distributed sensors and suitable intelligent decision support systems must be considered to understand and govern these systems better. Moreover, appropriate data analysis and machine learning strategies should be developed to realize optimal decision policies.
Regarding system modeling, hybrid dynamical systems constitute a suitable framework for representing physical systems that embed continuous, discrete, and event-based dynamics. For this reason, the Ph.D. candidate will investigate the possibility of casting the above-mentioned electrical energy distribution systems into the hybrid systems framework. This will constitute a solid methodological starting point for optimal decision policies. Subsequently, the second goal will be the design of Lyapunov-based control techniques for optimizing the efficiency of the conversion systems (power converters). In particular, by exploiting the hybrid structure of the mathematical models, Lyapunov matrix-based min-projection control laws will be applied to ensure uniform asymptotic stability of the entire system. In addition, further constraints should be included, through appropriate cost functions, to increase the system's efficiency.
Finally, the last key aspect of analyzing is to exploit the flexibility enabled by different power sources (photovoltaic panels, wind farms, batteries, fuel cells, etc.) and power users because it gives chances for a synergistic approach, where a supervisory control can be designed to address the global efficiency of the system. Policy optimization techniques should be proposed for designing a power management controller for this task.
The activity will make use of the laboratories of the hosting University.

Requirements:
The Ph.D. candidates must hold a master's degree, preferably in Engineering, with good control systems and data analysis background. Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. Applicants should have strong motivation toward theoretical analysis and synthesis of automatic control systems.

References:

- Goebel, R., Sanfelice, R. G., & Teel, A. R. (2009). *Hybrid dynamical systems*. IEEE control systems magazine, 29(2), 28-93.

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- Sferlazza, A., Albea-Sanchez, C., Martínez-Salamero, L., Garcia, G., & Alonso, C. (2019). *Min-type control strategy of a DC–DC synchronous boost converter*. IEEE Transactions on Industrial Electronics, 67(4), 3167-3179.

- Strasser, T., Andren, F., Kathan, J., Cecati, C., Buccella, C., Siano, P., ... & Mařík, V. (2014). *A review of architectures and concepts for intelligence in future electric energy systems*. IEEE Transactions on Industrial Electronics, 62(4), 2424-2438.

- Kar, S., Hug, G., Mohammadi, J., & Moura, J. M. (2014). *Distributed state estimation and energy management in smart grids: A consensus + innovations approach*. IEEE Journal of selected topics in signal processing, 8(6), 1022-1038.

Type of scholarship:
DM 118/2022 – Project on Public Administration

Study and research period outside the Public Administration:

- Period length: 6 months;
- Public Administration: INstitute for Marine engineering (INM), section of Palermo, National Research Council of Italy (CNR).