RESEARCH INTERNSHIP - ENGINEER / MASTER
Academic year 2023-2024
INTERNSHIP PROPOSAL

Title	**Smart Hierarchical Control of Electro-thermal Microgrid for Smart Cities**
Description of the internship	**<u>Keywords :</u>** Renewable Energy System, Modeling, Control, Combined Heat and Power, Micro-grid, Smart-Cities; **<u>Context and scientific objectives :</u>** The current energy transition from carbon-based to renewable sources has created a very strong pressure on the power grid. Indeed, electricity has been the preferred energy vector in the integration of renewable energies, electric vehicles and intelligent buildings. As a result, this network is often led to congestion and its limit of stability. At the same time, about 40% of the electricity consumption of businesses and homes is dedicated to heating/air conditioning. In addition, the electrical and thermal dynamics are very different, and therefore thermal inertia can represent a natural storage compared to electricity. There are few articles that study combined electrical and thermal models. One can cite the series of works such as [1] and [2] that propose the notion of Energy Hub. Each Energy Hub contains three basic elements: connections, power converters and storage. In this way it is possible to develop the model of an Energy Hub, as well as the electrical and thermal distribution networks, through a system of non-linear equations. Other works such as [3] [4], or [5] for railway stations, propose an analysis of these combined networks. These analyses are performed in several steps, first isolated and then together, of the electric and thermal power flow, which are then combined in a state vector of important order. The general system is then linearized (as [6]), and the analysis is performed by the time solution of its Jacobian matrix by a Newton-Raphson algorithm. More recently, [7] has developed a combined model and analysis, which has allowed the calculation of an Optimal Power Flow so as to minimize system costs and losses, while respecting the limitations of power flows. The group involved in this work wishes to develop algorithms and schemes for the control/management of an electro thermal smart grid at the scale of a neighborhood. The problem is quite difficult due to the size and complexity of these networks, and to the diversity of the dynamics involved (electrical, thermal and possibly mechanical). The objective of this internship is therefore to create a dynamic multi time-scale model and to simulate the combined architecture. As a second step, control algorithms will be developed, following previous results like [7]. The concept is very innovative and challenging, because even if very logical, it is also quite complex. The algorithms will be developed based on these new elements and should enable the seamless integration of renewable energy sources and electric vehicles into existing networks. This integration will leverage the flexibility provided by the coordinated management of multiple energy vectors and potentially incorporate distributed information and weather forecasts. It is crucial to highlight that the ultimate objective is to empirically validate the efficiency, performance, and accuracy of the proposed methodologies. These

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experiments will be carried out using the smart grid test bench available at ESTP in France.

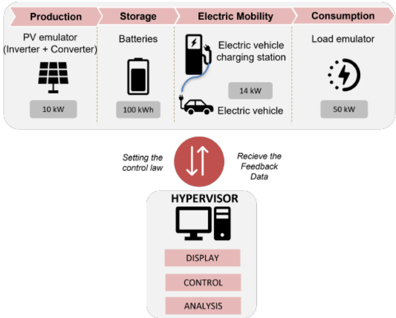

Figure. The smart grid test bench and its synoptic diagram

<u>References</u>
[1] Geidl, M. and Andersson, G.,“Optimal Power Flow of Multiple Energy Carriers’’, IEEE Transactions on Power Systems,vol22,num1,February,2007
[2] Geidl, M.,“Integrated Modeling and Optimization of Multi-Carrier Energy Systems’’,Ph.D. Thesis, ETH Zurich, 2007
[3] Liu, X.,“Combined analysis of electricity and heat networks’’,Ph.D. Thesis,Cardiff University,2013
[4] Liu, X. and Wu, J. and Jenkins, N. and Bagdanavicius, A.,“Combined analysis of electricity and heat networks’’, Applied Energy, vol162, pages 1238–1250, January,2016
[5] Siad Benamane, G. Damm, L. Galaï-Dol, A. De Bernardinis, “Design and Control of a DC Grid for Railway Stations”, 265-272, PCIM Europe 2017, 16-18 May 2017, Nuremberg.
[6] Fang, J. and Zeng, Q. and Ai, X. and Chen, Z. and Wen, J.,“Dynamic Optimal Energy Flow in the Integrated Natural Gas and Electrical Power Systems’’, IEEE Transactions on Sustainable Energy, vol9, num1, January,2018
[7] Chaoyun Wang, Damien Faille, Lilia Galai-Dol, Gilney Damm, “Optimal Power Flow for a Multi-Energy Vector MicroGrid’’, IFAC World Congress 2020, Berlin, Germany, July 12-17, 2020.

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<tr><td>Required skills</td><td>The skills required are in one or more of the fields of control systems, electric grids, thermal systems, mathematic modeling. Expertise in numerical Matlab Simulink tools and multi-scale modeling will be acknowledged. The work may be carried out in English or French following the language skills of the candidate.</td></tr>
<tr><td>Internship Supervisors</td><td>Dr. Asma ACHNIB (asma.achnib@estp.fr, Associate Professor with ESTP),
Dr. Hichem BENZAAMA (hbenzaama@estp.fr, Associate Professor with ESTP) and
Pr. Gilney DAMM (gilney.damm@ univ-eiffel.fr, Senior Research Scientist with Univ. G. Eiffel)</td></tr>
<tr><td>Laboratory</td><td>ESTP, 28 avenue du Président Wilson, 94230 Cachan</td></tr>
<tr><td>Duration</td><td>From February 2024 to July 2024 (6 months)</td></tr>
<tr><td>Gratification</td><td>4.05€/hour; 50% reimbursement of transport costs; luncheon vouchers</td></tr>
<tr><td>Application</td><td>To apply, please send an email with your CV, covering letter and most recent transcripts to aachnib@estp.fr, hbenzaama@estp.fr and gilney.damm@ univ-eiffel.fr</td></tr>
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