Research Internship Proposal – TFE Engineer or M2

Predictive Control of Coupled Electro-Thermal Networks for Multi-Building Urban Energy Flexibility

Supervisors:

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I. Context and description

Urban planning, energy production systems, and consumption patterns must evolve to meet ambitious greenhouse gas reduction targets, such as those of COP30 and the Paris Agreement [1]. Cities play a critical role in this transition, requiring sustainable and resilient energy infrastructures that optimize resource use, increase efficiency, and integrate low-carbon and digital technologies.

The electricity sector remains a major source of greenhouse gas emissions. Renewable energy sources (RESs) [2], particularly wind and solar, are being deployed at increasing scales, but their inherent variability creates operational challenges, as a real-time balance between generation and demand must be maintained. Emerging solutions such as MicroGrids and SmartGrids, supported by advanced information and communication technologies, promise to enhance grid flexibility, reliability, and resilience.

At the same time, nearly 40 % of electricity consumption in buildings is used for heating and cooling. Unlike purely electrical systems, thermal systems have natural inertia that can be exploited as short-term energy storage. Coordinating electrical and thermal domains, an approach known as the multi-energy vector concept, offers significant potential for cost-effective flexibility and load balancing.

Classical approaches, such as Optimal Power Flow (OPF) [4,5] or the Energy Hub concept, optimize energy flows but are often static and do not capture continuous building thermal dynamics or the electrical consumption of circulation pumps. Model Predictive Control (MPC) [6], offers a dynamic alternative; however, most existing studies focus on single buildings or purely thermal regulation, without explicit multi-building coordination.

Building on recent work that developed a coupled electro-thermal MPC framework for a simplified district heating network, explicitly integrating pump electrical consumption and building thermal dynamics, this internship aims to further extend and generalize this approach toward more realistic urban-scale applications.

II. Objectives

The objective of this internship is to extend and enhance a coupled electro-thermal MPC framework for district heating networks, with the aim of improving electrical grid flexibility while ensuring thermal comfort in buildings. The work will focus on extending the existing MPC framework from a simplified multi-building case study to a larger neighborhood with heterogeneous buildings and thermal characteristics. It will also involve incorporating additional electrical constraints, such as power limitations and grid congestion scenarios, as well as integrating intermittent RESs (e.g., photovoltaic generation) and electric vehicles (EVs) to assess system performance under realistic operating conditions. The proposed control strategy will be evaluated in terms of peak power reduction, energy flexibility, and indoor thermal comfort, and its performance will be compared with conventional control approaches, such as PID control.

III. Work Plan

The internship will be organized around the following main steps:

1. Review of the literature on district heating networks, multi-energy systems, and building energy flexibility;
2. Familiarization with the existing electro-thermal models and MPC framework developed in previous work;
3. Extension and adaptation of existing electro-thermal models to more complex urban configurations;
4. Development and implementation of advanced control strategies for multi-building energy management;
5. Simulation-based evaluation under various operating scenarios.

IV. Required Skills

The required skills include strong motivation and a background in one of the main fields of this work: control, mathematics, power systems, or thermal system. Expertise in numerical tools like MATLAB/Simulink/Simscape and multi-scale modeling will be appreciated. The work can be conducted in English or French, depending on the candidate's language skills.

V. Internship Information

Duration: 5 to 6 months, with a planned start date between February 1 and March 31, 2026.
Location : Le CNAM Paris, 292 Rue Saint-Martin, 75003 Paris, France
How to Apply: Please send your CV, most recent transcripts, and motivation letter to:
asma.achnib@univ-eiffel.fr, gilney.damm@univ-eiffel.fr, brice.tremeac@lecnam.net
Application Deadline: **January 15, 2026**

VI. References

[1] D. Raimi *et al.*, "Global energy outlook 2024: Peaks or plateaus," *Resources for the Future*, 2024.
[2] K. Calvin *et al.*, *IPCC, Climate Change 2023: Synthesis Report*, IPCC, Geneva, 2023.
[3] Y. Li, W. Wang, Y. Wang, Y. Xin, T. He, and G. Zhao, "A review of studies involving the effects of climate change on the energy consumption for building heating and cooling," *International Journal of Environmental Research and Public Health*, vol. 18, no. 1, p. 40, 2021.
[4] M. Geidl and G. Andersson, "Optimal power flow of multiple energy carriers," *IEEE Transactions on Power Systems*, vol. 22, no. 1, pp. 145–155, 2007.
[5] C. Wang, D. Faille, L. Galai-Dol, and G. Damm, "Optimal power flow for a multi-energy vector microgrid," *IFAC-PapersOnLine*, vol. 53, no. 2, pp. 12942–12947, 2020.
[6] M. Schwenzer, M. Ay, T. Bergs, and D. Abel, "Review on model predictive control: An engineering perspective," *The International Journal of Advanced Manufacturing Technology*, vol. 117, no. 5, pp. 1327–1349, 2021.