Research Internships (M1-M2)

# A mean-field game approach for balancing intermittent power generation and consumption in electrical networks

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## I Context

Electrical energy production (and consumption) is undergoing a profound transformation, driven by two factors whose impact is steadily increasing: (i) the growing share of intermittent sources (solar, wind) in the energy mix; (ii) technological advances making it possible to monitor the use of electrical appliances in households. Adapting the irregular and diffuse production to an increasingly flexible consumption will pose a significant challenge to energy distribution and regulation in the coming decades.

An ideal framework to address this challenge is game theory, where coordination among agents arises as a Nash equilibrium [1]. The large number of agents structured in a complex network implies that such a "game" cannot be tackled via brute force but calls for a mean-field approximation [2, 3]. Here, the dynamically adaptive optimisation of a single agent is not coupled to the individual decisions of all other agents but to a mean-field describing their aggregated behaviour.

## II Project

To model a network reliant on renewable energy sources, we adopt a simplified framework in which agents act as both producers and consumers (cf Fig. 1). The goal is to study the interaction (competition, coordination) between the agents within a game theoretic approach. Two tasks, each the subject of an internship, are crucial: (i) the construction and study of a novel Mean Field Game describing the agents' behaviour; (ii) the related "game design" problem faced by the "central authority", i.e. the entity setting the external rules of the game. The work requires to define the relevant variables, to model the type of network and the noise, to write down the equations and to interpret the numerical solutions for the optimal strategies.


## III Environment

The two internships are part of the project "Jeux de réseau", funded by the CEA program "Audace!", and involving the LPTMS (https://www.lptms.universite-paris-saclay.fr/) and SPEC (https://iramis.cea.fr/spec/). The possibility of continuing the internship with a Ph.D. can be discussed.

## References

[1] Maschler, M., Solan, E., and Zamir, S. (2015) Game Theory, Cambridge University Press, .

[2] Lasry, J.-M. and Lions, P.-L. (2006) Jeux à champ moyen. I – Le cas stationnaire / Mean field games. I – The stationary case. *C. R. Acad. Sci. Paris, Ser. I,* **343**, 619–625.

[3] Ullmo, D., Swiecicki, I., and Gobron, T. (2019) Quadratic mean field games. *Phys. Rep.,* **799**, 1–35.