# Master thesis proposal :
# Physics-based modeling of smart grids

The distribution of electrical energy is at the core of decarbonised societies. It must cope with the increasing use of renewable and decentralized energy sources. Traditionnally, power engineers try to optimize the electrical grid by a simulation-based approach based on very detailed models at component level. In this project, the objective is to adopt a more physical approach where the focus is on the general relations between the network structure and the power flows. There is indeed an analogy between the formulation of electron fluxes on a lattice at the nanometric level and the formulation of power flows in electrical networks. The distribution of power flows results from a Laplacian operator which is similar to a quantum Hamiltonian. Therefore, one can transfer theoretical techniques of the quantum mechanics to the study of power flows, and study the influence of the electrical network structure and the rate of penetration of renewable energy sources. Thus the power flow distribution will be studied by different methods that are familiar to the condensed matter physics : renormalization, spectral approaches and Green's function for example.

As a first step the student will consider the distribution of power flows in simplified models of electrical distribution networks. Some of these networks can be theoretical like Bethe lattices, which are well known in theoretical physics. These networks allow analytical calculations and their radial structure is close to that of distribution grids. Other networks that are more realistics will be considered such as those of the IEEE or those of French or European cities.

By its definition this research project is at the interface of three domains of science : electrical engineering, physics of complex systems and applied mathematics. This project is proposed by two senior scientists : Pr N. Retière is a researcher in electrical engineering dedicated to the modeling of power systems. Dr D. Mayou is a physicist specialized in the theory of quantum electronic properties of condensed matter and of photovoltaic systems.

This internship can be continued by a PhD thesis. The subject of the PhD thesis will be to generalize the results of the internship to transmission networks (used to transmit power at regional and national or even larger scales) which have the peculiarity of being meshed. Dynamical studies of electrical network will also be considered in relation with the question of stability.

No specific knowledge of the electrical networks is required. Yet the candidate will have to be motivated and able to conduct analytical and numerical studies using theoretical approaches that come from the physics of condensed matter or complex systems. The internship will take place at Institut Néel in Grenoble.

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