Dynamic Nonlinear Pricing in Electricity Markets: A Principal–Agent Perspective

PhD position : *optimal transport*, *mean-field limit*, *stochastic process*, *risk*

Electricity retail pricing is increasingly shaped by volatility, renewable uncertainty, and the growing role of flexible assets. This thesis aims to design tariffs and incentive contracts that create value from flexibility while managing risk in realistic market conditions.

Deterministic framework

In the static setting, nonlinear pricing and screening problems have recently seen major breakthroughs, including the works Carlier [2, 3] and Zhang [14] for general existence results under adverse selection, Figalli, Kim, and McCann [6] for convexity results in the quasi-linear case, McCann and Zhang [9] for fully nonlinear models, McCann and Zhang [10] for the two-dimensional Rochet–Choné characterization in [12]. See other recent advances include interior and global $C^{1,1}$ regularity results for principal-agent models [11].

This PhD project will extend this line of research by introducing a genuinely **dynamic (time-dependent)** formulation and developing the corresponding theoretical results (e.g., existence, structural properties, and principled characterizations), while maintaining close contact with energy-market interpretations.

Stochastic extension

Real markets are uncertain: prices spike, forecasts err, and operational constraints matter. In continuous-time settings, the classical Holmström–Milgrom paradigm [8] models output as a diffusion process where the drift is controlled by the agent. This framework was significantly extended by Sannikov [13], who introduced the agent's continuation value as a key state variable. More recent literature [1, 4, 5, 7] leverages dynamic programming and (2)BSDE techniques to design contracts that may also depend on quadratic variation. These advanced mathematical tools are uniquely suited to energy applications, where intrinsic uncertainty and stringent risk constraints are paramount.

Building on the dynamic foundations above, this part will develop **risk-aware adaptive tariff principles** and numerical tools aimed at practical questions.

Candidate profile

Strong background in analysis, probability, optimization, PDE and related areas; interest in energy systems and real-world modelling; coding skills are a plus.

Contact

Please email a CV and a short statement of interest (and optionally transcript + reference contacts) to :

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