



Offer #2025-08650

PhD Position F/M [Allocation Région 2025] Game Theory for Energy System Decarbonization (F/M)

Contract type : Fixed-term contract

Level of qualifications required : Graduate degree or equivalent

Other valued qualifications : Master 2 degree

Fonction : PhD Position

About the research centre or Inria department

Created in 2008, the Inria center at the University of Lille employs 360 people, including 305 scientists in 15 research teams. Recognized for its strong involvement in the socio-economic development of the Hauts-De-France region, the Inria center at the University of Lille maintains a close relationship with large companies and SMEs. By fostering synergies between researchers and industry, Inria contributes to the transfer of skills and expertise in the field of digital technologies, and provides access to the best of European and international research for the benefit of innovation and businesses, particularly in the region.

For over 10 years, the Inria center at the University of Lille has been at the heart of Lille's university and scientific ecosystem, as well as at the heart of Frenchtech, with a technology showroom based on avenue de Bretagne in Lille, on the EuraTechnologies site of economic excellence dedicated to information and communication technologies (ICT).

Context

The development of renewable energy production (solar, wind) defines new challenges in the management of energy production and transport systems, as well as in the functioning of electricity markets.

Currently, these markets are operated centrally by a market operator, whose objective is to maximize the social welfare (or equivalently, minimize the social cost) of participants, while ensuring the balancing of supply and demand. The connection between producers and consumers is done via an auction system.

The aim of this thesis is to define and implement computational game theoretic approaches making use of artificial intelligence for the management of electricity markets. At the scientific level, the integration of pollution constraints and learning models into "multi-leader single follower" optimization models represents a major challenge. At the application level, this tool could be used as a prototype to accelerate the decarbonization of the electricity system.

Assignment

We consider an electricity market involving electricity producers with different technologies. We assume that producers are strategic (their market shares may vary) and that their decisions are likely to influence the market price. In addition, a single producer may have several technologies at their disposal and some producers may also be consumers (in this case they are called "prosumers"). These producers and prosumers will be called "agents" or "players" in the context of game theory. Note that they also have at their disposal flexibility induced for example by batteries deployed for the storage of surplus production, or via demand response technologies. These agents must define, one day in advance (in "day ahead"), price and quantity auctions. These auctions are submitted to the market operator who defines the market price in order to minimize the social cost of the electricity system. Generally, two strategies are considered: "pay as clear" or "pay as bid". This problem can be modeled as a Stackelberg game (multi-leader single-follower) involving several leaders (the producers) and a follower (the market operator). More precisely, the agents interact according to a Nash equilibrium at the first level. Each of them aims to determine the strategy (price, quantity) allowing them to maximize their profit. Each agent then seeks to solve a bi-level optimization problem. In other words, the agents are in competition with each other but each agent, separately, integrates the behavior of the market operator when making their decision.

Main activities

The innovative aspects of this thesis are: i) integrating pollution measures into the market operator's decision-making model. More precisely, the form of these constraints complicates the reformulation of each agent's bi-level optimization problems as a single-level optimization problem with complementarity constraints; ii) integrating notions of flexibility when defining auctions; iii) integrating

uncertainty regarding renewable energy production. In addition, we will consider iv) different strategies to represent the uncertainty related to the strategies of competing agents when an agent makes a decision. A first approach, inspired by the Bayesian games literature, consists in considering a stochastic formulation where the competitors' strategies are represented via probability distributions. Another approach is based on the use of multi-agent reinforcement learning methods of the actor-critic type. In particular, we will seek to establish convergence guarantees for continuous non-zero-sum games. This is therefore a real challenge at the scientific and application level. The fact that the auctions are repeated every day produces a dynamic game theory model, where a new game instance is defined every day and in which a learning process by the producers can be introduced whose equilibria are complex to calculate. This will lead us to shift the problem from the concept of equilibrium to how players could reach this equilibrium through an online or adaptive learning process and to perform equilibrium tracking. On the algorithmic level, we will be faced with large non-linear problems.

Skills

The candidate will have graduated (or be in progress) with a Master 2, and will have followed courses in optimization and game theory. An interest in issues (non-exhaustive) related to complex systems, artificial intelligence, and the restructuring of electricity markets is a plus.

Benefits package

- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage

Remuneration

2200 € monthly gross salary from October to December 2025

2300 € monthly gross salary after January 1st 2026

General Information

- **Theme/Domain** : Optimization, machine learning and statistical methods
Statistics (Big data) (BAP E)
- **Town/city** : Villeneuve d'Ascq
- **Inria Center** : [Centre Inria de l'Université de Lille](#)
- **Starting date** : 2025-10-01
- **Duration of contract** : 3 years
- **Deadline to apply** : 2025-04-20

Contacts

- **Inria Team** : [INOCS](#)
- **PhD Supervisor** :
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About Inria

Inria is the French national research institute dedicated to digital science and technology. It employs 2,600 people. Its 200 agile project teams, generally run jointly with academic partners, include more than 3,500 scientists and engineers working to meet the challenges of digital technology, often at the interface with other disciplines. The Institute also employs numerous talents in over forty different professions. 900 research support staff contribute to the preparation and development of scientific and entrepreneurial projects that have a worldwide impact.

Warning : you must enter your e-mail address in order to save your application to Inria. Applications must be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.

Instruction to apply

Please send your CV and cover letter.

Defence Security :

This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST). Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

Recruitment Policy :

As part of its diversity policy, all Inria positions are accessible to people with disabilities.