- PhD Opportunity -

Optimal design of flows in industrial symbioses: Industrial ecology for decarbonizing production systems

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Context

The recent conclusions issued by the International Energy Agency to achieve the objective of carbon neutrality by 2050 show in particular a need for massive investments in the field of clean energy and energy networks (electricity, gas and thermal). The decarbonisation of the industrial sector is one of the important levers and France has integrated it in its fourth "Programme d'Investissements d'Avenir" (PIA4) via priority research programs (PEPR). The thesis is therefore part of the PEPR SPLEEN on the Decarbonisation of industries and will be foundd by the ACT-4-IE project (A systemic and territorial approach to decarbonise activity areas with Industrial Ecology). This project aims to develop a systemic approach to decarbonise industrial areas by promoting industrial symbioses. This project involves several complementary academic partners: the Chemical Engineering Laboratory (LGC), the Environmental and Food Process Engineering Laboratory (GEPEA), the Grenoble Electrical Engineering Laboratory (G2ELab), the Lorraine Research Laboratory in Computer Science and Applications (LORIA) and IFP Energies nouvelles (IFPEN).

Keywords: multi-objective optimization, multi-agent based modelling, decarbonization, energies, industrial symbioses

Objectives and planning

Based on various works already carried out in the host department (theses of M. Ramos[1] and F. Mousqué[2]), the aim will be to develop a generic multi-agent based model for the optimal design of resource exchange networks (water, materials, energy). By adopting a systemic approach, the model will have to take into account aspects related to temporality, flexibility, environmental impacts of an eco-industrial park, as well as its integration in the territory. The aim is to develop a modular approach

[1] Ramos, M. A., Rocafull, M., Boix, M., Aussel, D., Montastruc, L., Domenech, S. 2018. Utility network optimization in eco-industrial parks by a multi-leader follower game methodology. Computers & Chemical Engineering, 112. 132-153.
[2] Mousqué, F., Boix, M., Montastruc, L., Domenech, S., Negny, S., 2020. Optimal Design of Eco-Industrial Parks with coupled energy networks addressing Complexity bottleneck through an Interdependence analysis.Computers and chemical engineering, 138.

able of taking into account the constraints of a great variety of cases study: port areas, urban industrial areas, agricultural areas, etc.

Different approaches including consultation, optimisation or multi-criteria decision support will be deployed and coupled in order to obtain a formal strategic and digital framework. The modelling of the resource exchanges network will have to take into account energy supplies (produced under different ways: on-site renewable, from the network, etc.), different types of utilities depending on the demands within the companies, and steam production. Technological building blocks will be introduced into the model to anticipate future CO_2 reduction technologies in the industrial systems considered.

To meet these objectives, the thesis will be composed of the following steps:

- A bibliographical study will allow a review of the methodological, numerical and optimisation tools developed on multi-actor problems.

- **Exploitation of adapted KPIs** (Key Performance Indicators) (defined in partnership with the other members of the project: costs, reliability of the overall system, environmental and societal impacts, territorial impacts).

- **Modelling and mathematical formulation of the problem**: the model will have to take into account the constraints on the production processes of the companies, the contradictory objectives of the actors in the symbiosis, the needs related to the temporality and flexibility of the network.

- **Development of optimisation tools**: development of a resolution methodology and an adapted optimisation strategy.

- **Application to industrial sites/territorial areas:** the planning tools developed will be tested and adapted in relation to the industrial sites/territorial areas selected by the project partners.

Skills required:

The candidate should have strong skills (Master 2 level) in Process Engineering, Energy Engineering or Industrial Engineering and a taste for numerical and mathematical tools, optimisation and modelling. An overall taste for research and teamwork is expected.

Good communication skills will also be appreciated as well as a good level in French and English.

Contact:

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