



Master thesis proposals 2022-2023

Pr. J. Blondeau

1. Use of green hydrogen in the heating sector

EU has an ambitious target that to achieve fully decarbonization by 2050. Hydrogen-based technologies have an important potential to accelerate the process of scaling up clean and renewable energy. It, therefore, seems that the deployment of integration of hydrogen-based energy systems with other green heat sources (waste heat, bioenergy, heat pumps, geothermal power,...) could contribute to the decarbonization of the heat sectors in EU. However, its integration of hydrogen in DHNs compared to other alternatives remain little studied.

The main tasks to be carried out in this master thesis are the following:

- Literature review about hydrogen technology development.
- Develop a hydrogen-based energy system for a community, to investigate the optimal design and operation of the system for different economical and environment objectives.

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2. Analysis of a 100% renewable energy system in Belgium in 2050

EU has an ambitious target that to achieve fully decarbonization by 2050, but the pathway of this energy transition is still uncertain. The main challenges concern the cost, technology feasibility, resource availability and social acceptance. As each country has its own economic structure and resources, it is essential to carry out studies of various scenarios for specific regions or countries.

EnergyPlan, an open source system analysis tool, is a deterministic model allowing for the definition of national energy strategies by assessing the feasibility of a varieties of technologies. It is used by many researchers, consultants and policymakers worldwide.

The main task of this project will be to use EnergyPlan to addresses the Belgian energy transition and develop a strategy for the energy transition.

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3. Technical options for carbon capture from biomass

In collaboration with ENGIE Laborelec.

Bioenergy with Carbon Capture and Storage (BECCS) is a promising technological route to achieve negative carbon emissions. Several technologies can however be used as a basis for this purpose: post-combustion capture, pre-combustion capture, oxy-fuel combustion, chemical looping combustion, ... In this master thesis, the student will first compare these technologies based on a literature review. Some of them will then be selected and modelled to assess their performances in a few realistic case studies.

4. Performance analysis and advanced modelling of riothermal systems

In collaboration with Vivaqua.

Riothermal systems allow for the valorisation of heat from sewage water as a cold source for heat pumps. Vivaqua has patented such a system and currently operates two full-scale installations in Brussels. In this master thesis, the student will analyse the operational data retrieved from these two systems to assess their performances and use them to improve the accuracy of an existing thermodynamic model. Such systems will then be compared to their conventional alternatives (geothermal heat pumps, air/air heat pumps, ...) to draw conclusions on the conditions under which they are competitive from the techno-economic point of view. The optimal control of riothermal system can also be investigated, using Model Predictive Control.

5. Optimal design and operation of District Heating Networks

In collaboration with Resolia.

Resolia is active in the development and the operation of advanced, decarbonised heat networks. In this master thesis, the student will work on the optimal design and/or operation of heat networks based on geothermal heat pumps, waste heat and/or biomass. Real cases will be used as a basis. The needed hypothesis and data will be provided by Resolia. Depending on the detailed scope of the study, industrial optimisation softwares could be used.

8. Techno-economic feasibility of heat recovery from wastewater in a new district

In collaboration with Resolia.

Wastewater is a potential source of residual heat that can be used as a basis for domestic or district heating using heat pumps. The techno-economic feasibility of systems aiming at collecting this waste heat is however not guaranteed. In this master thesis, the student will carry out a techno-economic feasibility study for the specific, real case of a new-built district. The various ways to collect waste heat from wastewater will be compared, and a few technical options will be selected to study their economic and environmental benefits. Both the individual and the collective options will be studied.

9. Medium-term extrapolation of very short-term wind shear data

In collaboration with 3E.

Context:

- Using very short-term wind measurement campaign reduces time to market
- However, using seasonally biased short-term introduces additional uncertainties
- Development and characterisation of models is required to make best use of such data

Financial results of prospective wind farm projects are subject to significant uncertainties arising from the many steps in the modelling chain, from wind measurement to wind turbine performance modelling, until the sales of

electricity itself. The assessment of the wind resource usually relies on the measurement of wind characteristics over a duration of one year. In order to reduce the lead time to market and minimise costs, developers are increasingly looking into reducing the duration of those measurement campaigns. However, the seasonality of some wind characteristics, mainly the shear profile, limits their representativity and acceptability for wind resource characterisation.

Objectives:

The student will analyse data from a large series of short-term measurements campaigns stemming from meteorological masts and other wind measurement devices such as LiDARs and SODARs scattered around western Europe to characterise the seasonal variability of the shear and its geographical dependency. Based on this empirical analysis and on the physical principles at play, the student will develop a model to extrapolate very short-term data to the medium term while correcting for the seasonal bias. The student will cross-correlate the results against flow models such as WAsP (a simplified flow model widely used in the industry) and analyse the geographical dependency of model parameters such as the surface heat flux that have a strong impact on the wind shear profile.

Required skillset:

- Strong programming skills in Python
- Good knowledge of standard Python ecosystem for data science: Pandas, Numpy, Scipy, Xarray, Matplotlib, Seaborn, Bokeh, Plotly, etc.
- Good background in statistics and familiar with meteorological time series
- Familiar with wind turbine technology
- Knowledge of atmospheric modelling/meteorology is a plus
- Solution-oriented and practical, end-to-end minded
- Curious, eager to learn quickly
- Able to work in team and autonomously
- Fluent in English, or French (oral and written)

10. Quantification and validation of wind turbine icing losses in moderate climates

In collaboration with 3E.

Context:

The energy yield of wind turbines may be affected by ice accretion on the blades. The magnitude of production losses in Belgium can rise as high as 10% during winter months. Such losses can be divided in two types: losses due to the shutdown of the turbines to comply with safety standards, and aerodynamic performance losses due to the accretion of ice during operation. The first category of losses is very sensitive to the strategy of wind farm operators with respect to such events, and to the national regulations, while the second can be very tedious to model as it requires to estimate the rate of accretion of ice particles on the blades and its impact on the aero-elastic performance of the blade.

Objectives:

Icing events will be characterised based on operational (SCADA) data from a large fleet of wind assets across Europe and correlated with meteorological data, either stemming from site measurements, or from global weather models. A semi-empirical, scientifically pragmatic statistic method will be developed against observed data to compute the expected energy yield losses of a wind farm based on ambient conditions from long-term meteorological datasets such as reanalysis models (e.g. ERA5, New European wind atlas, etc.). The model shall be easily transferrable to sites where short-term measurements are not necessarily available, nor representative of the long-term.

Required skillset:

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- Solution-oriented and practical, end-to-end minded
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