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Natural Environment Research Council

2020_01: Machine learning analysis of micro-scale industrial energy systems

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(a) Motivation for the project

Industrial Energy Systems, which are responsible for furnishing power, heat, and electricity for industrial manufacturing processes, play an indispensable role in industry. Combustion in industrial energy systems is responsible for over 45% of carbon dioxide emissions and in many industrial applications, high quality heat is the most important input after primary feedstocks.

Energy system models are powerful frameworks to design energy systems and support policies based on sound quantitative evidence. However, majority of these models are macro-scale and Industrial energy provision is often simplified to keep the models tractable. Hence, they are not able to efficiently support energy policy in fulfilling the net-zero greenhouse gas target for the industrial sector. Micro-scale models for industrial energy systems are based on detailed engineering techniques, therefore can capture heterogeneity in energy demand by sector and temperature.

The UK has taken a cluster scale approach to industrial decarbonization since industrial clusters are important for encouraging a low carbon economy, symbiotic relations in clusters can reduce the CO2 emissions by 35%. There is need to formulate energy system models on a cluster scale to support decarbonization by aggregating several micro-scale models for plants within a cluster. Micro-scale models can be trained to form cluster-scale models using advances in machine learning. Such links are necessary to further maximise the benefits of industrial symbiosis in clusters and provide feasible pathways for decarbonisation that can be implemented in each process plant within a cluster.

The aim of this project would be to implement modern machine learning approaches to generate learnings from several micro scale industrial energy systems and form a cluster-scale model. Improved model prediction can identify and maximize the benefits of strategies and technologies to transition to clean industrial energy systems. By bringing in someone from a quantitative discipline we hope to improve model prediction via machine learning analysis, thereby keeping the models tractable.

(b) Context and background

The placement is a good fit for the REP scheme because the student will gain experience of using quantitative skills to support policy creation for decarbonization of energy provision in industrial clusters.

This project will give the student the opportunity to develop well beyond a standard STEM undergraduate syllabus, requiring them to use initiative in working out the appropriate machine learning approach relevant to training and generate learnings from micro-scale models. The micro scale models for several plants has already been developed using detailed process engineering techniques.

The student will also understand real world data collection techniques and apply this insight to validate the cluster-scale model developed.

My group hosts extended research on clean industrial energy systems from a multidisciplinary perspective, and the student will gain first-hand experience of data collection as well as mentorship on industrial energy systems.

Overall, this will create an enriching experience appropriate to the timescale available.

(c) Objectives and methodology

The objective for the student would be to develop a work-flow that goes from selecting the best machine learning technique, obtaining learnings and outputs from micro-scale detailed engineering models, and using these to formulate a cluster-scale model, followed by analysis and interpretation.

This is a significant undertaking for 10 weeks; however, all the tools are already in place. Including the detailed engineering model.

This work can be carried out and written up as a stand-alone project, which will feed into the wider project looking at creating macro-scale hybrid models from cluster-scale models.

The work-flow is itemized below:

- Learn how detailed engineering models for industrial energy systems are built
- Review relevant machine learning literature
- Capture relevant learnings and output data from micro-scale models
- Develop method for building cluster-scale models from such learnings
- Validate with data collection from a UK industrial cluster

Project length: 10 Weeks