

# Modelling the Transition to a Low-Carbon Energy Supply

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# **1 Background and Research Question**

## **1.1 Background and research question**

- Introduction to problem of climate change and requirement for decarbonization.
- Requirement of shift in heating, transport, and industry to electricity.
- Inability to use traditional machine learning and statistical tools to project into future due to rapid disruption.
- Use of long-term agent-based model to simulate into the future (eg. 2050) allowing policy makers and energy market players to assess effect of decisions made.
- Agent-based models can be used to model the impact of heterogenous investors
- Enable policy makers to assess the impact of market power and collusion
- Ability to use reinforcement learning to give agents intelligence

## **1.2 Literature Review**

- Literature review on state-of-the-art models and applications
- Agent-based model tools
  1. Absence of open-source tool with stochasticity (table).
- Optimisation tools

## **1.3 Work Completed**

- Short-term load forecasting
- Completion of agent-based model at yearly granularity
- Results of yearly granularity of agent-based model

- Use of Northern Ireland scenario for optimisation of carbon tax using reinforcement learning (preliminary results)

## 2 Remaining Work

1. Increase granularity to hourly.
  - (a) Selection of best representative days for long-term - Comparison to literature that selects best day for single year.
2. Parametrise model using genetic algorithm or other optimisation tool.
3. Add intelligence to agents using reinforcement learning for:
  - (a) Investment decisions.
  - (b) Bidding strategy.
  - (c) Impact of collusion (variable sharing between two or more agents).
4. Complete work on carbon tax optimiser
5. Comparison of optimisation and agent-based model in different scenarios.
  - (a) Same initialisation parameters and project to future (form of cross-validation).
  - (b) Collusion.
6. Further scenarios and results as examples
  - (a) Decreasing costs of technology over time
  - (b) Different countries
  - (c) Improving availability and capacity factors
  - (d) Uncertainty in fuel prices
  - (e) Changing demand curve shape due to increase in electric vehicles

### **3 Progress against First Year Plan**

## 4 Remaining Work Plan

## 5 Thesis Outline

### 5.1 Chapters

1. Introduction
2. Literature review
3. Data analytics of smart meter data
  - (a) Short-term
  - (b) Long-term load forecasting (inadequacy of long-term load forecasting)
  - (c) Demand segmentation
4. ElecSim: An open-sourced agent-based model
  - (a) Yearly granularity
  - (b) Hourly granularity
5. Adding Intelligence to Agents
  - (a) Reinforcement learning techniques for agents
  - (b) Collusion
6. Scenarios
7. Agent-based model and Optimisation tool: A comparison
8. Conclusion and future work

## 6 Research Outputs

- Note-paper at e-Energy '18
- Poster at e-Energy '19
- Paper at 2nd International Workshop on Electricity Market Engineering at e-Energy '19?