

Modelling the Transition to a Low-Carbon Energy Supply

Alexander Kell

April 29, 2019

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?