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. Comparison of optimisation and agent-based model in different scenarios.
    (a) Same intialisation parameters and project to future (form of cross-validation).
    (b) Collusion.
5. 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?