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# Deep Reinforcement Learning to Minimize Long-Term Carbon Emissions and Cost

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## Abstract

1 Abstract goes here

## 2 1 Introduction

3 A transition from a high carbon electricity supply to a low-carbon system is central to avoiding  
4 catastrophic climate change [1]. Much of the work in decarbonisation relies on a low-carbon  
5 electricity supply, such as cooling, heating and automotive, amongst others. Such a transition must be  
6 made in a gradual approach to avoid frequent collapse of the electricity supply.

7 Renewable energy costs, such as solar and wind sources, have dropped in price making them cost  
8 competitive with fossil fuels. This is projected to continue into the future [2]. The future cost of  
9 generation, demand and fuel prices, however, remain uncertain over the long-term future. These  
10 uncertainties are risks which investors must analyse while making long-term investment decisions.

11 In this paper, we use the deep deterministic policy gradient (DDPG) reinforcement learning algorithm  
12 to simulate the behaviour of investors over a 50-year horizon [3]. The environment used was a  
13 modified version of the FTT:Power model [4]. FTT:Power is a global power systems model that uses  
14 logistic differential equations to simulate technology switching.

15 We modified the FTT:Power model to use the DDPG algorithm in place of the logistic differential  
16 equations to simulate investment decisions, as well as only simulating two countries: the United  
17 Kingdom and Ireland. The DDPG algorithm allowed us to simulate the decisions made by investors  
18 made under imperfect information over a 50-year period. That is, they did not have knowledge of  
19 future demand, fuel and generation costs.

20 The reinforcement learning algorithm enabled us to model the behaviour of an investor without  
21 perfect knowledge of the future, with a view to reduce carbon emissions and overall cost of the  
22 system. The reinforcement learning agent is a single actor that invests in both the UK and Ireland.  
23 This work enabled us to see whether a low-carbon mix is possible over the next 50-years to avert  
24 climate change.

25 Through this work, it is possible to assess whether a low cost, low-carbon electricity mix is viable  
26 over the long-term using a reinforcement learning investment algorithm.

- 27 • Requirement to reduce carbon emissions globally.
- 28 • This must be achieved cost effectively.
- 29 • Requirement for a global solution to find optimal mix of electricity mix with imperfect  
30 information about the future (eg. costs and demand).
- 31 • Use of reinforcement learning to take into account all uncertainties to achieve goal of a cost  
32 effective and low-carbon solution

- 33 • Use of FTT:Power model to simulate investment in the UK and Ireland over a 50 year  
34 horizon
- 35 • Examples of existing literature

## 36 **2 Model and methodology**

- 37 • Use of simplified FTT:Power model (Ireland + UK)
- 38 • Explain DDPG algorithm
- 39 • Detail how we adopted the algorithm to minimize both cost and carbon emissions

## 40 **3 Results**

- 41 • Display electricity mix over time-horizon
- 42 • Investment in solar, offshore, onshore and wave
- 43 • Visualise carbon emissions and electricity price over time
- 44 • Discuss these results and detail

## 45 **References**

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