AI for Efficient Allocation of Renewable Energy Sources under uncertainty in the UK.

James Page

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Abstract

With climate change continuing to be an unsolved issue, the importance of installing new renewable energy generation facilities is ever increases. When

planning the installation of these new systems, generation efficiency is the main consideration. We investigate methods to ensure this efficiency when considering a range of location where the performance of the renewable energy is not certain. Using regression techniques to predict wind turbines generation amount with respect to weather features and a genetic algorithm approach we show that these AI techniques are well suited to tackling the large search space this problem presents and allows for an insight into the most suitable locations for future funding in the renewable energy sector.

Introduction

Due to the ongoing threat of climate change in the current day, the focus on carbon neutral energy sources has never been higher. As such, weather dependent renewable energy generation is demanding a rising amount of investment to transition away from traditional carbon-based fuels. With this rising investment and the importance of these new energy sources, the generation efficiency of the sources installed with this investment is as high as possible as to not waste the opportunity presented. The problem is that the most common renewable energy sources, Wind & Solar are inherently weather reliant, introducing the uncertainty and inconsistency often referenced in any pushback against these energy types.

With the aim of achieving a high efficiency we discover two main problems, how do we predict the amount of energy a location is going to produce, and how do we find a set of locations to optimise the overall generation amount? This presents us an intractable problem evaluating every combination of locations to find the best possible solution, a problem that AI techniques are very well suited for. However, "AI techniques" covers a wide range of approaches, some much more suitable than others so we will be investigating the best combination of algorithms and implementations to ensure our solution is scalable, consistent, and reliable.

In this report we will detail how a combination of existing techniques can be changed to be applied to a real-world use case, with the goal of producing a solution that can return us an "optimal" configuration of renewable energy sources. This will include two main sections of implementation, each focused on one of the two main challenges this problem poses us: Generator Output Prediction; and Optimal Location Selection, each requiring a unique approach with their own issues to tackle.

Background

To understand how to model this problem appropriately we need to understand the background and intricacies of this area. Specifically, the areas requiring further research are the types of renewables currently being invested in; their

pros and cons; locations that are being invested in; requirements for setting up new renewable energy source; and how weather factors can impact generation. This information will guide our decision making to ensure that we are describing a problem that we can feasibly solve while still giving us meaningful insight into the problem.

Renewable Energy Types

There are a wide range of renewable energy sources in use across the UK. However, to keep this project focused we will initially focus into the most common weather-based sources. In 2021 in the UK the highest growth in capacity was in Onshore & Offshore Wind, closely by Solar Photovoltaics (Department for Business, Energy & Industry Strategy, 2021). We also see that of the reported renewable energy types, the most electricity generation came from Wind energy, making up 15.1% (onshore & offshore combined) of the UK's electricity generation in Q3 2021. Next highest was Bioenergy related generation, however as we are focusing on the impact on location-based factors such as weather we will not be considering bioenergy as a candidate energy type. Finally, the last sizeable portion of the renewable energy generated was made up by solar photovoltaics (PV) which generated 6.2% of the UKs energy in the same period.

From these two energy types, we can examine the difference in costs. As we are looking to make the most efficient use of an investment the first step to doing that is to ensure we are using the most cost-effective generation method. From the International Renewable Energy Agency (IRENA) generation costs report in 2020 we can compare the costs per kW of capacity of different technologies in different countries. For our case, the relevant values are the price per kW of solar photovoltaics, onshore and offshore wind in the UK. From this report we can see that in the UK the cost of commercial scale solar photovoltaics was 1545 USD/kW with the cost decreasing year to year at a rate of 7%. Extrapolating that cost trend gives us a figure of 1336 USD/kW in 2022. To verify these values, we can compare to installation quote estimations from greenmatch.co.uk which gives a cost of 1337.67 USD/kW (when including a 20% VAT) for a 60kW installation, close to the extrapolated value from the report, giving us further confidence in the values it presents. Viewing similar values from the report for offshore wind is by far the most expensive in our considerations with a cost of over two times that of any other at 4552 USD/kW. Finally looking at onshore wind, we see that in 2020 the cost in the UK was 1710 USD/kW making it more expensive than solar, however, when we factor in the 13% year to year price decrease and extrapolate to the current year as we did for solar, we see that the cost of 1294 USD/kW is the cheapest energy source we look at. These downward price trends are a result of increasing adoption and investment into the technology driving advancements that allow for the prices to drop.

Looking at both these pieces of information we can see the most viable candidate for this project is onshore wind power, simply due to it currently being the most relevant and invested in renewable technology and it being on track to be the

cheapest per unit of generation. This decision will allow us to be confident in our results being relevant as guidance in the real world while keeping the scope limited to a fixed energy type.

Locations

Just as important as the different energy types, the candidate locations we consider for investment will have a major impact on the feasibility and performance of our solutions. As we are modelling a real-world scenario, price of land, land ownership and planning permission are variables that we should take into consideration. If we ignore these, we risk finding a result that cannot be implemented in the real world due to prohibitive land costs or some restriction in what the proposed location can be used for.

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