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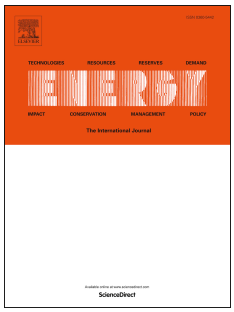

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Forecasting Energy Demand, Wind Generation and Carbon Dioxide Emissions in Ireland using Evolutionary Neural Networks

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Abstract

The ability to accurately predict future power demands, power available from renewable resources and the environmental impact of power generation is vital to the energy sector for the purposes of planning, scheduling and policy making. Machine learning techniques, neural networks in particular, have proven to be very effective methods for addressing these challenging forecasting problems. This research utilizes the powerful evolutionary optimisation algorithm, covariance matrix adaptation evolutionary strategy, as a means of training neural networks to predict short term power demand, wind power generation and carbon dioxide intensity levels in Ireland over a two month period. The network is trained over one month and then tested over the following month. A neural network trained with covariance matrix adaptation evolutionary strategy performs very competitively when compared to other state of the art prediction methods when forecasting Ireland's energy needs, providing fast convergence, more accurate predictions and robust performance. The covariance matrix adaptation evolutionary strategy trained network also gives accurate predictions when predicting multiple time steps into the future.

Keywords: Wind Power Generation, Power Demand, CO2, Forecasting, Neural Networks, Covariance Matrinx Adaptation Evolutionary Strategy

1. Introduction

Worldwide there is an ever increasing demand for energy due to population growth, increased living standards and industrial development. This ever increasing appetite for energy gives rise to a number of problems, namely: 1) Producing the energy necessary to meet the power demand, 2) Reducing the harmful atmospheric pollutants that result from the power generation process, 3) Incorporating renewable energy sources into the power generation process. In each of these problems facing the energy sector, it is vital to develop accurate forecasting methods.

When generating power it is crucial to be able to accurately forecast energy demands in both the short term and long term. Long term energy forecasting enables policy makers, planners and engineers to prepare for future energy needs by building and developing infrastructure to generate power. Short term energy forecasting is critical to energy production as it is vital to know how much energy will be needed in the near future so that power generators can be scheduled to meet future energy needs.

Minimizing the carbon footprint of the power generation process is very important to the energy sector in recent years. It is well known that burning fossil fuels such as coal will produce harmful atmospheric pollutants such as Sulfur Dioxide (SO_2), Nitrogen Oxide (NO_x) and Carbon Dioxide (CO_2). This is a problem as these chemical compounds directly contribute to global warming. In the 2015 Paris Climate Conference (COP21) nearly 200 countries worldwide agreed to cut green house gas emissions in the coming years. In order to reduce the production of these harmful atmospheric pollutants, it is vital to be able to predict how much of these pollutants will be produced.

Due to the harmful atmospheric effects of burning fossil fuels, many countries world wide have resorted to renewables as a source of energy, e.g. wind, wave and solar energy. The primary drawback