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Carbon emissions from electricity: The influence of the North Atlantic Oscillation

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Carbon emissions from electricity: The influence of the North Atlantic Oscillation[1]

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Introduction

The harsh winter of 2009–2010 with an extended period of very cold temperatures and low wind speeds has been attributed to the North Atlantic Oscillation (NAO). The NAO is the change in pressure difference between the Azores High and the Icelandic Low pressure systems and it is the main driver of winter climate variability over the North Atlantic region. Positive NAO phases are associated with wet, warm and windy conditions in Ireland and, as in 2009-2010, negative phases with dry, cold conditions and calm winds.

When temperatures are very low there is usually an increase in electricity demand. If this coincides with low wind speeds and therefore idle wind turbines the electricity sector relies on thermal generation (e.g. coal or gas fired) resulting in higher than usual carbon emissions from the electricity sector. The purpose of this research was to examine how climate variability via the NAO will affect the carbon intensity of the Irish electricity system.

Emissions from the electricity sector also depend on which are the predominant fossil fuels used (i.e. coal or gas), which in turn depend on their price. For example, what would be the impact of an unusually cold winter, leading to high electricity demand, along with low levels of wind generation and high gas but low coal prices? This study uses a computer model of the electricity system that enables us to examine many different scenarios for NAO phases, electricity demand, wind generation and fossil fuel prices. In total we analysed 10,000 winter scenarios each six month's duration, October to March, to assess the impact of NAO on the electricity system.

Research Results

Our analysis finds that on average across the 6 winter months monthly mean wind speeds are 22% higher during positive NAO phases compared to negative NAO phases. More wind means higher wind turbine output but wind turbines are shut down in very high winds for safety reasons. Consequently power output from wind turbines is just 13% higher in positive NAO phases compared to negative NAO phases. The impact of NAO on emissions obviously depends on the

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level of wind penetration within an electricity system. At 2 GW of installed wind capacity, which is close to the current installed capacity on the Irish system, monthly mean carbon dioxide (CO_2) emissions from the electricity sector decline by 3% in positive NAO phases compared to negative NAO phases. At 4 GW installed wind capacity, which is the anticipated capacity on the Irish system by 2017, emissions would be 9% lower. From an emissions intensity perspective, CO_2 emissions per unit electricity output (tCO_2/MWh) falls by 4% in NAO positive compared to NAO negative phases at 2 GW wind capacity, and by 10% at 4 GW wind capacity.

Policy Implications

These research findings are encouraging in light of energy policy that advocates an expansion in the share of renewable energy in the electricity sector. But the research also underscores the policy risks associated with using fixed targets for renewable energy. Increasing wind generation capacity from current levels will reduce CO_2 emissions but the variability of NAO phases means that there can be large variations in emissions depending on the NAO phase. For any time period and any level of installed wind generation capacity the level of emissions will vary by NAO phase, which introduces a risk associated with decarbonising the electricity system. Consequently, compliance with policy targets is susceptible to the vagaries of the NAO. Also relying on wind data to inform policy or investment decisions without acknowledging NAO phase is likely to lead to inefficient outcomes.