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Location, location, location: determining the optimal long-run expansion of the Irish electricity system considering spatial and network impacts [1]

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INTRODUCTION

Electricity system operators require robust planning tools that allow them to design and develop the electricity sector in the cheapest way possible, while respecting physical and environmental requirements. Generation Expansion Planning (GEP) and Transmission Expansion Planning (TEP) models have been the preferred tools for determining long-run electricity system development to date. GEP models determine the optimal investment in power plants, such as coal, gas and renewable generation units, while TEP models determine the optimal development of network assets, including transmission lines and transformers.

Concerns over climate change have led to sustained investment in renewable generation sources, such as wind and solar. The optimal location of these generation units is driven mainly by the supply of the underlying energy resource (wind or sun) rather than the location of demand. Furthermore, renewable sources of energy are variable and of limited predictability, and so determining the optimal long-run power system development has increased greatly in complexity. It is therefore increasingly important to include locational details in GEP models, and to consider the effects on the transmission system also.

An extensive review of the relevant literature found that over 50 per cent of GEP models to date ignore locational considerations altogether, and so do not consider the transmission network at all. The vast majority of the remaining models ignore at least some of the physical characteristics of electricity networks, while the two studies in the literature that include the effects of transmission as well as generation expansion do so for very simplified models of power systems. This research therefore developed a new model, called the Electricity Network and Generation INvEstment (ENGINE) model, which includes locational and network data, as well as detailed data on wind and solar production.

[1] This Bulletin summaries the findings from: Fitiwi, D., Lynch, M.Á. and Bertsch, V., "Enhanced network effects and stochastic modelling in generation expansion planning: insights from an insular power system", *Socio-Economic Planning Sciences*, Available online: https://www.sciencedirect.com/science/article/abs/pii/S0038012119304975

ENGINE can determine the optimal investment in generation assets, network assets, or both, and so is a combined GEP and TEP model. The electricity system impacts of changes in supply and demand, new technologies such as battery storage, and new policies such as increased renewable targets or increased carbon prices can all be determined using ENGINE.

RESULTS

We use the ENGINE model to determine the optimal development of the Irish power system out to 2030 considering the phase out of older inefficient fossil fuel generation and/or the development of the planned North-South interconnector. Generation investments are primarily in onshore wind and efficient gas-fired generation. Power system costs, comprising investment costs, generation and maintenance costs and carbon costs, and emissions are significantly reduced in the scenario that retires inefficient power plants, relative to a scenario where they remain online. There is no long-run change to costs from the North-South interconnector, but the reliability of the electricity system is significantly compromised in the scenarios where the interconnector is not built.

The analysis above requires that the model respect policy-driven renewable generation targets. A sensitivity analysis that increases the carbon prices faced by generators does not see any increase in renewable energy investment, and consequently there is no further reduction in emissions, even for very high carbon prices. Total generation costs do increase however. This suggests that there is a misalignment between renewable electricity targets and carbon prices. For the electricity generation sector therefore, the renewable targets drive the wind investment completely, rendering carbon pricing ineffective as a policy instrument.

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