



Optimal Power Generation Portfolios with Renewables: An Application to the UK

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In recent years, geopolitical events have raised questions about the security of European energy supplies and which electricity generation technologies present an optimal fuel mix. Likewise, private investors need to allocate their capital efficiently by devising portfolios of generation assets. This paper applies the Modern Portfolio Theory (MPT) to determine an optimal portfolio based on four of the main electricity generation technologies.

We focus on investment incentives for private investors, considering fuel-mix diversification as a strategy for mitigating exposure to uncertain electricity, fuel and carbon prices. We show when the correlation between electricity, fuel, and CO₂ prices is taken into account, private investors would achieve the best outcome by investing in a combination of CCGT, wind, and nuclear generation assets.

Firstly, we discuss how electricity market liberalisation has affected investment incentives. We then introduce the case for using diversification as a risk-mitigation strategy under a Mean-Variance Portfolio theory framework. In so doing, we extend the approach developed by Roques *et al.* (2008) to assess the impact of adding renewable electricity generation to the energy mix.

Using UK electricity and fuel price data and European carbon allowance prices for the period 2009-2013, we find that inclusion of coal assets increases portfolio risk and decreases the overall returns to the portfolio, whilst a combination of gas, nuclear and wind assets allows an investor to maximise risk-adjusted return. We show while some utilities have disposed



of renewable assets such as wind these could improve the characteristics of their generation portfolios.

In addition, we examine the role of power purchase agreements (PPAs) to assess whether predictable revenues can create more appealing portfolio characteristics.

We find that such contracts reduce portfolio returns, highlighting the importance of the set prices and their possible fluctuations over time. The findings support electricity market reform that discourages coal investment and supports investment in renewable technologies. The results also suggest that power purchase agreements could make sense for independent renewable generators, although this would require modelling of the uncertainty of variable load factors and operating costs.