ACHIEVING 100% RENEWABLE GENERATION IN NEW ZEALAND

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Overview

In New Zealand the goal of nearly or fully renewables-based electricity supply has been long discussed (e.g. Bertram and Clover 2010) but frequently challenged because the intermittent nature of wind and solar power must be offset in some way to sustain 100% renewable generation. Our paper asks whether the long-established hydro assets, that already supply two-thirds of demand, could provide an effective backstop to intermittent renewables - not only over days and weeks but also over dry years - if those assets were controlled by a social planner rather than under the current market arrangements. We model a feasible roll-out of wind and solar generation capacity that, combined with hydro and geothermal generation, could fully meet projected 2035 demand of 48 TWh under the actual historical weather and economic conditions that prevailed over the years 2000-2020. We check the feasibility and cost of our solution.

Methods

We set up a spreadsheet with 7,674 rows, one for each day between January 2 2000 and January 1 2021. We enter the actual historical daily weather and business-cycle state of the New Zealand economy over the twenty years 2000-2020. We then scale up each day's electricity demand to match the projected 2035 demand of 48 TWh per year and model how this could be supplied utilising (i) already-existing hydroelectric generating plant, (ii) geothermal supply scaled up from the existing 900 MW to the 1700 MW predicted to be feasible, and (iii) a portfolio of solar and wind generation with feasibly-achievable installed capacity (1789 MW of solar and 3862 MW of wind) operating at actual capcity factors taken from https://renewables.ninja/. We constrain the hydro assets to be operated subject to minimum-flow constraints (a must-run volume of 800 MW) and a predetermined range of allowable lake levels, with provision for hydro spill if necessary to meet these constraints. Whenever possible the hydro assets are operated to provide the residual supply required after geothermal, wind and solar power have been delivered. However, when the constraints on hydro management bind, then wind and/or solar power is spilled. The crucial features of this modelling exercise are the deliberate installation of excess wind and solar generating capacity relative to the requirements for normal years, and re-dispatch of the long-established hydro assets to provide the backstop to intermittent renewables (wind and solar), rather than simply pursuing maximum profit. The existing fossil-fuelled thermal generation plant is held idle throughout (implicitly either decommissioned or mothballed).

Results

Our roll-out of feasible wind and solar generation capacity, combined with our hypothetical re-dispatch of the 3700 MW of hydro assets from profit-maximisation to functioning as a system battery and residual supplier, succeeds in fully meeting demand over the range of daily climatic outcomes observed over the two decades 2000-2020, including the dry year 2001. Because the exogenously-specified portfolio of new-renewable assets must be sufficient to meet demand in dry years such as 2001, excess supply capacity prevails in normal years, which would have to be accounted for and costed. The minimum-flow hydro constraint binds frequently, forcing spill of wind and solar. The key remaining issue is the cost of installing and maintaining sufficient excess wind and solar capacity to secure 100% renewable supply. Wind has higher capital cost per installed MW but a three-times-greater capacity factor than solar; solar has more predictable timing of output over the day. We explore various combinations of the two technologies over a range of capital and operating costs.

Conclusions

Our results demonstrate the physical feasibility of achieving 100% renewable electricity supply in the near future in New Zealand, and provide some estimates of the cost of doing so compared with business-as-usual. That cost varies quite widely depending on the precise mix of wind and solar investment and the constraints imposed on dispatch of the hydro assets. Whether adoption of the fully-renewable model is cost-effective will depend on the expected cost of carbon emissions and the value placed by policymakers upon elimination of fossil fuels from electricity generation.

References

Bertram, G.and D. Clover (2010), Kicking the fossil fuel habit: New Zealand's ninety percent renewable target for electricity. Chapter 14 in F.P. Sioshansi (ed) *Generating electricity in a carbon-constrained world*. Amsterdam: Elsevier.