IMPACT OF A CHANGING CLIMATE ON OUR ENERGY SYSTEM

How will climate change influence hydro lake levels?

How will wind speeds change under different scenarios?

What impact will floods have on hydro lake storage?

How do I access the data?

"A 2% decrease in capital costs by 2050 might not seem like much, but when $42 billion is planned to be spent before 2030 alone on energy generation infrastructure, we realise that the implications of climate change are significant and must be planned for."

Jen Purdie

This research investigated climate change impacts on the wind and water needed for the energy transition. Datasets and guidance from this research can be used by energy sector professionals to incorporate energy-sector specific climate change projections and insights into their planning.

START ADAPTATION PLANNING TODAY

IMPACT OF A CHANGING CLIMATE ON OUR ENERGY SYSTEM

DEEP SOUTH CHALLENGE RESEARCH DISCUSSED: Jen Purdie "Climate change impacts on NZ electricity": https://deepsouthchallenge.co.nz/research-project/climate-change-impacts-on-nz-electricity/

This research shows climate change impacts on wind and water will likely

- **Slightly reduce the need for new generation capacity by 2050**
- **Reduce periods of system shortage**
- **increase hydro generation and spill**

WHAT DID THIS RESEARCH DO?

This research investigated climate change impacts on the wind and water needed for the energy transition. Projections of wind and water, sourced from Global Climate Models (GCM) and downscaled to local level (MfE 2018, Collins, Montgomery & Zammit 2018) were combined with high resolution electricity system modelling, to explore how changes to wind and water will impact our ability to generate enough renewable electricity to support New Zealand's decarbonisation goals.

Results from this research are expected to be published in 2024. Additional outputs can be found at https://deepsouthchallenge.co.nz/research-project/climate-change-impacts-on-nz-electricity/

BACKGROUND

Huge investment is needed in the energy industry in coming decades. Decarbonising our economy is leading to significant electrification of both transport and industry, resulting in a likely doubling of electricity demand in New Zealand in the next 30 years (BCG 2022). Significant new electricity infrastructure development will primarily consist of new wind and solar farms, as well as distributed energy such as rooftop solar.

The proportion of renewable electricity in our system will increase from 85% now to close to 100% by the mid-2030s, and wind generation is projected to make up ~30% of our electricity mix by 2050 (BCG 2022). With this transition, however, either storage (e.g. hydro storage, batteries, pumped hydro) or firm dispatchable power (e.g. geothermal) will be needed to firm up the intermittency of these highly variable renewables. Hydro storage as a mechanism to firm intermittency will become more important.

Climate change will also impact the amount and seasonality of these critical renewable generation "fuels", wind and water, which, until now, has not been factored into multi-decadal energy modelling. Current industry practice uses 90 years of historical wind and hydro inflow records to estimate how much wind and water will be likely available for generation in 2050, but with climate change, estimates based on these historical data are misleading.

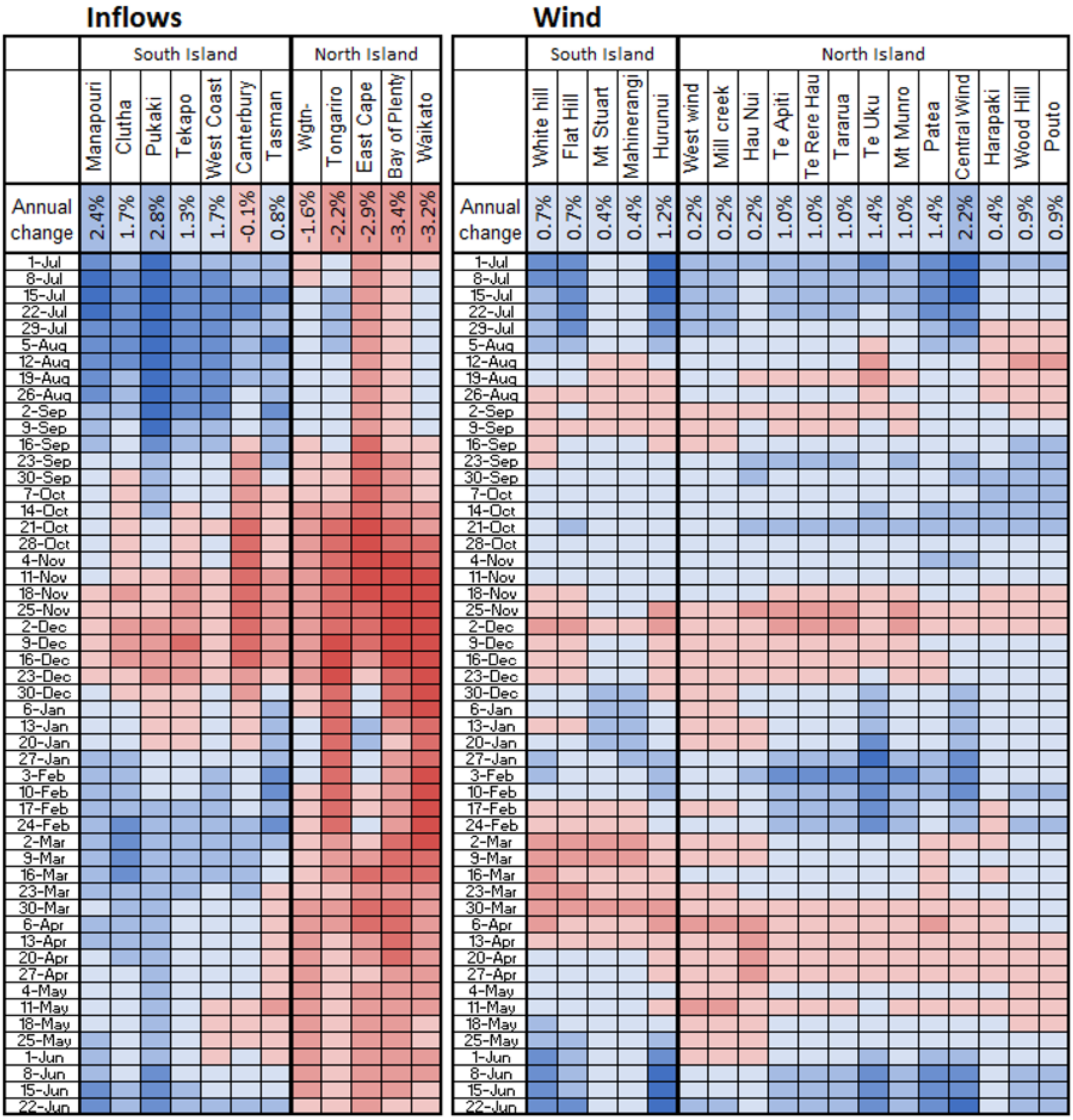
There is debate around the best way to incorporate climate change information in the design of systems or infrastructure (Newsroom 2024), but it is generally agreed that this information needs to be included in energy planning in some form (e.g. ICOLD 2018). This research provides the link between these projected climatic changes and their implications for energy generation in New Zealand.

WHAT THIS RESEARCH TELLS US?

Wind and water

Local-scale projections show significant changes to both lake inflows and wind speeds by mid-century. On an annual basis, South Island hydro lakes are expected to get wetter and North Island hydro drier over time. Seasonally, the biggest changes between now and 2050 are projected to be 8% higher winter inflows in the big South Island snow-fed catchments and 8% lower summer lake inflows in the North Island hydro catchments (under a mid-range emission scenario; see Figure 1).

It is projected to get sightly windier everywhere, on an annual basis. Seasonally, by mid-century, winds are expected to get less windy in summer and autumn and windier in winter under a mid-range emissions scenario (see Figure 1).



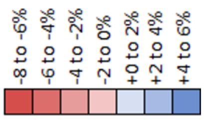


Figure 1: Projected percentage changes to weekly hydro inflows (left) and wind speeds (right) in electricity model regions between 2022 and 2050 under a mid-range (RCP4.5) emissions scenario. Regions/catchments to the left of the black line are in the South Island, regions/catchments to the right of the black line are in the North Island.

Floods are expected to get larger over most of the South Island, and dry periods drier in the biggest hydro catchments. In the North Island, both floods and dry periods are expected to get drier over time. Wind speeds are generally expected to get windier across the range of wind speeds, with both low wind speeds and high wind speeds increasing over time (see Figure 2).

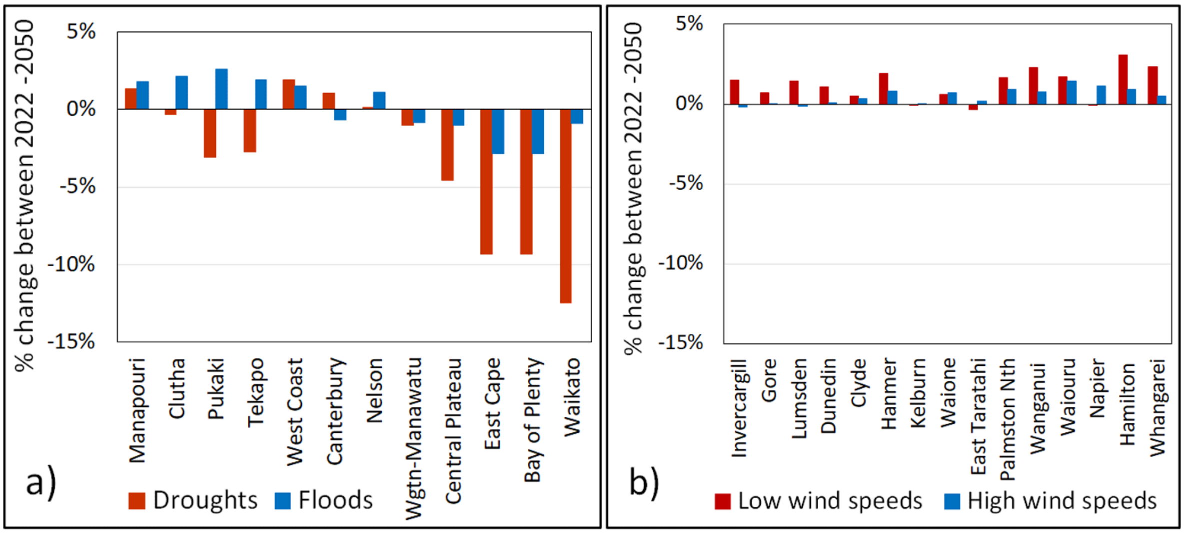


Figure 2: Projected percentage changes to the a) magnitude of flood peaks (change to 95th percentile inflows) and drought depth (change to 5th percentile inflows), and b) to the magnitude of high wind speeds (change to 95th percentile wind speed) and low wind speeds (change to 5th percentile wind speed) for various New Zealand regions, between 2022 and 2050.

Implications for the electricity system and electricity infrastructure investment

The New Zealand electricity system is generally modelled out to 2050 using inputs of a long history of hydro lake inflows and wind speeds. For this research, projections of future water and wind were also put through an industry sourced electricity system model. Three scenarios were modelled:

a. Using historical hydro inflows and wind records

b. Using RCP 4.5, mid-range emissions scenario projections of wind and water

c. Using RCP 8.5, high-range emissions scenario projections of wind and water

All other model assumptions were kept the same (generation plant, transmission grid, and demand side climate change impacts (electrification of transport and industry, changes to heating and ventilation load, doubling of demand and large build programme of new generation)).

Results showed that increases to wind and water under the climate change scenarios led to a slightly lowered need for new generation capacity (and subsequent new build capital costs) relative to using historical wind and water (see Figure 3 for summary of results). Although this was a small percentage change (2-4% reduction in costs), this is significant when it is considered that $42 billion is expected to be spent by 2030 alone on new infrastructure in the energy system (BCG 2022). This equates to about one less wind (or solar) farm under a mid-range emissions scenario, and four less farms under a high-range emissions scenario.

As flood peaks get bigger under the climate change scenarios, more hydro water will be spilt down spillways without being generated with, and as lake inflows are partially shifted out of summer and into winter, spill

Implications for the electricity system and electricity infrastructure investment, cont.

will be more likely to occur through much of the year instead of being mostly confined to summer. As more water is expected overall, annual hydro generation will increase. The variability in hydro storage will decrease (as incoming water shifts out of summer and into winter, when it is needed), especially in late winter, where climate change scenarios project that lake levels will not drop as significantly as they do currently.

The seasonal and spatial changes to wind and water lead to less system shortages in the climate change scenarios (and therefore less demand response and battery use). As hydro lakes won't spend so much time in the lowest ranges, hydro water is more often available to firm up the intermittency of wind and solar energy.

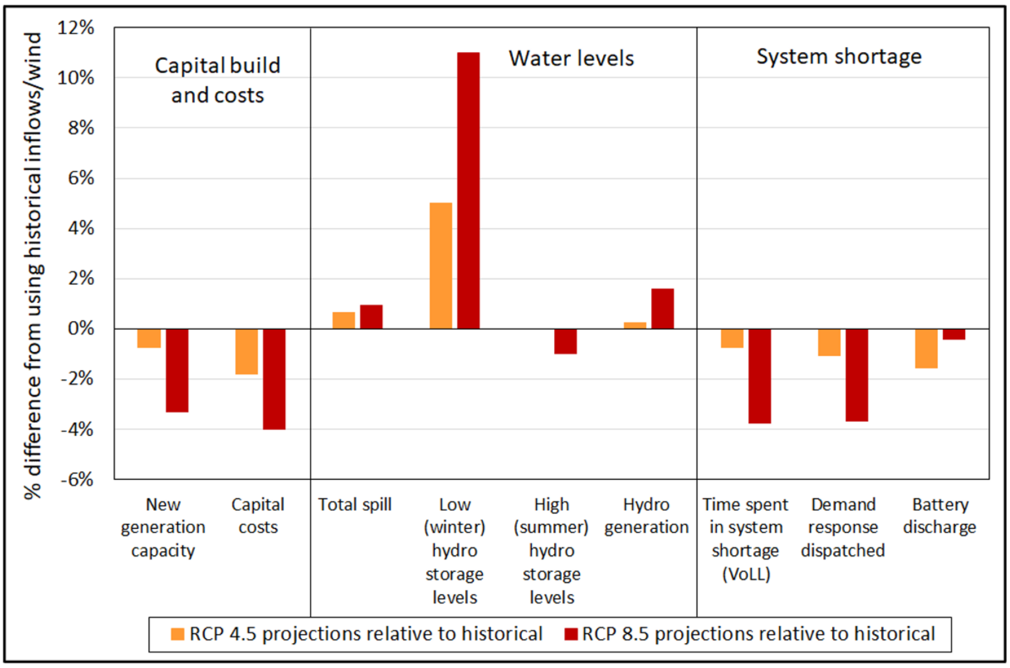


Figure 3: Changes in modelled electricity system by 2050, relative to using historical wind and water data.

Acknowledgements

Climate change data were supplied by Dr Christian Zammit, NIWA (hydrological projections) and Dr Richard Turner, NIWA (wind projections).

The electricity system model used in this research was on license from Meridian Energy Ltd.

Where to go for more information?

The data produced through this research is available on request, by contacting Jen Purdie: Jen.Purdie@otago.ac.nz

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