Meeting Date: 24 October 2018

HIGH-LEVEL IMPLICATIONS OF CLIMATE CHANGE ON ELECTRICITY SECURITY OF SUPPLY

SECURITY AND RELIABILITY COUNCIL

Current models suggest that electricity security of supply will generally be improved by climate change, though there is considerable uncertainty involved in such conclusions. The key reasons to suspect an improvement are: expected increases in total hydro-catchment inflows on average, increases in average wind speeds and flatter inter-seasonal demand for electricity.

Note: This paper has been prepared for the purpose of the Security and Reliability Council. Content should not be interpreted as representing the views or policy of the Electricity Authority.

Contents

1. High-level implications of climate change on electricity security of supply

1.1. The Electricity Authority Board received a paper in June 2018 highlighting key implications for the electricity sector arising from climate change. The Board found it an informative, high-level paper and expressed willingness for the SRC to receive a copy.

1.2. The SRC was advised of this at its 22 June 2018 meeting and agreed to receive the paper. Sections 2-7 of this paper is drawn from the body of the paper received by the Board.

Questions for the SRC to consider

1.3. The SRC may wish to consider the following questions.

Q1. What further information, if any, does the SRC wish to have provided to it by the secretariat?

Q2. What advice, if any, does the SRC wish to provide to the Authority?

2. Introduction

2.1. There are two key cyclical climate patterns that impact New Zealand's weather; the El-Niño Southern Oscillation (ENSO), and the Inter-decadal Pacific Oscillation (IPO). The ENSO cycle has short-term impacts on New Zealand's weather, particularly on rainfall in the South Island. The IPO is a longer-term cycle that influences the behaviour of the ENSO cycle.[1]

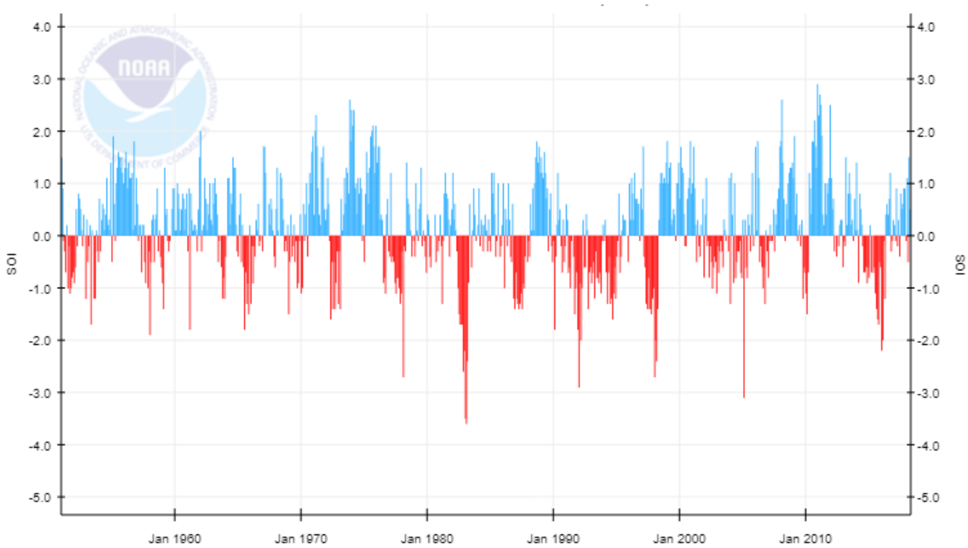
2.2. Long term climate models suggest that global increases in temperature will have an impact on the behaviour of these cycles. In summary, it is expected that there will be an increase in both hydro-catchment inflows and wind in New Zealand, however the year-to-year volatility of total generating output from these sources may increase if installed wind capacity grows.

3. The climate cycles influence the probability of short-term local outcomes

3.1. The ENSO cycle involves changes in the temperature differences between the western and eastern Equatorial Pacific regions. The cycle switches between two 'states'; these states are known as 'El Niño', when the Eastern Pacific heats up relative to the Western Pacific, and 'La Niña', when the Eastern Pacific is relatively cooler.

3.2. The strength of the ENSO cycle is often reported using the Southern Oscillation Index (SOI). The SOI measures sea-level pressure differences between Tahiti and Darwin. Generally, an El Niño (La Niña) 'event' will be declared if the SOI remains strongly and persistently negative (or positive). Figure 1, shows the SOI from 1950 to 2018. A positive SOI (in blue) indicates a La Niña state and a negative SOI (red) an El Niño state.

Figure 1: Southern Oscillation Index



Source: US National Oceanic and Atmospheric Administration

[1] The descriptions and analysis included in this note draw heavily from a joint 2010 NIWA/Meridian Energy Limited paper titled "The effects of climate variability & change upon renewable electricity in New Zealand"

3.3. In an El Niño state, New Zealand generally experiences cooler conditions and stronger westerly winds on average. This generally leads to higher rainfall in western regions, and drier conditions in the north and east.

3.4. In a La Niña state, New Zealand generally experiences reduced westerly winds, with warmer conditions, particularly over summer. Rainfall is higher in the north and east on average, and lower in the west and south.

3.5. It is important to recognise that these impacts are 'on average'. There are significant variations in the New Zealand climate from year to year resulting from local conditions. It is quite possible to get extremely wet conditions in western regions despite being in a La Niña state; which generally exhibits drier conditions on average.

3.6. The IPO cycle impacts on the ENSO cycle, moving between periods of increased El Niño events, to periods of increased La Niña events over a 20 to 30 year cycle. Data suggests that the IPO cycle has been in a high La Niña phase since 2000.

4. El Niño generally increases both wind and hydro generation

4.1. In an El Niño state, stronger westerly winds generally increase the likelihood of rainfall in the West Coast and alpine regions, which comprise the main catchment areas for hydro plant in the South Island. This is offset to some extent by the likelihood of reduced rainfall in the north and east, which encompasses many of the catchments feeding the North Island hydro schemes, and some of the smaller east coast South Island hydro schemes.

4.2. The net effect is an expected increase in average national hydro inflows in an El Niño state. Due to the stronger westerly winds, wind generation also generally increases during El Niño conditions. The opposite is true for La Niña conditions, where rainfall is generally lower in the West Coast and alpine regions, and wind generation drops.

4.3. Analysis of historical wind data and hydro inflows conducted by the Electricity Commission in 2010 supports a moderate correlation between wind and hydro output.[2] Wind speeds were generally found to be higher in periods when total hydro-inflows were higher (although not for all wind farms). The correlation between wind farm output and hydro-inflows has implications for future security of supply management. As the total capacity of installed wind generation increases, the total combined volatility of annual wind and hydro generation output will increase.

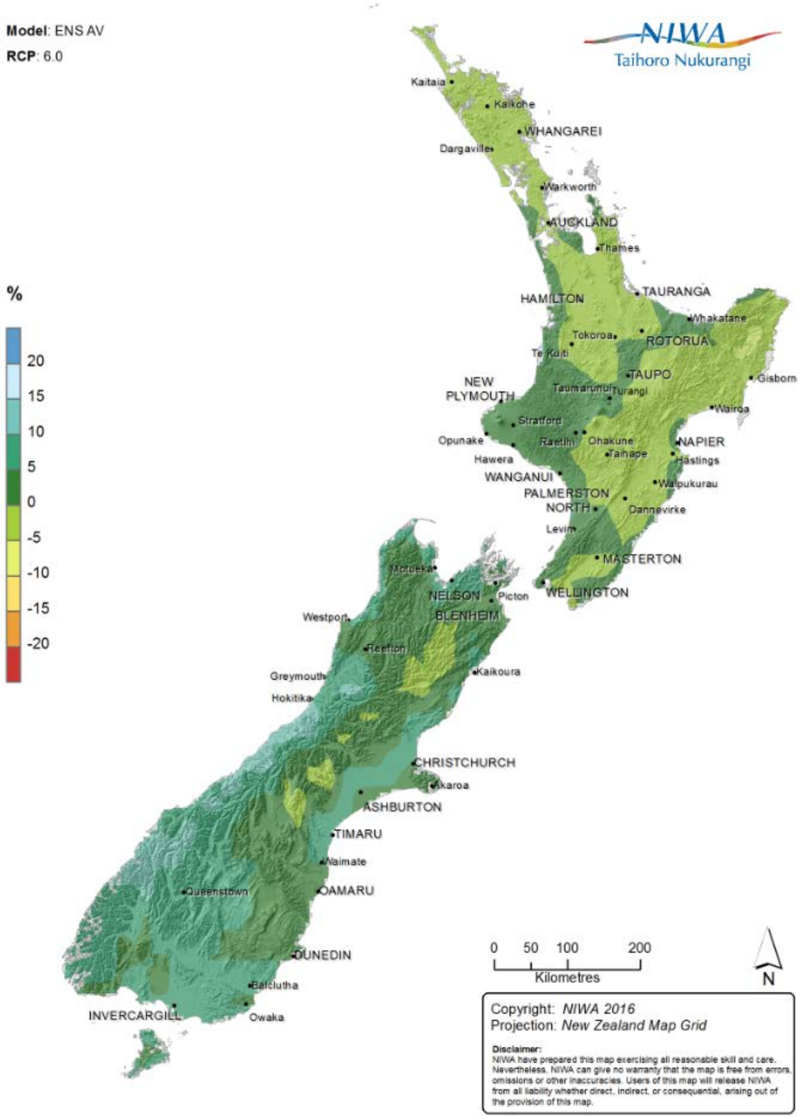
5. Climate change is expected to decrease the likelihood of dry-year events

5.1. Climate models suggest that rising global temperatures will increase westerly wind flows over New Zealand, particularly during winter and spring. There may be some reduction in westerly flows during summer. As with El Niño conditions, the increased westerly flows will generally increase catchment inflows in the South and

[2] Correlation values ranged between 0.33 and 0.44 depending on the windfarm portfolio (a correlation of 1 indicates a perfect positive linear relationship, 0 no relationship, and -1 a perfect negative relationship)

reduce them in the North, with a net increase in total. Over the next few decades it is expected that the probability of dry years will reduce as a result, as the probability of high hydro-inflows increases. NIWA projections are that precipitation will increase by 5-15% by 2055 in the Waitaki catchment area.[3] Rainfall across most North Island catchment areas is expected to reduce by up to 5%.

Figure 2: Projected mean rainfall change between 1995 and 2055



5.2. The increase in average temperatures also suggests that that more precipitation will fall as rain, rather than snow. This may increase the level of inflows into the hydro lakes during winter, at the expense of inflows later in the year resulting from snow melt.

5.3. In the short to medium term, higher temperatures may also result in increased inflows from glacial melt. It is expected that inflows from this resource will eventually

---

[3] Meridian Investor Day presentation November 2017. Projections based on a 'middle of the road' emissions scenario (NIWA RCP6.0 six-model average).

be exhausted if glacial storage shrinks significantly or disappears completely. Glacial melt represents approximately 6-10% of inflows into the Waitaki catchment.

5.4. Meridian Energy maintains a snow storage model that they use to estimate the amount of potential hydro-generation that may result from snow melt during the course of the year. The model, which covers the Waitaki catchment for the period from 1988 onwards, estimates seasonal snow storage based on temperature and precipitation data. The modelling suggests that on average, longer-term snow (or ice) storage has reduced by the equivalent of about 100 GWh each year over the past 30 years. That is, the amount of snow melt that occurs is on average 100 GWh higher than the amount of new snow that is laid down. For comparison, seasonal short-term snow storage captured by the Meridian modelling peaks at an average of around 1,500 GWh each year, although it can vary significantly.

5.5. The estimated reduction in the long-term snow pack during the 2017/18 year was a record 700 GWh. The reduction in long-term snow storage is evidenced by the extent of retreat seen in the South Island glaciers over the past few decades. NIWA projections are that average winter snow depths will reduce by 20-50% by 2090.

5.6. Peak flood volumes may also increase as rainfall increases. This may result in increased short-term spill through some hydro-schemes in order to cope with extremely high inflow events.

5.7. An increase in westerly wind flows would also be expected to result in higher wind generation in total. While the utilisation of existing wind farms should increase, there is also an increased likelihood of extreme wind events which may result in an increased number of times where turbines need to shut down to avoid damage from strong winds. Extreme wind events (and flooding for that matter) also pose risks for transmission and distribution network assets.

6. The annual demand profile through the year is likely to change

6.1. An increase in average temperatures will also have implications for demand patterns in New Zealand. There is likely to be an increase in summertime cooling requirements in the northern parts of New Zealand. Wintertime heating requirements are likely to reduce. The net effect will be a general flattening of the annual demand profile. Daily consumption profiles may become peakier in some areas if air-conditioning loads increase significantly in response to increased summer temperatures.

6.2. The combination of a flatter annual demand profile and changing inflow patterns associated with more precipitation falling as rain may have some impact on the requirement for inter-seasonal hydro storage. Higher hydro inflows in winter combined with lower demand over that period will help to better balance demand and supply over the year.

7. Conclusion

7.1. While it is not possible to be completely certain about the future impact of climate change on security of supply, current models suggest that the expected increase in westerly wind flows over New Zealand will result in increased total hydro-catchment inflows on average, and increased average wind speeds. This should increase the average total output of existing hydro and wind generating plant. The inter-seasonal balance between demand and supply may improve as more precipitation falls as water in the winter rather than snow, and demand profiles across the year flatten. These are generally positive outcomes from a security of supply perspective.

7.2. The correlation between wind speed and hydro-inflows means that a dry year also carries an increased risk of lower wind farm output. If the installed capacity of wind plant in New Zealand significantly increases, then the combined impact of lower hydro-inflows and lower wind output could become more challenging to cope with during a dry year as the absolute difference between average output and dry-year output grows.

Table 1: Summary of the general impact of each climate pattern

	El Niño	La Niña	Climate change
North Island inflows	↓	↑	↓
South Island inflows	↑	↓	↑
Total inflows	↑	↓	↑
Average wind speed	↑	↓	↑
Total impact on hydro/wind output	↑	↓	↑