Within-island basis risk: Quantifying the risk

Preview of statistical analysis for the LPRTG

January 2013

Contents

Figures

1 Purpose of this report

1.1 The locational price risk technical group (LPRTG) are considering ways to manage within island basis risk (WIBR). In order to determine how WIBR can best be managed, it is important to first describe and quantify the risk.

1.2 The Electricity Authority (Authority) intends to release a consultation paper on options for managing WIBR during June 2013. In order to achieve this objective, the paper “Within-island basis risk: Characterising the risk”, was tabled at the LPRTG meeting on 27 November 2012. That paper set out a methodology for quantifying WIBR and demonstrated how it could be applied. This paper applies that methodology and discusses the outcomes.

1.3 LPRTG members are asked to review the findings of this paper. At the LPRTG’s next meeting on 14 February 2013, the group will be asked to consider the merits of several high-level options for managing within-island basis risk (WIBR), based on the analysis in this paper.

2 Summary of findings

2.1 In applying the framework, this paper:

(a) recaps the framework for the statistical approach in light of feedback from LPRTG

(b) estimates the level of WIBR associated with each region of the country, and separates this “regional risk” into *tidal flows* and *spikes*, noting that:

  (i) *tidal flows* cause WIBR throughout the country, but participants should largely be able to manage such risks using products denominated at Otahuhu (OTA) and Benmore (BEN)

  (ii) *spikes* can cause much higher WIBR in some local areas – especially in areas where pivotal supplier situations occur

(c) sets out several key design decisions in the statistical methodology (some of which were queried by the LPRTG at the November 2012 meeting), showing how the results might change if different decisions had been taken, and concludes that the results appear reasonably robust to changes in the approach

(d) tests several different future scenarios, on the basis that 'the future may be different from the past', and concludes that these scenarios do not undermine the key findings, but do raise the issue that increased locational price risk (LPR) may arise in the lower North Island

(e) discusses some specific challenges associated with managing locational price risk (LPR) in the lower North Island, concluding that such risks can be managed using a combination of products denominated at OTA and BEN, but this may be expensive and some risk may remain

(f) estimates the level of WIBR *within* each region of the country (“local risk”), noting again that *spikes* can cause high levels of WIBR in some local areas.

2.2 The results presented are **draft**. Please provide any feedback by 5pm 30 January 2013, so that the analysis can be finalised before the LPRTG meeting on 14 february 2013.

3 Agreed framework for the statistical approach

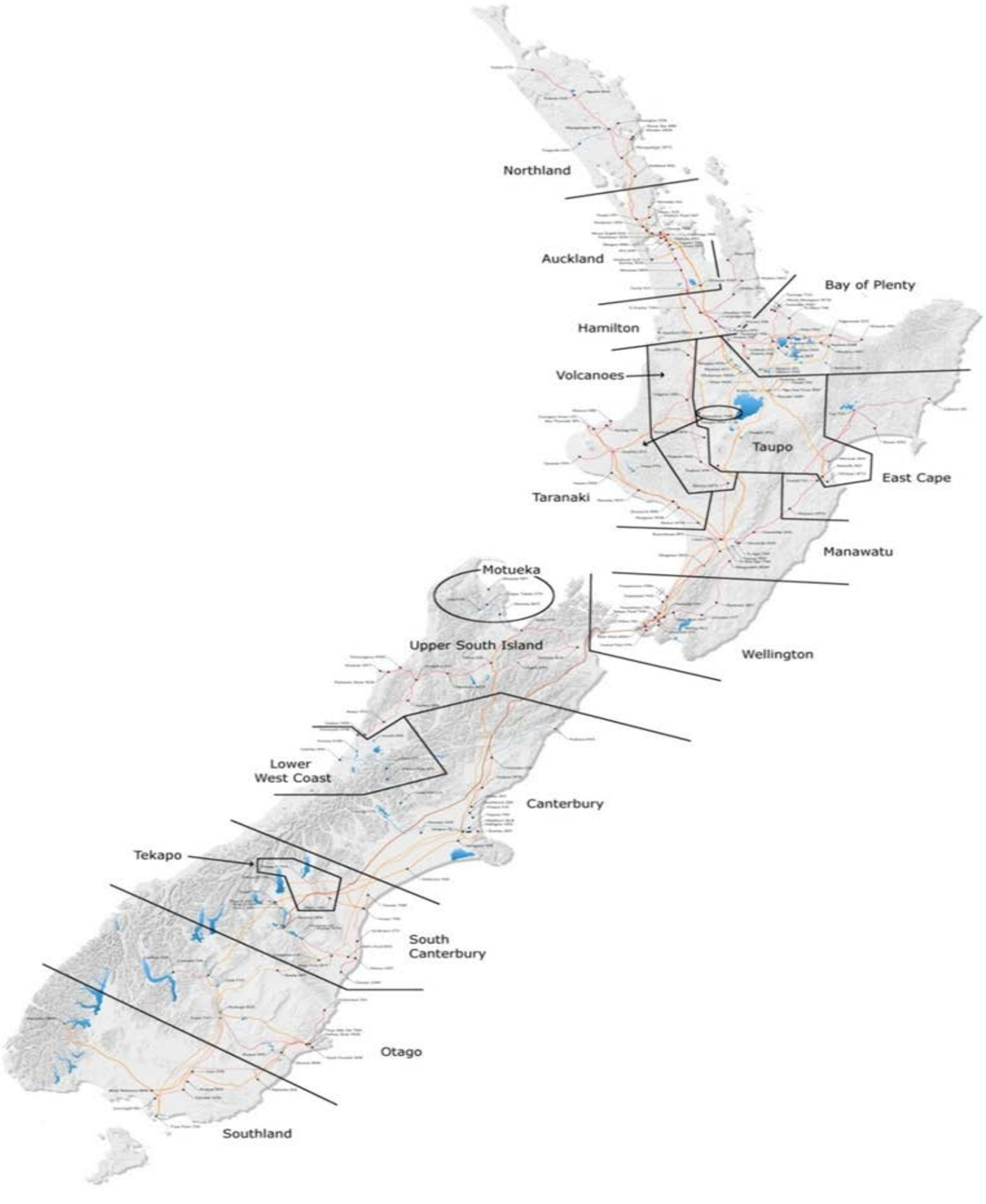
3.1 This paper distinguishes between:

(a) **regional risk** (defined in terms of differences between the price at a reference node in the region and an appropriate linear combination of prices at OTA and BEN – representing the component of price risk that cannot be managed by products denominated at OTA and BEN)

(b) **local risk** (defined in terms of differences between the price at an individual node and a scalar multiple of the price at the regional reference node).

3.2 The regions used for the purposes of analysis (which have not changed since the 27 November 2012 paper) are shown below.

Figure 1 Regions used for the purpose of analysis



3.3 At the 27 November 2012 meeting, the LPRTG asked whether these regions are consistent with distributor network areas. The answer is no – they are not well aligned with network areas at all. The region boundaries used here are based on actual price risks experienced on the system, and these need not have anything to do with network ownership.

3.4 The basic measure of regional locational price risk is:

RR_{reg} = root-mean-square over m of ($MM_{ref(reg)}$, $_{m}$ – (A x $MM_{OTA, m}$ + B x $MM_{BEN, m}$))

where: RR_{reg} is a measure of the regional risk associated with region *reg*;

m are months;

$MM_{n,m}$ is the mean price at node n during month m;

ref(reg) is a reference node within region *reg*; and

A and *B* are chosen so as to minimise squared differences between $MM_{ref(reg), m}$ and (A x $MM_{OTA, m}$ + B x $MM_{BEN, m}$) under normal conditions. The differences that remain represent the locational price risk.

3.5 This measure has changed in two respects since the Nov 27 paper:

(a) it is now based on root-mean-square (RMS) rather than standard deviation – the two only differ if the mean difference between the regional price and the hedge price is nonzero

(b) the hedging coefficients are now fitted based on a dataset that excludes spikes – this reflects that participants do not have perfect foresight and might not foresee extreme price events when making their hedging arrangements. (For the avoidance of doubt, the spikes are excluded when fitting *A* and *B,* but reincluded when calculating RR_{reg}*.).*

3.6 Some alternative measures have also been considered in response to LPRTG feedback. In particular, section 5 of this paper explores the consequences of measuring WIBR:

(a) using coefficient of variation (CVar) rather than RMS

(b) on a daily timeframe rather than a monthly timeframe

(c) based on a limited portion of the available historical data (e.g. the last 5 years, or the preceding 5 years, rather than the entire last decade)

(d) relative to various different hedging strategies (e.g. hedging at a single reference node, rather than using a linear combination of OTA and BEN)

(e) for a shaped profile rather than a flat profile.

3.7 The basic measure of local locational price risk is:

LR_{n} = root-mean-square over m of ($MM_{n, m}$ – *alpha* x $MM_{ref(reg)}$, m)

where: LR_{n} is a measure of the local risk associated with node n in region reg;

m are months;

$MM_{n, m}$ is the mean price at node n during month m;

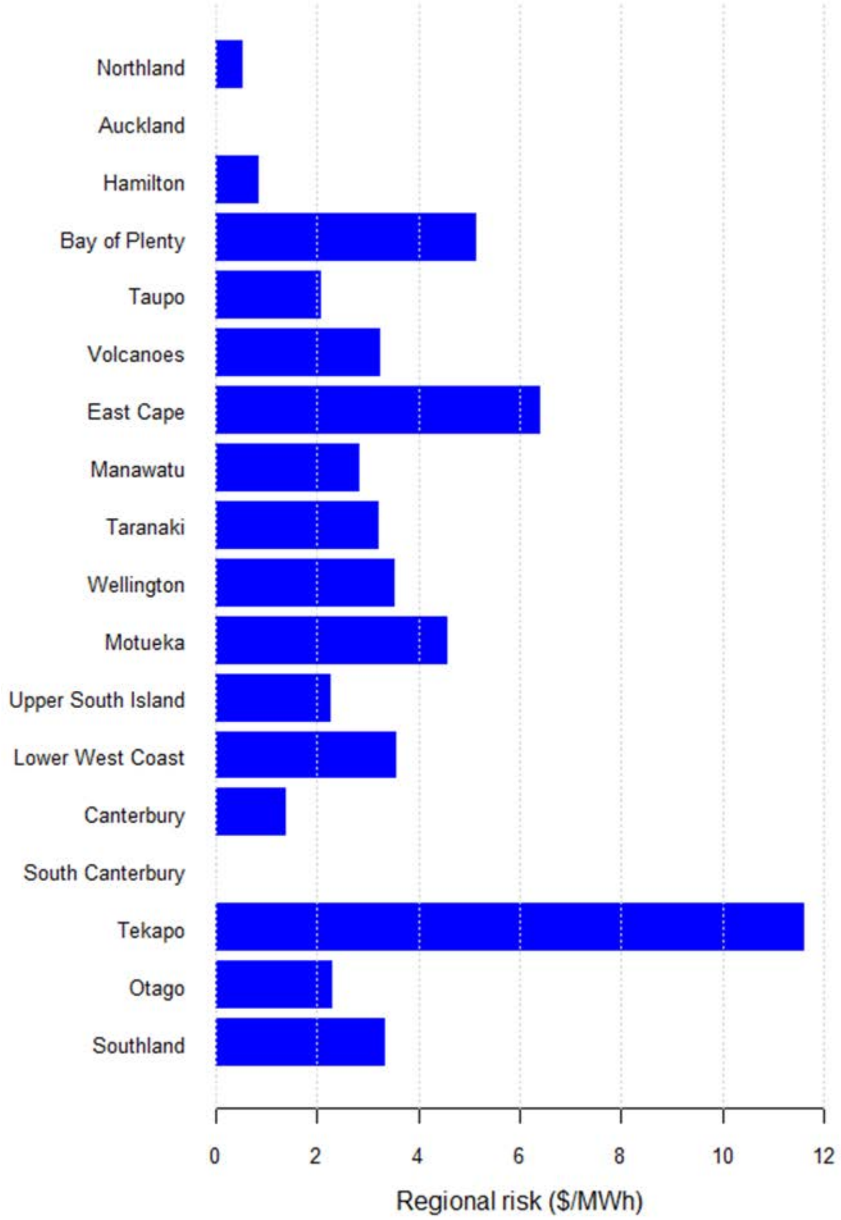
ref(reg) is the reference node within region *reg*; and

alpha is chosen to minimise squared differences between MM_{n} and *alpha x* $MM_{ref(reg)}$ under normal conditions.

4 Regional risk: Tidal flows cause WIBR that can be managed; spikes can cause higher WIBR in some regions

4.1 Here is the basic measure of regional risk, based on historical data from Jan 2001 to Sep 2012.

Figure 2 Basic measure of regional risk



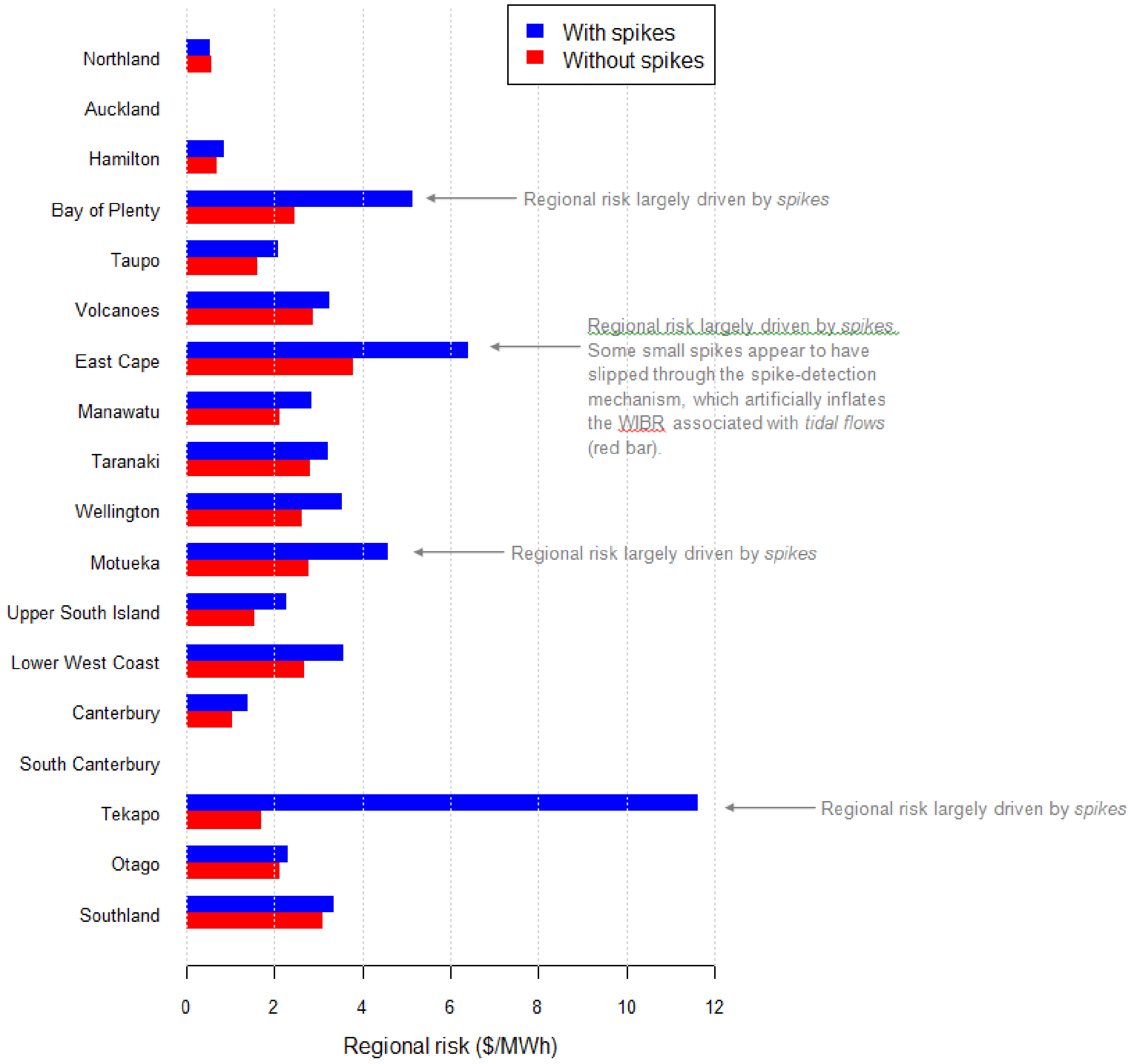
4.2 In interpreting these results, bear in mind that they represent a root-mean-square, which is quite similar to a standard deviation.

4.3 So, if the regional risk measure was $X/MWh, and regional risks were normally distributed, then a 90% probability interval for the difference between the regional mean price and the hedge price in a given month would be [-1.65 x $X/MWh, 1.65 x $X/MWh]. However, as will be shown, regional risks are typically skewed to the right.

4.4 Figure 3 shows that the highest regional risks (e.g. at Tekapo) are associated with *spikes*.

4.6 By removing *spikes* from the source data (using the criteria set out in the 27 Nov paper), we can isolate the part of the risk that stems from *tidal flows* (red):

Figure 3 Basic measure of regional risk with spikes removed



Regional risk largely driven by *spikes*

Regional risk largely driven by *spikes*. Some small spikes appear to have slipped through the spike-detection mechanism, which artificially inflates the WIBR associated with *tidal flows* (red bar).

Regional risk largely driven by *spikes*

Regional risk largely driven by *spikes*

4.7 The level of locational price risk associated with *tidal flows* does not appear to be commercially material. There are no regions where the component of the risk driven by tidal flows is substantially above $3/MWh. Compare this with the benchmarks set out in the 27 Nov paper:

(a) basis risk at Otahuhu has a monthly standard deviation of over $40/MWh

(b) *inter*-island price risk has a monthly standard deviation of over $10/MWh

(c) net retail margins may be on the order of $10-15/MWh.

4.8 The conclusion is that participants should largely be able to manage WIBR associated with *tidal flows* using products denominated at OTA and BEN. *Spikes* can, however, cause a much higher level of WIBR in some local areas. These include Tekapo, Motueka and East Cape – all of which have been affected by pivotal supplier situations in recent years.

4.9 Appendix A shows how regions differ in terms of “magnitude” – i.e. the amount of load and/or generation they contain.

5 Alternative approaches to estimating regional risk show key results are reasonably robust to changes in the approach

5.1 This section tests how the results might change if different approaches to the framework had been made.

Using CVar instead of RMS

5.2 The LPRTG noted that it may be useful to measure regional risk using CVar rather than standard deviation (which was the proposal at the time and is nearly equivalent to RMS).

5.3 Indeed, RMS has some disadvantages. It does not distinguish between situations where the regional reference price exceeds the hedge price (a downside risk to parties that are *short* in the region) and situations where the reference price is less than the hedge price (a downside risk to parties that are *long* in the region). It is also sensitive to extreme outliers.

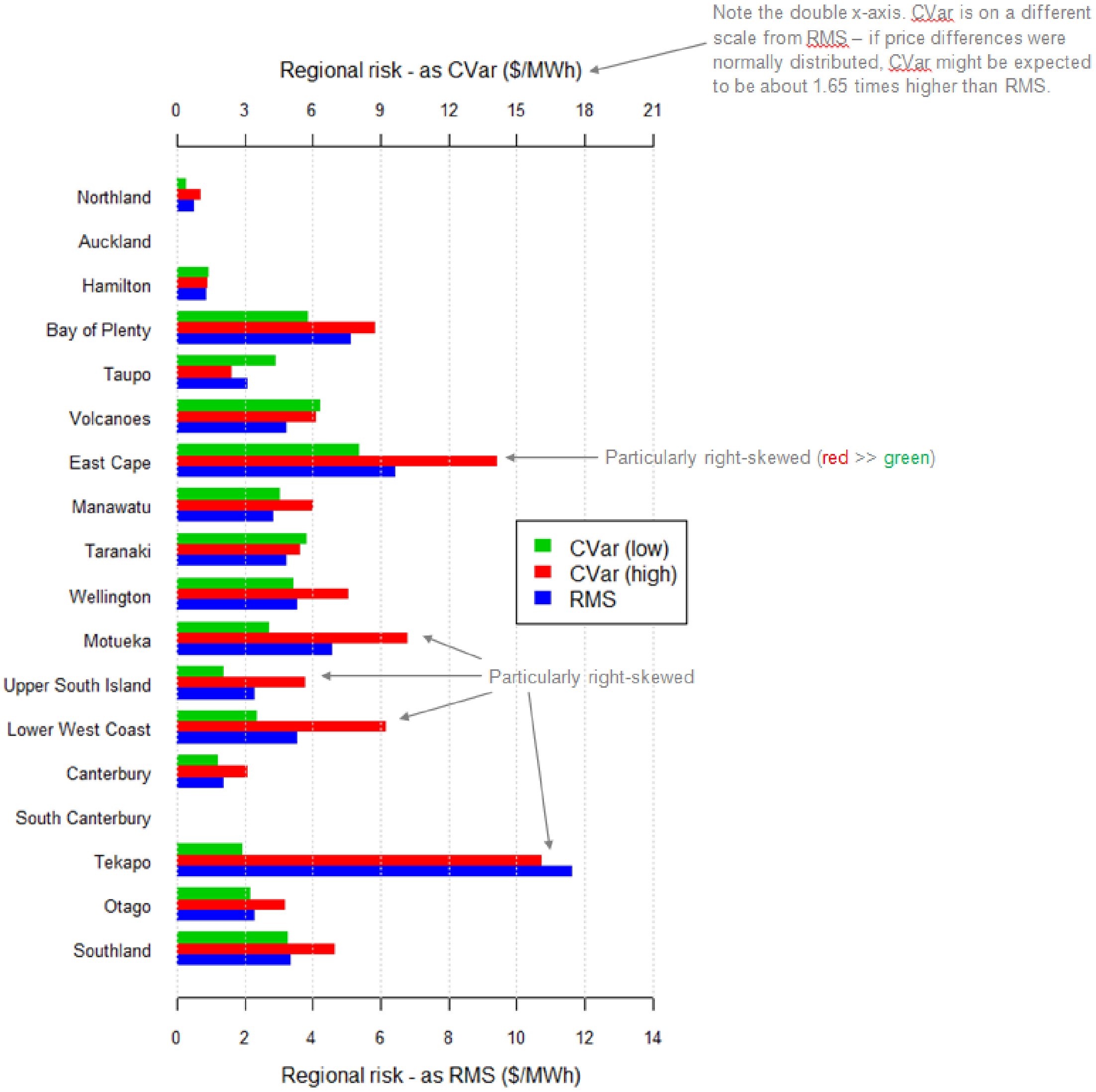
5.4 Figure 4 compares three measures of regional risk (including both *spikes* and *tidal flows*):

(a) “CVar low” – the mean of the bottom 10% of price differences, measuring the risk faced by parties that are long in the region

(b) “CVar high” – the mean of the top 10% of price differences, measuring the risk faced by parties that are short in the region

(c) RMS.

Figure 4 Three measures of regional risk (including both *spikes* and *tidal flows*)



Note the double x-axis. CVar is on a different scale from RMS – if price differences were normally distributed, CVar might be expected to be about 1.65 times higher than RMS.

Particularly right-skewed (red >> green)

Particularly right-skewed

5.5 The CVar measures show broadly the same story as RMS, except that differences between regional prices and hedge prices are right-skewed. “CVar high” exceeds “CVar low” for most regions, particularly East Cape, Motueka and Tekapo (which are all affected by *spikes*) as well as Upper South Island and Lower West Coast. In other words, the downside risk faced by a local purchaser is typically greater than the downside risk faced by a local supplier.

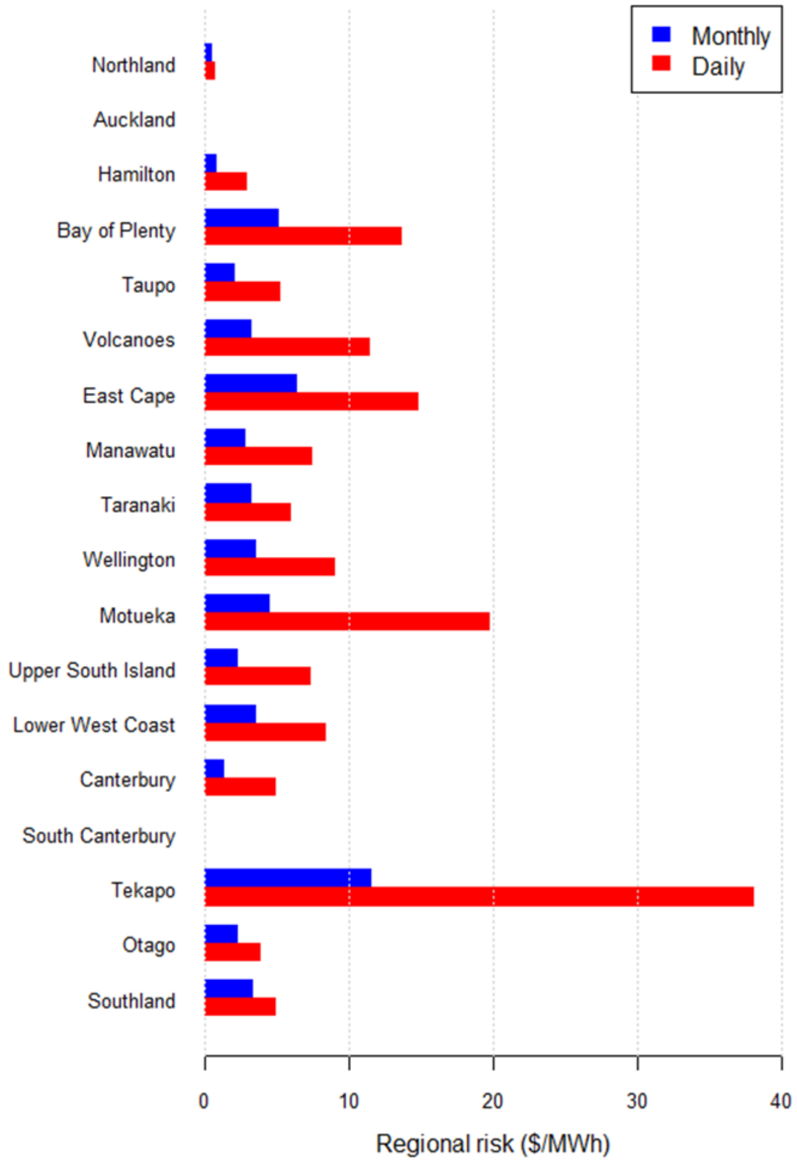
5.6 The remainder of this paper uses RMS rather than “CVar high” and “CVar low”, because the two approaches are broadly similar and it is easier to show a single measure rather than two separate measures.

Daily timeframe instead of monthly

5.7 The LPRTG asked for the results to be presented on various time scales, from half-hourly up to monthly. Due to time constraints it has not been possible to show all these time scales – however, daily results are presented below.

5.8 Figure 5 compares daily and monthly regional risks in absolute terms:

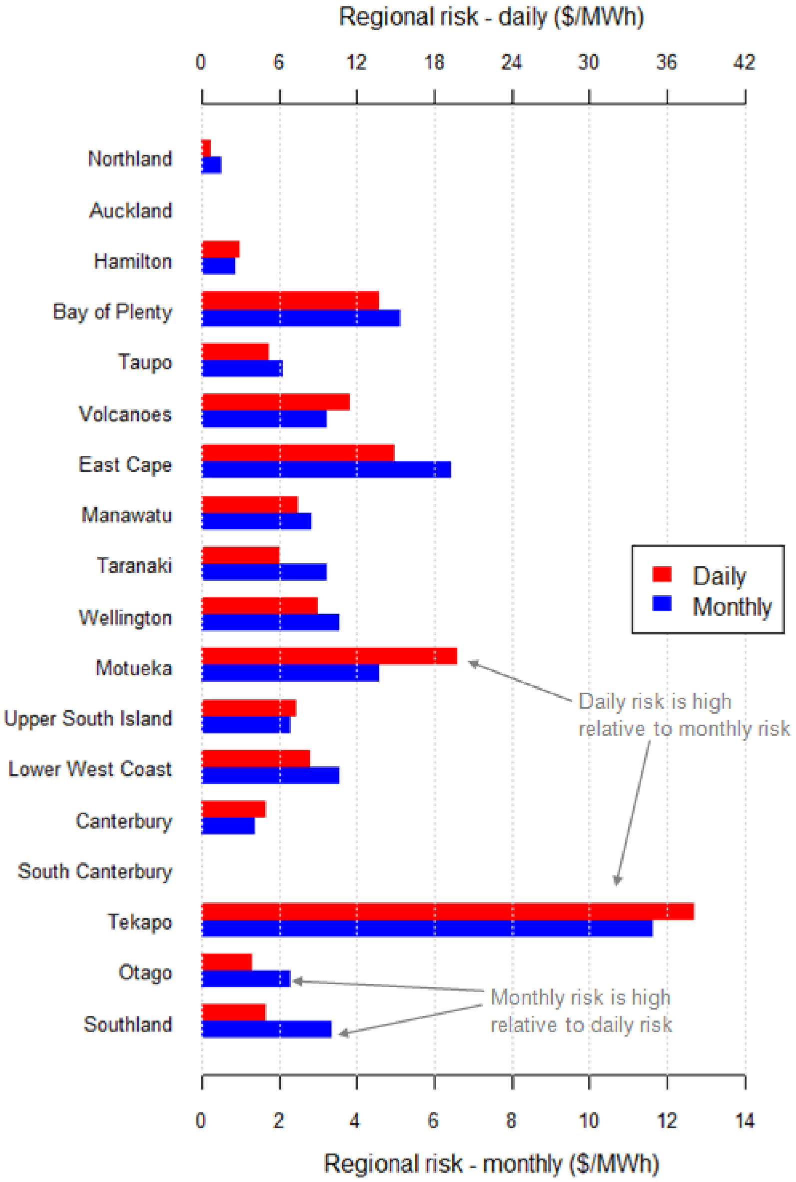
Figure 5 Daily and monthly regional risks in absolute terms



5.9 Clearly the level of regional risk is higher on a daily basis than on a monthly basis – there is more price variability from day to day than from month to month. This is true not only of WIBR, but also of inter-island basis risk and overall basis risk.

5.10 Figure 6 uses a double x-axis to compare daily and monthly risks in relative terms:

Figure 6 Daily and monthly risks in relative terms



5.11 The daily analysis shows broadly the same trends as the monthly analysis, except that the measure of daily risk is more driven by *spikes* (e.g. red is longer than blue for Motueka and Tekapo) and the measure of monthly risk is more driven by *tidal flows* (e.g. blue is longer than red for Otago and Southland).

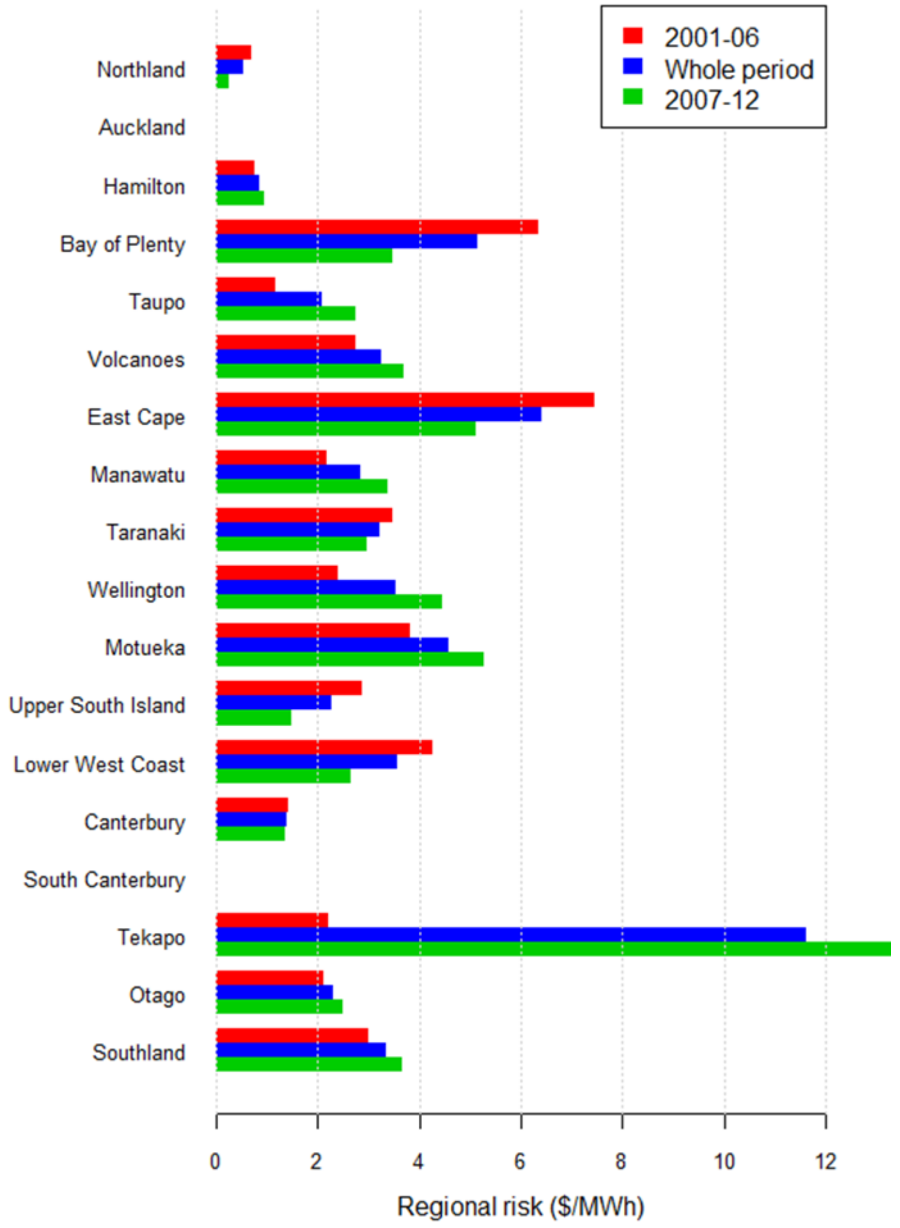
5.12 The remainder of this paper is based on monthly risks rather than daily risks.

5.13 If the analysis was instead to be carried out in terms of daily risk, then the benchmarks of commercial materiality (such as the level of *inter*-island price risk) should also be expressed on a daily level – which would tend to push them substantially higher. As a result, overall conclusions might not differ greatly – except that more emphasis would be placed on *spikes* and less on *tidal flows*.

Using a limited portion of the historical data

5.14 The Nov 27 paper showed how the results are affected by using a limited portion of the historical data, for a subset of regions. This analysis is repeated here, for all regions.

Figure 7 Regional risk with limited historical data



5.15 Generally the pattern of risks remains broadly the same, but there are some significant differences:

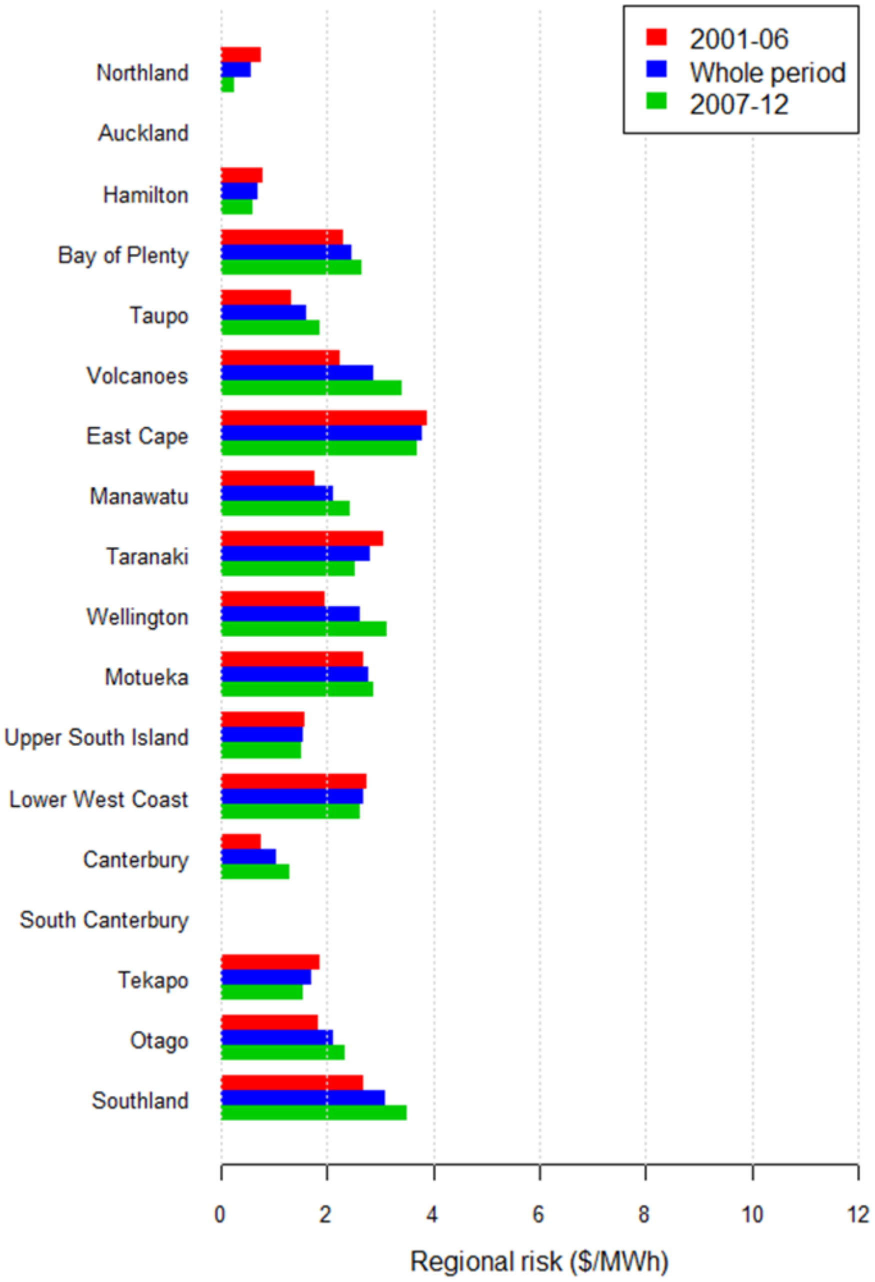
(a) Bay of Plenty, East Cape, Upper South Island and Lower West Coast experienced more variability in the early 2000s (red > green)

(b) Tekapo and Motueka experienced more variability in the recent past, associated with pivotal supplier situations (green > red).

5.16 Wellington also experienced more variability post 2007, associated with increasingly frequent North Island price spikes – as discussed later in the paper (see Section 7).

5.17 Many of the differences are driven by inclusion or exclusion of the year(s) in which *spikes* occurred. The comparison is therefore repeated with *spikes* removed:

Figure 8 Regional risk with limited historical data, spikes removed



5.18 The component of regional risk associated with *tidal flows* changed relatively little over the last decade.

5.19 The remainder of this paper uses the full dataset (2001 to 2012), in order to obtain the largest possible sample size.

Different hedging strategies

5.21 The base case assumes that participants will hedge regional risks using a linear combination of products at OTA and BEN (which might be energy hedges or obligation FTRs). The LPRTG commented that some participants may use less sophisticated approaches in practice and suggested that different hedging strategies should be considered.

5.22 Accordingly, four hedging strategies are modelled.

(a) no hedging at all (so the participant is exposed to the full variability of prices at the regional reference node)

(b) hedging each 1 MW in the region with 1 MW at the island reference node (OTA or BEN)

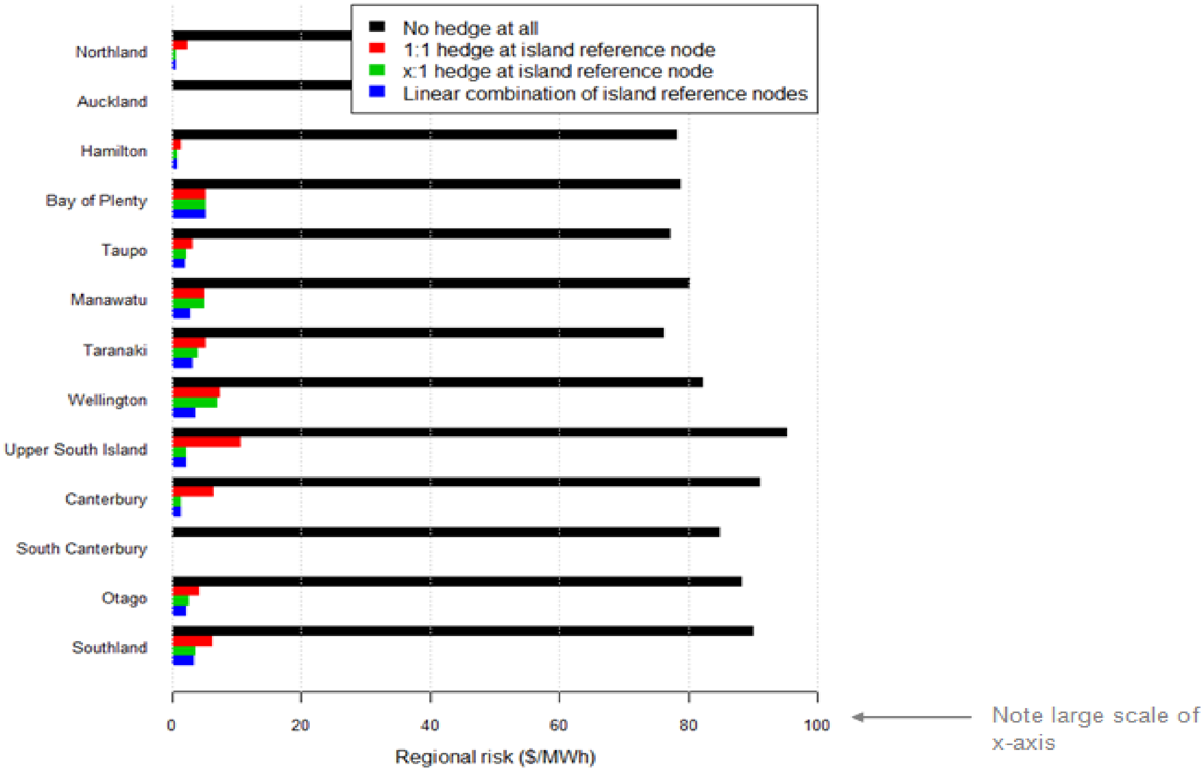
(c) hedging each 1 MW in the region with X MW at the island reference node (OTA or BEN), where X is chosen to minimise errors

(d) the base case – hedging each 1 MW in the region with A MW at OTA and B MW at BEN, where A and B are chosen to minimise errors.

5.23 All four strategies are somewhat simplistic – as the intention is to assess the nature and extent of WIBR, rather than to model the full complexity of real-life hedge arrangements.

5.24 Figure 9 shows the level of regional risk associated with each hedging strategy.

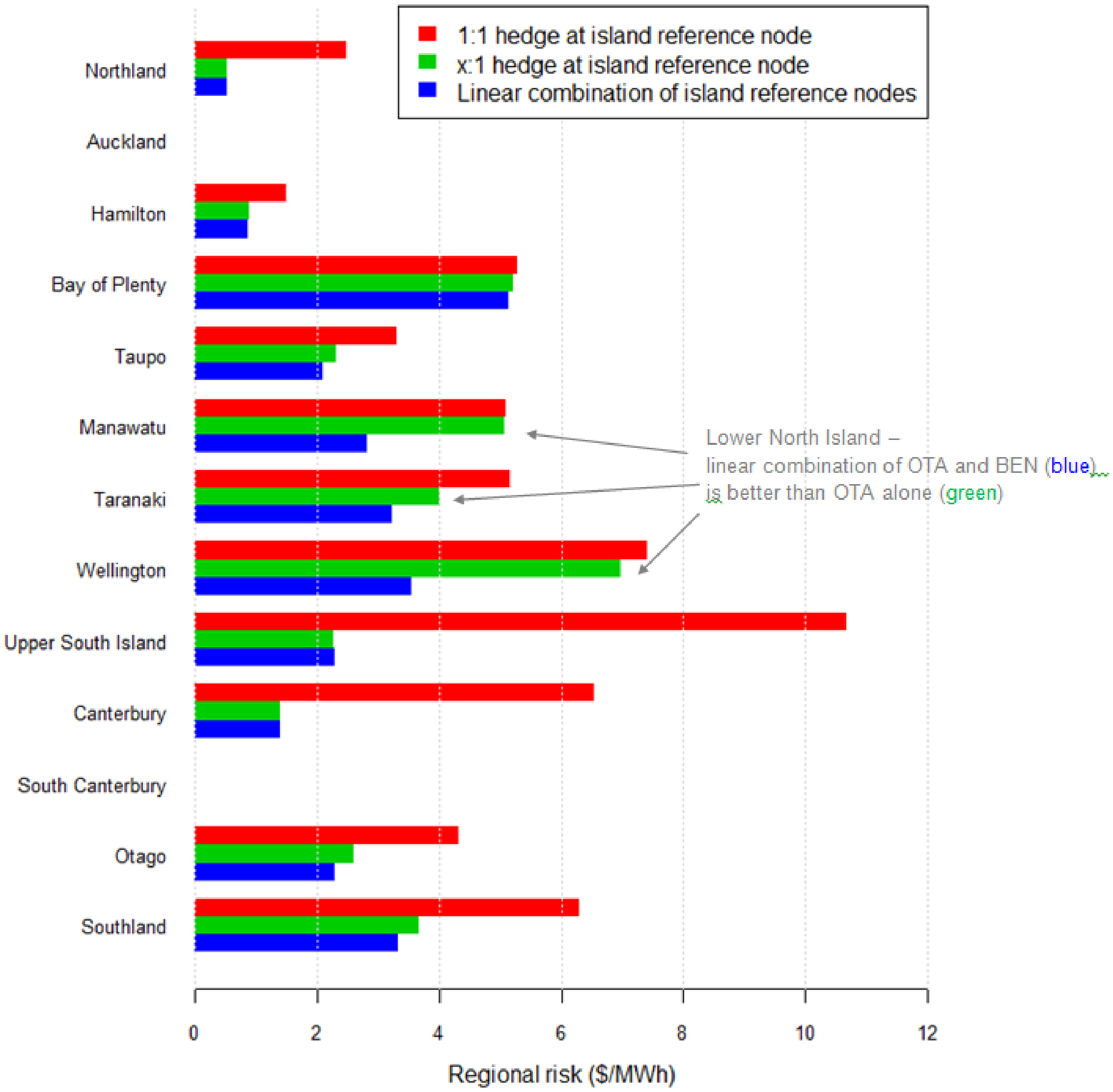
Figure 9 Level of regional risk associated with each hedging strategy



5.25 Clearly, if there are participants that are unable to hedge at all, then they are exposed to a great deal of price risk (**black** bars).

Figure 10 is more legible, as the black bars are omitted, it shows the level of regional risk associated with the three hedging strategies:

Figure 10 Level of regional risk associated with three hedging strategies



5.26 The 1:1 hedge at the island reference node (red) is a poor option for remote regions with high location factors (such as Northland or the Upper South Island).

5.27 The X:1 hedge at the island reference node (green) is a good option in most areas. However it performs poorly in the Lower North Island. Prices in the LNI are “somewhat like OTA”, but also “somewhat like BEN”. Using an OTA-based hedge alone is not sufficient here (see Section 7).

5.28 The linear combination of OTA and BEN is the best option overall.

5.29 The analysis of regional risk in this paper is based on the assumption that participants can hedge to a linear combination of OTA and BEN. However, if some participants in the Lower North Island were unable to make such arrangements, then they could be exposed to material levels of WIBR.

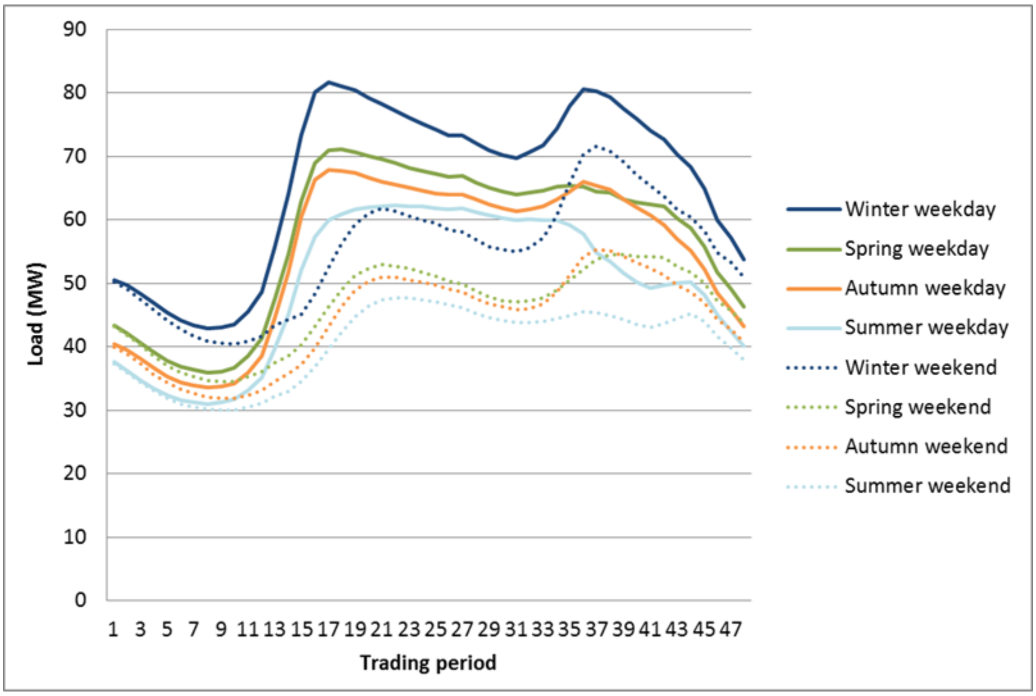
5.30 Hedge coefficients may be of interest and are shown in Appendix B.

Shaped profile instead of flat profile

5.31 The base case analysis is based on monthly time-weighted average prices (TWAP), so it implicitly assumes a flat profile, such as might be associated with a flat industrial load or a baseload generator. The LPRTG asked for the analysis to be repeated using a shaped profile.

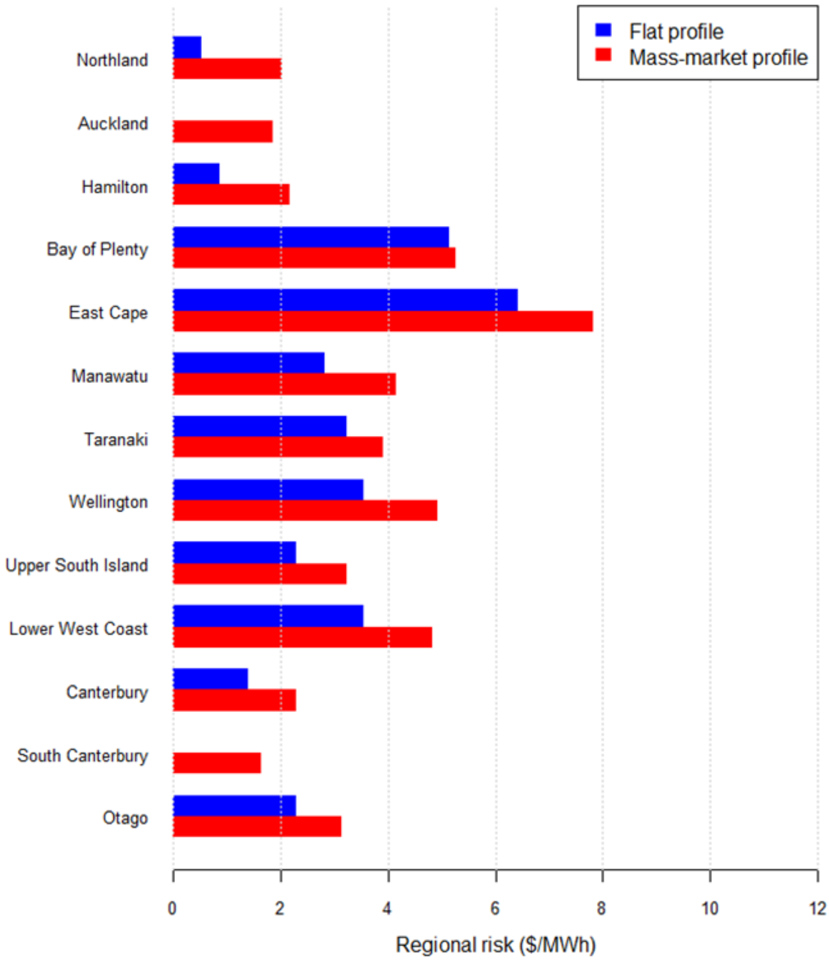
5.32 The analysis has been carried out for the following load profile, which might be typical of a mass-market (mixed commercial and residential) load.

Figure 11 Base case analysis for a shaped profile



5.33 Figure 12 shows the differences in regional risk between a flat load and the mass-market profile. In both cases, the load is hedged against flat products at BEN and OTA.

Figure 12 Differences in regional risk between a flat load and the mass-market



5.34 The mass-market load (red) is exposed to increased price risk in all regions, even at BEN and OTA (where hedges are available). This is a consequence of trying to hedge a shaped load with a flat hedge product. In other words, the risk shown is no longer WIBR alone, but is now a combination of WIBR and **within-day** price risk.

5.35 In other respects, the trends shown for the mass-market profile are reasonably consistent with those shown for the flat profile.

5.36 The remainder of this paper is based on flat profiles rather than shaped profiles, on the basis that using a flat profile focuses on WIBR alone – which is preferable to rolling WIBR and within-day risk together.

6 Scenario analysis shows key results are robust, and raises concerns about LPR in the LNI

6.1 The LPRTG agreed that “the future is different from the past” and that scenario analysis should be undertaken to test how the nature and extent of WIBR may change over time. However, LPRTG provided relatively little guidance as to what scenarios should be considered. A selection of key scenarios has therefore been put together.

6.2 The scenarios considered are:

(a) dry-year events becoming more or less common (or prices in such events becoming more or less extreme – it turns out that the same experiment tests both contingencies)

(b) wet-year events becoming more or less common

(c) North Island-wide price spikes becoming more or less common (or, again, prices in such events becoming more or less extreme)

(d) north flow constraints on the North Island backbone becoming more or less common

(e) north flow constraints on the South Island backbone becoming more or less common

(f) changes in offer behaviour in pivotal supplier situations.

6.3 The LPRTG had also suggested that the effect of the North Island Grid Upgrade (NIGU) becoming available should be considered. This case has not been included, however, as the absence of the NIGU has had very little impact on WIBR to date.

6.4 The LPRTG had also suggested that the effect of some North Island thermal generation becoming unavailable should be considered. This case has not been explicitly included, but its effects might be implicitly covered through some of the scenarios above.

6.5 All of the above scenarios have been addressed in the same way – by selecting the set of historical months that meet the relevant criterion, and increasing or decreasing the weight assigned to those months in the calculation of regional risk. For instance, the scenario where “dry-year events become more common” is modelled by multiplying the weight assigned to May-July 2008 by a factor of four.

6.6 This approach was selected because it is easy to implement and (arguably) quite intuitive.

6.7 Upweighting a set of months by a factor of **four** can be interpreted as:

(a) the relevant system conditions becoming **four times** more common or

(b) prices being **twice as high** under such system conditions as they have been in the past.

6.8 Conversely, downweighting a set of months by a factor of **four** can be interpreted as:

(a) the relevant system conditions becoming **a quarter** as common or

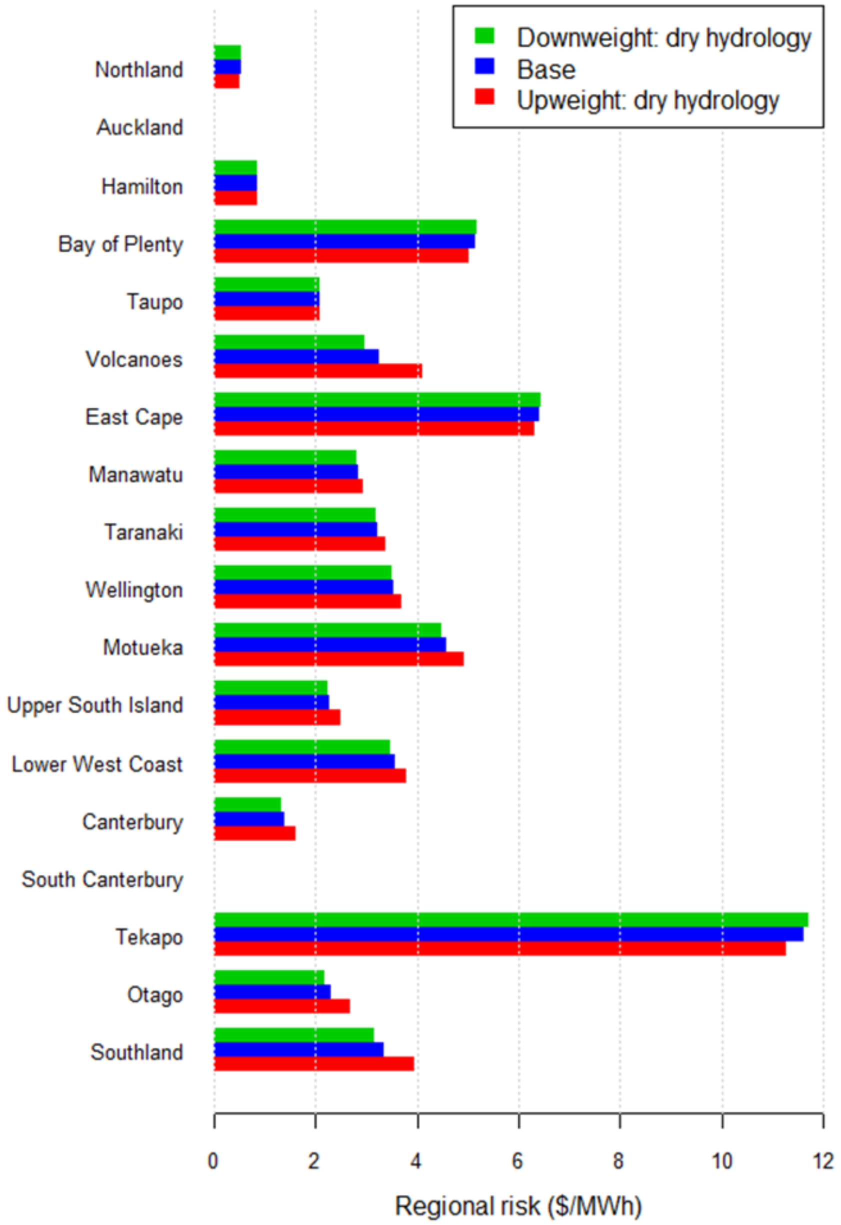
(b) prices being half as high under such system conditions as they have been in the past.

(c)

Dry periods

6.9 It is credible that the frequency of dry-year events might change (perhaps due to changes in the supply-demand balance) or that the level of prices during such events might change (perhaps due to commercial decisions by participants). Figure 13 shows the effect of upweighting or downweighting the dry winter of May-July 2008 by a factor of four.

Figure 13 Effect of upweighting or downweighting the dry winter of May-July 2008



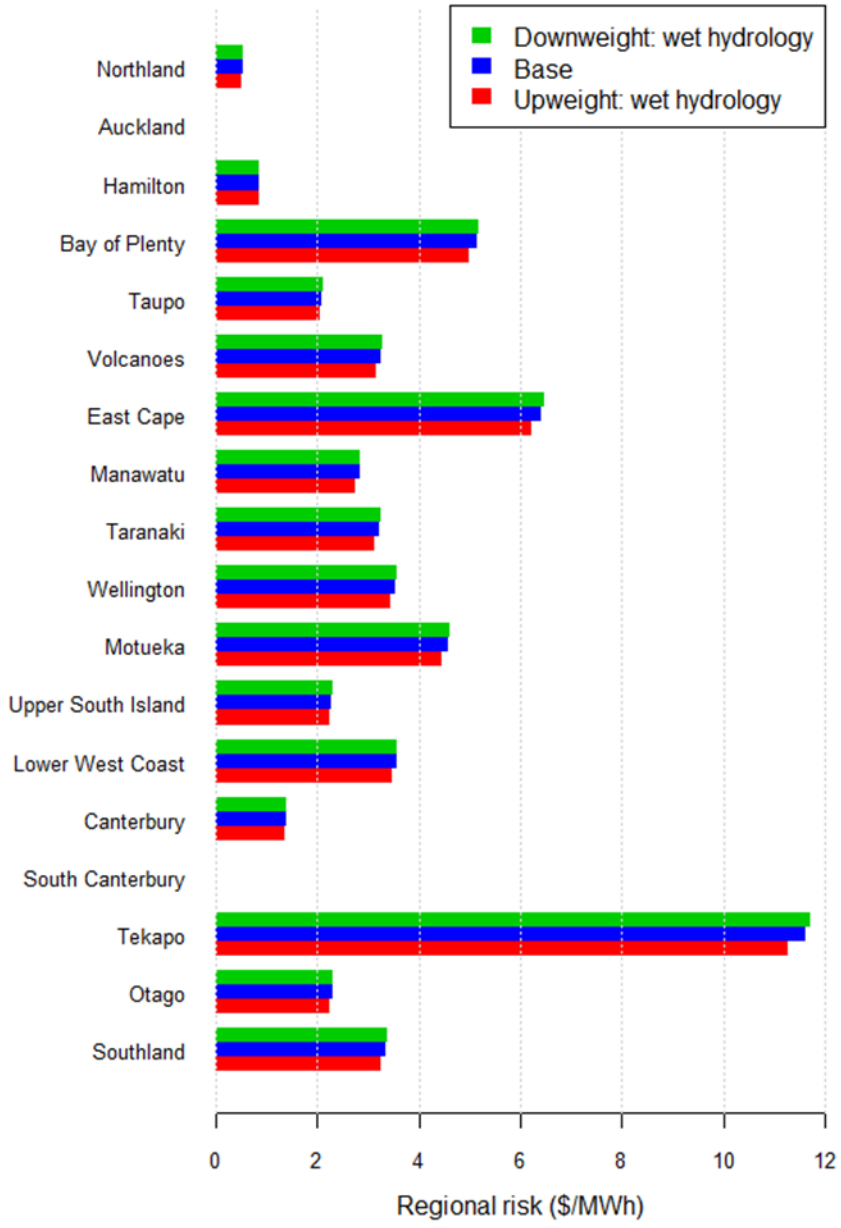
6.10 More frequent dry periods, or higher prices during dry-year events, would doubtless lead to increased *inter*-island price risk and increased quantity risk for many parties. However, the analysis above suggests that the effect on *WIBR* would actually be quite small (at least, for parties pursuing a prudent hedging strategy using products at OTA and BEN).

6.11 This scenario does not challenge the key findings on page 1.

Wet periods

6.12 Figure 14 shows the effect of upweighting or downweighting the summer of Nov 2007 – Jan 2008 by a factor of four. This period featured wet hydrology and steady north flow on the bipole HVDC link. It is credible that such conditions might become more common in future, particularly once HVDC Pole 3 is in operation.

Figure 14 Effect of upweighting or downweighting the wet summer of Nov 2007 – Jan 2008



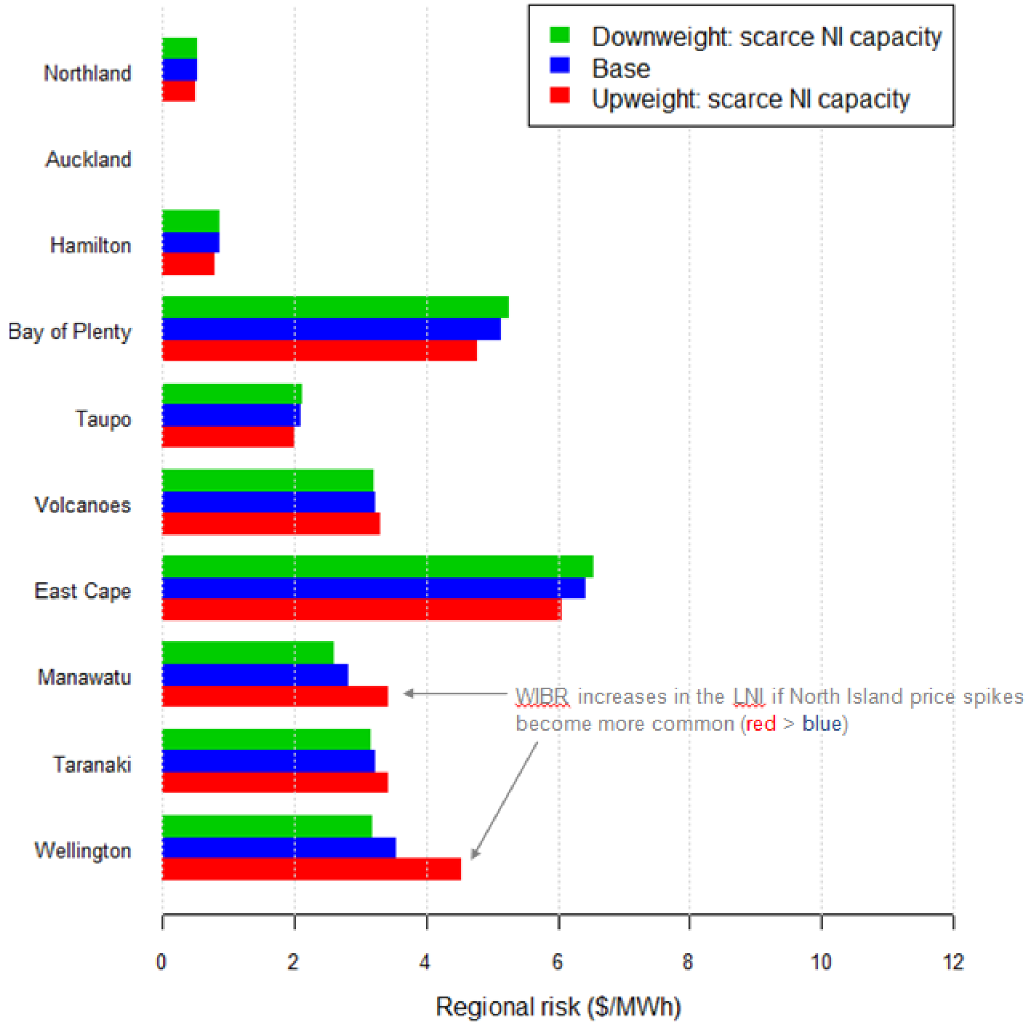
6.13 More frequent wet periods would doubtless affect *inter*-island price risk and quantity risk for many parties. However, the analysis above suggests that the effect on *WIBR* would actually be quite small (at least, for parties pursuing a prudent hedging strategy using products at OTA and BEN).

6.14 This scenario does not challenge the key findings on page 1.

North Island price spikes

6.15 It is credible that the frequency of North Island price spikes might change (perhaps as a result of HVDC Pole 3 availability and/or changes in the supply-demand balance) or that the level of prices in such events might change. Figure 15 shows the effect of upweighting or downweighting May-Nov 2009, Feb 2010, Jul 2010 and Sep 2010 – all of which included North Island-wide price spikes – by a factor of four.

Figure 15 Effect of upweighting or downweighting North Island price spikes



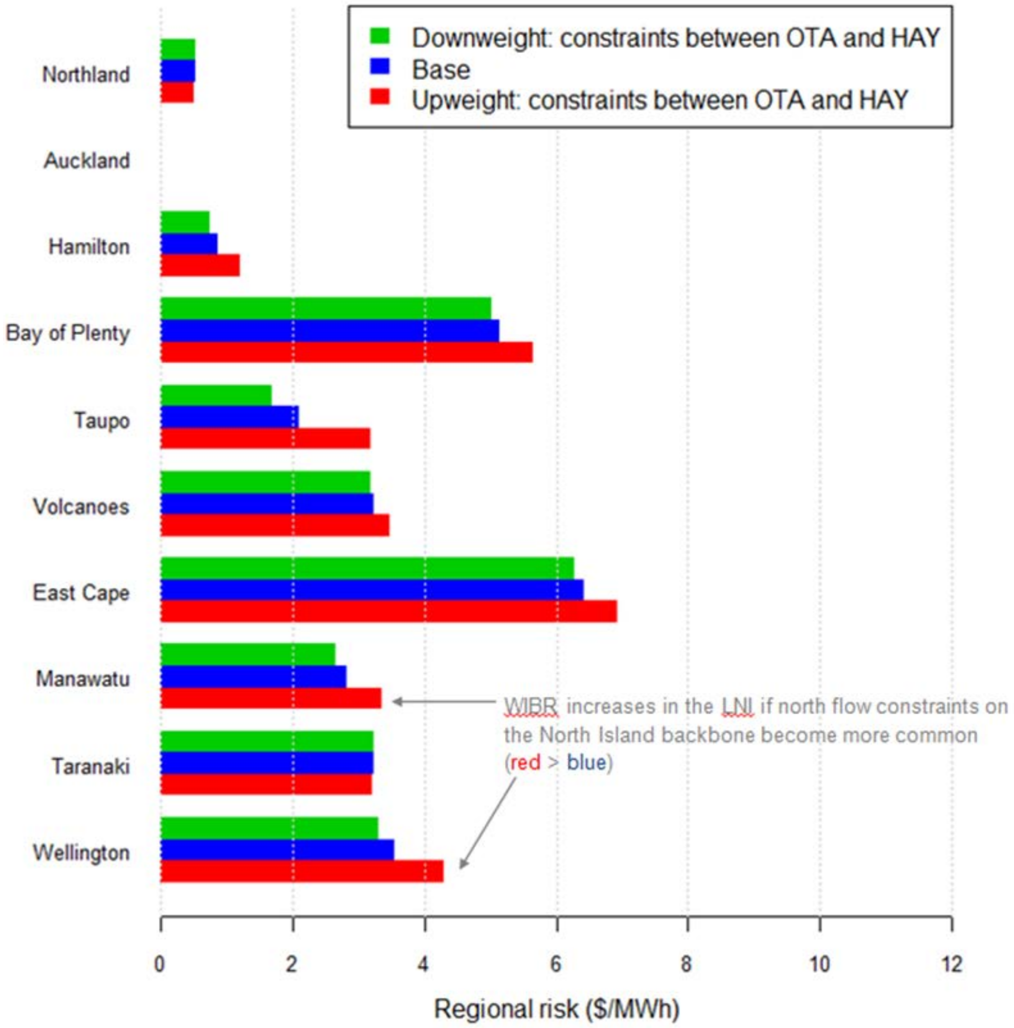
6.16 For some regions, there is relatively little impact. However, for the lower North Island, WIBR may increase if North Island price spikes become more common or more intense. The reason for this is explored in more detail later in the paper – it is a result of hedging lower North Island loads with a combination of BEN and OTA. When there is an island-wide price spike, the combination of BEN and OTA is lower than the price at e.g. Haywards (HAY).

6.17 This scenario supports the key result on page 1 that there may be commercially significant levels of WIBR in the lower North Island.

North flow constraints on the North Island backbone

6.18 Figure 16 shows the effect of upweighting or downweighting Nov 2011, Dec 2011, May 2012, and Jun 2012 by a factor of four. All of these months included periods in which there was a price spike at OTA but the price was much lower at HAY. For instance, Dec 2011 included the AUFLS event; in trading period 27 of 13 Dec, prices reached $8,028/MWh at OTA but only $477/MWh at HAY.

Figure 16 Effect of upweighting or downweighting north flow constraints on the North Island backbone



WIBR increases in the LNI if north flow constraints on the North Island backbone become more common (red > blue)

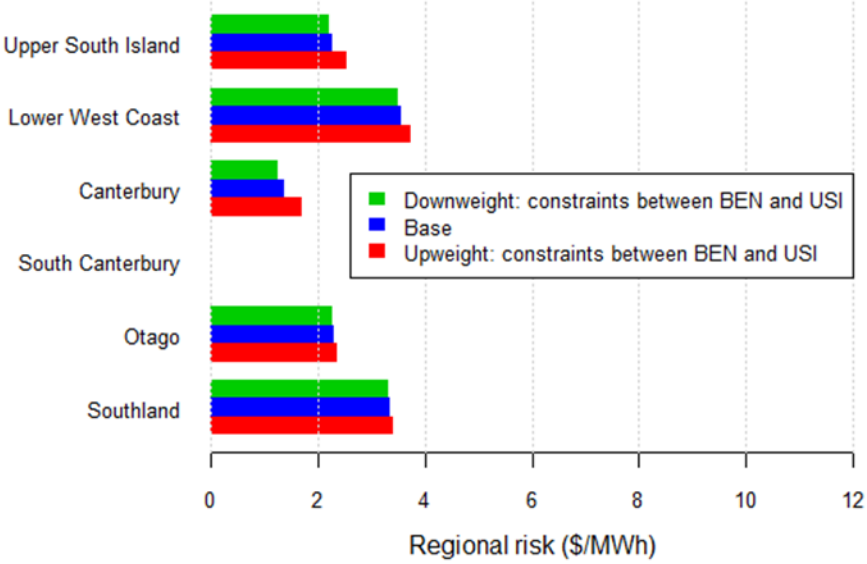
6.19 For some regions, there is relatively little impact. However, for the lower North Island, WIBR may increase if price spikes in the upper North Island (associated with north flow constraints) become more common or more intense. Again, the reason for this is explored in more detail in section 7, and is a result of hedging lower North Island loads with a combination of BEN and OTA.

6.20 This scenario supports the key result on page 1 that there may be commercially significant levels of WIBR in the lower North Island.

North flow constraints on the South Island backbone – north of Benmore

6.21 Figure 17 shows the effect of upweighting or downweighting Feb 2003, Mar 2004, Dec 2004, May 2005, Oct 2005, Jan 2006, Apr 2006, Jul 2010 and Jan 2012 by a factor of four. All of these months included periods in which constraints north of Benmore resulted in high prices in the upper South Island.

Figure 17 Effect of upweighting or downweighting north flow constraints on the South Island backbone



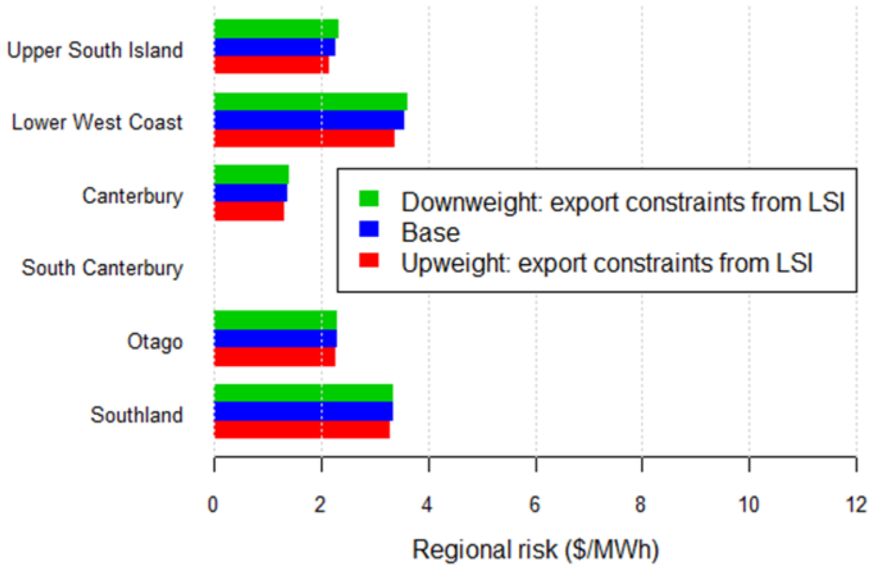
6.22 There is relatively little impact on WIBR in the affected region (in large part because prices in the upper South Island have historically been quite moderate, even during constrained periods).

6.23 This scenario does not challenge the key findings on page 1.

North flow constraints on the South Island backbone – south of Benmore

6.24 Figure 18 shows the effect of upweighting or downweighting Oct 2008 – Jan 2009 and Dec 2009 – Jan 2010 by a factor of four. All of these months included periods in which constraints south of Benmore resulted in low prices in the lower South Island.

Figure 18 Effect of upweighting or downweighting north flow constraints on the South Island backbone



6.25 There is relatively little impact on WIBR in the affected region.

6.26 This scenario does not challenge the key findings on page 1.

Pivotal supplier situations

6.27 Figure 19 shows the effect of upweighting or downweighting the following months by a factor of **nine** (not four as in the preceding plots):

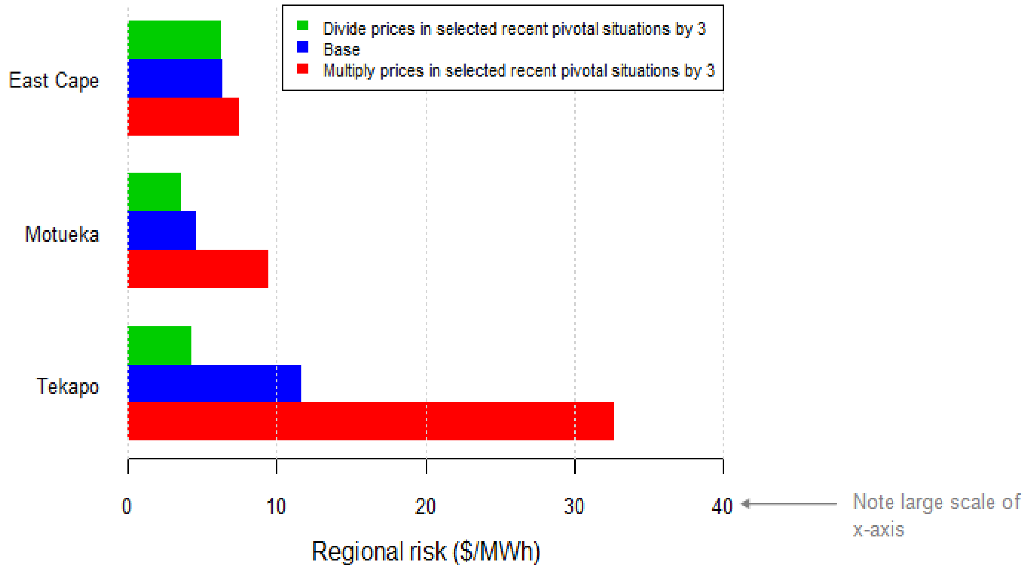
(a) Apr 2012, for the Motueka region (when prices went to $3,000/MWh during a pivotal supplier situation)

(b) Feb 2012 and Aug 2012, for the Tekapo region (when prices went to $3,000/MWh and over $2,000/MWh respectively)

(c) Apr 2004, Feb 2009, Apr 2009, Apr 2010 and May 2010 for the East Cape region (in which there were price spikes at Gisborne, resulting in elevated monthly mean prices. These are just a sample of the months in which such conditions occurred.).

6.28 Upweighting by a factor of nine could be interpreted as tripling prices during pivotal supplier situations – for instance, from $3,000/MWh to nearly $10,000/MWh. This may be a credible contingency under current market arrangements.

Figure 19 Effect of upweighting or downweighting during pivotal supplier situations



Note large scale of x-axis

6.29 Clearly there is the potential for a significant increase in WIBR in these regions, associated with changes in offer behaviour during pivotal supplier events.

6.30 There are other regions in which pivotal supplier events are known to occur – some are set out in the Authority's investigation report "Locally net pivotal generation" of 2012.

6.31 This scenario supports the key result on page 1 that *spikes* can cause high levels of WIBR in some local areas.

7 Particular challenges remain for managing WIBR in the lower North Island

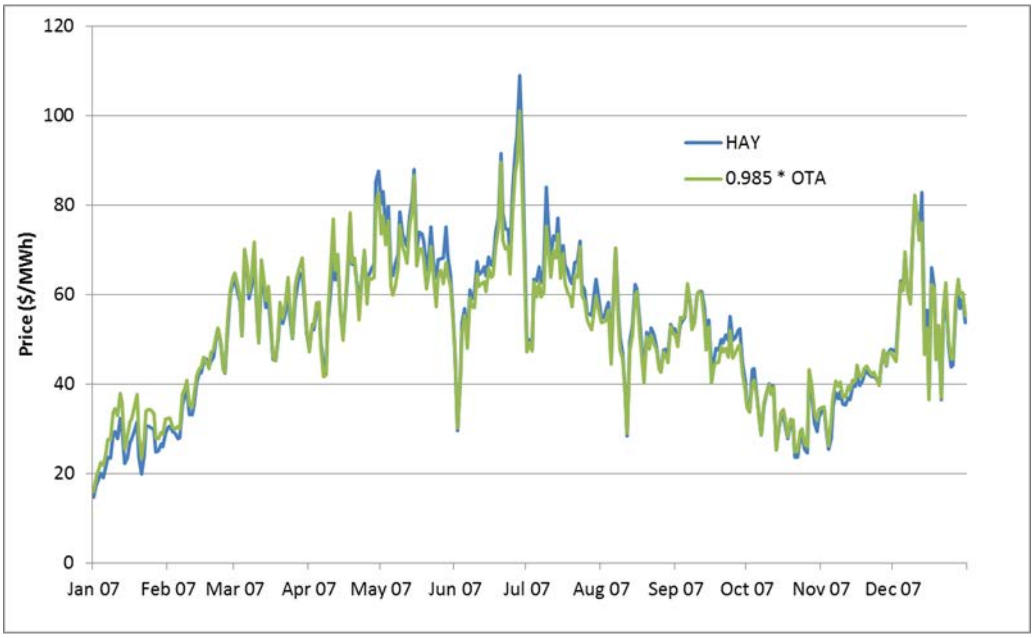
7.1 Some of the analysis carried out in sections 5 and 6[1] indicates that there may be an elevated level of WIBR in the lower North Island.

7.2 The level of WIBR in the lower North Island region is unlikely to exceed any of the three benchmarks of commercial significance – i.e. the overall level of price risk, the level of inter-island basis risk, and typical retail margins. However, it appears likely that it will be higher than the general "background level" of *tidal flow* WIBR that occurs throughout the country. It therefore deserves further investigation.

7.3 This section goes into more detail about the nature of WIBR in the lower North Island area, and how participants can deal with it. Various possible ways of hedging price risk in this area are considered. It turns out that none of these approaches is entirely satisfactory, and that participants might well prefer to have access to other options.

7.4 Under normal system conditions, prices at HAY can be well hedged using energy hedges at OTA alone. (In Figure 20 the blue line is very close to the green line.)

Figure 20 Hedging HAY at OTA under northwards flow

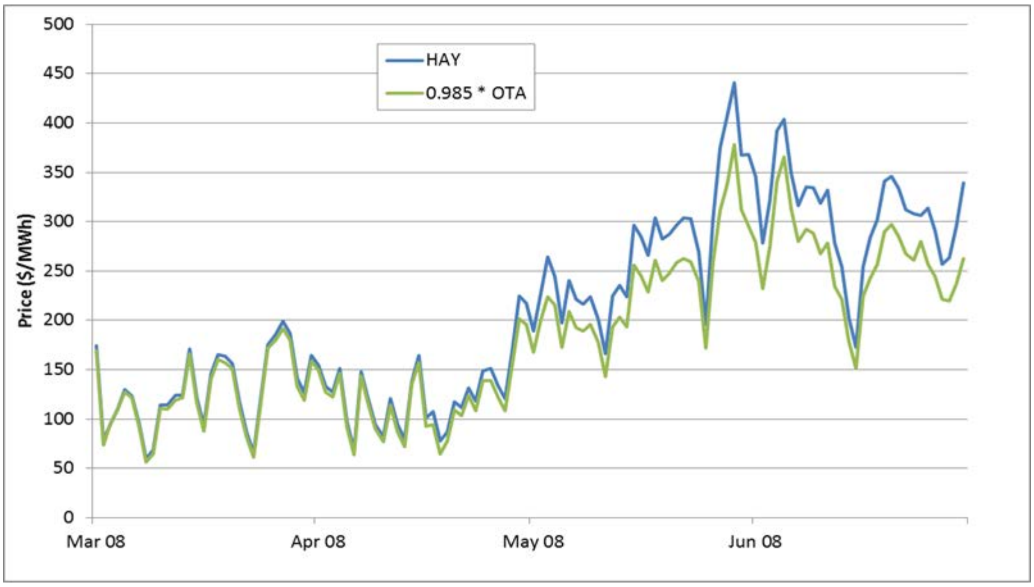


---

[1] See analysis with time limited historical data (paragraph 5.16), use of different hedging strategies (paragraph 5.27) and north flow constraints on the North Island backbone scenario (paragraph 6.19).

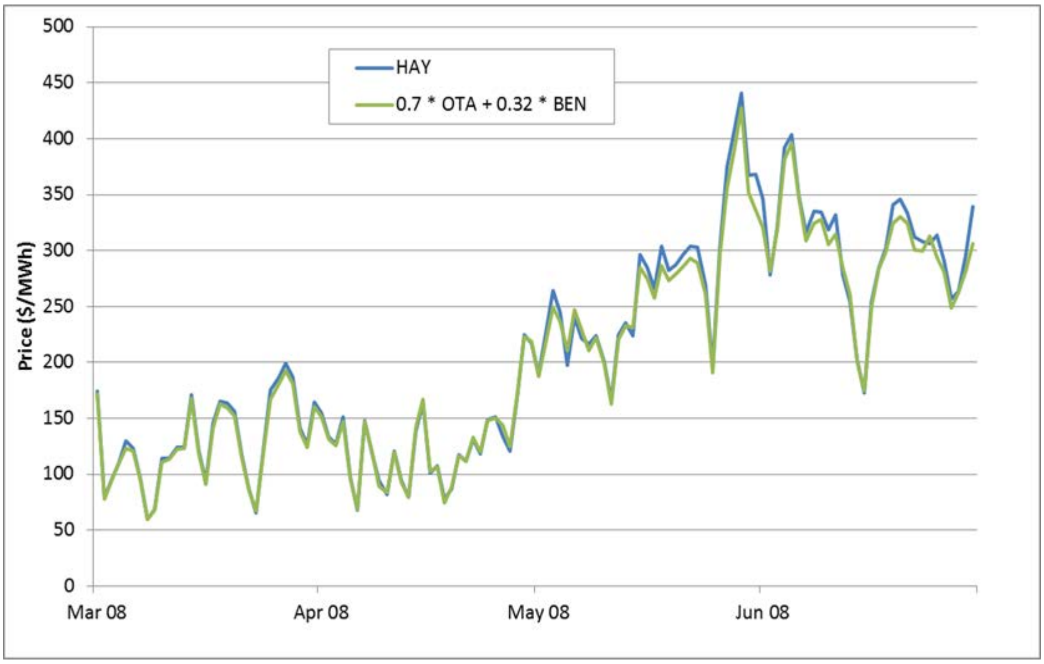
7.5 However, this approach is less effective when there is south flow. (The blue line diverges from the green line.)

Figure 21 Hedging HAY at OTA during southwards flow



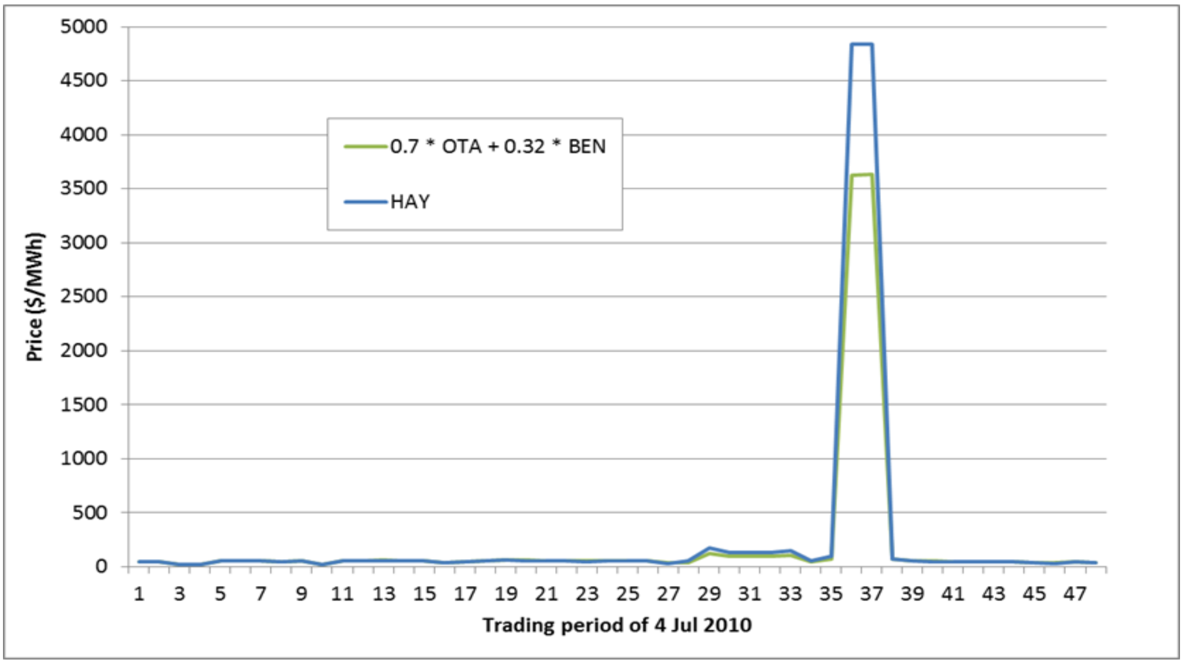
7.6 When there is south flow, a linear combination of products denominated at OTA and BEN (which may be energy hedges and/or obligation FTRs) may work better:

Figure 22 Hedging HAY with a combination OTA and BEN during southwards flow



7.7 However, this approach is less effective when there is a North Island-wide price spike. (Again, the blue line diverges from the green line.)

Figure 23 Heding HAY with a combination of OTA and BEN during North Island wide spike



7.8 A combination of energy hedges at Otahuhu and southward option FTRs (red) is better than either of the above options – it can handle normal periods, south flow periods *and* North Island price spikes.

Figure 24 Hedging HAY with OTA and southwards FTRs

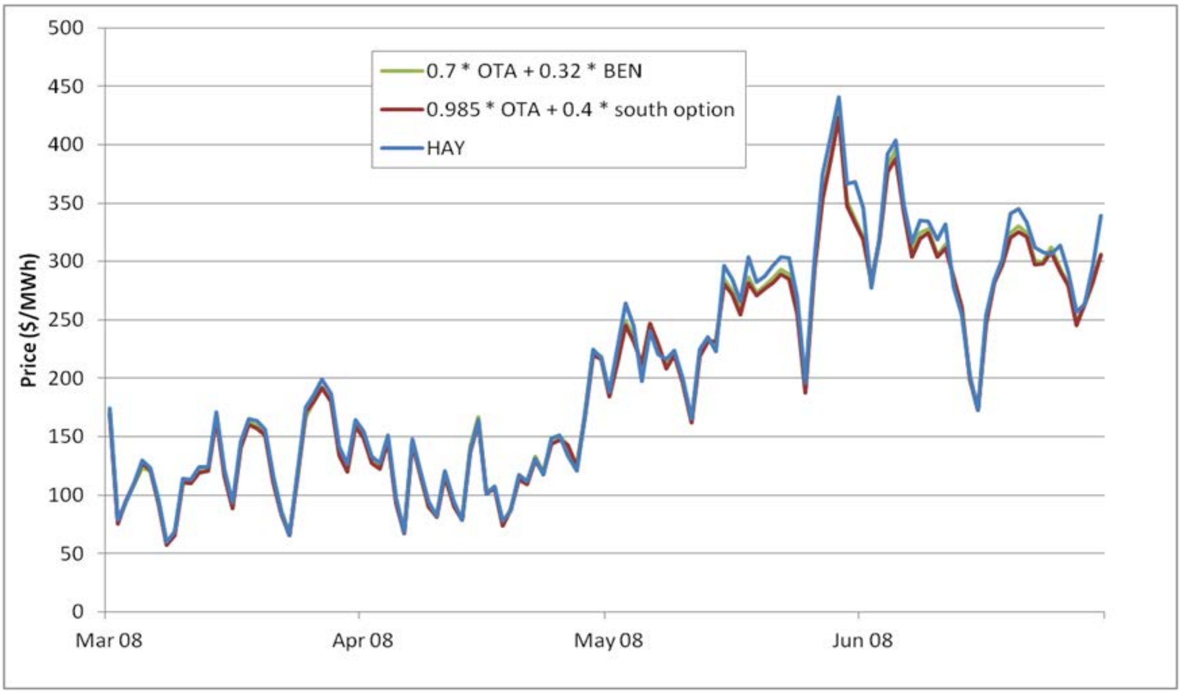
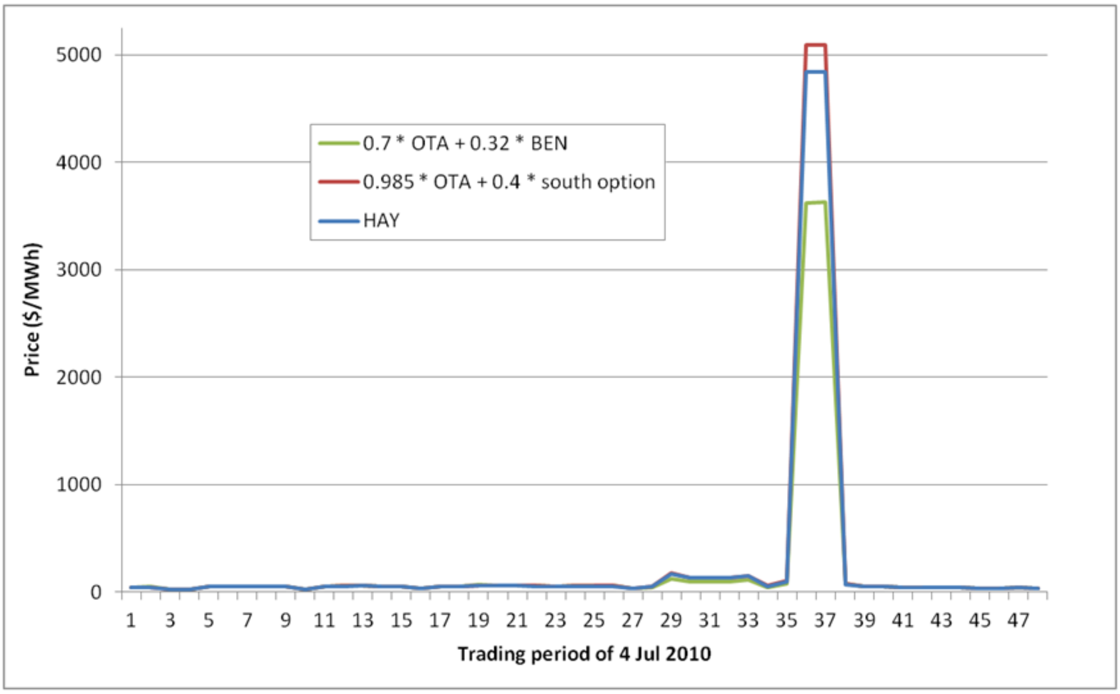


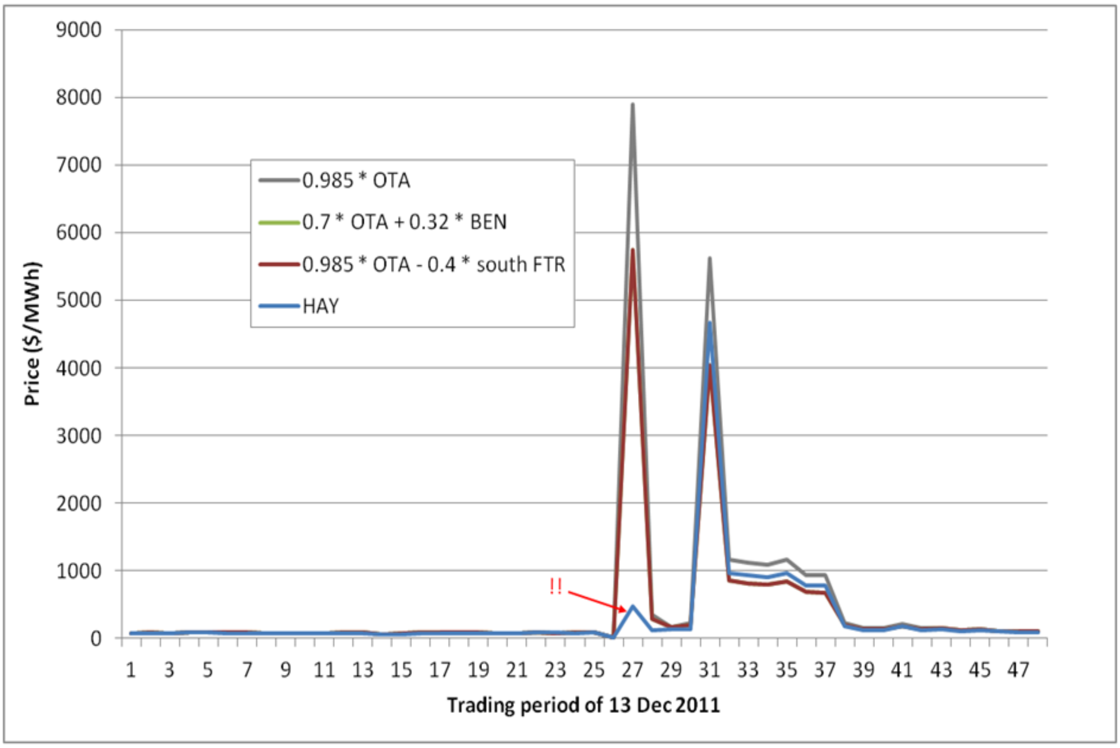
Figure 25 Hedging HAY with OTA and southwards FTRs during North Island wide spike



7.9 However, this is only a viable option if the southward option FTR is available at a reasonable price.

None of the above options works well in a price spike that is specific to the lower North Island (in Figure 26, neither the grey nor the green nor the red line is a good match to the blue line).

Figure 26 All hedging options for HAY during lower North Island price spike



7.10 The conclusion is that it may be difficult to manage WIBR in the lower North Island using products denominated at OTA and BEN alone. Participants might prefer to manage their risks using products denominated at a lower North Island node such as HAY, if such products were available.

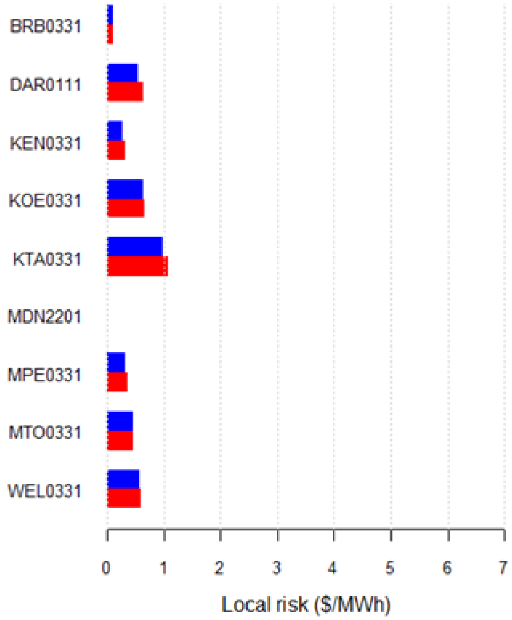
8 Local risk: Spikes can cause relatively high WIBR at some nodes

8.1 The remainder of this document quantifies local risk. Recall, this is defined in terms of differences between the price at an individual node and a scalar multiple of the price at the regional reference node. Both the full local risk (blue) and the risk excluding spikes (red) are shown.

8.2 Overall, the results support the key finding that *spikes* can cause relatively high levels of WIBR in some local areas. Price differences can arise in various ways, notably including pivotal supplier situations and spring washer.

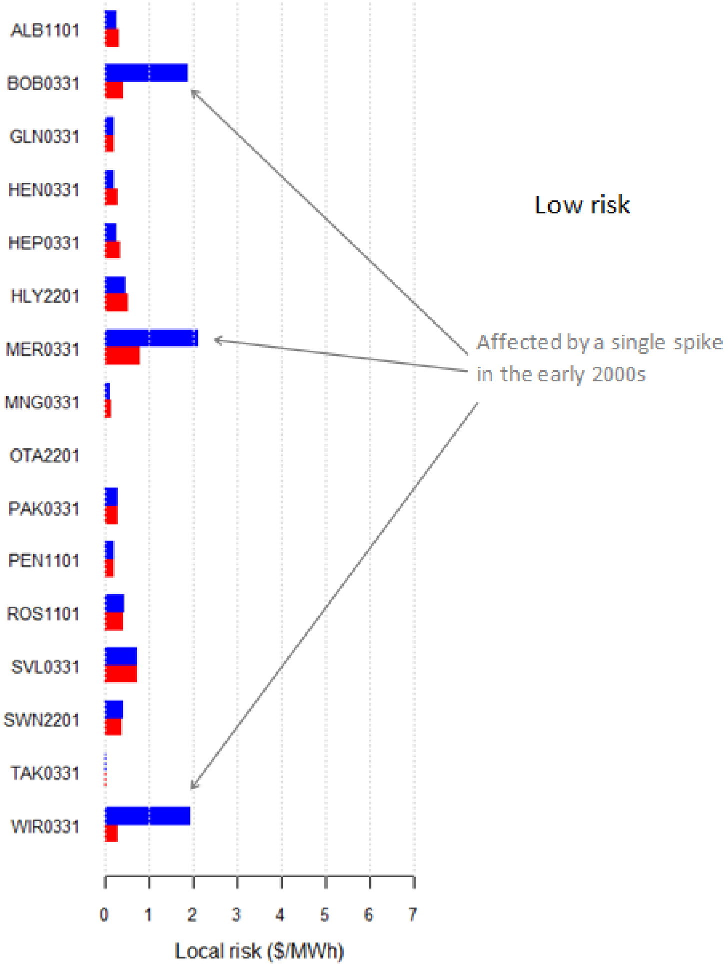
8.3 In some cases the results may be more indicative of a flaw in the region definition, rather than WIBR

Figure 27 Northland



Low risk

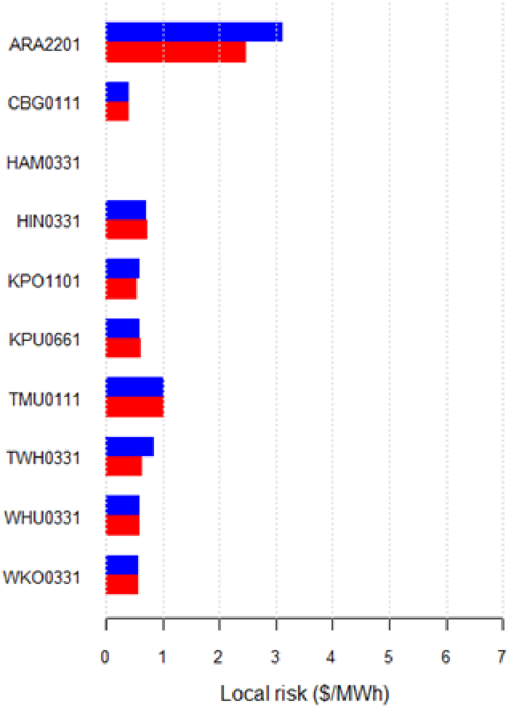
Figure 28 Auckland



Low risk

Affected by a single spike in the early 2000s

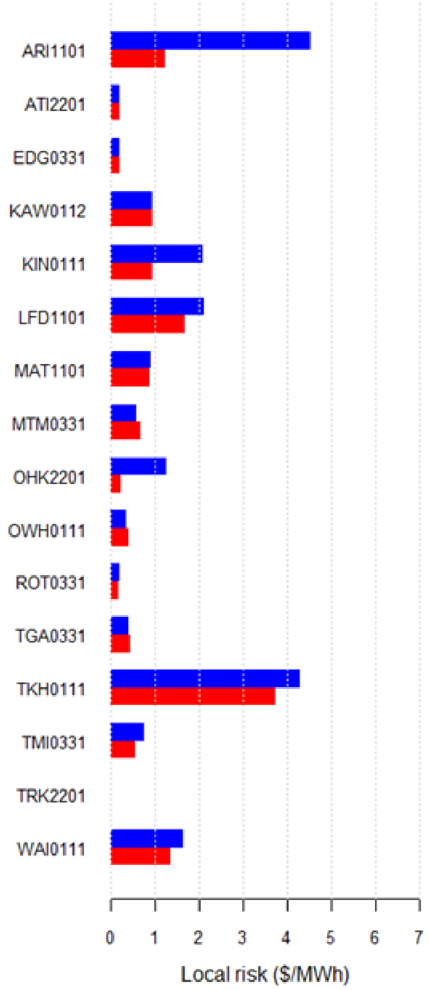
Figure 29 Hamilton



Some risk at Aratiatia, otherwise low risk.

Aratiatia should perhaps be in a different region – it is on the cusp of three regions.

Figure 30 Bay of Plenty

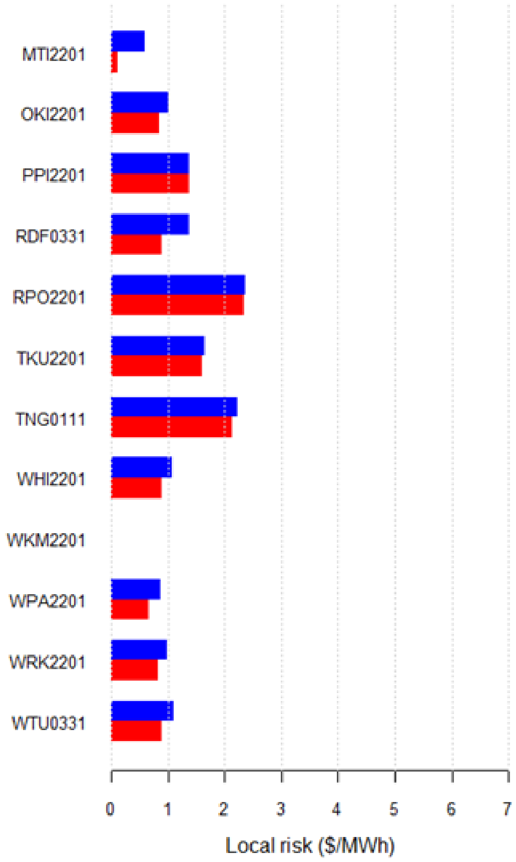


Some risk at Arapuni and Te Kaha, otherwise low risk.

Arapuni has been affected by spikes.

Te Kaha is tiny.

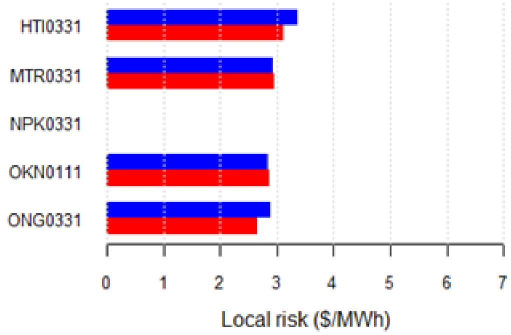
Figure 31 Taupo



Some risk at Rangipo, Tokaanu and Tangiwai, otherwise low risk.

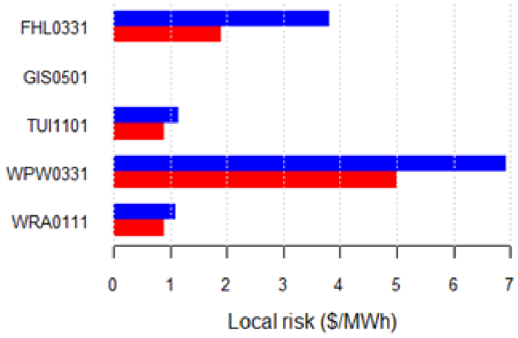
Perhaps the southern part of this region should be separated from the north.

Figure 32 Volcanoes



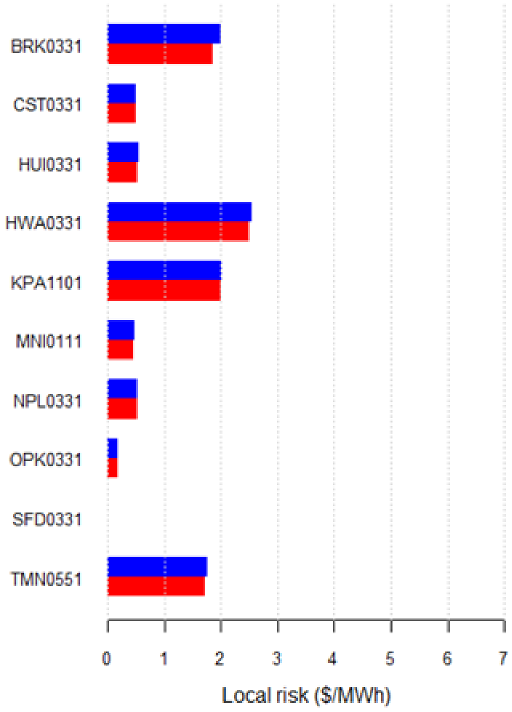
Apparently moderate risk throughout – National Park may not have been the best choice of reference node; it can be poorly correlated with other nodes in the region.

Figure 33 East Cape



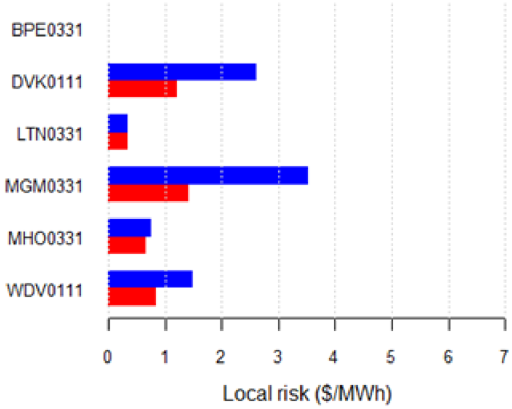
High risk within this region (associated with pivotal pricing, spring washer, etc).

Figure 34 Taranaki



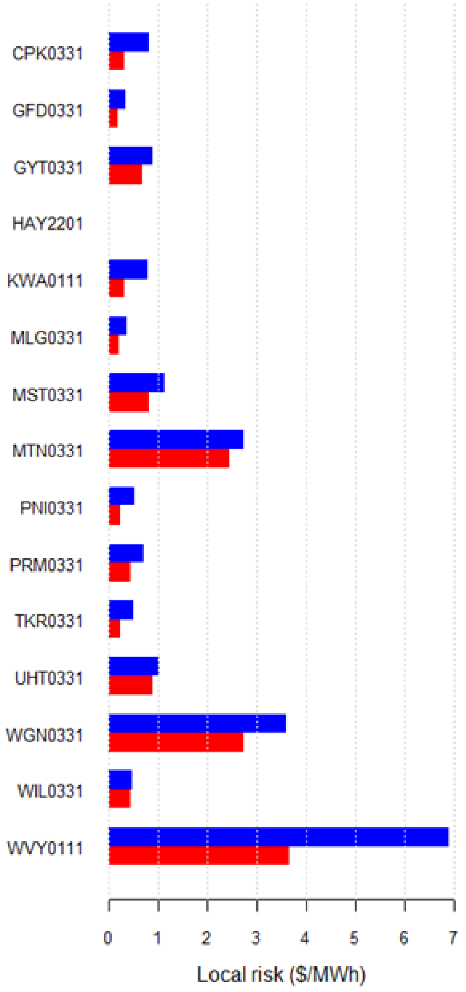
Moderate risk in the southern and eastern parts of the region.

Figure 35 Manawatu



Dannevirke, Mangamaire and Woodville can all be affected by spring washer – this will depend on how the grid is developed and operated.

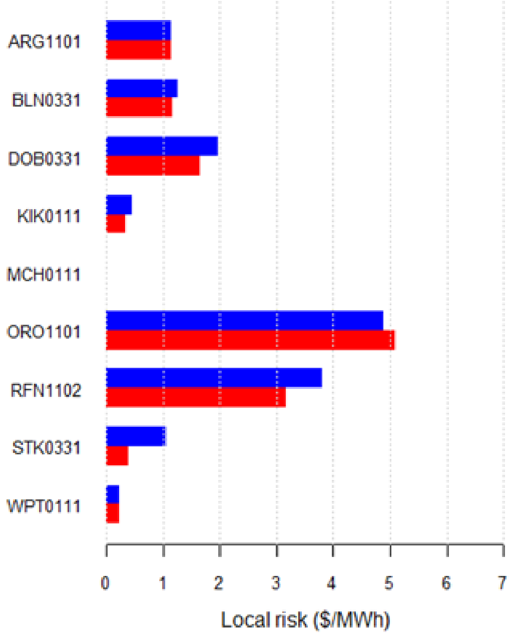
Figure 36 Wellington



Some risk at Marton, Wanganui and Waverley, otherwise low risk.

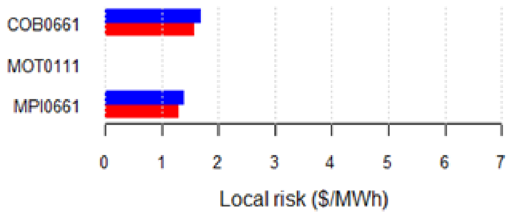
Perhaps the northwest part of this region should be separated from the southern part.

Figure 37 Upper South Island



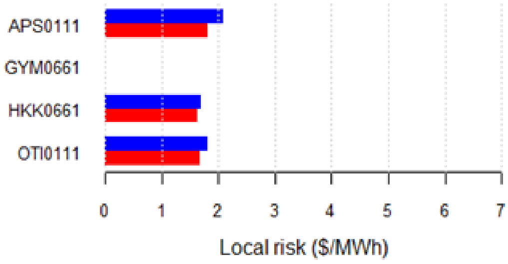
Significant risk on the upper West Coast

Figure 38 Motueka



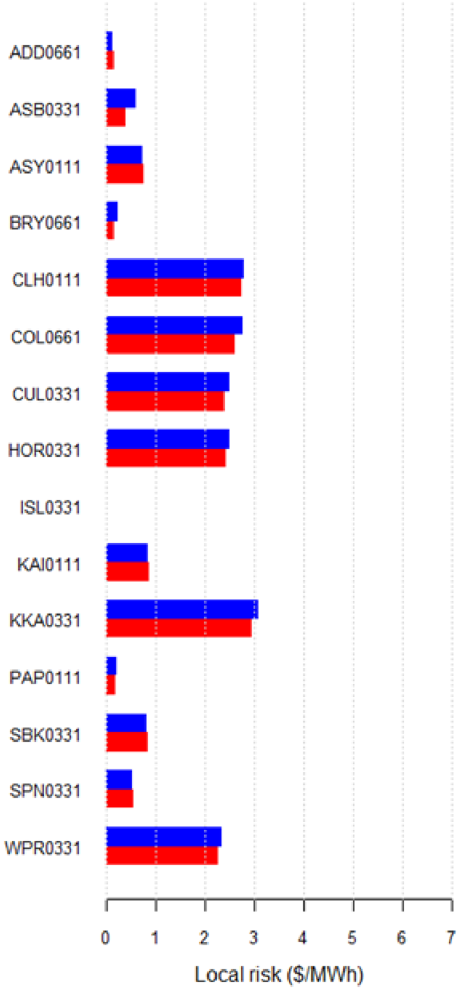
Moderately low intra-region risk

Figure 39 Lower West Coast



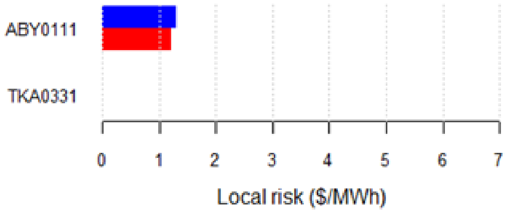
Moderately low intra-region risk

Figure 40 Canterbury



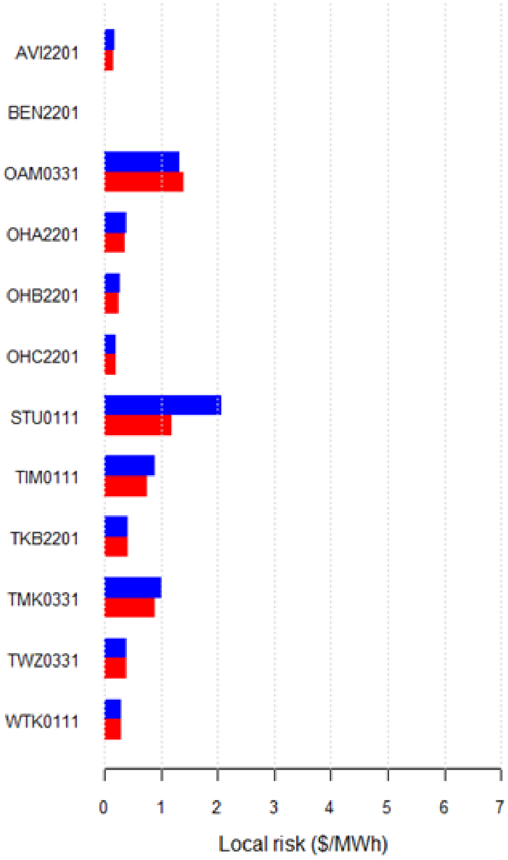
Moderate risk outside Christchurch

Figure 41 Tekapo



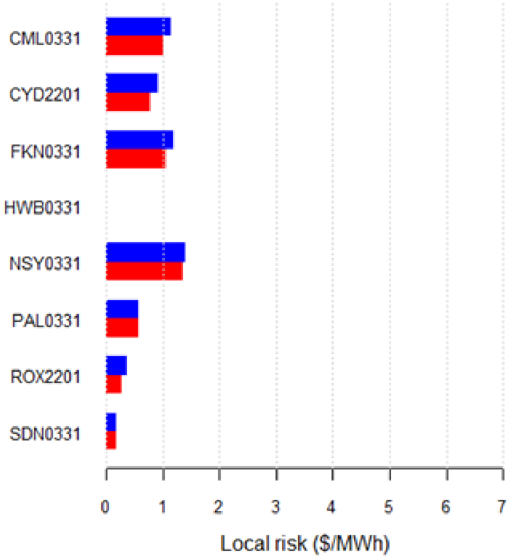
Low intra-region risk

Figure 42 South Canterbury



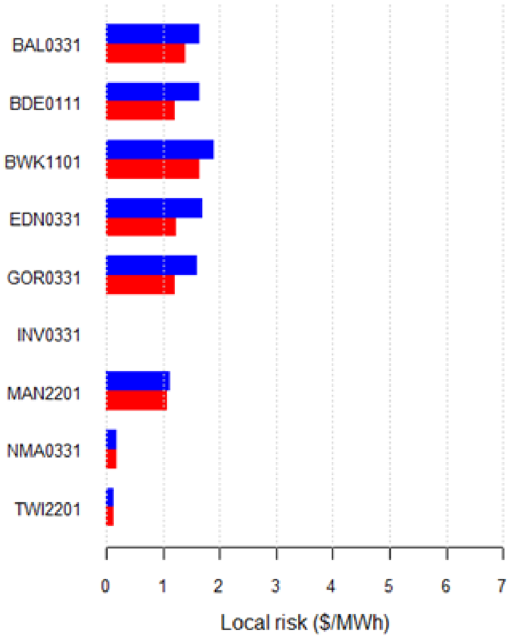
Low risk

Figure 43 Otago



Low risk

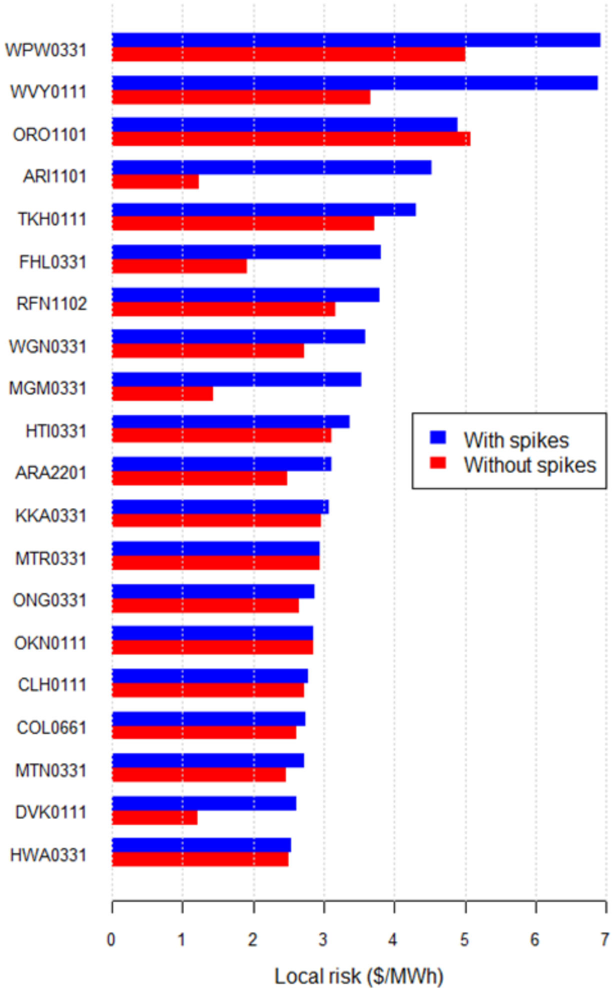
Figure 44 Southland



Low risk

8.4 It is also useful to look at the nodes with the highest levels of local risk:

Figure 45 Nodes with highest level of risk



8.5 There are particularly high levels of local risk associated with the Aratiatia, Arapuni, Fernhill, Waipawa, Mangamaire, Wanganui, Waverley, Orowaiti and Reefton nodes.

8.6 These local risks are larger in $/MWh terms than the risks associated with the larger regions discussed earlier in the document – but they affect considerably smaller volumes of load and generation.

8.7 Products denominated at OTA and BEN will be of little use in managing these local risks.

9 Conclusions

9.1 Key findings of the statistical analysis are that:

(a) *tidal flows* cause WIBR throughout the country, but participants should largely be able to manage such risks using products denominated at OTA and BEN

(b) *spikes* can cause much higher WIBR in some local areas – especially in areas where pivotal supplier situations occur

(c) there may be commercially significant levels of WIBR in the lower North Island. Such risks can be managed using a combination of products denominated at OTA and BEN, but this may be expensive and some risk may remain.

9.2 The next step will be to seek to determine high-level options that can assist participants to:

(a) manage locational price risk in the lower North Island and/or

(b) manage locational price risk associated with *spikes* in local areas throughout the country.

Appendix A Difference of regions in terms of magnitude

A.1 The following pages show how regions differ in terms of “magnitude” – i.e. the amount of load and/or generation they contain. It would be reasonable to suggest that WIBR is most commercially significant if the regional risk measure is high *and* there is much load and/or generation. The regions satisfying these criteria are those closest to the *top right corner* of the plots.

Figure 46 Variability (including spikes vs load)

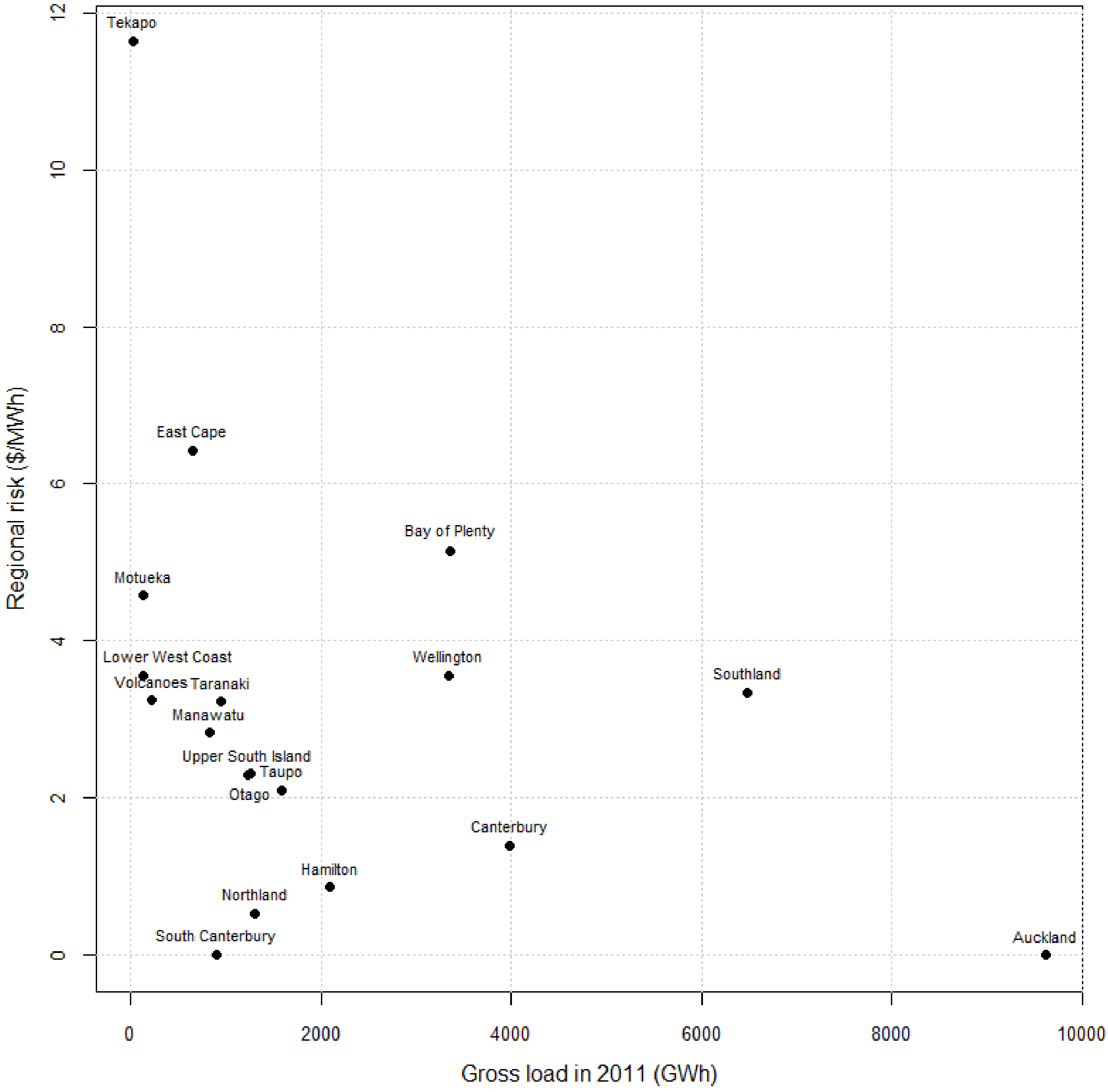


Figure 47 Variability (without spikes) vs load

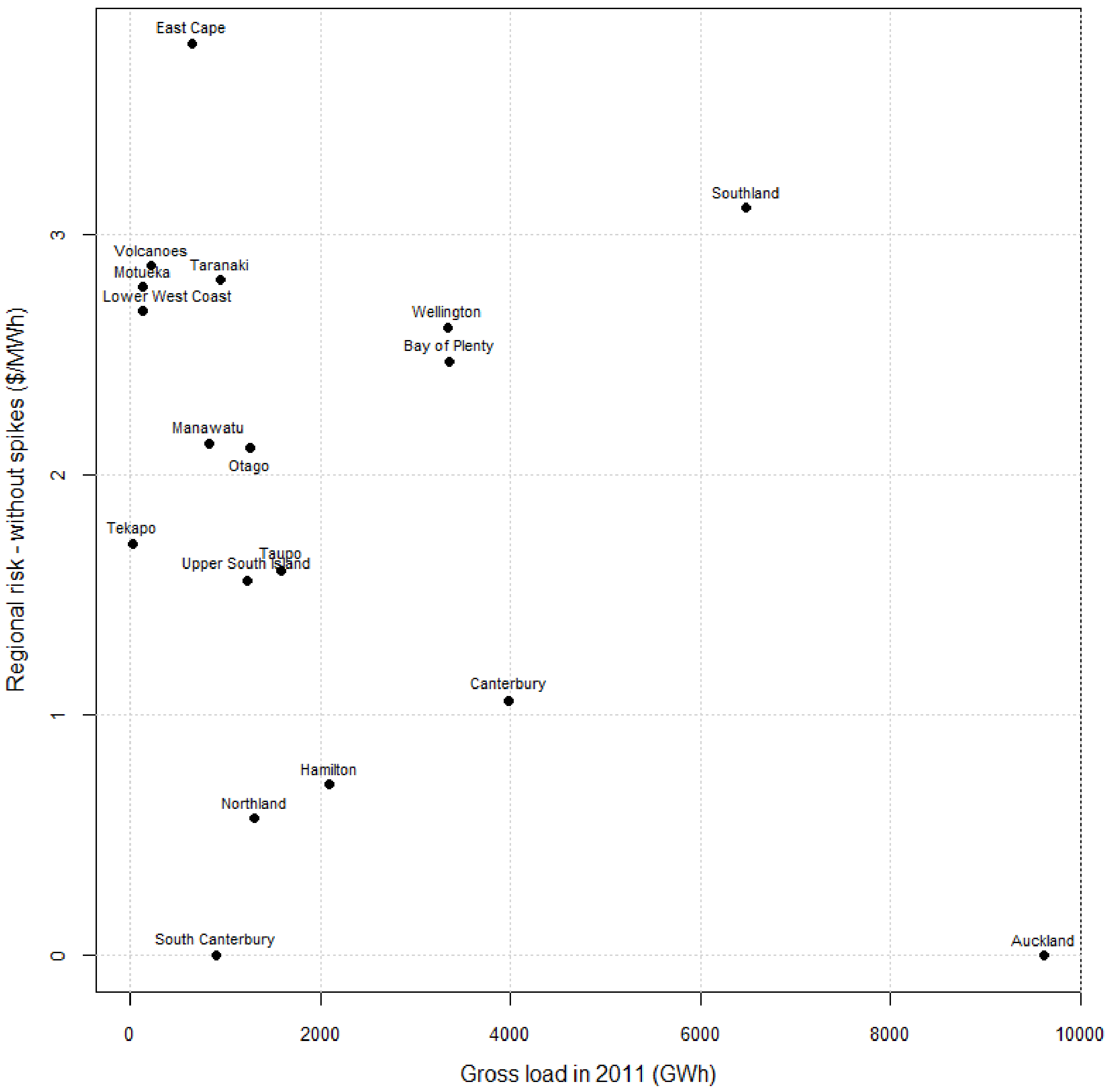


Figure 48 Variability (including spikes) vs generation

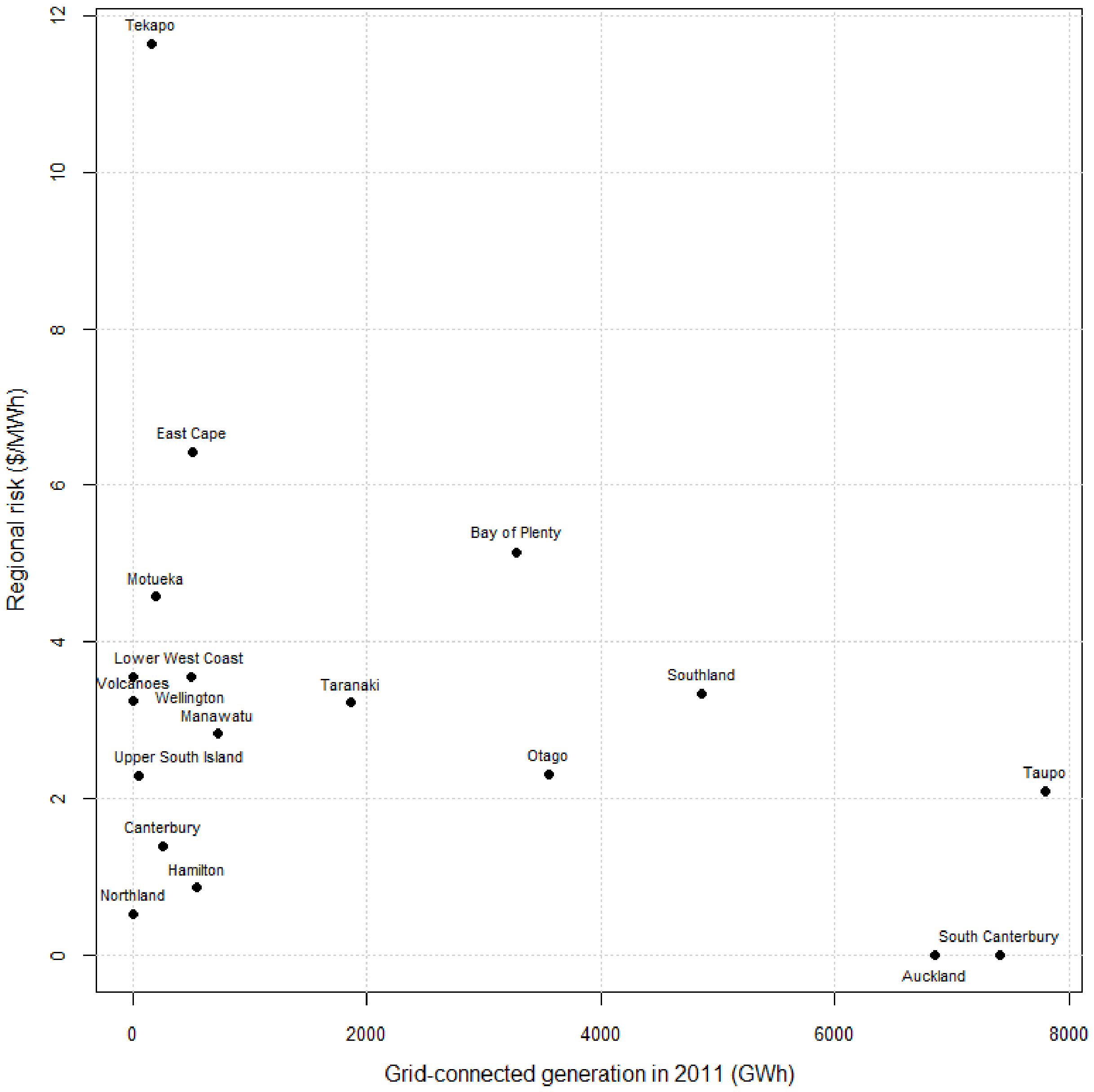


Figure 49 Variability (without spikes) vs generation

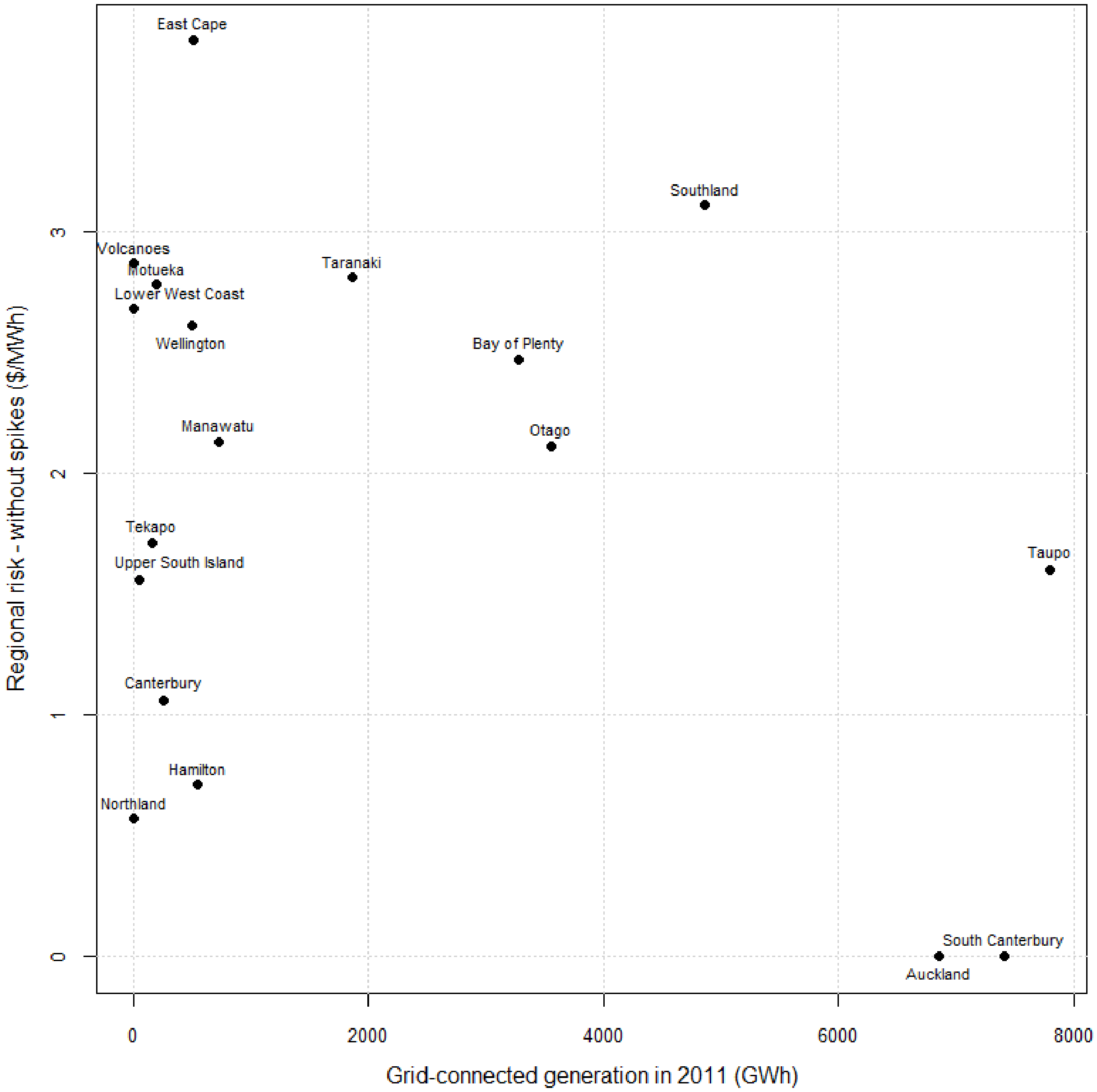


Figure 50 Variability (including spikes) vs sum of load and generation

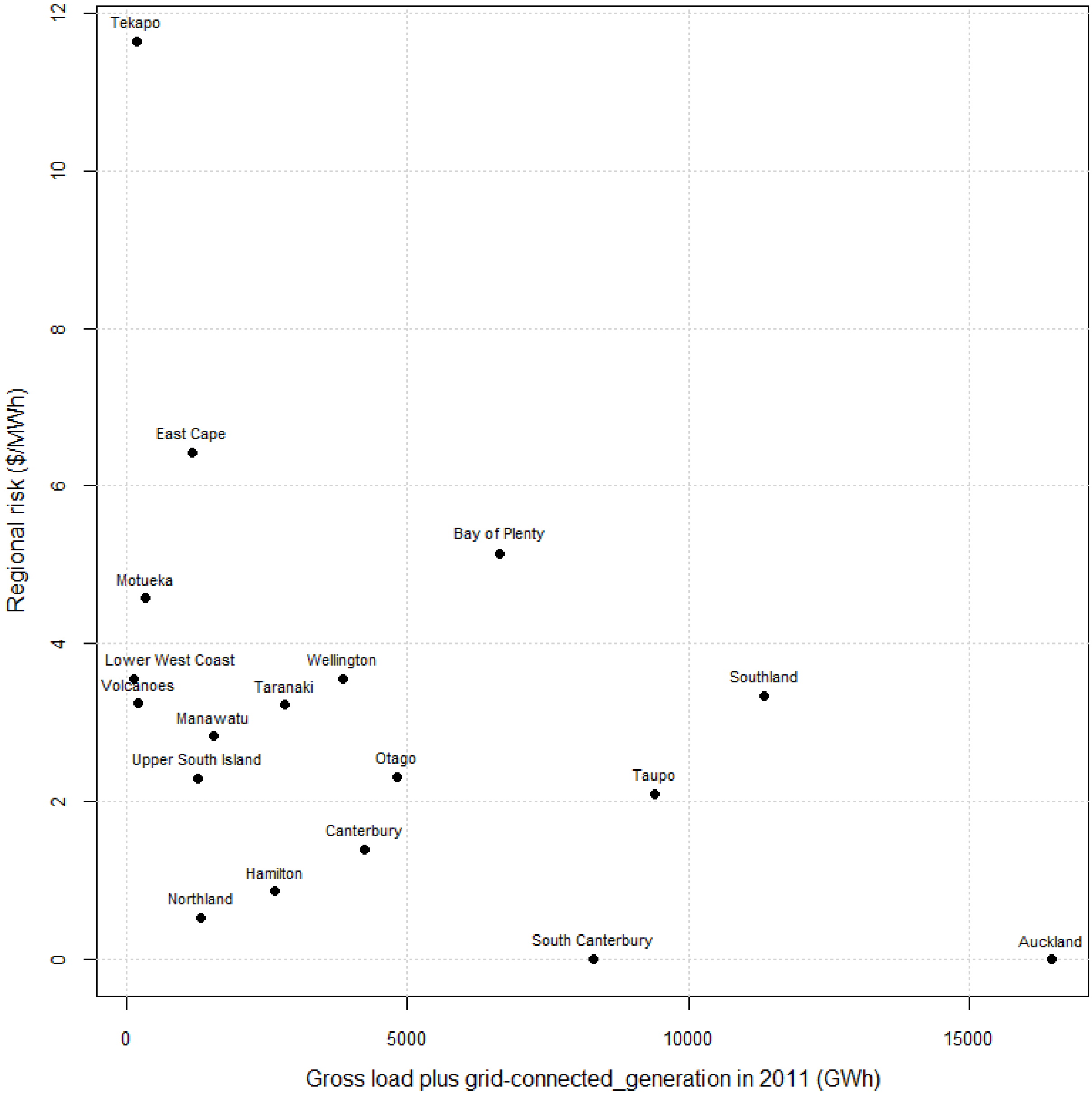
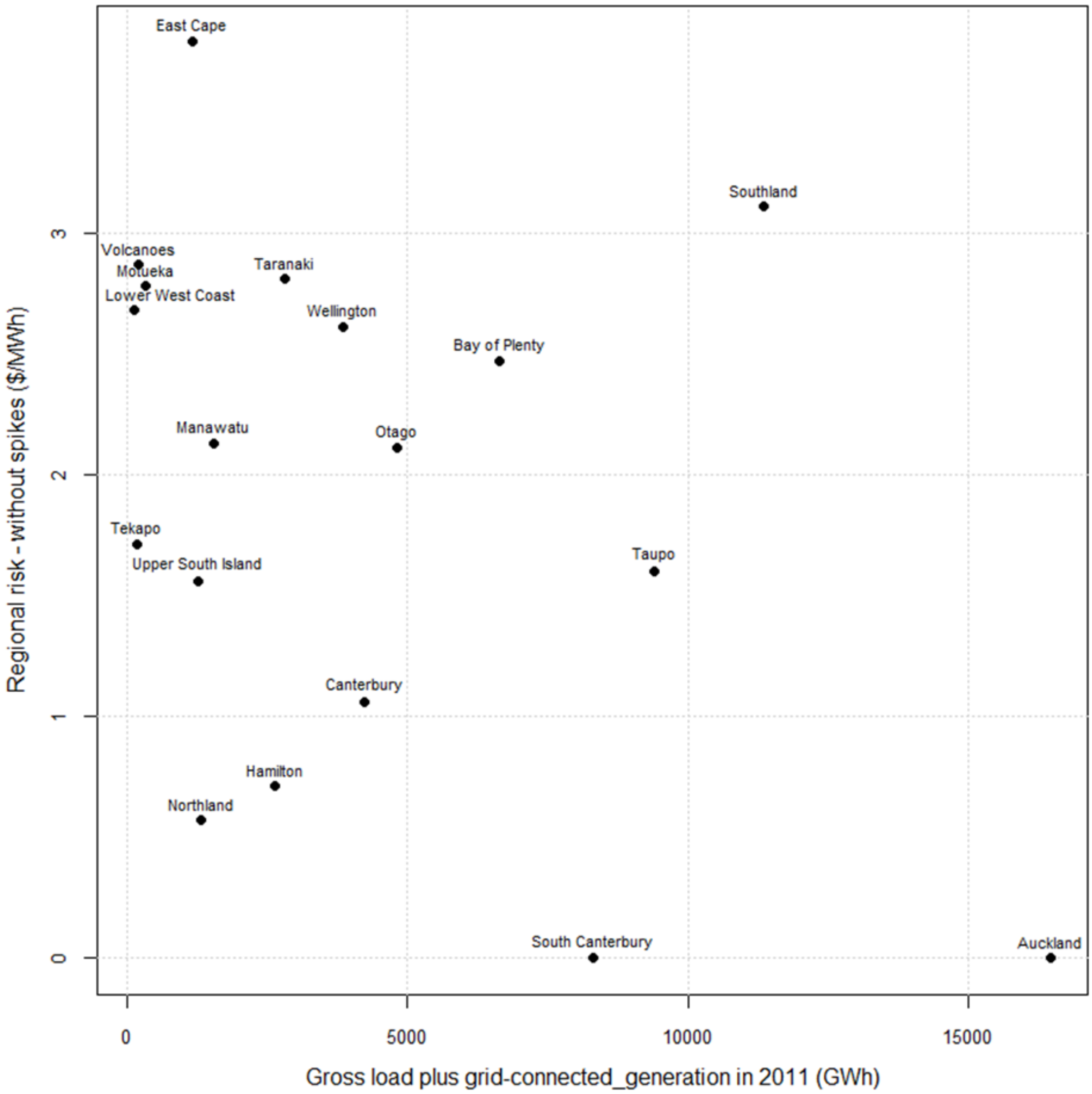


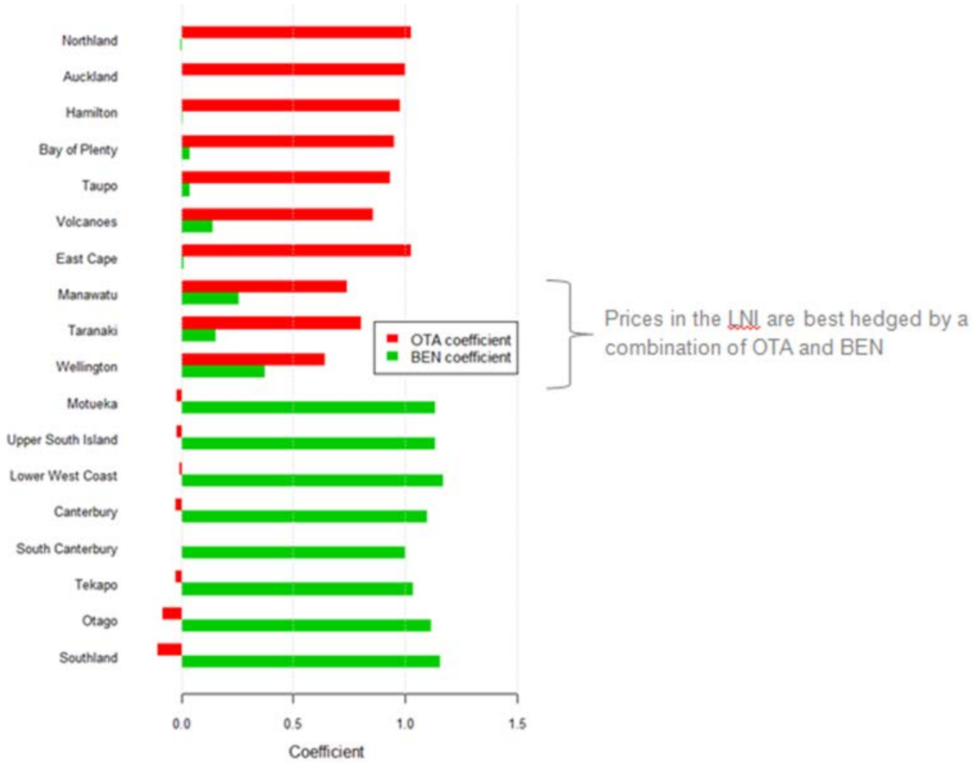
Figure 51 Variability (without spikes) vs sum of load and generation



Appendix B Hedge coefficients

B.1 The hedge coefficients may be of interest to some. Here are the values of A and B in the “linear combination of Otahuhu and Benmore”

Figure 52 Values of A and B in the “linear combination of Otahuhu and Benmore



B.2 And here are the values of X for the “X:1 hedge at the island reference node”:

Figure 53 The values of X for the “X:1 hedge at the island reference node