

HVDC MWh and diluted HAMI charge

Sensitivity analysis

Summary I

- We have analysed the potential market impact of changing the current HAMI charge to: an energy (MWh) charge or a diluted HAMI charge.
- That analysis used the vSPD market model, simulating counterfactual scenarios with the different HVDC charges over the post pole 3 period (01 Aug 2013 to 31 Jul 2014).
- The outcome of the analysis indicated a net system cost reduction (benefit) of both alternatives relative to the status quo of \$12.8m and \$10.7m for MWh and diluted HAMI (N = 10,000) respectively.
- The Authority has undertaken an extensive review of this analysis. That review indicated the benefits in our (Scientia) analysis could be overestimated because:
 - a large proportion of the benefits accrue during the period of the planned Tekapo outage in Jan/Feb 2014
 - a large portion of the benefits are due to the additional generation capacity at BEN, CYD and ROX displacing other generators on the same hydro scheme (WTK and CLU)
- The review also noted that previous analysis undertaken by the Authority could have understated the dispatch inefficiency of the current HVDC charge.
- The review proposed several options to consider as sensitivities to test the robustness of the results to these issues.

Summary II

- We have considered the Authority's proposed options. These options tested low side sensitivities – thus ensuring the benefits are not overstated.
- Neither we nor the Authority explored potentially plausible scenarios / instances that could increase benefits (and consequently the benefits in the analysis are likely to err on the low side.
- In addition to exploring these options, we have corrected an issue noted during the review where the cost of daily energy constraint violations were not included in the system cost assessment. This correction reduce the benefit of the MWh and diluted HAMI from \$12.8m and \$10.7m to \$11.3m and \$10m respectively.
- The results from the sensitivity analysis show the MWh option providing positive system benefits relative to the status quo and greater system benefits relative to the diluted HAMI alternative for all of the tested sensitivity options (see table on next slide).

Summary III

Scenario ¹	MWh	Diluted HAMI
Base (Scenario used for HVDC analysis ² submitted on 13 Feb 15 with energy violation correction)	\$11.3m	\$10m
Option 1 (Exclude Tekapo outage period)	\$8.8m	\$7.9m
Option 2 (Exclude within scheme benefits)	\$6.1m	\$5m
Option 3 (Use maximum offer price for scheme)	Not tested	Not tested

- An average of these scenarios would result in a more conservative benefit estimate of \$8.7m and \$7.6m for MWh and diluted HAMI (N = 10000) respectively. An advantage of averaging is that the estimate is less sensitive to the input assumptions in each scenario.

¹ Further details on the different options and their assessment are provided in section 3.

² See https://www.transpower.co.nz/sites/default/files/uncontrolled_docs/Scientia-Consulting-HVDC-report.pdf

Outline

1. Overview of approach taken for the HVDC analysis and results
2. Review and proposed sensitivities
3. Sensitivity assessment and summary

1. OVERVIEW OF APPROACH

1.1. Overview of approach

- We used the Electricity Authority's vSPD model to estimate the potential market impact of the alternate HVDC charging regimes relative to the status quo over the post-pole 3 horizon Aug13 to Jul14.
- In using the market model, we assume that market offers reflect the marginal economic cost of production at each location and in each time period.
- Under this approach, market offers are taken to reflect fuel costs (water values) but also incorporate other local conditions (e.g. hydro/ transmission constraints or financial positions in the different markets).
- One implication of this approach is that offers often deviate from an aggregate estimate of fuel costs (as observed at Benmore from late Jan to early Mar 2014 during periods of spill at Tekapo or higher-priced offers at Manapouri during periods of spill in Jan 2013).

1.2. Estimation of system benefits

- Because offers are assumed to reflect the marginal economic cost of production we record a:
 - cost saving if output from a station with lower offer price displaces output from a station with a higher offer price
 - cost increase if output from a station with a higher offer price displaces output from a station with a lower offer price.
- We recognise that estimated fuel costs (water values) at some of these stations might sometimes differ from market offers, reflecting that market offers incorporate other information in addition to fuel cost estimates.
- We use market offers in the calculation of the system costs. We consider this to be robust and consistent with system cost impacts of other analysis undertaken using the vSPD market model.

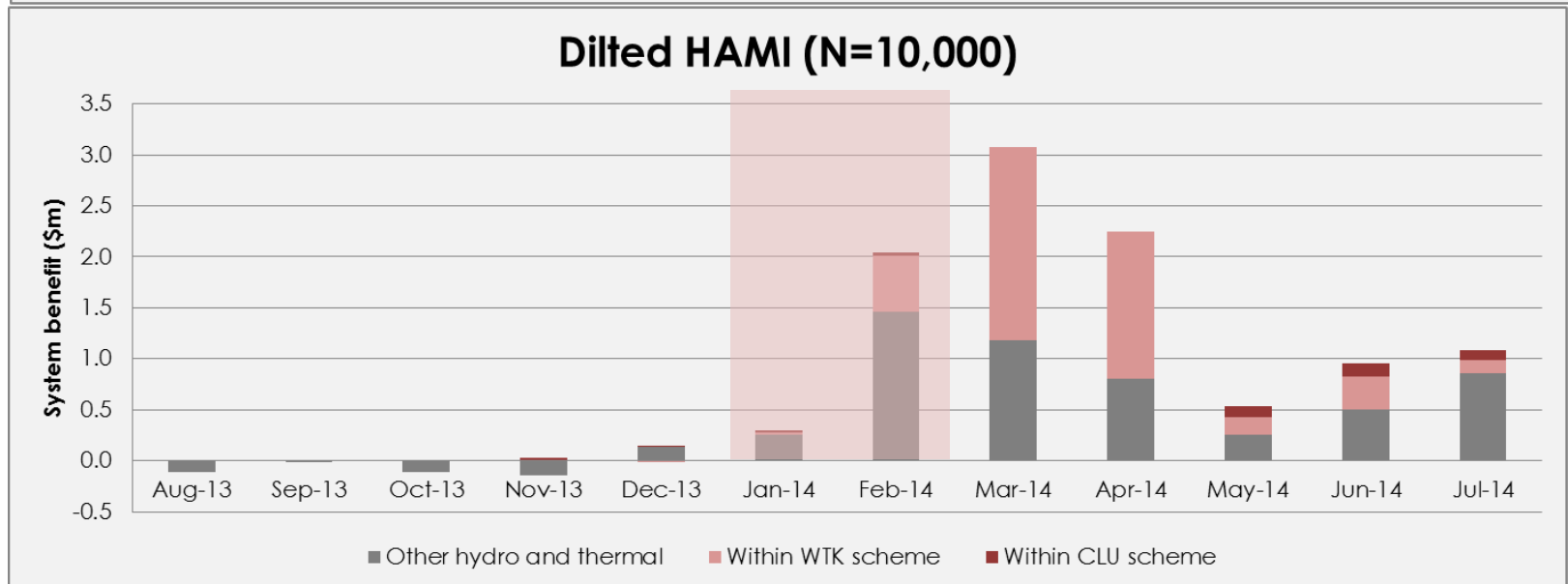
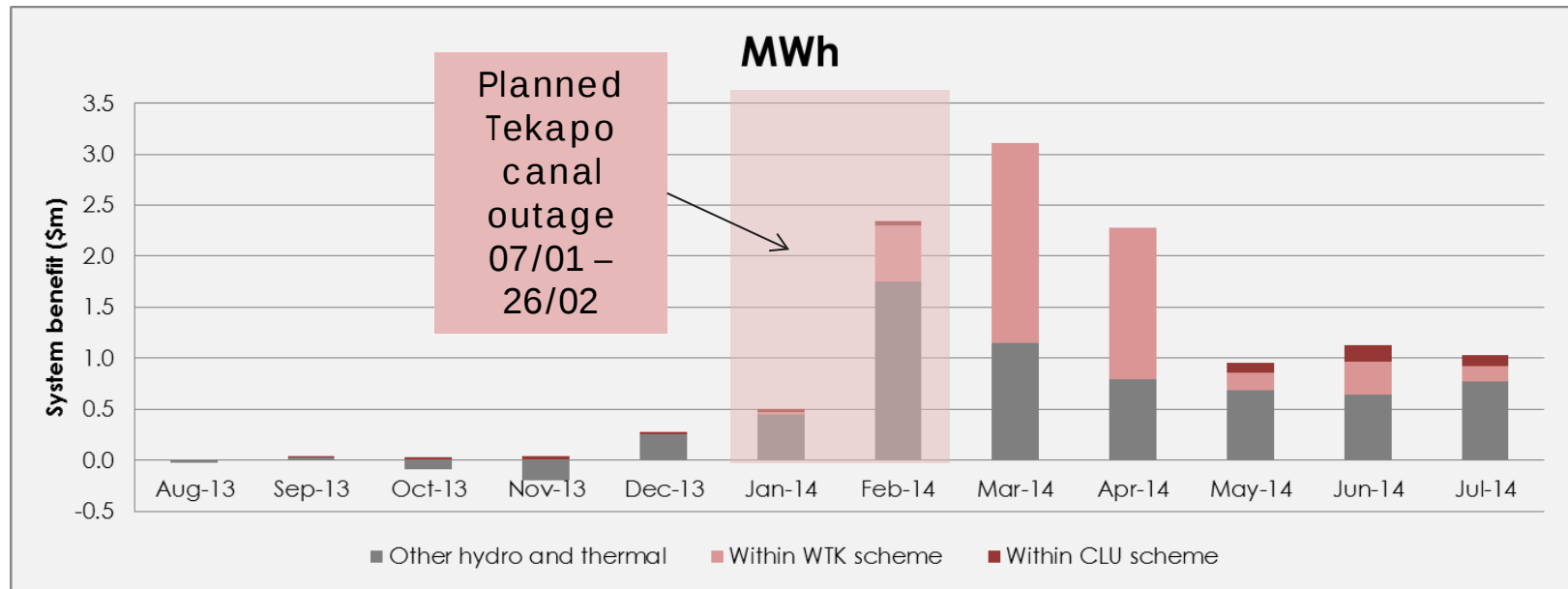
1.3. Estimating offer price of incremental MW

- In determining the marginal economic cost of production of incremental generation at the HAMI-constrained stations (Benmore, Roxburgh, and Clyde) we adopt the offer price of the last MW offered at each of the stations (i.e. the highest priced offer) in each trading period.
- Therefore, in trading periods where the maximum offer price is high (high marginal economic cost of using the last MW offered), we adopt this offer price for the additional offered capacity at the station.
- Similarly, during periods when the maximum offer price is low, we presume that the additional generation offered at the station would also be offered at the same price of the last MW offered.
- We make these presumptions provided the total storage and energy from hydro storage schemes is similar to actual observed values.

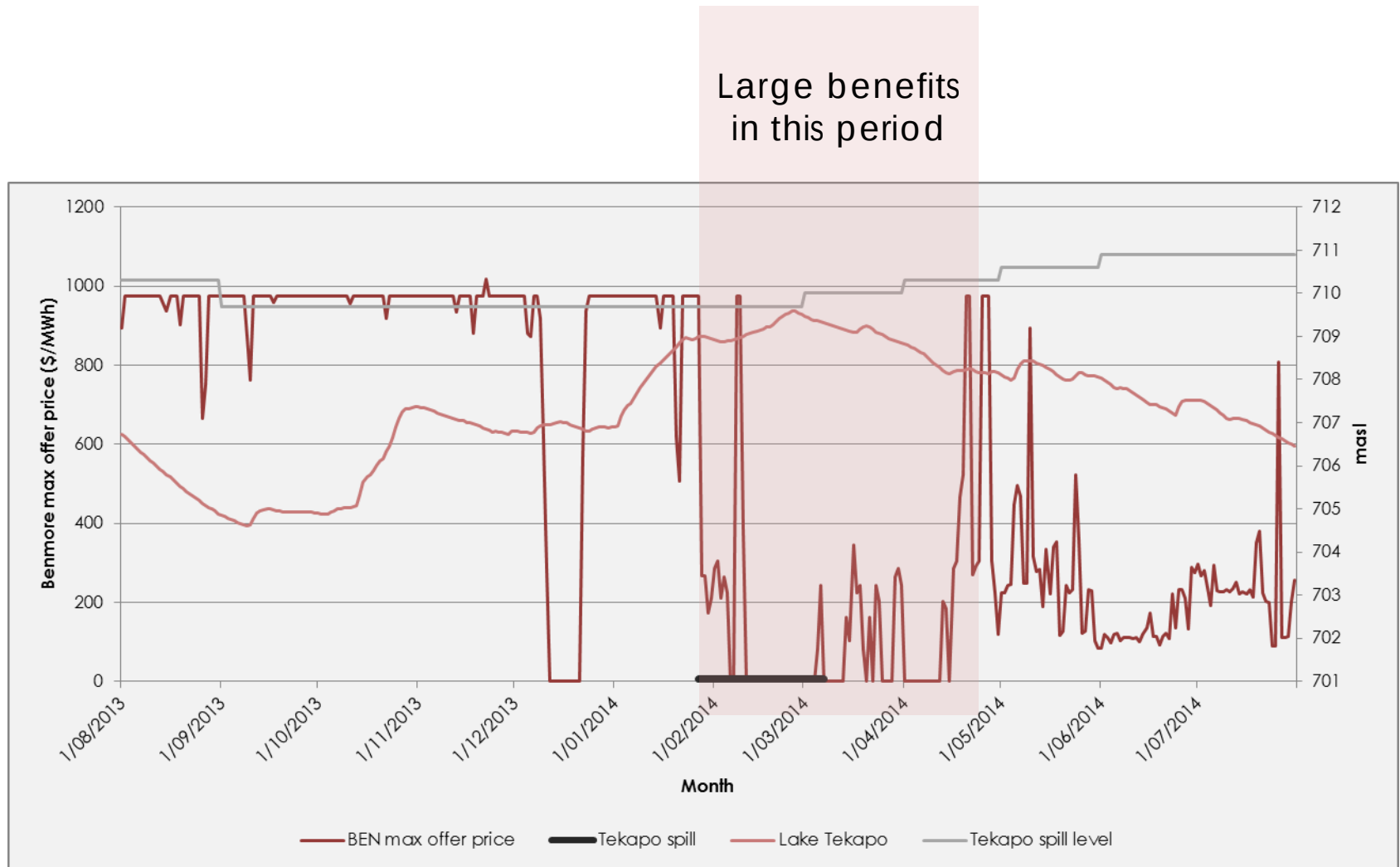
1.4. Benefits assessment

- Both MWh and diluted HAMI indicate benefits relative to the status quo (see slide 11).
- A large proportion of the benefits are accrued due to low offer prices at Benmore power station which is one of the HAMI-constrained stations. This primarily occurs during the period of the Tekapo outage and periods of Tekapo spill but also extends beyond this (see slide 11 and 12).
- The additional capacity offered at Benmore (under the MWh and diluted HAMI) displaces other higher-priced generation. Some of the displaced generation is other hydro and thermal generation however some is generation within the Waitaki hydro scheme and both are accumulated as system benefits.
- A similar situation occurs, although to a lesser extent, with additional offered capacity at the HAMI-constrained stations (Clyde and Roxburgh) on the Clutha scheme (see slide 11).

1.5. System benefit components



1.6. Benmore offers and Tekapo spill



2. ELECTRICITY AUTHORITY'S REVIEW

2.1. Authority's review

- The Authority has undertaken an extensive review of the HVDC analysis.
- While in broad agreement over the underlying analysis and its conclusions, the review raised a concern that the estimated benefits could be overstated for the following because:
 - a larger proportion of the estimated benefits accrue during the Tekapo canal outage. This “abnormal” event and the benefits associated with it could be excluded from the assessment
 - a large proportion of the estimated benefits accrue to generation rescheduling within the Waitaki and Clutha hydro schemes (with the additional generation capacity). These benefits could be overstated as the same water is being used.
- The review proposed options to illustrate the impact of these issues on the benefits and also to test the robustness of the rankings of the proposed HVDC charging options, relative to the status quo.

2.2. Correcting for daily energy constraint violations

- During the review it was discovered that the violation costs of the daily energy constraints were not included in the system benefit assessment.
- Daily energy constraints were introduced into the model to restrict utilisation of existing hydro storage schemes based actual usage. This feature was introduced following feedback from the workshops.
- A violation of the daily energy constraint was permitted provided the penalty price was paid. The corresponding violation cost for each scenario (violation energy x price) should be included to the system cost estimate for that scenario however was not.
- Both the alternatives MWh and diluted HAMI (N = 10,000) incurred violations which reduce the estimated benefits of the MWh and diluted HAMI from \$12.8m and \$10.7m to \$11.3m and \$10m respectively.
- The overall trend of results are still maintained, that is MWh and diluted HAMI both show benefits relative to the status quo with MWh indicating larger potential benefits as shown in the table below.

Scenario	System benefit (excluding violation) (\$m)	Daily energy constraint violation cost (\$m)	System benefit including violation cost (\$m)
MWh	12.8	-1.5	11.3
Diluted HAMI (N = 10,000)	10.7	-0.7	10

2.3. Authority's proposed options

- The review proposed several options to consider as sensitivities to test the robustness of the results to these issues:

Option 1: exclude period of Tekapo outage

Option 2: exclude within scheme cost benefits

Option 3: price additional MW at max offer price of the scheme rather than at the station

Option 4: benefits provided by the EA analysis may be too low (consider using \$50/MWh rather than at \$80/MWh price threshold) → while this is not a sensitivity (i.e. not adjusting parameters in the analysis), it does provide another benchmark¹ on the range of the results

¹ The Authority analysis did not consider alternate HVDC charging options. These options were included in Option 4 to allow comparison with the other options.

3. SENSITIVITY OPTIONS

3.1. Option 1: exclude period with Tekapo outage?

- This option assumes that the period of the Tekapo canal remediation project represents an “abnormal” period that should be excluded from the assessment period
- Both Tekapo generators were on outage during the canal remediation project from 07 Jan – 26 Feb 2014
- Excluding this period has the following impact on the estimated benefits¹:
 - MWh: \$11.3m → \$8.8m (zero benefit during the Tekapo outage)
 - Diluted HAMI: \$10m → \$7.9m (zero benefit during the Tekapo outage)
- Both the MWh and diluted HAMI show a benefit relative to the status quo with the MWh providing a larger benefit → no impact on option ranking

¹ Excluding this period reduces the assessment period by 69 days. This is equivalent to assuming zero benefit during this period.

3.2. Option 1: assessment

- While we agree the Tekapo canal outage is an uncommon occurrence, events that have a similar impact in terms of increased system benefit (with the additional SI generation capacity) are more common. For example:
 - Constrained fuel conditions: high SI and low NI hydro, low southland storage, planned/unplanned thermal fuel supply
 - Constrained supply-demand conditions: planned and/or unplanned outages of generation, higher than expected demand conditions, reduction in output of intermittent generation (with increased wind penetration). The Authority's analysis indicates that there is an increased likelihood of constrained supply-demand conditions occurring due to a combination of factors¹
 - Significant supply-demand events: decommissioning/storage of NI thermal plant, increase/decrease in demand at Tiwai Point
- The underlying principle being illustrated during the Tekapo outage period is the advantage of increased flexibility of SI generation capacity which can manifest as (potentially large) system benefits under varied market and system conditions (a few of which have been highlighted above).
- Excluding periods of increased benefits whilst still including other periods where benefits could be lower due to other uncommon conditions (e.g. plant commissioning periods² or extended plant outage periods³) would tend towards a more conservative estimate of these benefits.

¹ See 2014 Winter Grid Emergencies (pg: 7-10), available from <http://www.ea.govt.nz/monitoring/enquiries-reviews-and-investigations/2014/grid-emergency-on-19-august/>

² HVDC pole 2 control system commissioning occurred from Sep 13 to Dec 13

³ Benmore unit 5 and 6 on outage from 26 Aug to 10 Oct 2013

3.3. Option 2: exclude within scheme cost savings

- This option excludes benefits attributed to the additional generation capacity modelled at Benmore, Roxburgh and Clyde when displacing higher-priced generation on the same scheme as it is the same water (i.e. similar aggregate water values).
- This issue primarily relates to low maximum offer prices at Benmore, which were also assumed for the additional generation capacity modelled at Benmore, displacing higher-priced generation offers within the Waitaki scheme. A similar issue is observed on the Clutha scheme with the additional generation capacity modelled at Clyde and Roxburgh (as shown on slide 11)
- Excluding these within scheme benefits due to the additional generation capacity has the following impact on the estimated benefits:
 - MWh: \$11.3m → \$6.1m
 - Diluted HAMI: \$10m → \$5m
- Both the MWh and diluted HAMI show a benefit relative to the status quo with the MWh providing a larger benefit → no impact on option ranking

3.4. Option 2: assessment

- In using the market model, we assume that market offers reflect the marginal economic cost of production at each location and in each time period. As indicated earlier, these offers can sometimes diverge from aggregate estimates of fuels costs (water values) where they can incorporate other local conditions (e.g. hydro/ transmission constraints or financial positions in the different markets).
- While low-priced offers at Benmore coincide with spill at Tekapo¹, which may have reflected a localised condition, low-priced offers at Benmore continue beyond the period of Tekapo spill. In these periods, it is not apparent whether the low-priced Benmore offers are related to local conditions or broader market effects.
- Given the impact of these within-scheme benefits on the results we consider this a practical sensitivity option where generators on these schemes could potentially reschedule generation at lower costs/benefits than indicated in their offer prices.

¹ See Pg 7 of

<https://www.genesisenergy.co.nz/documents/10180/14574/2014+Tekapo+PS+Environmental+Report.pdf/8196ea35-ce43-4beb-b1ec-8b827afb708b>)

3.5. Option 3: Price additional MW at max offer in scheme (rather than just station)?

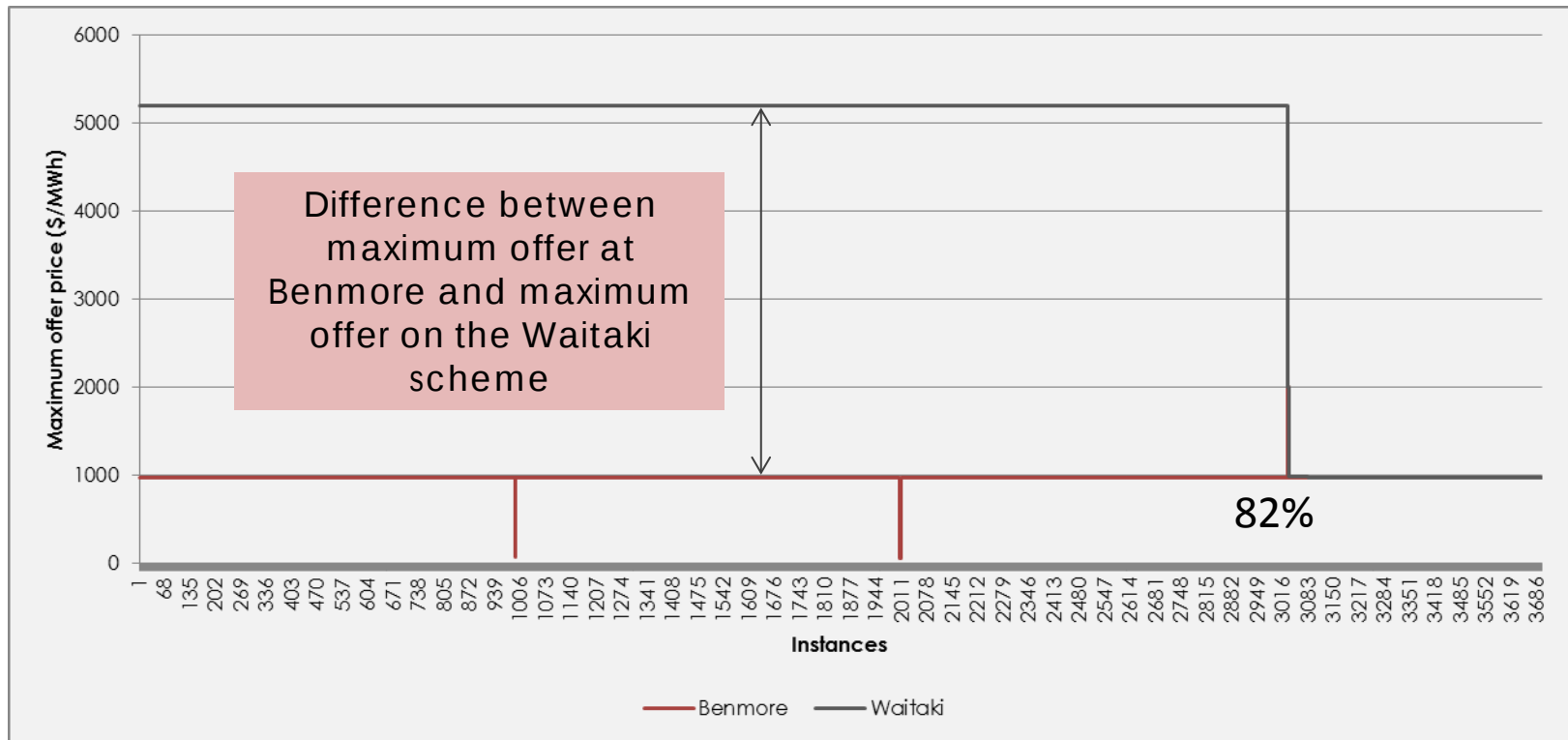
- This option assumes the maximum hydro scheme offer price as an alternate estimate for the additional generation capacity at stations on the scheme.
- The primary issue with this approach is that it could result in offers for the additional MW that could diverge from the local conditions affecting the generator with the additional MW and potentially reflecting local conditions affecting another generator's offers.
- To test this, we compared offer data from the Waitaki scheme over the period 01 Aug 13 to 31 Dec 14 when Benmore offered above its HAMI² (see next slide). This revealed significant differences between Benmore's maximum offer price and the maximum offer price on the Waitaki scheme for the majority of the instances (~82%), indicating that during instances when Benmore offered above its HAMI, the maximum offer price on the Waitaki scheme was not a reliable indicator for the maximum offer at the station.
- There could be various reasons for these differences, one of them being the presence of transmission constraints. These constraints can affect generators on the same scheme differently¹. This could influence a generator's offer price (e.g. to prevent a binding transmission constraint). It would be incorrect to transfer this offer to another station on the scheme that has a different (or no) impact on the constraint.
- Given the potential discrepancies with this approach and the fact that the previous sensitivities (options 1 and 2) address the underlying concerns raised in the review, we have not proceeded any further with this option.

¹ This issue and a list of the transmission issues in the Otago region is provided in:

<http://www.systemoperator.co.nz/sites/default/files/bulk-upload/documents/Part%20D%20GZ13.pdf>

² This occurred in ~3600 trading periods

3.6. Differences between Benmore max offer price and Waitaki scheme max offer price



These 3698 instances represent periods when Benmore offered energy above its HAMI (474MW)

3.7. Option 4: Authority's analysis should be an upper bound on cost savings

- The review highlighted that previous analysis undertaken by the Authority¹ could have understated the potential benefits of removing the current HVDC charge.
- In its analysis, the Authority estimated system cost benefits of ~\$3.5m (over the period Aug 2011 to Jul 2014) when comparing a scenario of no HVDC charge relative to the status quo. We understand that the majority of these benefits are in the post pole 3 period (01 Aug 13 to 31 Jul 14). The Authority did not assess the relative impacts of alternate HVDC charging regimes.
- The Authority's analysis assumed a minimum price of \$80/MWh on the additional generation capacity that could be available if the current HVDC charge were removed. The review proposed using a lower minimum of \$50/MWh as a sensitivity on the Authority's analysis
- While we do not have access to the Authority's model, we adopted an approach similar² to that described by the Authority¹ and applied the MWh and diluted HAMI charging options. We then applied the reduced threshold price for the additional SI generation capacity (50/MWh) and simulated the impact over post pole 3 period 01 Aug 2013 to 31 July 2014
- This provided benefit estimates of \$6.9m and \$5.6m respectively for MWh and diluted HAMI (N = 10000)

¹ See Transmission pricing methodology: Problem definition paper relating to interconnection and HVDC assets working paper available from <http://www.ea.govt.nz/development/work-programme/transmission-distribution/transmission-pricing-review/consultations/#c13929>

² Using our modified version of the vSPD model with specified price thresholds (and excluding daily energy constraints). We note that there are still differences in that we maintain the frequency keeping constraints and utilise a 1% tolerance to HAMI to detect periods of HAMI-constrained capacity. We understand the Authority relaxes the frequency keeping constraints and uses fixed detection bands for HAMI-constrained capacity. We do not consider these differences to materially affect the results.

3.8. Option 4: Assessment

- This sensitivity provides a check on the estimated benefits using an alternate analytical approach however there are differences in these approaches.
- The primary difference between the Authority's approach and ours is that the Authority uses a fixed price threshold as a means to set the minimum opportunity cost for the additional capacity, whereas in our approach this is dynamically calculated for each day through the use of the daily energy constraints on hydro schemes.
- We did not extend the analysis to pre-pole 3 periods as we considered that market conditions would have been sufficiently different under historic HVDC monopole operation which would impact the benefit assessment.
- We do not think that it is valid to view the Authority's analysis as an upper bound on the estimate of benefits (for the reasons discussed with the Authority).

3.5. Summary of sensitivities

- The impact of the tested sensitivity options is shown in the table below
- In all of the plausible sensitivities, the ranking of the options are consistent with the MWh alternative providing greatest net system benefits
- The sensitivities provide a range on the potential impacts considering issues highlighted in the review (though likely to be biased towards the lower range as some unexplored instances could increase benefits)

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Option 3 (Use maximum offer price for scheme)	Not tested	Not tested

ADDITIONAL SLIDES

Consider cost benefits of generation scheduling across hydro schemes

- Different hydro schemes could be experiencing different local hydrological conditions and constraints as reflected in their offer prices
- There is a weaker argument to support the potential for low-cost reallocation of generation between SI generation from different schemes
- Hence we consider system cost benefits of generation rescheduling across hydro schemes

Difference across schemes

