Appendix E Preliminary Cost-Benefit Assessments

Contents

1. Introduction

1.1 This appendix considers the potential benefits that extending frequency keeping to multiple providers might be able to deliver in New Zealand.

1.2 Section 1 considers the nature and range of benefits that might be achievable if the straw man design were to be implemented. This analysis draws on experience in the Australian National Electricity Market (NEM) and the Singapore electricity market.

1.3 Section 2 considers the potential benefits of the stage one proposal. This draws on New Zealand historical frequency regulation offer data given that existing providers would compete to supply a share of the frequency keeping requirement in the other island through the HVDC.

1.4 Any decision to implement the full regulation market design would take into account stage one implementation and the potential for additional benefits beyond that, recognising that some of the straw man benefits will have been achieved and some straw man infrastructure costs incurred in implementing the stage one proposal.

2. Preliminary Assessment of Straw Man Benefits

Nature of benefits

2.1 The overall objective of the straw man frequency regulation market should be to minimise the sum of direct and indirect costs associated with normal frequency management to deliver net present public benefits. These benefits could be achieved through a combination of factors including:

(a) Increased competition:

- Opportunities for more, and smaller, providers to participate.
- Greater discipline on providers.
- More competition between providers (including nationally).

(b) Better performance:

- Providers could offer smaller quantities at faster rates.
- The system operator could adjust quantities / quality more readily.

(c) Lower procurement costs:

- Requirements could be selected from the cheapest offered tranches, taking account of interactions and interdependencies between regulation, instantaneous reserves and energy.

- Inter-island diversity could reduce overall regulation requirements.

(d) Future proofing:

- Potential to adjust frequency keeping quantities/frequency targets in future. e.g. if wind penetration increases overall frequency keeping requirements.
- Enhanced quality of supply; increased system capacity to accommodate intermittent/ renewable generation.

2.2 Given its preliminary nature, the following analysis focuses on the potential procurement cost savings that might be achievable under the straw man proposal.

Australian National Electricity Market (NEM) Experience

2.3 Like the New Zealand market, the NEM includes the concept of co-optimisation, although it is applied more widely than in New Zealand where co-optimisation is limited to instantaneous reserves (fast and sustained 'raise' services) and energy. The NEM, summarised in Appendix A (para 8), includes co-optimisation of separate 'raise' and 'lower' frequency control ancillary services (FCAS) and co-optimisation also extends to 5 minute raise and lower regulation products. The NEM arrangements are similar to the proposed straw man design although differences between the New Zealand and Australian markets make it difficult to directly translate NEM experience to the New Zealand context. For example:

(a) The Australian system is physically larger, with a greater proportion of thermal generation.

(b) The NEM 'normal frequency' standard is ±0.15 Hz for 99% of the time compared to the New Zealand standard of +/- 0.2Hz except for momentary fluctuations.

(c) The NEM has more participants.

(d) The NEM raise and lower regulation markets were developed around a legacy AGC system.

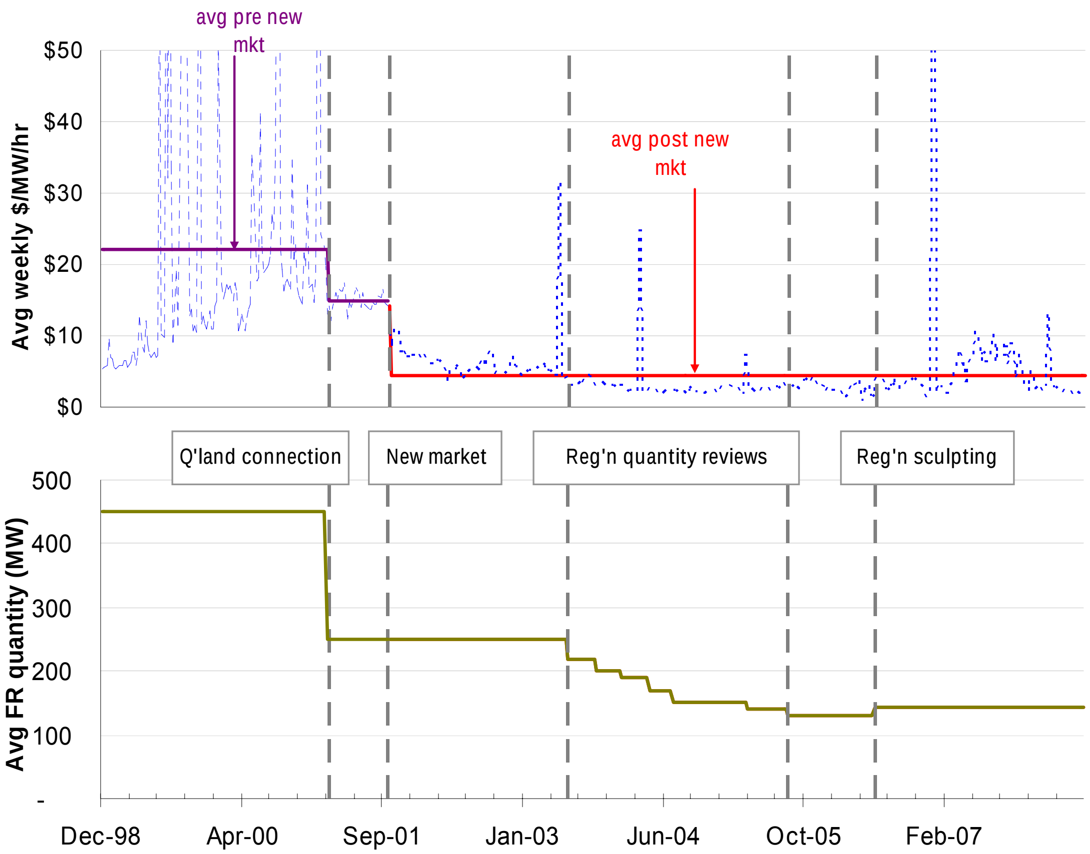
(e) The costs of regulation raise and lower services are allocated to generators and off-take customers on the basis of causer-pays factors.

2.4 Nevertheless, NEM experience offers useful insights into the potential benefits which might be available in New Zealand if the straw man frequency regulation market were to be implemented.

2.5 Note that the following analysis is based on Australian dollars.

2.6 Figure 39 shows weekly average procurement costs for raise and regulation reserves (top chart) and regulation requirements (lower chart) changed in the mainland NEM between December 1998 and July 2008. The charts exclude Tasmania (data is not available over all years and Tasmania only joined the NEM in May 2005). Average procurement costs have been calculated from the sum of 'raise' and 'lower' costs for each week divided by the average raise and lower range. This makes comparison with New Zealand more straightforward given that there is no distinction between raise and regulation requirements here.

Figure 39: Changes in the frequency regulation in the Australian NEM



2.7 Key points to note with regard to Figure 39 are that:

(a) In late February 2001 interconnection with Queensland was established. When this occurred, frequency regulating reserve requirements reduced from 450MW to 250MW and average procurement costs fell to around $15 per MW per hour, a reduction of approximately one third. At that stage, frequency regulation requirements were still being procured by NEMMCO under long term contracts, although AGC was available.

(b) In late September 2001, the NEM introduced competitive spot markets for frequency control ancillary services, including 5 minute raise and lower regulation services. When the new market arrangements were implemented, the average cost of frequency regulation fell immediately to around $10 per MWh, a reduction of approximately one third.

(c) Over the following 18 months, average procurement costs fell further by around 50%, an overall reduction from the introduction of the new market arrangements of around two thirds.

(d) Between July 2003 and August 2005, frequency regulation requirements were progressively reduced from 250MW to 130 MW, with average procurement costs over that period also falling.

(e) Following trials in July 2006, different raise and lower regulation requirements have been procured. The lower quantity has been reduced to 120 MW and the raise quantity varies between 130 MW and 250 MW during peak demand ramping periods. The time weighted weekly average raise quantity is approximately 165 MW. The time weighted raise and lower quantity is approximately 135 MW. Since these changes were introduced, average procurement costs increased again but have more recently reverted to previous levels.

2.8 While difficult to translate into the New Zealand market, the above analysis suggests extending frequency regulation to multiple providers could offer significant savings in direct procurement costs.

(a) Prior to the introduction of the current NEM regulation market arrangements in late September 2001, average procurement costs in the NEM were more comparable to New Zealand's current frequency keeping costs. Unlike New Zealand, the NEM already had a legacy AGC system in place over that period.

(b) Interconnection with Queensland helped to lower overall NEM procurement requirements and the average cost of procurement. Using the HVDC link to transfer frequency keeping between islands is a possible parallel in the New Zealand market. Although the ability to reduce procurement quantities here is likely to be proportionately less, South Island procurement costs are often less than in the North Island. Analysis in the next section of this appendix considers potential benefits associated with transferring regulation between islands via the HVDC.

(c) Through a series of reviews, including the frequency standards, overall NEM procurement requirements have been reduced. The ability to vary regulation requirements more readily in New Zealand would enable similar and more dynamic trade-offs to be made here.

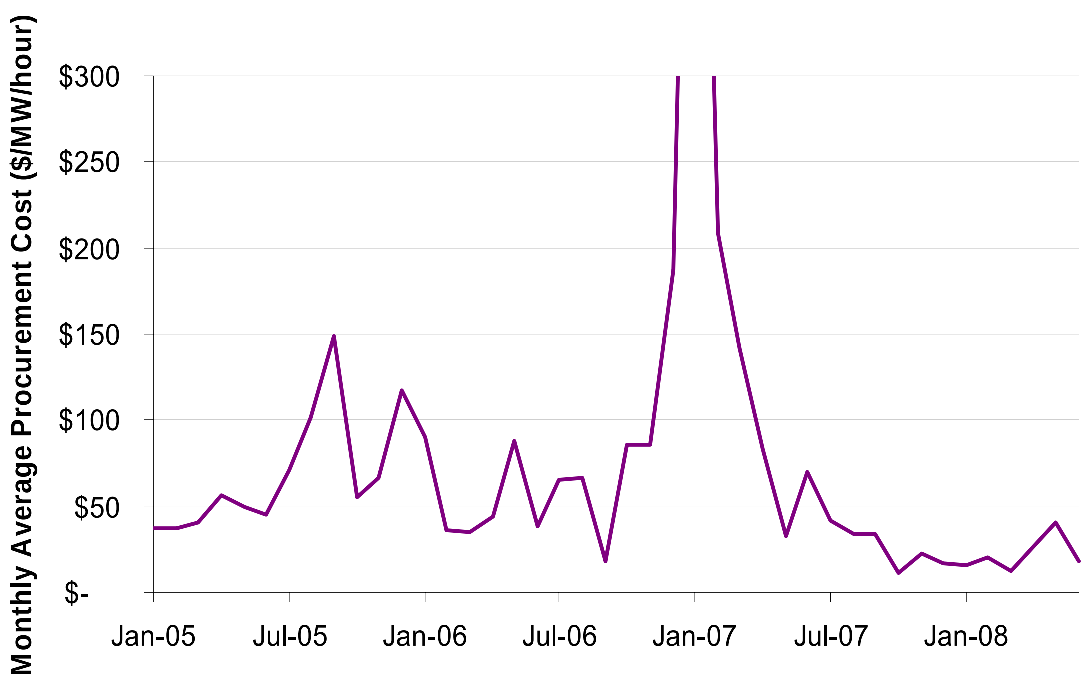
(d) Market prices for frequency keeping procurement may not reflect the full costs associated with frequency regulation, although it appears that both increased competition and reduced procurement quantities have contributed to significant NEM procurement cost reductions.

(e) The potential costs of market complexity need to be accounted for, noting that New Zealand is a smaller market and does not have a legacy AGC system.

Singapore

2.9 As for the Australian market, the Singapore frequency regulation market is conceptually similar to the straw man design proposal in this paper. However, experience in Singapore has been significantly different to that in Australia as can be seen in Figure 40, showing average monthly regulation procurement costs (in Singapore dollars).

Figure 40: Singapore average monthly procurement costs



2.10 The Singapore and New Zealand electricity systems are similar in size. Regulation requirements are also similar. However, the Singapore market is almost entirely thermal, with a relatively small number of large units, and a small number of participants. Until early 2007, frequency regulation prices were high. A number of factors appear to have contributed but a surveillance review in 2007[178] noted that three participants controlled 90% of regulation market requirements of around 100 MW, with typically around 120 MW being offered. It also noted that, particularly in early 2007, increasing offer prices and CCGT outages contributed to high regulation costs.

2.11 It is understood that a fourth participant (a new entrant generator) joined the market in April 2007. The quantity of regulation offered into the market has subsequently increased. The market clearing engine formulation has also been adapted (see the discussion on integer programming in Appendix C) to overcome technical constraints on regulation under certain circumstances. The System Operator also now adjusts regulation requirements according to market conditions instead of the previously fixed quantity of 100 MW.

2.12 It seems reasonable to assume that the reduction in monthly regulation costs since mid 2007 is permanent. In some respects the New Zealand situation is perhaps like the current Singapore situation, with four providers able to offer. However, in New Zealand the amount of regulation available relative to system requirements (assuming multiple providers are simultaneously scheduled) is proportionately larger

178 http://www.emcsg.com/f9175,149636/149636_MSCP_final_online_version_31Mar08_.pdf

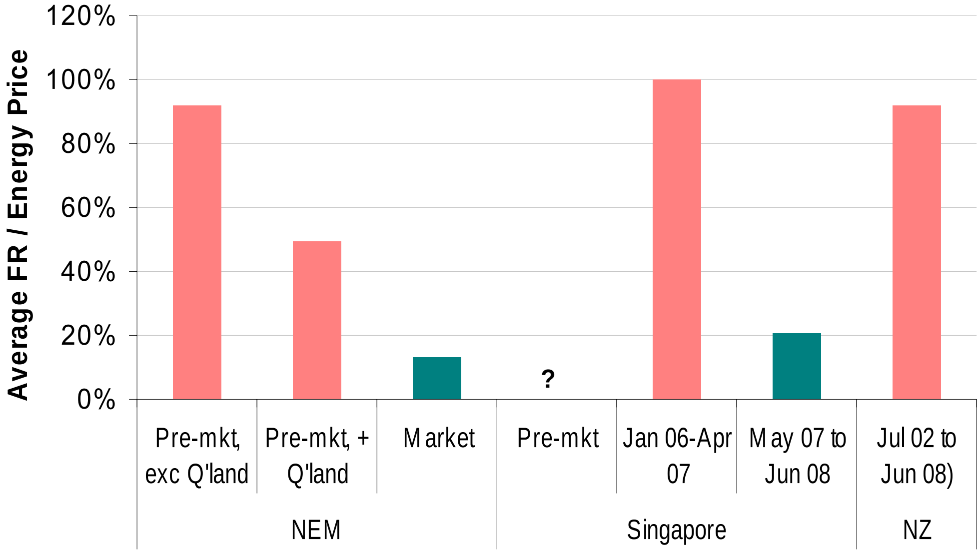
than in Singapore. Prior to the additional new entrant provider entering the market in April 2007, of the 120 MW typically available, 100 MW was required.

Potential Straw Man Procurement Savings

2.13 The ratio of regulation to energy costs is a useful benchmark for comparing regulation costs in different jurisdictions since generation capacity provides both products with related opportunity costs. It also compensates for exchange rates differences.

2.14 Figure 41 compares the ratio of frequency regulation costs to wholesale energy costs in New Zealand, Australia and Singapore over various timeframes. Recall that in Singapore circumstances changed considerably following the entry of a fourth participant in around April 2007. No pre-market data is available for Singapore although the 2003 Singapore market review report noted that total reserve costs, including regulation reserves, dropped to about 10% of pre-market levels.

Figure 41: Ratio of frequency regulation and energy costs in NZ, Singapore and NEM



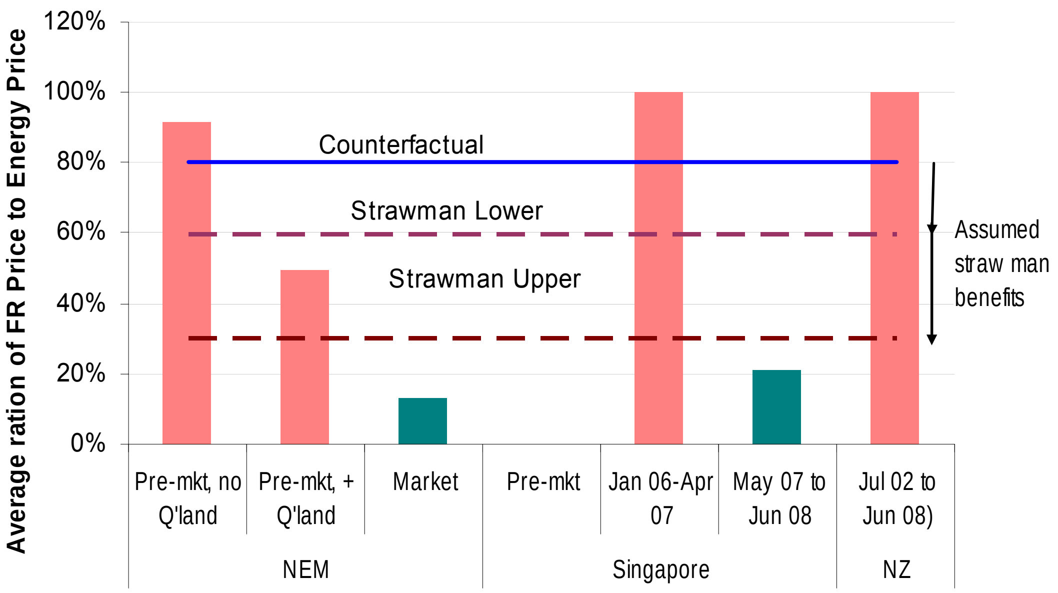
2.15 It is difficult to predict how New Zealand regulation procurement costs would alter under the straw man market design. It seems plausible to assume that regulation prices could reduce to current Singapore levels given the situation there now is comparable to New Zealand regarding regulation requirements and participant numbers. The Australian experience suggests the possibility that larger reductions could occur although the New Zealand market size may be a limiting factor.

2.16 It is also necessary to establish a New Zealand market baseline against which to measure any procurement cost savings. Procurement costs tend to be volatile and a conservative approach to estimating savings is prudent. The Commission has therefore used the average ratio of frequency keeping to wholesale energy procurement costs over the period July 2002 to Jun 2008 (approximately 100%) to estimate base procurement costs going forward.

2.17 It is possible that the recent change to the System Operator's selection methodology could result in ongoing procurement cost savings. However, there is insufficient data to know how effective that change will be. It is possible for example, that offer prices may change to reflect the risk constrained on costs. It is also possible that other measures could reduce procurement costs. For example, reducing procurement requirements at off peak times. Given the uncertainties involved, the Commission has therefore assessed potential benefits going forward relative to a counterfactual assuming a procurement cost ratio of 80% (instead of 100% as above). For benefit assessment purposes, the Commission has assumed that, under the straw man market, the procurement cost ratio could fall to between 60% and 30%.

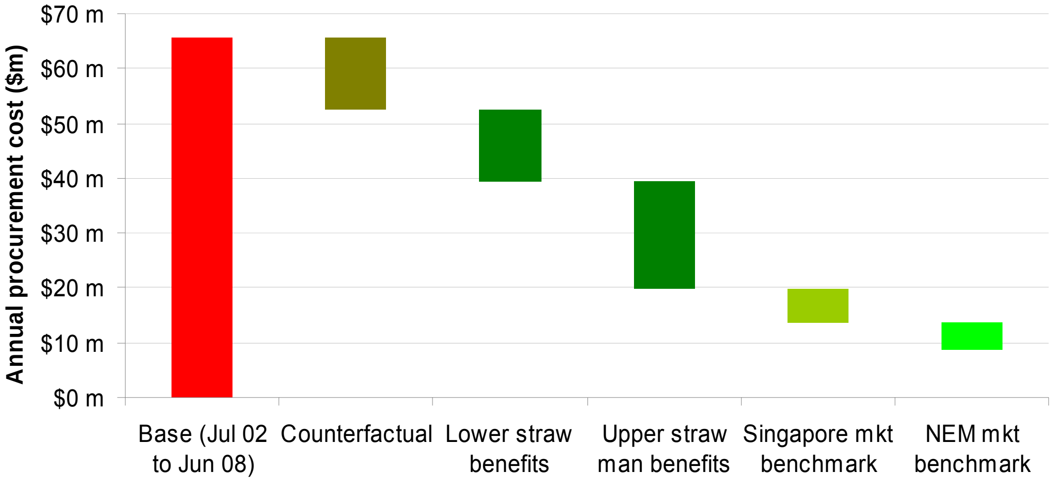
2.18 To put these straw man benefits assumptions into perspective, Figure 42 compares them to historical data New Zealand data, the counterfactual ratio and Singapore and Australian benchmarks.

Figure 42: Procurement cost ratio assumptions for straw man benefits assessment



2.19 Assuming a long run energy cost of $75 per MWh, Figure 43 shows how procurement costs would be affected under the above assumptions. It also shows the level of benefits if the Singapore and NEM market benchmark were achievable.

Figure 43: Relative procurement cost reductions pa



2.20 Lower and upper estimates of straw man procurement savings, relative to the counterfactual, are approximately $13m and $33m per annum.

2.21 Other potential benefits could include:

- The ability to more readily adjust regulation requirements over time to trade-off procurement costs and frequency quality, including sculpting requirements as system requirements vary. This feature has been done progressively in Australia as discussed above.
- Reductions in the amount of frequency regulation required, taking advantage of interisland diversity via the HVDC regulation transfer role.
- Regulation requirements could be increased more readily if system intermittency increases over time given increased renewable generation and the possibility of generation with conventional free governor being displaced.
- This would have potential quantity of supply and/ or long term investment benefits, enabling the system to more efficiently accommodate new generation technologies.

Implementation and Ongoing Costs

2.22 Detailed investigations will be required to determine final design and implementation requirements and costs. KEMA [4] attempted to develop broad cost estimates for establishing AGC capabilities and related infrastructure and local site requirements but were unable to obtain sufficient information from participants and Transpower in part due to uncertainty over the market design at the time site visits were made.

2.23 The Commission has therefore assumed straw man implementation (including rule change and system requirements) and ongoing annual costs of $3.5m to $5m and $0.5m to $1m respectively.

Estimated Straw Man NPV

2.24 Combined with lower and upper procurement cost savings estimates of approximately $13m and $33m per annum (as discussed above), that represents net benefits of approximately $63m to $177m[179] over a 10 year period.

3. Preliminary Assessment of Stage One Proposal

3.1 Stage one involves developing the capability to coordinate a single provider in each island and the HVDC so as to transfer frequency regulation from one island to the other.

Potential Stage One Benefits

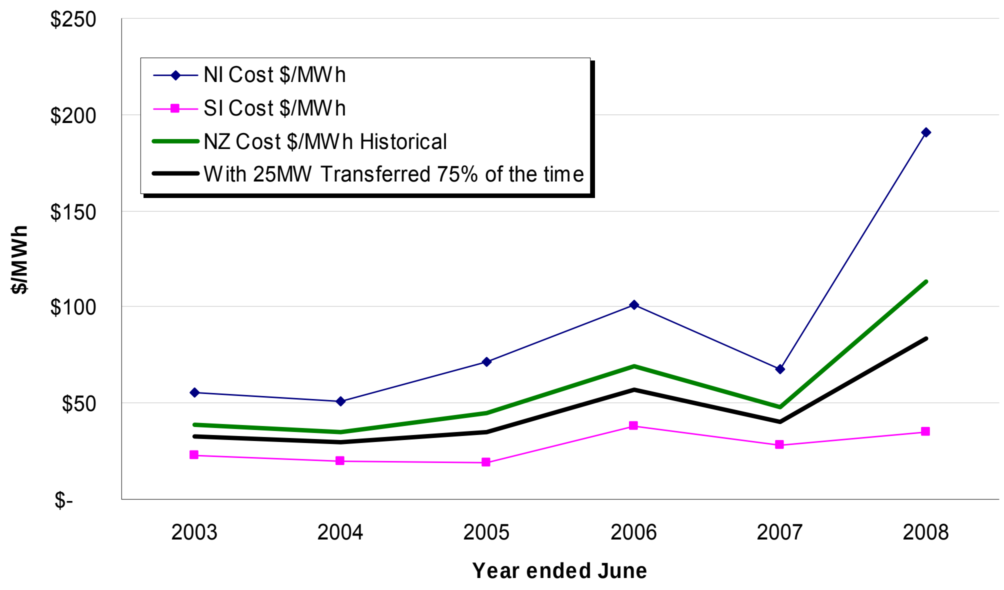
3.2 It is difficult to estimate how much stage one would reduce procurement costs as market behaviour may change. However, an indicative estimate can be made from historical frequency keeping costs in each island.

3.3 Historically around 50MW of frequency keeping reserve has been procured in each island. The potential savings can be assessed on the assumption that 25MW of reserve can be transferred from the cheaper island to replace reserve provided in the more expensive island for some percentage of the time when there is sufficient regulating capacity on the HVDC. On a historical basis, it is estimated that the HVDC would be able to transfer 25MW around 75% of the time.

3.4 Figure 44 shows the average North Island and South Island frequency keeping cost over the last 6 years. Total New Zealand average frequency keeping cost with 50MW procured in each island is shown in green. If, for 75% of the time, the South Island could provide 75MW frequency keeping and this was transferred via the HVDC so the North Island only need to provide 25MW, then the New Zealand total frequency keeping costs could be reduced by around 20% (shown by the black line).

179 Discount rate of 10% pa using higher cost /lower benefit assumptions for the lower NPV estimate and lower cost/ higher benefit assumptions for the upper NPV estimate.

Figure 44: Historical frequency costs



3.5 As a cross check on the indicative cost savings a more detailed analysis based on actual frequency keeping offers and HVDC transfer levels. The approach involves comparing the existing selection costs (offer price only) to the cheapest offer or combination of offers from either island to meet the frequency keeping requirement, but constrained to trading periods where the HVDC was already transferring sufficient energy and had spare capacity to transfer at least another 25 MW more or less. July and August 2006 were chosen as there were a range of 25MW, 50MW and 75MW offers in each island. This analysis indicated that frequency keeping offer costs would be reduced by around 10-25% over the 2 months. It was not possible to estimate what the impact on constrained on and off costs would have been, but it is likely that there would have been a similar or greater saving[180]. Thus the 20% cost reduction indicated by high level analysis would appear to be supported by the more detailed analysis based on actual historical offers.

3.6 As for the straw man assessment, to project the benefits of stage one it is useful to express historical frequency keeping costs relative to energy prices. Table 3 show the historical ratio of frequency keeping and wholesale energy costs and high, middle and low estimates of the ratio under stage one.

3.7 The percentage of time that the HVDC is able to transfer 25MW is uncertain and so the high estimate assumes 25MW is transferred for only 50% of the trading intervals. It is possible that more than 25MW could be transferred, and hence the low estimate is based on 35MW being transferred 70% of the time. This implies savings of between 13% and 25% relative to historical frequency keeping costs.

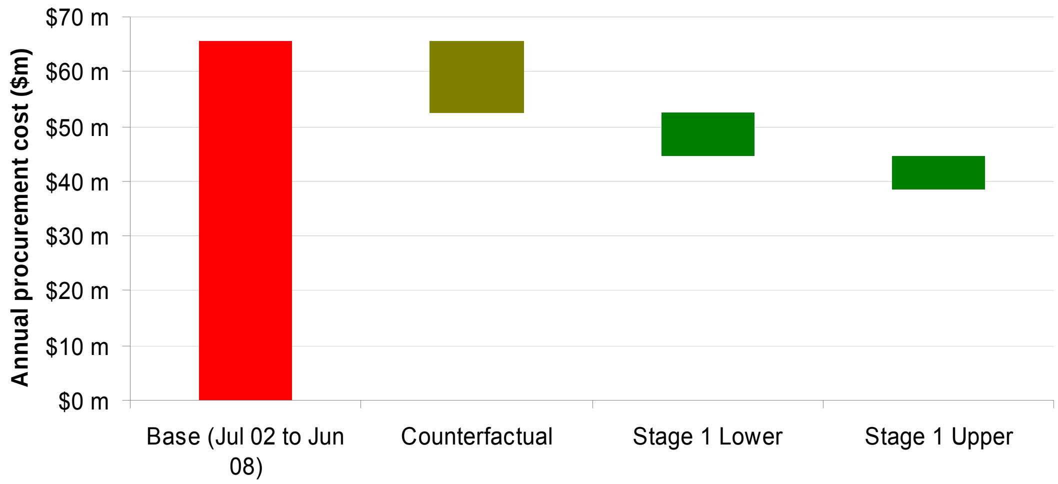
180 Given that typically constrained on/off costs were around 20% of total FK costs in the North Island, compared with only 5% in the South Island.

Table 3: Historical frequency costs expressed relative to energy prices

Year end June	NZ Historical	High cost NZ with 25MW transfer 50% of time	Medium cost NZ with 25MW transfer 75% of time	Low cost NZ with 35MW transfer 70% of time
2003	80%	72%	67%	64%
2004	105%	94%	88%	83%
2005	103%	89%	82%	75%
2006	75%	66%	61%	57%
2007	105%	94%	89%	84%
2008	119%	98%	87%	77%
Avg 2003 to 2008	98%	85%	79%	73%
Saving		13%	19%	25%

3.8 Assuming a long run energy cost of $75 per MWh and counterfactual cost savings of 20%, as for the straw man assessment, Figure 24 shows potential stage one annual procurement cost reductions.

Figure 45: Assumed Stage One procurement cost reductions



3.9 Lower and upper estimates of straw man procurement savings, relative to the counterfactual, are approximately $8m and $14m per annum.

3.10 Other potential benefits could include:

(a) Reductions in the amount of frequency regulation required, taking advantage of interisland diversity via the HVDC regulation transfer role.

(b) The possibility of larger regulation transfer capability than assumed.

Implementation and Ongoing Costs

3.11 The System Operator has provided to the Commission an indicative estimate of stage one implementation and operating costs, from the System Operator's perspective. The estimates, attached to this appendix, sum to $1.8m for implementation and $0.1m for annual operating costs. The Commission has added to these estimates a rough provision for other costs, such as communication of frequency control error signals providers, and interfacing with their local control systems etc. Sums of $0.2 (implementation) and $0.05m (ongoing pa) have been assumed for each of the four existing providers.

3.12 Total assumed implementation and annual operating costs are therefore $2.6m and $0.3m respectively. The Commission wishes to make it clear that neither the System Operator's estimates nor the Commission's estimates of generator related costs are budget estimates. Budget estimates will need to be established through detailed investigation of requirements following consideration of feedback on this paper.

3.13 The Commission has also assessed sensitivity to total implementation and ongoing costs by assuming they could be 150% higher than the above estimates.

Estimated Stage One NPV

3.14 Given the above cost estimates and lower and upper procurement cost savings estimates of approximately $8m and $14m per annum (as discussed previously), net benefits of approximately $38m to $75m[181] over a 10 year period have been estimated.

4. Conclusions

4.1 Preliminary estimates suggest the straw man market design has the potential for substantial benefits, on the basis of procurement cost savings alone. As indicated in Figure 46, moving towards that goal by implementing the stage one proposal could provide significant initial net benefits.

181 Discount rate of 10% pa using higher cost /lower benefit assumptions for the lower NPV estimate and lower cost/ higher benefit assumptions for the upper NPV estimate.

Figure 46: Preliminary NPV comparisons