Review of

Assessment for Reserve Energy Requirements in 2005

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Executive Summary

1. Concept Consulting have outlined a methodology for computing a Minimum Hydro Zone (MHZ) and applied it to 2005 under a number of assumptions.

2. Concept's MHZ is computed from sample paths of inflows, and so it is a statistical estimate of the true MHZ, with an associated error that can also be estimated.

3. Concept's MHZ specifies a strategy rather than an outcome. The true probability of shortage is determined by how likely it is that a storage trajectory enters the MHZ.

4. Simulation is sensibly used to check the performance of Concept's MHZ.

Introduction

The report "Assessment for Reserve Energy Requirements in 2005" authored by Concept Consulting was commissioned by the Ministry of Economic Development (MED) to consider the security of the national electricity supply in 2005. Concept were especially asked to consider the role to be played by (publicly owned or controlled) reserve energy, including in particular the definition of a Minimum Hydro Zone (MHZ) within which market intervention should take place. The types of intervention being contemplated by the government are sketched in a September 2003 Government Policy Statement (GPS).

Methodology

The approach taken in the Concept report is to define the MHZ at any time *t* to consist of those storage levels for which, assuming

- all thermal plant runs constantly from *t* onwards, and
- there is no public conservation campaign,

the probability of reaching zero storage exceeds 1/60. This approach appears to be both simple and consistent with the usage of the term "1 in 60 security standard" in the GPS.

For computational purposes, the "1/60" probability level is estimated by computing the maximum decrease in storage that would occur if any of the 72 available historical inflow sequences were to recur. From a statistical point of view, this estimation procedure is subject to fairly large errors – see the Appendix to this review.

The "look ahead" period over which the maximum decrease is computed is stated on page 7 to be 12 months (though this is not shown on Figure 1 on this page.) It appears from Figure 4 that 12 month sequences are taken for each starting month.

Results

Using their method the Concept report computes the MHZ for 2005. The highest storage level meeting the MHZ conditions is approximately 1500GWh during June 2005. At other times of the year, the minimum storage requirement is much lower, notably so during February, March, and April. This may seem unintuitive, but is consistent with the way the MHZ has been defined. During these late summer months, there is still time for thermal generation to add enough energy to the system to avoid any shortages - and by assumption, such thermal generation will be forthcoming.

However, it should be noted that the above approach to defining the MHZ specifies a strategy rather than an outcome. If the Commission (or MED) follows a policy of intervening when storage levels meet the above conditions, this will not imply any particular probability of avoiding shortages or public savings campaigns for the year in question. These probabilities depend on the likelihood of reaching the MHZ during the year. (There is also the possibility of entering the MHZ more than once, in a "double dip" storage trajectory similar to those which occurred in 1992 and 2003.)

Furthermore, the assumptions defining the MHZ are possibly quite unlike those which might occur if low storage levels were reached in practice. The experience of 2001 and 2003 suggests that even quite low storage levels may be insufficient to commit all thermal plant; in addition, a public conservation campaign would certainly begin at some point before storage fell to zero.

Finally, a real supply shortage might well occur at very low (but still positive) storage levels. Some stations will run out of water before others (inflows might be quite different on North and South Islands) and those with water still available may be sufficiently constrained in capacity and transmission terms to make system dispatch infeasible in peak periods.

In the light of these issues, it is important not only to compute the upper limit of the MHZ, but to simulate likely storage trajectories over the full winter season. The authors of the Concept report appear to understand this well, and have devoted space to an assessment of the likelihood of reaching the MHZ in 2005. This is a much more difficult problem than computing the MHZ itself, as it must consider the behaviour of both hydro and thermal generators during normal market conditions, rather than simply assuming that thermals will always be dispatched. The report's conclusions in this regard should probably be regarded as less robust than its other results.

Another issue to be considered here is that of correlation between inflows before and after reaching the MHZ. Entering the MHZ in itself implies that this is a drier-than-normal year, a fact ignored in the MHZ calculation. The Concept report draws attention to this in footnote 12, but does not attempt to allow for it. Our own EPOC research suggests that ignoring such a possible correlation is a reasonable approximation for MHZ purposes: the correlation coefficient between seasonally-adjusted NZ total weekly inflows four weeks apart has been estimated to be less than 0.1.

The Electricity Commission will also be responsible for initiating public conservation campaigns when it deems this to be prudent. (GPS paragraphs 33 & 60: "Within this minimum zone, the EC should have a second zone that would trigger a conservation campaign, on the basis that we are in a worse than 1 in 60 event" and "the Government expects the Commission to activate an effective conservation campaign in a timely manner".) Policy on this is not covered by the Concept report. However, it should be noted that the "second zone" referred to by the GPS might not lie entirely within the MHZ as suggested by Concept. The experience of 2001 and 2003 suggests that in some circumstances (e.g. storage of 1300GWh on 1 April 2005), a public conservation campaign might begin even though the MHZ had not yet been reached.

Appendix – Estimation of the likelihood of extreme events

Figure 4 illustrates well the MHZ concept as used by Concept in their report. The storage starting at 1500GWh in June becomes zero in only one of the inflow scenarios – the one giving the maximum decrease in storage. This means that in 1 out of 72 of historically observed inflow sequences the storage will hit zero.

Does this mean that there is a 1 in 72 chance of a shortage if we begin with 1500GWh in June? It is hard to say because we do not have a full description of the stochastic processes governing inflows; we have only 72 sample paths. These can only give us estimates of probabilities of shortage, not exact values.

To explain this let $S(t)$ be the random storage trajectory obtained starting from $t=0$ (corresponding to June 2005). Let

$$X = \max\{S(0)-S(t) \mid 0 \le t \le T\}.$$

Here T could be 12 months. Now the MHZ value is the minimum number M such that

$$Pr\,(X \ge M) = 1/72.$$

So M is such that

$$Pr\,(X<M) = 71/72.$$

Suppose we now take 72 (independent, identically distributed) random samples $X(j)$, $j=1,2,\ldots,72$ from the distribution of X. Then the maximum of these will be less than M only if all of them are, so

$$Pr\,(\max\{X(j), j=1,2,\ldots,72\}<M) = (71/72)^{72} = (1-(1/72))^{72} \approx e^{-1} \approx 0.368\,.$$

This means that there is a 37% chance that starting from the true MHZ value the worst storage trajectory from 72 years of data will not hit zero. In other words, there is a 37% probability that the MHZ we compute from the procedure proposed by Concept is lower (takes more risks) than the true 1 in 72 MHZ. This might seem to be somewhat alarming since it indicates a 37% probability that the procedure is not conservative enough. However there is also a 63% chance that the procedure is too conservative.

To estimate the magnitude of the likely errors, we can repeat the above analysis by considering the MHZ at a probability of p. This is the minimum number M such that

$$Pr\,(X \ge M) = p$$

Suppose we now take 72 random samples $X(j)$, $j=1,2,\ldots,72$ from the distribution of X. Then the maximum of these will be less than M only if all of them are, so

$$Pr\,(\max\{X(j), j=1,2,\ldots,72\}<M) = (1-p)^{72}\,.$$

This means that with probability $(1-p)^{72}$, the "1 in 72" MHZ we compute from the procedure proposed by Concept fails to achieve security level *p*. For example, putting *p=1/25* shows that there is a 5% chance that the true security level of the MHZ in the Concept report is worse (i.e. has a higher shortage probability) than 1 in 25. Similarly, there is a 23% chance that it is worse than 1 in 50. At the other extreme, there is a 7% chance that the true shortage probability for this MHZ is less than 1 in 1000.

We believe that this is an issue that requires some careful thought. The Concept report talks of return periods longer than 72 years, which is misleading terminology since any observed inflow sequence recurs with probability zero. With only 72 sequences to play with, the most conservative MHZ we can calculate using the Concept procedure has quite a high chance of being riskier than we are led to believe. If using this MHZ in 2005 causes a shortage, then it will not be possible to claim in hindsight that the 2005 inflows were a worse than 1 in 72 event.