Submission on

Consultation Paper: Instantaneous Reserves Pricing and Dispatch

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Executive Summary

1. The Electricity Commission has carried out an analysis of proposed changes in the way instantaneous reserves are scheduled, priced, and dispatched. The effect of these changes is to provide remuneration for reserve offers in circumstances when the current run of SPD (including nonzero reserve requirements) is infeasible.

2. The changes entail using different constraint violation penalty parameters for energy and reserve constraints, so that energy constraints are satisfied if possible by a dispatch (even if it is impossible to meet the reserve requirements). It can be proven mathematically that such a choice of constraint violation penalty parameters always exists.

3. It is not obvious from the discussion document that the maximum proposed constraint violation penalty value of $800,000/MWh for unserved energy achieves the objective. This would also depend on the constraint violation penalty value for reserve.

4. The use of essentially arbitrary constraint violation penalties to signal infeasibility carries serious risks of mispricing both energy and reserve in SPD. To truly signal infeasibility constraint violation penalties must exceed any potential spot price that might be achieved by a feasible dispatch in SPD. In the presence of spring-washer effects such prices might exceed $800,000/MWh.

5. The correct constraint violation penalties in SPD should ideally come from value of lost load figures (presumably very much less than $800,000/MWh). In the presence of active demand-side participation in the spot market, these values should be defined for each consumer of electricity as part of their demand-side bid.

Introduction

The Electricity Commission has carried out an analysis of proposed changes in the way instantaneous reserves (IR) are scheduled, priced, and dispatched. The effect of these changes is to provide remuneration for reserve offers in circumstances when the current run of SPD (including nonzero IRAFs) is infeasible, but would be feasible if the reserve requirement were relaxed.

The proposed approach supersedes the practice of setting the reserve requirement to zero, and re-solving SPD in the hope of obtaining a dispatch with no energy shortfall. In the new approach, the constraint violation penalties are set so that any optimal solution will satisfy the energy balance constraints if it is possible, and meet the reserve constraints as much as possible. In this circumstance we expect all the reserve to be dispatched, and for those offering reserve to be remunerated.

Constructing feasible dispatches

Before discussing the reserve pricing proposals in detail, it is worth discussing the use of constraint violation penalties in SPD. These should be used, and interpreted, with caution.

Constructing a feasible solution to a linear program (as SPD is) is typically done by one of two methods. The *Phase1-Phase2* method first seeks any dispatch that meets the constraints without attempting to minimize the objective function. It does this in Phase 1 by penalizing constraint violations with a positive cost and then minimizing the sum of these. The instance of the problem has a feasible solution if and only if the Phase 1 problem has a solution with zero cost. Optimization of the dispatch cost can then start by iterating from this starting point.

The *Big-M* method seeks an optimal feasible solution in one solve, by penalizing constraint violations at the same time as minimizing the cost of the dispatch. If the penalties on constraint violations are too small then the resulting solution might not be feasible, so these penalties must be chosen sufficiently large to ensure that a feasible solution will be found if one exists.

The pricing and dispatch software SPD adopts the Big-M method for ensuring a feasible dispatch. The value of the energy constraint violation penalty (M) is currently set to be $100,000/MWh. This is equivalent to placing an offer of unlimited quantity at this price at every node. The effect of this is to place an upper bound on the spot price of energy of $100,000/MWh. If the nodal price at any node is $100,000/MWh then the instance is declared infeasible. This raises some important questions:

1. *Is $100,000/MWh high enough to guarantee that SPD will find a feasible solution if one exists?*
   Feasible instances of SPD have been known to occur with very high nodal prices (due to spring-washer effects rather than highly-priced offers). In fact, if the network data and other constraints are held constant, the maximum nodal price can

be bounded in terms of the maximum offer price, but the factor in this bound can be very large. Of course in the absence of a bound on offer prices, there is no bound on nodal price. So with a constraint violation penalty of $100,000/MWh, an instance of SPD might be declared infeasible, when it is not.

2. *Should SPD adopt a Phase 1-Phase2 approach?*
   If for some reason the constraint violation penalty cannot be chosen to be greater than the maximum nodal price, then a Phase 1-Phase 2 approach is the only way of identifying a truly infeasible problem.
3. *How should wholesale market participants interpret constraint violation penalties?*
   From a large purchaser's perspective there is not much practical difference in a price of $100,000/MWh and a price of $200,000/MWh. In the absence of a contract for differences, the purchaser would face almost certain ruin if these prices were sustained, and so they would be scrambling to decrease load. Indeed, if the customer were hedged, then a reduction in load at these prices would still yield a substantial profit, assuming that the marginal value of the electricity to the consumer was significantly less than these prices. This means that such prices will inevitably signal consumers to shed load. For many participants this load shedding would occur at smaller prices than $100,000/MWh, and so constraint violation penalties should accommodate this through demand-side bidding. The demand-side bids that occur in NZEM in practice are mostly at much lower price levels than the constraint violation penalties being considered here – but there are relatively few of them, probably due to administration costs and other barriers. It seems likely that at price levels of hundreds of thousands of dollars per MWh, most purchasers would, in principle, be willing to decrease their load, thus implicitly defining the energy constraint violation penalty. Such demand-side bidding avoids the need to set artificial energy constraint violation penalties, and results in a downward pressure on spot prices.

Using different constraint violation penalties

The discussion document proposes the use of different constraint violation penalties for reserve and energy. The document indicates that a price of $800,000/MWh for unserved energy will be sufficient for this purpose, although it is not clear from the discussion document how this value has been derived. No value for the constraint violation penalties for reserve is given. There are no indications in the document how these values should be chosen.

The EPOC paper "On setting penalty parameters in electricity dispatch software" appended to this submission (and subsequently referred to as [1]) shows that any energy constraint violation penalty that exceeds the maximum nodal price will deliver a feasible energy dispatch if one exists. Of course this maximum is not known in advance, although it is possible to compute an upper bound on it (using Proposition 1 in [1]) if the SPD instance is feasible.

Responses to particular questions

Question 3 – pricing in the event of offer shortage

Two options are proposed for the event of offer shortage – pricing determined by the constraint violation penalties (option 1) or pricing determined by the highest offer price (option 2, achieved by relaxing the reserve requirement). Both energy and IR prices will be higher under option 1. Note that option 2 is equivalent to option 1 with the constraint violation penalties chosen at the lowest level that will achieve the desired dispatch.

The main deficiency of option 1 is that the constraint violation penalty values are essentially arbitrary. It is difficult to justify allowing these arbitrarily chosen values to influence final energy and reserve prices.

The main deficiency of option 2 is that the resulting energy and reserve prices are too low. At these prices, the provider (of IR, or energy, or demand-side curtailment) with the highest offer price will be indifferent between providing the resource or not providing it. But the system is not indifferent – it has a strong preference for more IR to be available. So the price fails to convey the system's preferences to the participants. Consequently, less IR (or energy, or demand-side curtailment) may be offered in future periods than would have been the case if higher prices had been paid.

In order to derive non-arbitrary prices which are appropriately higher than in option 2, it would be necessary to consider in more detail what is achieved by having a level of IR which covers only some of the possible contingencies. Our response to question 8 considers this further.

Question 8 – other suggestions

Covering lesser contingencies

Given that insufficient generation and IR have been offered to meet the usual IR requirement (i.e. to cover the largest contingent event), a natural consideration is whether smaller contingent events can be covered. There is a clear difference between a situation in which all contingent events bar the largest are covered, and one in which the ten largest contingent events are not covered. Arguably, the number (and nature) of contingent events not covered is a better measure of the IR deficiency than the number of megawatts lacking. This line of thinking would lead to a variant of the constraint violation penalties approach.

Integration with frequency keeping

With the increasing penetration of intermittent generation – wind power, in particular – the system's frequency-keeping and instantaneous reserve requirements are becoming less conceptually distinct. Even in the present-day system, reserve shortfalls and contingent events are situations in which resources committed to frequency-keeping become a kind of de facto IR. It may thus be desirable, in the longer term, to develop a market mechanism which dispatches IR and frequency-keeping in a more similar way.

References

[1] Philpott, A.B. On setting penalty parameters in electricity dispatch software, downloadable as www.esc.auckland.ac.nz/EPOC/OnSPDPenalties.pdf.