Although the MIO project did not include the extension of the MIO theory to the calculation of uniform prices (unconstrained sequence), the MIO Working Group did identify a number of issues that need to be addressed prior to incorporating MIO pricing in the unconstrained sequence. These issues are described below, along with the MIO WG's recommendation for addressing each.

Use of shadow prices from the first or second pass of the MIO algorithm

The first pass performs a full optimization for all of the identified intervals together (dispatch interval and future critical intervals). Non-linear constraints that relate the dispatches of two sequential intervals are either linearized (ramp limits) or are ignored (such as periods of steady operation). This pass is used to provide the minimum and maximum limits for the units to be applied in the second pass in order to achieve "near optimality". (Optimality could only be achieved if we were to do a joint optimisation in pass 1 while considering all constraints including non linear ones.) This identifies the units that needed to be ramped up (down) early in pass 1 to achieve a more economic outcome overall. In pass 2, we consider all the constraints and use the results of pass 1 to set the minimum and maximum of the units. This will force them to ramp up (down) early as required. The second pass performs an optimization for each identified interval in turn using these limits. The previous interval (or the initial conditions in the case of the first interval) will be used to set a ramp limit for each unit. The output of the unit will also be constrained in order to satisfy the dispatch (as calculated in the first pass) in the following identified interval (except for the last one).

The first pass dispatches and prices are not accurate due to the approximations made of the constraints. The shadow prices produced by this pass will, however, represent the cost of supplying an additional MW of demand in each interval, and factors in the impact of ramping up more expensive units early to meet a later demand. An additional calculation could be used to ascertain the highest price slice used in the identified intervals.

The second pass uses accurate constraints. The output from this pass is used to actually dispatch units. As in the first pass calculation, the shadow prices produced by this pass will represent the cost of supplying an additional MW of demand in each interval, and do not factor in the impact of ramping up more expensive units early to meet demand in a later interval. An additional calculation could be used to get the highest price slice used.

The recommendation of the MIO WG was that prices as determined from the second pass, without any additional calculations, be used.

Timing options

This issue relates to the time at which the sequence is run. This dictates the use of a particular combination of actual demand (for the past intervals) and forecast demand (for the future intervals). Any delay in running the sequence beyond the interval of interest will result in a delay in issuing the Market Clearing Price (MCP) report to the Market Participants. The three options considered were:

- Pre (or ex-anti) analysis using the same forward-looking intervals as the current MIO real time sequence. This would remove one of the differences between the constrained and unconstrained sequences. The use of forecast demand for the dispatch interval to calculate MCP may introduce some errors in the calculation.

- Post analysis using a look back over 11 intervals. This is the other extreme. The actual demand would be used for all intervals. There would be a delay of 50 minutes in issuing the MCP report. The difference between the constrained and the unconstrained sequences is the greatest for this option.

- Post analysis using a single interval which combines looking back one interval and looking forward over 10 intervals. This is the closest to what we are doing now. The actual demand would be used for the dispatch interval and forecast demands would be used for the other intervals. There would be no delay in issuing the MCP report. The MIO WG recommended this option.

Use of 1X or 12X ramp:
The MIO WG recommended using 1X ramp in incorporating MIO pricing in the unconstrained sequence.

Non-compliant units setting the MCP:
The MIO WG agreed that the non-compliant units - units that are producing more than their constrained schedule amount - should not set the price.

Introduction of new constraints in the unconstrained sequence:
As part of the implementation of MIO, new constraints in the constrained MIO real time sequence were introduced to address some dispatch issues. These include minimum loading point, forbidden regions and periods of steady operation. The MIO WG recommended that these constraints be included in the unconstrained real time sequence to reduce the differences between the constrained and the unconstrained sequences.

Units that are constrained because of minimum loading point, forbidden regions, de-rating and ramping limits setting the price:
The MIO WG recommended that these units should not set the price, which is consistent with a philosophy in which only resources that can be dispatched up or down are able to set price.

How the MCP would be calculated:
Two options were considered:

- The first option is to set the price based on the incremental cost of meeting the next incremental demand. This is consistent with the uniform price calculation now, but does not take into consideration the actions that MIO introduced (constraining units on/off early) to minimise the overall cost. There is a need to compensate the units that are constrained on

(and may be off) early to reduce cost in future intervals. The issue of how to compensate these units was discussed but no agreement was reached.

- The second option is to set the price based on the highest price for a slice used after excluding the non-compliant units and the units that are constrained for any reason other than meeting future demand. This is expected to result in a higher price than the first option. It has the advantage that there will not be a need for the additional compensation to be paid. Its disadvantage is that it yields a higher price that is applied to all settled transactions.

The MIO WG could not agree on a recommendation for the choice of option here, with load representatives in favour of the first option and the generator representatives in favour of the second option. There was also disagreement about the type of compensation for the units that are constrained on to meet future demand and whether the units that are constrained off should be compensated.