Energy Market Company

REVIEW OF PRICE REVISION IN THE NATIONAL ELECTRICITY MARKET OF SINGAPORE (NEMS)

Finalised March 2008

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LIST OF ABBREVIATIONS

AEMC	Australian Energy Market Commission
CVP	Constraint Violation Penalty
EMC	Energy Market Company
IEQ	Injection Energy Quantity
LSMP	Locational System Marginal Price
MCE	Market Clearing Engine
MEP	Market Energy Price
MOS	Market Outlook Scenario
NEM	Australia National Electricity Market
NEMMCO	National Electricity Market Management Company
NEMS	National Electricity Market of Singapore
NWSF	Network Status File
P&I	Pricing & Information
PDS	Pre-Dispatch Schedule
PSO	Power System Operator
RCP	Rule Change Panel
RTS	Real-Time Schedules
SMP	System Marginal Price
STS	Short Term Schedule
USEP	Uniform Singapore Electricity Price
VSTLF	Very Short Term Load Forecast
WEM (Argentina)	Argentina Wholesale Electricity Market
WEM (Philippines)	Philippines Wholesale Electricity Market
WEQ	Withdrawal Energy Quantity

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1 INTRODUCTION

1.1 BACKGROUND

Since 2003, the National Electricity Market of Singapore (NEMS)[1] has adopted an ex-ante pricing regime whereby the spot prices for energy, regulation and reserve are determined by the market clearing engine (MCE) just prior to the start of each half-hour dispatch period.

The choice of an ex-ante pricing arrangement was based on the recommendations of consultants PHB Hagler Bailly[2], who advocated ex-ante pricing for the certainty it offers market participants about prices prior to dispatch. The downside of ex-ante pricing is the possible divergence between projected schedules and actual dispatch quantities, but this is a manageable condition given the limited volatility of both electricity supply and demand in Singapore.

In addition, PHB pointed out the need for ex-post revisions to ex-ante pricing schedules in cases of (a) re-dispatches due to significant contingencies, or (b) market operator errors in calculating the original ex-ante prices. Accordingly, the Market Rules include provisions for price revision. When feasible, prices are revised by re-running the MCE; if not, prices are determined by taking an average of the previous 30 days' prices.[3]

These provisions for ex-post price revision have become a contentious issue for market participants.[4] While some recognise the role of price revision in accurately reflecting prevailing market conditions, others argue that ex-ante prices should be binding to both buyers and sellers. Revising prices ex-post could result in financial losses to generators, as the (lower) revised prices may not cover their marginal costs of dispatch.

This stalemate led the Rules Change Panel (RCP), at its May 2006 meeting, to task Energy Market Company (EMC) to evaluate the rationale and circumstances for price revision. EMC was to review existing price revision procedures and assess the impact of its recommendations, both on various stakeholders and on overall market efficiency.

This paper assesses the arguments for and against price revision, and draws comparison to two other ex-ante pricing markets, the Australia National Electricity Market (NEM) and the Argentina Wholesale Electricity Market (WEM). It then presents EMC's recommendations, which strive to balance the interests among all NEMS stakeholders.

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1 The price revision process takes place in the wholesale market of the NEMS only. Thus, all discussions in this paper relate only to the wholesale market.

2 *Wholesale Market Design*, 2 August 2000, PHB Hagler Bailly.

3 Except if: (1) there was a load shed; in that case the market energy price (MEP) and the Uniform Singapore Energy Price (USEP) shall be equal to the energy price ceiling; or, (2) the average price of the past 30 days exceeds the applicable upper price limit specified in Appendix 6J; in that case the price shall be set to that upper limit.

4 The debate began with a rule change proposal on '*Compensation Arising from Revised Market Energy Price*' (Paper No.: EMC/RCP/25/2006/253), presented at the Rules Change Panel (RCP) meeting in March 2006.

1.2 SCOPE OF REVIEW

This review aims to:

1. Study the practices in other jurisdictions to find out:
   - Whether or not ex-ante prices are subject to revision. If so, how and under what circumstances can such prices be revised? Can market participants seek compensation arising from price revision, and if so, who pays the compensation costs?
   - How does the market address situations in which no real-time dispatch schedule is produced, or when erroneous input data is used to generate the real-time dispatch schedule? Is compensation available to market participants in such situations?

2. Study internal procedures used by EMC for price revision, and examine, for each historical case of price revision in the NEMS:
   - The circumstances giving rise to the need for the price revision; and
   - The frequency and impact of the price revision on the market;

3. Consider the rationale for price revision in the NEMS and to recommend whether or not price revision should remain; if so, whether the NEMS should:
   - Retain the current price revision arrangement; or
   - Augment the current price revision arrangement with some recommended changes;

4. Evaluate how the recommendations in (3) would affect various stakeholders, and the efficient and fair operations of the market;

5. Identify, in relation to the recommendation in (3):
   - Changes to the current Market Rules required to support the recommendation; and
   - Possible measure(s) to mitigate any adverse impact on specific stakeholder groups.

2 EMC'S REVIEW AND RECOMMENDATIONS

2.1 GUIDELINE FOR REVIEW

In this review, EMC is guided by the key principles underpinning the NEMS market design, the most fundamental of which is economic efficiency. The other principles are, in no particular order:

- Robustness;
- Transparency;
- Equity and Fairness;
- Minimization of transaction costs.

EMC's recommendations should also account for physical and system constraints (e.g., constraints associated with electricity transmission).

2.2 PRACTICES IN OTHER JURISDICTIONS

As part of its review, EMC analysed the pricing regimes in other markets, as summarised in Table 1.

Table 1: Pricing Regimes in Other Markets

Market	Pricing Regime	Nodal/Market Type/Algorithm
NEMS (Singapore)	Ex-ante	Full nodal on supply side, single price (USEP) for loads, 30-minute real time market.
NEM (Australia)	Ex-ante	Zonal pricing, real-time market, co-optimized.
WEM (Argentina)	Ex-ante	Full nodal, hour-ahead market.
NZEM (New Zealand)	Ex-post	Full Nodal, real-time market, co-optimized.
Ontario (Canada)	Ex-post	System marginal pricing, real-time market, co-optimized.
NORD POOL (Norway, Sweden, Denmark, Finland, and the Netherlands)	Ex-post	Zonal pricing, full demand participation, runs an ex-ante day-ahead and ex-post real-time balancing market.

Market	Pricing Regime	Nodal/Market Type/Algorithm
New England (US)	Hybrid of ex-ante and ex-post	Full nodal on supply side and zonal on load side, (ex-ante) day-ahead and (ex-post) real-time balancing markets.
PJM (US)	Hybrid of ex-ante and ex-post	Full nodal, (ex-ante) day-ahead and (ex-post) real-time balancing markets, co-optimized.
Philippines Wholesale Electricity Market (WEM Philippines)	Hybrid of ex-ante and ex-post[5]	Zonal, ex-ante and ex-post energy pricing. Ex-ante prices apply to ex-ante quantities, while ex-post prices apply to only difference between ex-ante and ex-post quantities.

The markets listed above represent a spectrum of pricing regimes, ranging from ex-ante (e.g., the NEMS, NEM) to ex-post (e.g., NZEM, NORD POOL), to a hybrid of both ex-ante and ex-post pricing regime (e.g., PJM, WEM Philippines). In this review, we draw learning points from the two markets adopting ex-ante pricing regimes (the Australia National Electricity Market (NEM) and the Argentina Wholesale Electricity Market (WEM) Argentina), particularly regarding price revision.

2.2.1 Australia National Electricity Market (NEM)

Background

The market operator for the Australia NEM is the National Electricity Market Management Company (NEMMCO). Prior to 2006, the National Electricity Rules did not allow NEMMCO to revise prices when erroneous inputs were fed to the dispatch engine. As a result, incorrect prices passed through to the spot market settlement process, and persisted as incorrect market signals.

The issue on price revision was first brought up by NEMMCO in 2001 for industry consultation. At that time, the industry decided that NEMMCO should focus on reducing the number of instances of incorrect inputs used by the dispatch engine to improve pricing accuracy.

Although considerable improvements had been made since 2001, the potential for erroneous inputs to the dispatch engine remains. For instance, NEMMCO noted that there were four such events in 2004, which affected the average annual spot price for each region by up to AU$0.14.[6] NEMMCO reported that these events had a net effect of reducing the total inter-regional settlement residue by about AU$315,000 in 2004.

5 In this hybrid regime, rules provide for the revision of ex-ante prices when no ex-ante prices can be determined, or if the ex-ante prices calculated are believed to be in error due to load shedding or any other reasons.

6 For more information on the net effect on average price for the various regions, please refer to NEMMCO's proposal at: http://www.aemc.gov.au/electricity.php?r=20051214.195534.

NEMMCO noted that these events "though infrequent, have a small but still material impact". Also, "such events, which do not reflect the prevailing supply-demand balance, can affect average prices and price volatility, resulting in distortion of market signals". Consequently, a proposal was made to introduce price revisions arising from incorrect inputs to the dispatch engine.

Price Revision in the NEM – Scope and Processes

NEMMCO proposed permitting price revision for spot energy and ancillary service prices when these prices are based on manifestly incorrect inputs to the dispatch engine. Such inputs included measurements of power system status, five-minute demand forecast values, constraint equations entered by NEMMCO or during software setup, but excluded dispatch bids and offers submitted by market participants.

The price revision process would apply if selected key outputs were identified to exceed certain pre-defined trigger levels, and a manifestly incorrect input was identified within a fixed time limit.[7] Identification is a 2-stage process involving:

- The automatic identification of suspect dispatch periods, which will be marked as 'subject to review'; and
- The manual rejection of suspect dispatch periods, determined by NEMMCO to be affected by manifestly incorrect input(s).

NEMMCO noted that the ideal way to replace erroneous ex-ante prices is to re-run the dispatch engine using correct inputs. However, such resolution may require a significant amount of time, depending on the type of input error that occurred. To balance price accuracy with administrative simplicity, NEMMCO proposed replacing erroneous prices with prices from the preceding dispatch period. Such prices would be reasonable proxies of the prevailing market conditions, and could be established more quickly and with greater certainty to market participants.

NEMMCO conceded that introducing price revision would increase short-term uncertainty as to whether or not published ex-ante prices for a given dispatch interval would stand for settlement purposes. However, this shortcoming would be offset by the benefits of reducing erroneous and distortionary pricing signals in the NEM.

The proposal was approved by the Australian Energy Market Commission (AEMC) and put into effect on 1 June 2006.[8] In arriving at its decision, the AEMC was satisfied that the proposal will contribute to the economic efficiency of the NEM by improving the quality and reliability of spot market price signals, which are relied upon by market participants and investors.

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7 NEMMCO has defined the trigger for each region to be: (1) unusual change in dispatch price and unusual change in interconnector flow; OR (2) unusual change in dispatch price and isolated region. The trigger level settings have been determined in consultation with the industry. For details, please refer to '*Setting of Trigger Levels for Determination of Dispatch Intervals Subject to Review Due to Manifestly Incorrect Inputs*', http://www.nemmco.com.au/dispatchandpricing/dispatch_pricing.htm.

8 For more information on NEMMCO's proposal and the AEMC's decision, please refer to documents on the AEMC website: http://www.aemc.gov.au/electricity.php?r=20051214.195534.

Price Revision in the NEM – Safeguards and Compensation

To minimise short-term uncertainty to market participants, NEMMCO proposed a number of safeguards, including flagging-out potentially incorrect published prices prior to dispatch, and replacing these prices within 30 minutes if they are found to be based on manifestly incorrect input(s). Furthermore, NEMMCO is required to report on each event of price revision, and review annually the effectiveness of the price revision process.

The revised rules also provide for compensation to participants in the event of a price revision. The compensation will be paid out from a Participant Compensation Fund of $5 million, funded by participants through a weekly fee. The Dispute Resolution Panel will determine the amount of compensation,[9] although NEMMCO's liability is limited to the balance of the compensation fund.

2.2.2 Argentina Wholesale Electricity Market (WEM)

Spot Market Price Determination

Argentina WEM is an ex-ante market in which spot energy prices are calculated before the start of a trading period.

The spot energy prices consist of hourly prices calculated to value generated energy for each dispatch period. A spot energy price, called the 'Market Price', is set at each load-centre node. The market price is equal to the short-term marginal cost of supplying the next demand increment at that node, taking into account grid losses and production costs declared by generators.

CAMMESA, the market operator, carries out hourly, real-time generation units' optimum economic dispatch, based on generators' production costs, for the purpose of minimizing overall production costs.

9 In determining the level of compensation, the Dispute Resolution Panel must, among other points, (1) determine compensation on the basis of the prevailing loading level and not on the 'dispatch instruction' applicable to the relevant 'scheduled generating unit' for that 'dispatch interval'; and (2) use the 'spot price' as determined under clause 3.9 ("Determination of Spot Prices"), including any spot prices that have been adjusted in accordance with clause 3.9.2B ("Pricing Where NEMMCO Determines A Manifestly Incorrect Input"). The rules on the compensation regime can be found in Chapter 3, Section 3.1.6.2, of the National Electricity Rules (http://www.aemc.gov.au/rules.php).

Spot Market Price Revision

Ex-ante spot energy prices will be used for settlement if the information used in calculating them does not differ from the reality. However, the rules provide for revision to spot energy prices after a trading period if CAMMESA determines that erroneous data had been used in the determination of the (ex-ante) spot energy prices.[10] Currently, the rules make no provisions to compensate generators adversely affected as a result of a price revision.

2.3 EMC'S INTERNAL PROCEDURES FOR PRICE REVISION

2.3.1 Price Revision/MCE Re-Run in the NEMS

Declaration of Whether Prices are Final or Provisional

The Market Rules require EMC to confirm by 12 noon each day whether the prices determined for the previous trading day are final or provisional. Provisional prices may be revised, pending investigation by EMC.

Under the rules, EMC has up to five business days to finalise provisional prices of a trading day. If price revision is required, EMC must first perform a re-run of the MCE. If it is not possible to conduct an MCE re-run, the rules provide for the use of an average of last 30 days' prices to establish the revised prices.[11]

Cases Subject to Price Revision/MCE Re-Runs

Currently, the following types of cases are subject to price revision/MCE re-runs, as indicated in Table 2:

[10] The rule book for Argentina WEM is under the purview of the Government of Argentina's Secretary of Energy. Unfortunately, no official version of the rules is available in English. The information we have obtained is provided by an analysis and control manager working in CAMMESA. The manager is also a respondent and contact person for the 'Electricity Market Operation Benchmarking Survey 2005' administered by EMC.

[11] The revised price for a dispatch period is the average of the prices for the corresponding dispatch periods for the previous 30 days. This however does not apply to price revision relating to Type 4.

Table 2: Various Types of Price Revision/MCE Re-Run Cases

Type of Price Revision/MCE Re-Run Cases	What EMC Does	Intention
Type 1 Cases in which the MCE has failed[12] to produce a real-time schedule (RTS) for a dispatch period for any reason other than a real-time market suspension.	Re-run the MCE to produce the real-time pricing schedule (Section 9.2.6, Chapter 6)	To determine prices for settlement.
Type 2 Cases in which the MCE has used input data that are not what should have been supplied to it, at the time the RTS for a dispatch period was produced.	Re-run the MCE by using the correct input data that should have been used by the MCE at the time of the original run (Section 10.2.5, Chapter 6)	To ensure that prices for settlement are based on correct and timely input data to the MCE.
Type 3 Cases in which the MCE has used the adjusted nodal load forecasts which take into account the energy shortfall specified by the Power System Operator (PSO) for a dispatch period.	Re-run the MCE by using the 'unadjusted' nodal load forecasts to determine (i) the prices for settlement, and (ii) compensation for affected generators under Appendix 6I of Chapter 6. (Section 10.2.8, Chapter 6)	To ensure that prices for settlement reflect the energy shortfall in the dispatch period.
Type 4 Cases in which the MCE has applied the constraint violation penalty (CVP) for line constraint for a dispatch period, and the PSO has subsequently confirmed that there was no load shed in that period.	Re-run the MCE by using the maximum actual line flow values supplied by the PSO; if no such values are received from the PSO, EMC will re-run the MCE by relaxing the line constraints in accordance with D.16.4, Appendix 6D of Chapter 6. (Section 10.2.3A, Chapter 6)	To ensure that prices for settlement reflect the prevailing line conditions for the dispatch period.

[12] This would include 'failed/missing/late' RTS. The word 'failed' means the MCE did not issue an RTS to market participants and PSO prior to 'T-30 seconds'(i.e., in accordance with the market operations timetable in Appendix 6A of the Market Rules).

Type of Price Revision/MCE Re-Run Cases	What EMC Does	Intention
Type 5 Cases in which the MCE has produced prices which do not reflect their respective locational system marginal price(s) (LSMP).	Re-run the MCE by using all correct input data that should have been used by the MCE at the time when the MCE runs. (Section 10.2.5, Chapter 6)	To ensure that all prices used for settlement reflect their respective LSMP(s).[13]

[13] In the absence of transmission congestion, all nodal prices should reflect one System Marginal Price (SMP) after adjusting for losses. However, when congestion occurs, there will be price separation with two or more SMPs established, and the nodes within different systems should reflect their respective LSMPs.

2.3.2 EMC's Internal Price Check Procedures

EMC conducts price checks based on a set of established internal procedures.[14] On a daily basis, EMC performs the following checks on the real-time schedules (RTS) to determine if price revision/re-run is required:

Table 3: Price Confirmation Checks for RTS

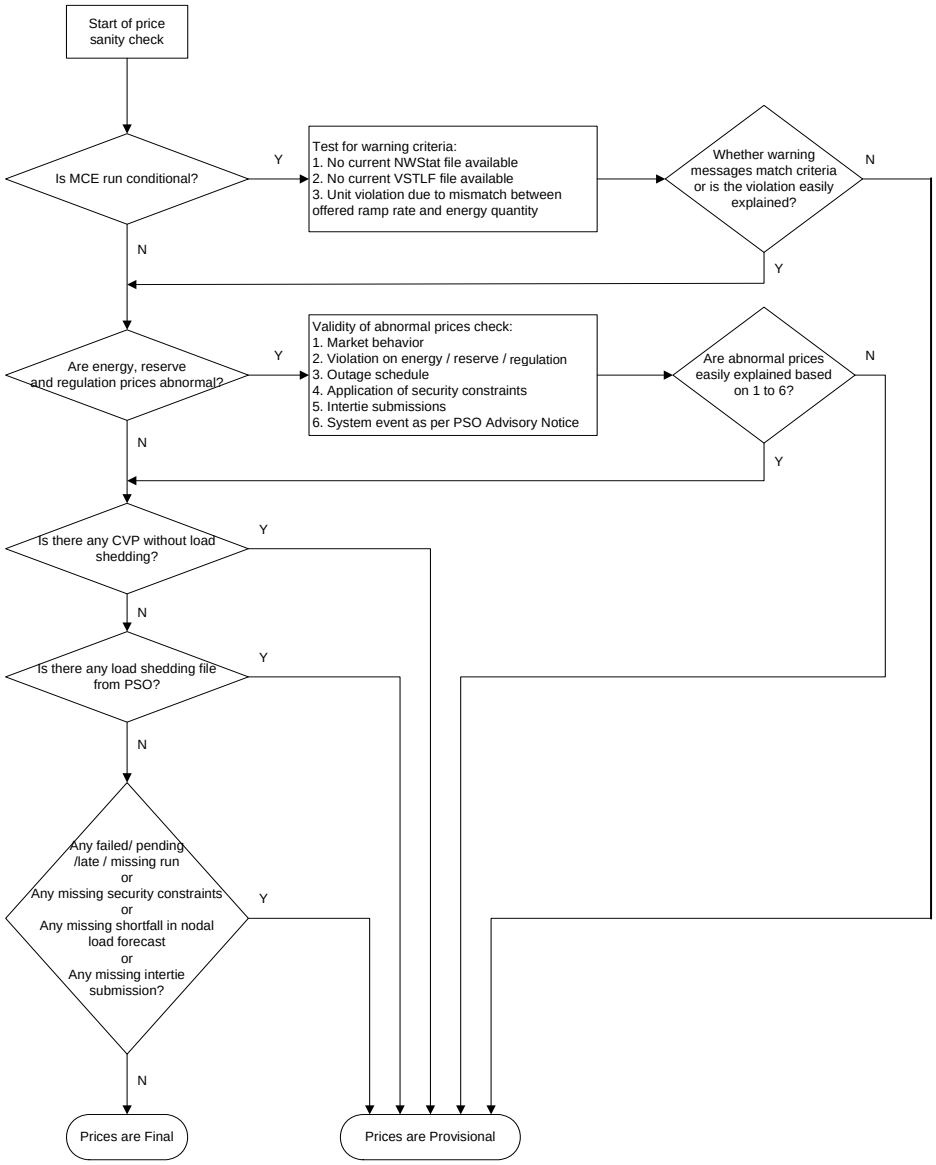
Check for:	Yes/No
Failed/Pending/Missing/Late RTS run	
Missing or late application of intertie offer submissions	
Missing or late application of security constraints	
Load shedding files from the PSO	
Energy shortfall	
Application of CVP for line constraint in the MCE	
Abnormal Prices for Energy, Reserves and Regulation	
Any other problems	

If the answers to any of the checks above is 'Yes', the prices will be declared 'Provisional' and a detailed investigation by EMC will be carried out before prices can be finalised.

[14] Specifically, pricing-related work (e.g., price checks, price revisions, etc.) are undertaken by the Pricing and Information (P&I) unit of the Market Operations and IT (MOIT) Team within EMC.

Figure 1 illustrates the routine daily price check process:

Figure 1: Flowchart on Daily Price Check Process[15]



Note:

- 'Easily explained', means whether or not P&I is able to ascertain a valid cause or reason for certain observed phenomena (e.g., abnormal price spikes) in the RTS and decide if a price revision is required within the time limit stipulated under the market rules. P&I has effectively four hours (i.e., from 8 am to 12 noon each day) to decide if prices for the previous day are final or provisional.

[15] Figure is extracted from Appendix 5 (Routine Checklist Process) of the *Pricing & Information Internal Procedures Manual*.

Detailed Investigation

If prices are flagged as 'provisional', a detailed investigation will be carried out before EMC determines if these prices need to be revised.

The following list serves as a non-exhaustive guide to EMC's detailed investigations:

- Check why violations occurred to render the MCE run conditional;
- Check if demand/system requirements are within a reasonable range and trend;
- Check if offer submissions are sufficient to meet demand/system requirements while satisfying constraints;
- Check if the outage schedule is the cause of violation(s) and abnormal prices;
- Check if a security constraint is the cause of violation(s) and abnormal prices;
- Check for variation in submissions (if any) and variation in scheduled output against demand/system requirements between periods before and after the abnormal price occurred;
- Check network configuration and line flows and determine if the status and numbers are lined up with the physical grid (where applicable);
- Check if energy, reserve, and regulation co-optimization is the cause of abnormal prices.

Following detailed investigations, EMC will determine if the provisional prices will remain firm or require revision.

2.3.3 Historical Cases of Price Revision/MCE Re-Runs

Number of Re-Runs from 1 January 2003 – 30 June 2006

From 1 January 2003 to 30 November 2006, the market had a total of 535 price revision/MCE re-run cases. Table 4 gives a detailed breakdown:

Table 4: Breakdown of Price Revision/MCE Re-Run Cases

Type of Price Revision/ MCE Re-run Cases	2003	2004	2005	2006 (01 Jan to 30 Nov)
Type 1: Failed/Missing/Late RTS[16]	23 (9%)	18 (26%)	23 (43%)	27 (16%)
Type 2: Erroneous/untimely inputs to MCE[17]	224 (91%)	48 (68%)	24 (45%)	9 (6%)
Type 3: Scheduling by MCE taking into account anticipated energy shortfall by the PSO	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Type 4: Application of CVP in the MCE due to violation of line constraints when there is no load shedding in real-time	N.A.	4 (6%)	6 (11%)	3 (2%)
Type 5: The MCE has produced prices not reflective of their respective LSMP(s)	0 (0%)	0 (0%)	0 (0%)	126 (76%)
Total	**247**	**70**	**53**	**165**

16 Such cases arose from both planned maintenance of the NEMS system and unplanned outages.

17 Such cases could be due to unplanned NEMS system outages (e.g., the latest NWSF not used), SCADA errors (e.g., incorrect NWSTAT status, wrong MVar), standing data errors and grid data errors (e.g., isolated bus bar).

The highest number of price revisions/MCE re-runs occurred in 2003, largely due to Type 2 re-runs caused by teething issues present at market commencement. Considerable effort has been taken to improve the quality of input data and enhance the market systems, greatly reducing the occurrences of Type 2 cases.

From 2003 to 2005, the number of price revision/MCE re-runs subsequently fell, dropping to an average incidence rate of 53 out of 17,530 dispatch periods in 2005. However, in 2006 (until 30 November), the number of price revision/MCE re-runs increased again, owing to a large rise in Type 5 cases.

While the EMC spares no effort in further reducing price revision incidences, it is impossible to completely eradicate them. As such, there is a need to address situations in which re-runs occur.

Impact of Price Revision on the USEP and the MEP

Price revision affects original pricing schedules[18] which in turn affects both loads and generators (since revised prices are used for settlement, and bind both parties). To assess the range of price impact, we quantify the largest and smallest price differential (i.e., determined by taking the revised price minus the original price) for the Uniform Singapore Electricity Price (USEP) and for the market energy price (MEP) resulting from all MCE re-runs in each year. Table 5 summarises the results:

Table 5: Price Impact Arising from Price Revision/MCE Re-Run

Year	Largest USEP Increase (consumers pay higher price with price revision)	Largest USEP Decrease (consumers pay lower price with price revision)	Largest MEP Increase (generators receive higher price with price revision)	Largest MEP Decrease (generators receive lower price with price revision
2003	$7.48	-$288.58	$46.64	-$4,397.75
2004	$6.12	-$116.66	$9,000.00*	-$4,426.22
2005	$49.08	-$2,220.30	$4,601.05^	-$2,940.28
2006 (until 30 Nov)	$0.49	-$169.27	$15.25	-$4,407.44

*The original MEP was -$4,500 and the revised MEP was $4,500.
^The original MEP was -$4,500 and the revised MEP was $101.05.

[18] Other than cases belonging to failed or missing RTS in which no original price has been determined.

Table 5 shows that price differentials resulting from price revision could have a significant impact on both consumers and generators.[19] Also, it is noteworthy that price revisions/re-runs could have either a favourable or unfavourable financial impact on consumers and generators.

2.4 FIRST DECISION: SHOULD PRICE REVISION BE ALLOWED?

In this section, we address the strategic issue of whether or not price revision in the NEMS should be permitted in the first place. We then identify the circumstances under which price revision/re-runs should apply, and suggest ways to enhance the price revision process.

As discussed previously, price re-runs will likely persist despite best efforts to enhance market systems. Bearing this in mind, there are two options to addressing erroneous/provisional prices:

- Option (A): Accept the erroneous/provisional prices as final and binding; or
- Option (B): Revise the erroneous/provisional prices ex-post.

We evaluate each of these options in turn.

2.4.1 Option (A): Accept Erroneous/Provisional Prices as Final and Binding

The following section addresses the benefits and shortcomings of adopting Option (A), in which erroneous/provisional prices are accepted as final and binding.

Benefits

Option (A) has the following benefits:

i) **Administrative Simplicity** – Since all ex-ante prices determined by the MCE remain final and binding under all circumstances,[20] there is no need to flag prices as provisional or to re-run the prices ex-post.

ii) **Certainty** – All market participants have full certainty that the stated ex-ante prices will be used for settlement.

Shortcomings

Option (A) has the following shortcomings:

19 To assess the full impact, we need to take into account the quantity consumed (i.e., the Withdrawal Energy Quantity [WEQ]) or the quantity produced (i.e., the Injection Energy Quantity [IEQ]). However, the focus here is to assess only price changes/differences, while ignoring quantities involved.

20 Except for the case of a missing RTS.

i) **Economic Efficiency** – Prices are fundamental to economic efficiency because they guide market behaviour and serve as inputs to decision making. In the short run, prevailing prices direct the generators' injection quantities; in the long run, they guide investment decisions (e.g., building a new plant). It is therefore imperative that market prices are accurate reflections of underlying demand and supply conditions.

Allowing for price revision has no impact on short-term efficiency because market participants have already made their decisions based on ex-ante prices, and cannot "replay" their past decisions based on ex-post price revision.

Allowing for price revision has limited impact on long-term efficiency. Although erroneous prices could vary significantly from the "correct" level, its frequency of occurrence is low and it is not systemically biased (i.e. it is not always higher or lower than revised prices). Since investors are likely to make their decisions based on average prices over a long time horizon, the presence of such infrequent outliers are unlikely to skew their decisions significantly.[21]

ii) **Fairness and Equity** – Allowing erroneous prices to stand could lead to consumers/generators feeling aggrieved that they are paying higher prices/receiving lower prices through no fault of their own. Such an arrangement could be construed as inequitable and unfair, undermining market confidence in the long run.

In addition, compared to generators, consumers are more likely to be adversely affected under this arrangement due to the absence of demand-side bidding - consumers cannot submit bids to reflect their willingness to curtail load when the market price exceeds a certain level.[22] As a result, consumers could potentially end up paying an extremely high (erroneous) price.

Unlike consumers, generators can submit their offers, reflecting their willingness to supply. Even in the event of a low (erroneous) price, generators will still be dispatched based on their offers (though only generators whose offer prices are equal to or lower than the clearing price will be scheduled for dispatch).[23]

In the spirit of equity and fairness, affected parties should be allowed to seek compensation from erring parties. However, this solution is feasibly only if:

- the erring parties can be clearly identified in relation to a particular pricing error;[24] and

21 Market participants and potential investors make long-term decisions based on historical prices over a period of time. Hence, a few incorrect prices will not have a major impact on long-term decision making. In the absence of any systematic bias, ex-ante prices will generally provide an unbiased estimate of ex-post prices, and thus provide an equally good price signal for long-run economic behaviour.

22 The MCE currently assigns a very high fixed value for each unit of fulfilled demand since there is no demand bidding. However, the highest price which consumers will pay is capped at $4,500.

23 This will normally be the case, except in cases of out-of-order merit dispatch of generators due to system constraints or requirements.

24 Erring parties potentially include the EMC, PSO and transmission licensees.

- the erring parties are made to pay for the compensation from their 'own pocket'.

However, it is often not easy to pinpoint the erring party, especially in the context of a complicated market system involving multiple parties. Also, pricing errors could involve several liable parties, which could lead to disputes over the relative extent of responsibilities. And finally, the existing regulatory framework may inhibit the ability to collect compensation from the erring party.

2.4.2 Option (B): Revise Erroneous/Provisional Prices

The section below extends the earlier analysis to Option (B), whereby erroneous/provisional prices are revised.

Benefits

Option (B) has the following benefits:

i) **Economic Efficiency** – As argued earlier, price revisions do not affect short term efficiency, but can have a slight positive impact on long term efficiency by correcting distorted price signals to investors. This was the main argument used by NEMMCO when it introduced price revision to the Australian NEM.

ii) **Fairness and Equity** – Option (B) can be generally considered fair and equitable, since consumers and generators settle based on correct prices. An exception occurs when a generator supplied based on the original price, but receives a revised price (even lower than its offer price) following a price revision. In this case, Option (B) appears unfair to the generator because it was wrongly induced to oversupply, and the revised prices may not cover its marginal production costs.

Shortcomings

Option (B) has the following shortcomings:

i) **Administrative Complexity** – With price revision, there is additional effort required to flag prices as provisional and re-run prices ex-post, although this is manageable.

ii) **Certainty** – Market participants no longer have full certainty that the stated ex-ante prices will be used for settlement. In situations in which ex-ante prices are very high based on real underlying demand and supply conditions, generators may not have the confidence to respond by providing high cost marginal supply, for fear of subsequent downward price revision.

2.4.3 Overall Evaluation

Whether or not price revisions should be allowed boils down to an issue between i) providing certainty and confidence in ex-ante prices to market participants and ii) ensuring equity and fairness by not making consumers/generators pay higher prices/receive lower prices through no fault of their own. Issues of economic efficiency and administrative simplicity have little weight in this issue.

EMC feels that the issue of equity and fairness is critical and hence recommends that the RCP support Option (B). To ameliorate the impact of Option (B) on generators that suffer financially due to a revision of prices to below their offer prices, a fair compensation arrangement is necessary. Please refer to the Annex for EMC's proposed compensation guidelines.

2.5 SECOND DECISION: WHEN SHOULD PRICE REVISION BE ALLOWED?

In this section, we first identify the circumstances under which price revision should apply, and subsequently study how the existing price revision process can be enhanced.

2.5.1 Applicability of Price Revision/MCE Re-Run

To recapitulate, price revision/MCE re-runs currently apply to the following cases:

Type 1: cases in which the MCE has failed to produce a real-time pricing schedule;

Type 2: cases in which the MCE has used the wrong input data in determining the RTS;

Type 3: cases in which the MCE has used the adjusted nodal load forecasts which take into account the energy shortfall specified by the PSO;

Type 4: cases in which the MCE has incurred CVP for line constraints for which there is no load shed in real-time; or

Type 5: cases in which the MCE does not produce prices reflective of their respective LSMP(s).

We will evaluate whether or not each type of case should remain eligible for price revision/MCE re-runs in the NEMS.

Type 1: Failed/Missing/Late RTS

In the case of failed/missing/late RTS, there are no ex-ante prices established in the first place, so the term "price revision" is not applicable per se. In any case, there are two ways to determine settlement prices in such cases:

- To use the last valid prices (i.e., the most recent prices established by the MCE for the affected dispatch period) from forecast schedules in place of the missing periods;[25] or

- To re-run the MCE to establish the prices for settlement.

Using last valid prices has the advantages of being administratively straightforward (since prices could be obtained more quickly compared to re-running the MCE), and gives market participants more certainty. However, these prices may not reflect the prevailing market conditions, in particular when the MCE runs the pre-dispatch schedules and market outlook scenarios (MOS) infrequently.[26]

However, re-running the MCE to obtain the prices would be a more attractive arrangement, as the primary objective is to have the prices accurately reflect the market conditions of the affected dispatch period.

Hence, we recommend the RCP supports re-running the MCE to obtain prices for settlement in cases of failed RTS.

For cases in which it is not possible to re-run the MCE, we recommend retaining the current arrangement of setting the price in the affected dispatch period to the average of previous prices for comparable dispatch periods over the past 30 days, as provided for in the current section 10.2.6, Chapter 6 of the Market Rules.

Type 2: Erroneous Inputs to the MCE

Erroneous inputs to the MCE necessitate price revision. Some associated issues include:

- What constitutes erroneous inputs to the MCE?

- If an MCE re-run is required, what time reference should be used for the inputs? This issue arises because certain inputs, such as the network status file (NWSF), are dynamic and change over time. The time reference is thus needed to fix the data as final and representative of the market conditions over the half-hour affected dispatch period.

What Constitutes Erroneous Input Data?

The MCE uses a broad range of inputs, including market participants' bids/offers and the current/future status of the power system (e.g., NWSF, demand forecasts, system constraints and requirements and others). EMC is not in a position to assess if a market participant's bid or offer is correct, as the bid or offer is up to the market participant's sole discretion. However, EMC could identify errors in input data derived from other sources, such as manually-entered information on system constraints, and the standing data of generators, load forecasts, NWSF, etc.

25 They are prices from the STS, and if the STS is not available, from the PDS. If the PDS is also not available, then prices from the MOS.

26 The more frequently the MCE runs the pre-dispatch schedules, the more accurate the last valid price is in reflecting prevailing market conditions. In the NEM for instance, the market uses last valid prices to replace erroneous prices because the valid prices would reasonably and accurately reflect market conditions because of 5-minute pricing.

Hence, EMC recommends that erroneous inputs to the MCE that can trigger price revision should include all inputs used by the MCE in determining the RTS, but exclude bids and offers from market participants that have been validated and accepted by the MCE.

What Time Reference should be set for the MCE inputs?

In theory, one could argue that input data is always "wrong" in retrospect, due to variations in supply (e.g., unexpected outage during dispatch period) and demand (load variations) over the dispatch period. Thus, if the MCE were to re-run each time such an "error" occurred, it would have to re-run every period, effectively shifting the NEMS to an ex-post pricing regime (as in the NZEM, for example).

While prices should be based on the most current market conditions as far as possible, this would be inconsistent with an ex-ante pricing regime. Hence, there is a need for a consistent time reference for input data to the MCE, with any changes to data occurring after that to be ignored. This data will then be taken to be reflective of the prevailing market conditions for the dispatch period, if a MCE re-run is required.

One possible option is to set the reference time at "T", if the objective of price revision is to ensure that prices accurately reflect the prevailing market conditions. However, for consistency, this time reference would have to be applied across all periods, not just for price re-runs. Practically, that would mean re-running the MCE to re-determine prices for all dispatch periods, immediately after dispatch schedules have been delivered in the NEMS (since the MCE runs at "T-5 minutes" to determine the RTS). Although this is feasible and could result in marginally more accurate prices, there is little to be gained as prices are not expected to change much, and it is impossible to disclose real time prices to market participants before "T".

An alternative to ensure that prices accurately reflect prevailing market conditions is to set the reference time after 'T'. Some possibilities include i) 'T+15 minutes', since it is the mid-point of the dispatch period or ii) 'T+ 30minutes', since generators are supposed to meet their scheduled energy by the end of a dispatch period.[27] Again, for consistency, the MCE should be re-run with this new time reference for all periods, even when there is no price revision.

To reiterate, any MCE re-runs for price revision should adopt the same input data as what would have been used by the MCE to produce the RTS for a dispatch period (currently 'T-5 minutes'). Since there is no strong case for one time reference over another, and that the variation is likely to be small, we recommend retaining the current time reference of 'T-5' minutes for MCE re-runs.[28]

In summary, we recommend that the RCP supports:

- A re-run of the MCE to obtain revised prices for settlement when EMC determines an erroneous input to the MCE;
- The scope of erroneous inputs to include all inputs used by the MCE, but exclude the latest valid offers/bids from generators in the determination of the RTS ;

27 No matter which reference time we fix, perfection will never be achieved. This is because some conditions, including load, which is the fundamental driver, vary throughout a dispatch period, while others, such as transmission system state, may change abruptly within the dispatch period.

28 This is the current arrangement, as provided for under section 10.2.5, Chapter 6 of the Market Rules.

- Erroneous inputs be defined as those not reflective of the prevailing market conditions for a dispatch period at the time when the MCE runs to produce the RTS (currently 'T-5 minutes'); and

- EMC using all input data that should have been supplied to the MCE to produce the RTS if a MCE re-run is required (i.e., currently 'T-5 minutes').

Type 3: The MCE has used the adjusted nodal load forecasts which reflect the energy shortfall specified by the PSO

This type of price revision applies only to cases in which the PSO sends EMC a load shed file. The market rules prescribe the following process in such cases:

Step 1: Adjusting nodal load forecasts

Step 2: Re-running of the MCE to determine prices for settlement

Step 3: Determining compensation amounts

The rationale behind each step is described below.

Step 1 ensures that the dispatch schedule produced by the MCE is both optimal and feasible, after taking into account the expected shortfall in energy. After deciding that the market could not respond to an anticipated energy shortfall (an energy shortfall advisory notice would already have been in place), which implies that involuntary load shedding in real-time is inevitable, the PSO will send EMC a load shed file indicating the locations of load shed and the associated quantities.

EMC will correspondingly upload the load shed file into the MCE. This uploading adjusts the nodal load forecasts for locations in which there will be load shedding, to ensure that the MCE can produce a feasible dispatch schedule when load shedding occurs.

Step 2 is designed to preserve the integrity of price signals in this situation. A re-run is performed using the unadjusted (or original) nodal load forecasts to determine the prices for settlement, so that prices will reflect load shedding in real-time (since the prices reflecting load shedding have been removed as a result of the MCE using the 'adjusted' nodal load forecasts).

Step 3 provides for compensation. Load shedding in practice usually occurs in large blocks of loads; hence, load shed may exceed the shortfall in capacity. As a result, some generators could not generate even though they have some available capacity. This arrangement ensures that generators providing supply in shortfall situations, in particular those providing peaking capacity, are adequately compensated and given the right financial incentives to offer supply in future similar situations.

This 3-step process is designed to achieve certain objectives in situations in which the PSO anticipates energy shortfall in real-time and sends EMC a load shed file. We consider the process, in particular the price revision at Step 2, appropriate because:

- The nodal load forecast adjustment in Step 1 is necessary to ensure that the MCE can determine a dispatch schedule that is both optimal and feasible, after taking into account the expected shortfall in energy. This is necessary mainly for the operation of the power system (otherwise the PSO would have to override the dispatch schedules determined by the MCE);

- With regards to Step 2 and Step 3, the benefits are primarily in terms of improved economic signalling by maintaining prices at the levels at which they would have been without load shedding, and generators are given incentive to provide peaking capacity.

Hence, we recommend that the RCP supports the retention of the price revision process pertaining to such cases.

Type 4: Incurrence of a CVP for line constraints in the MCE when there is no load shed in real-time

Current rules cater for price revision in cases where the MCE has applied a CVP for line constraints even though there is no actual load shed in real-time. In such cases, EMC will re-run the MCE, using the maximum actual line flow values supplied by PSO. If EMC does not receive such values from PSO, EMC will re-run the MCE by relaxing the line constraints (in accordance with D.16.4, Appendix 6D of Chapter 6).

The current rules seek to address a modelling imperfection in the MCE, whereby a line constraint violation ends up setting high settlement prices despite the absence of physical load shedding in the power system. In such cases, it is common practice in other markets to re-run the MCE by relaxing the line constraint, if there is no load shedding in the power system. However, there is a need to review such a procedure in Singapore's context.[29] There are two misconceptions associated with this issue, namely:

- First, there is concern that the CVP should not be allowed to set market prices. However, since we allow VoLL (Value of Lost Load = $5,000) to set market prices, when it itself is a form of CVP, there are no strong theoretical grounds to stop the CVP from setting prices. The only possible reservation is that unlike VoLL, which was set with some theoretical backing, CVPs are set as arbitrary multiples of VoLL (e.g., the Deficit Security CVP is set at 6xVoLL). As such, CVPs may not properly reflect the economics of the situation.

- A second common misconception is that the high prices set by CVP values are artificial by-products of how CVPs are applied, arising from constraint violations in the MCE. Thus, high prices could be eliminated by removing the constraints in the MCE. However, the reality is that the removal of such constraints would have given rise to even higher prices (theoretically infinite), if the constraint had been treated as inviolable, with no CVP applied.

[29] In our preliminary research, we observe that NEMMCO has a similar practice in which if the original prices are set by the CVP, these prices will be replaced by prices from a re-run of the dispatch engine with the offending constraint(s) relaxed (NEMMCO refers to such a circumstance as an "over-constrained" dispatch). The reasons for price revision in such cases are (i) the original prices are not a true reflection of the cost of energy and (ii) the application of the CVP in the dispatch engine has no effect on the dispatch of the power system.

We have identified four circumstances under which there is possible merit in re-running the MCE with the binding line constraints relaxed. They are:

(1) cases in which the constraints have been wrongly specified in the MCE (e.g., the line limit entered into the MCE was incorrect);

(2) cases in which the load-flows implicit in the MCE wrongly estimate real-time flows;

(3) cases in which the actual load and/or generation capacity differs from the forecast at the time of the ex-ante MCE run; and

(4) cases in which no untoward circumstance (e.g., load shedding) has actually occurred ex-post.

We will evaluate whether or not a re-run of the MCE is appropriate under each of these circumstances.

Circumstance (1)

This occurs when line constraints have been wrongly specified in the MCE. A MCE re-run would be appropriate in this case, although on grounds of erroneous input data. Such re-runs should be conducted by correcting the erroneous input data, not by relaxing the line constraints in the MCE. Thus, while price revision is appropriate in such a case, it is fundamentally a Type 2 re-run (erroneous/untimely inputs to the MCE) rather than a Type 4 re-run (incurrence of a CVP).

Circumstances (2) and (3)

For these cases, we do not consider them to be errors simply because the estimates/forecasts (e.g., load forecast) used in the MCE differ from the actual values in real-time. An ex-ante pricing regime will require the MCE to use certain estimates/forecasts of the physical conditions of a dispatch period (e.g., load forecast) as inputs in determining the ex-ante prices. When estimates or forecasts are involved, they are bound to differ from actual values, but this should not be construed as an 'error' or the basis for a MCE re-run.

The crux lies in whether or not these estimates/forecasts are based on the most current valid information at the time of the ex-ante MCE run. If they are, then we do not consider them to be erroneous. In such cases, a re-run of the MCE by relaxing the binding line constraints is inappropriate, and we would allow the ex-ante prices to stay.

Circumstance (4)

Finally, we note that it is a common practice to re-run the MCE with a binding constraint relaxed if no untoward circumstance (e.g., load shedding) occurred ex-post. However, we feel that this is not appropriate.

Many of the constraints in the MCE are precautionary in nature. Hence, one may think that just because no constraint or untoward circumstance occurred, the cost of complying with them was not justified. Such reasoning is flawed, analogous to paying an insurance premium, then claiming that since no claims were filed, the premium was unjustified and should be refunded.

Likewise, it may also seem unnecessary in hindsight to have carried any contingency reserve at all. By extrapolation, the constraints requiring such reserves could be relaxed (ex-post), resulting in an effective reserve price of zero.

The reality is that there are requirements to make ex-ante provisions for such contingencies, regardless of the actual outcome. Thus, it is inconsistent and inefficient to charge ex-ante prices only if the constraints were "necessary" in some periods (e.g., when an untoward circumstance has actually occurred), while "relaxing" the constraints and re-running the MCE, ex-post, in other periods when no untoward circumstance has actually occurred.

In conclusion, a re-run of the MCE involving a binding line constraint would be appropriate only if an input error is involved in the ex-ante MCE run (e.g., the line limit was incorrectly specified). But such a re-run does not seem justified in cases in which the constraints reported as binding in the MCE turned out ex-post to be absent or not as severe as they had seemed.

Accordingly, we believe that there is no proper basis for the current price revision relating to the relaxation of line constraints in the MCE re-run in which a CVP for line constraint has been incurred (ex-ante) but there is no load shed (ex-post). Hence we recommend that the RCP supports the removal of Type 4 price revision from the rules.

Type 5: Cases in which the MCE has produced prices not reflective of their respective LSMP(s)

Price revision for this type of case applies when the MCE has produced prices that do not reflect their respective LSMP(s).

The MCE is a marginal pricing model that establishes nodal prices reflective of their respective LSMP(s). In economic terms, the nodal price gives the per megawatt hours (MWh) cost that has to be incurred by the system in order to meet incremental demand at that node. In the absence of transmission constraints (or congestion), all nodal pries should reflect one SMP; i.e., each nodal price within a system should be that SMP after adjusting for losses associated with that node.

However, when there is transmission constraint (or congestion), one system would be broken into two or more separate systems. This will give rise to two or more SMPs, with the nodes within different systems reflecting their respective LSMPs. This phenomenon is known as *price separation*.

There exist instances in which the MCE establishes nodal prices that do not reflect their respective LSMP(s), due to MCE modelling errors or the existence of multiple optimal solutions based on inputs to the MCE. Such pricing outcomes are erroneous under the locational marginal pricing regime used in our market. Hence, it is necessary to perform price revision to ensure that the prices produced by the MCE correctly reflect their respective LSMP(s) and send out the correct pricing signals.

2.5.2 Summary on Applicability of Price Revision/MCE Re-Run

Table 6 summarizes EMC's recommendations on the applicability of price revision / MCE re-runs to the various types of cases.

Table 6: Applicability of Price Revision / MCE Re-Run

Situations	Applicable (Yes/No)	What EMC will do
Type 1: The MCE has failed to produce a RTS for a dispatch period for any reason other than a real-time market suspension.	**Yes**. (Note: As indicated earlier, this situation is not considered 'price revision' since the MCE failed to produce the real-time pricing schedule.)	Re-run the MCE to determine the prices for settlement.
Type 2: The MCE has used input data which were erroneous in its original ex-ante run.	**Yes**.	Re-run the MCE by using all correct input data that should have been used by the MCE at the time when the MCE runs (currently 'T-5' minutes.) 'Inputs' are defined as any values/data which the MCE uses in determining the RTS, except for bids and offers submitted by market participants.
Type 3: The MCE has used the adjusted nodal load forecasts which take into account the energy shortfall specified by the PSO for a dispatch period (Section 10.2.8, Chapter 6).	**Yes**.	Re-run the MCE by using the 'unadjusted' nodal load forecasts to determine the prices for settlement and to determine compensation for affected generators under Appendix 6I of Chapter 6.
Type 4: The MCE has applied a constraint violation penalty (CVP) for line constraint for a dispatch period, and the PSO has subsequently confirmed that there was no load shed in that period.	**No**.	We recommend the removal of current rules allowing for such a price revision.
Type 5: The MCE has produced prices not reflective of their respective LSMP(s).	**Yes**.	Re-run the MCE by using all correct input data that should have been used by the MCE at the time when the MCE runs. (This time is currently 'T-5' minutes.)

2.5.3 Enhancement of the Price Revision Process

In addition to the applicability of price revisions to the various types of cases, EMC also proposes the following enhancements to the price revision process:

- EMC will report to the RCP the number of price revisions and the circumstances giving rise to price revision;
- EMC will develop an appropriate compensation arrangement for generators adversely affected by price revision. EMC's proposed compensation arrangement is given in the Annex.

2.6 IDENTIFICATION OF RULE CHANGES REQUIRED

In this section, we identified some required changes to the rules if our recommendations are adopted.

2.6.1 Proposed Rule Changes

We present the proposed rule changes in Table 7.[30]

Table 7: Proposed Changes to the Rules

Sections of the Rules	Purpose of Rule	Proposed Changes and Reasons
Section 9.3.2C, Chapter 6	- allows prices to be provisional where constraint violation costs have applied by the MCE in accordance with section D.16 of Appendix 6D	Delete rules Reason: It is inappropriate for the current price revision process to allow for relaxation of line constraints in the MCE re-run where a CVP for line constraint has been incurred (ex-ante) but there is no load shed (ex-post).
Section 9.3.2B, Chapter 6	- spells out procedures relating to issuance of price revision advisory notice where prices have been confirmed to be subjected to revision	Delete reference to section 9.3.2C
Section 9.3.2D, Chapter 6	- allows EMC to request the PSO to confirm	Delete rules

[30] We have identified the key proposed rule changes, although this list may not be complete. EMC will table the detailed proposed rule changes to the RCP for consideration, if the RCP agrees to all our recommendations arising from this review.

Sections of the Rules	Purpose of Rule	Proposed Changes and Reasons
	whether or not load shedding has occurred, and provide to EMC the maximum actual line flow values of identified lines	Reason: Same as Section 9.3.2C above.
Section 9.3.2E, Chapter 6	- allows EMC to revise prices if PSO confirms no load shedding	Delete rules Reason: Same as Section 9.3.2C above.
Section 9.8.2, Chapter 5	- PSO to confirm with EMC within one business day of request whether or not load shedding has occurred in the affected dispatch period, and the maximum actual line flow values of the identified lines.	Delete rules Reason: Same as Section 9.3.2C above.
Section 10.2.2, Chapter 6	- stipulates what prices to be used for settlement, dependent on the issuance of the price revision advisory notice	Delete reference to section 9.3.2C
Sections 10.2.3A, 10.2.4A, 10.2.5A and 10.2.5B of Chapter 6	- spell out the procedures on how EMC should perform price revision relating to cases where constraint violation costs have applied by the MCE for line constraints but PSO has confirmed there is no load shedding	Delete rules Reason: Same as Section 9.3.2C above.
Appendix 6D, D3 Parameters: $AdditionalNumPoints_k$ $RevisedMaxLineRating_k$	- definition of parameters included to provide for relaxation of line constraints if there is a re-run of the MCE under section 10.2.3A.2 and section 10.2.5B of Chapter 6	Delete rules Reasons: Same as Section 9.3.2C above.

Sections of the Rules	Purpose of Rule	Proposed Changes and Reasons
Appendix 6D.16.4, Chapter 6	- provides for relaxation of line constraints if there is a re-run of the MCE under section 10.2.3A.2 and section 10.2.5B of Chapter 6	Delete rules Reasons: Same as Section 9.3.2C above.
Appendix 6D 21.2	- required by the existing section D.16.4.3 so that line flows exceeding line capacities do not incur violation penalties in the said case of a re-run of the market clearing engine.	Delete rules Reasons: Same as Section 9.3.2C above.

3 SUMMARY OF PROPOSAL

The RCP tasked EMC to undertake a review of price revision in the NEMS. As part of this Review, EMC identified five types of price revision/re-run cases in the NEMS currently catered to in the Market Rules, namely:

Type 1 – Cases arising from 'Failed/Missing/Late RTS';

Type 2 – Cases arising from 'Wrong/Untimely Inputs to the MCE';

Type 3 – Cases arising from the MCE using adjusted nodal load forecasts which take into account the energy shortfall specified by the PSO;

Type 4 – Cases arising from the application of a CVP in the MCE due to the violation of line constraints where there is no load shed in real-time; and

Type 5 – Cases when the MCE produce prices that do not reflect their respective LSMP.

This Review sought the direction of the RCP at two levels; first, regarding whether or not price revision should be allowed in the NEMS, and second, regarding the applicability of price revision / MCE re-runs in specific cases.

There are arguments for and against price revision. The arguments against price revision are that it introduces uncertainty to the market, and that ex-ante prices should not change after goods have been produced or consumed. Conversely, the argument for price revision rests mainly on equity and fairness. It is important that prices are determined correctly by the MCE and reflect the prevailing market conditions, or parties (who have to take prices churned out by the MCE as final and binding) will settle at the wrong prices. This can have serious implications, particularly if the price difference is substantial and adversely affects parties through no fault of their own.

Although price revision has no material impact on economic efficiency in the short-run, it can have small long-run efficiency gains. This is because uncorrected prices distort the true value of the goods produced/consumed and send out inaccurate financial signals that could misdirect long-run decision making to a limited extent.

We assess equity and fairness to be the most critical issue in deciding whether or not to allow price revision, and thus recommend that as a principle, price revision should be allowed in the NEMS.

We note that there will be cases in which generators are adversely affected by price revision, because they responded based on original high prices but were paid a lower revised price. For such generators, we recommend there be an appropriate compensation as outlined in the Annex.

Second, the Review assessed the applicability of price revision/MCE re-run in specific situations, and makes the following recommendations:

3.1 TYPE 1 CASES

- We recommend re-running the MCE to obtain prices for settlement in cases of failed/missing/late RTS. While it is possible to use the last valid prices (e.g., from the STS, PDS or even MOS) as replacement prices, this arrangement is not ideal as these prices may not be reflective of the prevailing market conditions.

3.2 TYPE 2 CASES

- We recommend a re-run of the MCE to obtain revised prices for settlement when EMC determines an erroneous input to the MCE;

- We recommend that the scope of 'erroneous' inputs include all inputs used by the MCE, except for the latest valid offers/bids used by the MCE in the determination of the RTS but which were subsequently claimed to be incorrect by market participants;

- We recommend that 'erroneous' inputs be defined as inputs deemed as not reflective of the prevailing market conditions for a dispatch period at the time when the MCE runs to produce the RTS (currently "T-5 minutes"); and

- We recommend that EMC uses all input data that should have been supplied to the MCE to produce the RTS if a MCE re-run is required (i.e., currently "T-5 minutes").

3.3 TYPE 3 CASES

- We recommend that the entire price revision process pertaining to Type 3 cases should remain as is. The entire process is designed specifically for situations in which the PSO anticipates energy shortfall in real-time and sends EMC a load shed file, and is intended for certain objectives (see section 2.5.1 of the paper for Type 3 cases).

3.4 TYPE 4 CASES

- We recommend that MCE re-runs pertaining to such cases be removed, as many constraints in the MCE are precautionary in nature and should not be removed ex-post simply because no untoward circumstance has occurred. A re-run is justifiable only if it involves an input error in the ex-ante run, in which case it would be covered under the provision for Type 2 cases.

3.5 TYPE 5 CASES

- We recommend a re-run of the MCE for cases in which the prices produced by the MCE do not reflect their respective LSMP(s). This ensures that the pricing outcome is reflective of the locational marginal pricing regime used in our market.

In addition to the above, we note the on-going efforts by various parties involved (the EMC, PSO and transmission licensee) to improve the quality of input data, so as to minimise the number of price revision/re-run pertaining to Type 2 cases. To further enhance the price revision process, we also recommend that:

- EMC reports to the RCP on the number of price revisions/re-runs, and explains the circumstances giving rise to the price revisions/re-runs; and

- EMC develops and establishes an appropriate compensation arrangement for generators adversely affected by price revision. (A proposal is attached in the Annex)

In addition, we have clarified the scope of 'erroneous input data', the criteria for defining 'erroneous data input data' and the reference time for input data that EMC should use if a price revision/re-run is required.

We recommend that the RCP supports all the recommendations raised in this Summary section.

4 DECISION BY THE RCP

4.1 DELIBERATION BY THE RCP

The RCP discussed this review over five meetings, from the 29th RCP meeting of November 2006 to the 33rd RCP meeting of July 2007.

The Panel supported the principle of price revision in the NEMS, and supports continuing with price revisions for Type 1, Type 2, Type 3 and Type 5 cases. The Panel also supported EMC's recommendation to remove price revisions pertaining to Type 4 cases.

5 ANNEX – PROPOSED COMPENSATION TO GENERATORS

5.1 BACKGROUND – PRINCIPLE OF MARGINAL PRICING

Figure 2: Market Equilibrium without Price Revision

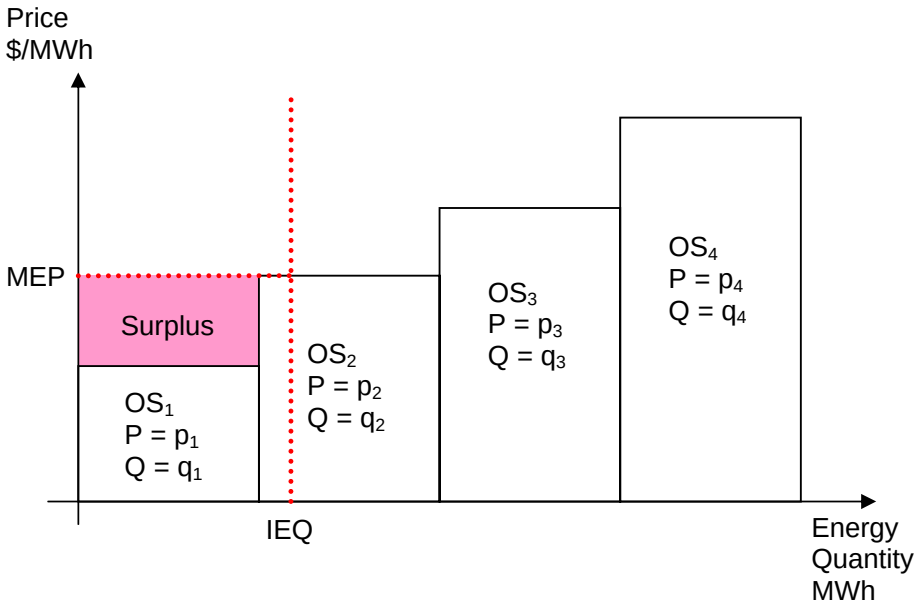


Figure 2 shows an individual generator's offer stacks ($OS_{1,2,3,4}$) and corresponding price-quantity pairs ($p_{1,2,3,4}$ and $q_{1,2,3,4}$) for a given dispatch period. Under the marginal pricing system, the offer stacks approximately correspond to the cost of producing the marginal energy quantity.

When the generator dispatches quantity IEQ into the grid, it receives the price MEP for the whole amount. The generator thus enjoys a surplus/profit (shaded in pink) because for the first q_1 amount of energy, it receives the MEP which is higher than its reserve price of p_1. This surplus/profit serves an economic function of compensating the generator for its fixed costs (e.g., the cost of building the generator plant).

5.2 SITUATION UNDER PRICE REVISION

Figure 3: Market Equilibrium with Price Revision

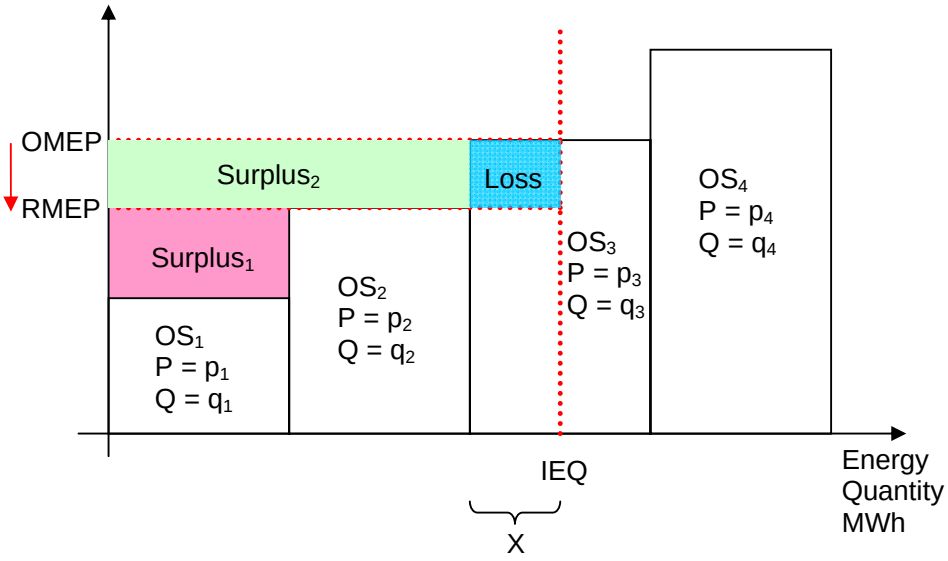


Figure 3 above shows the situation when price revision takes place. Based on the OMEP (original market energy price) the generator decides to supply IEQ. However, upon the downward revision of prices, the generator receives only the RMEP (revised market energy price) for the whole IEQ. The generator's revenue is reduced by (OMEP – RMEP) x IEQ, which can be broken down into two components: i) forgone surplus (labelled Surplus$_2$ in green) and ii) loss because the RMEP may not cover the cost (approximately p$_3$) of supplying marginal quantity X (labelled "Loss" in blue).

It is unfair for generators to incur losses by responding to erroneous price signals that they were not responsible for. Therefore, market rules should provide compensation to the generators so as to ensure equity and future confidence in the market. There are two possible compensation options, namely:

- Compensation (A) - paying the generators "Surplus$_2$" and "Loss", or
- Compensation (B) - paying the generators "Loss"

Erroneous ex-ante prices lead to deadweight losses because generators make decisions based on inaccurate pricing signals, and the dispatch becomes inefficient by not minimising costs to consumers. As such, all efforts will be taken to reduce erroneous ex-ante prices by minimising the number of re-runs (e.g., improving the accuracy of data used in MCE runs).

Although we note the need to compensate generators, we should also be mindful that given the existing regulatory framework, the compensation burden falls directly on loads and consequently on consumers, who are therefore also burdened by the pricing error. If we compensate generators generously (Compensation A), giving them a profit of $Surplus_1$ + $Surplus_2$, we would effectively make loads and consumers pay for the lost profits of generators, though they equally innocent. Thus Compensation A unfairly burdens loads and consumers.

A reasonable compromise would be to provide Compensation B. Assuming that generators offer supply based on marginal pricing, they would be no better and no worse off under Compensation B had the situation not occurred (i.e., the MEP ex-ante is at the RMEP, such that no re-run was required). In both cases, their profits would be $Surplus_1$. This compensation arrangement strikes a good balance between ensuring that neither generators nor consumers are unduly burdened by the pricing error.

Although there is merit in the generators' arguments that they should also be compensated $Surplus_2$, which was their original profit expectation when responding to the erroneous ex-ante prices, we note that this issue of compensation is not solely an economic one. Rather, it is one of equity and fairness, one of balance between the interests of two innocent parties, generators and consumers. If implemented, the compensation amount could then be recovered from market participants (e.g. in proportion to their WEQ weightages).