RCP PAPER NO.   :   **EMC/RCP/78/2015/CP54**

SUBJECT   :   **HANDLING OF FICTIONAL BUSBARS**

FOR   :   **CONSULTATION**

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Executive Summary

On 17 September 2013, price separation occurred for Periods 7 to 48 because the generation unit of a GRF was connected to an islanded fictional bus, resulting in the MCE assigning an extremely high price to this MNN. Even though the GRF was not scheduled, this high price episode sent a wrong signal to the market and necessitated Type 5 price reruns for these periods.

Upon investigation, it was found that the generation unit was islanded as a consequence of the dispatch network simplification process, whereby the MCE processes PSO's network status files to simplify them into an electrically-equivalent connectivity model. In this case, PSO designated fictional buses as both the main and alternate default busbars for this generation unit, which were then subsequently removed as part of the dispatch network simplification process (under Appendix 6D Section D.6.3 of the market rules).

The study analysed the case and explored the following solutions:

- Option 1: Require at least one of either main or alternate default busbar to be a real one

- Option 2: Notionally designate fictional buses assigned as main or alternate default busbars as real buses in the standing data

- Option 3: Change the Dispatch Network Simplification Process in the MCE

The concept paper was published on 04 November 2014, and no comments were received. Based on the analysis, EMC recommends that the RCP:

- Support Option 2, which resolves the islanded bus issue without incurring any costs associated to system changes, while ensuring flexibility to network flow; and

- Task EMC to draft changes to the Market Operations Market Manual - Standing Offers, Offer Variations and Standing Data (Chapter 6 Market Rules).

At the 77th RCP meeting, the Panel unanimously supported Option 2 and tasked EMC to make changes to the Market Operations Market Manual – Standing Offers, Offer Variations and Standing Data (Chapter 6 Market Rules). However, taking into account our external legal counsel's comments, the required changes will be made through EMC's internal documents governing the dispatch network simplification process instead of the market manual or market rules. This concept paper will then serve to inform market participants/the public of how EMC will notionally designate fictional buses as real buses in the simplification process, to prevent future recurrence of islanded buses.

At the 78th RCP meeting, the Panel noted that the change will be made through EMC's internal documents instead of the Market Operations Market Manual, with this concept paper serving as an information paper on the revised simplification process which would be implemented on **01 April 2015**.

1.   Introduction

When the network status file shows that a generation unit is physically disconnected, the market clearing engine (MCE) will connect the generation unit to its designated main or alternate default busbars[1]. This is so that all generation units will always be represented as connected in the MCE's dispatch network model, so as to allow them to be scheduled in the upcoming periods. The designated main and alternate default busbars are therefore meant to represent the generation unit's intended connection.

The PSO usually designates real buses as the main and alternate default busbars for a generation unit. So long as the designation reflects the intended physical connection of the generator, the MCE would produce the right pricing and schedules accordingly.

However, in the rare situation when the PSO designates fictional buses (which are real physical connections like real busbars, but comprise short connectors between switches) as the main or alternate default busbar for a generation unit, incorrect marginal pricing problems could occur. This is because fictional buses, when they are electrically equivalent to other buses, could be removed as part of the dispatch network simplification process by the MCE, as specified in Appendix 6D Section D.6.3 of the market rules.

This paper reviews how fictional busbars are handled in the dispatch network simplification process, so as to ensure that prices are reflective of their respective market network nodes (MNN) and instances of price revision are reduced.

2.   Background

Price Separation Incident on 17 September 2013

On 17 September 2013, MCE reported a price separation incident by a given generation registered facility (GRF) for Periods 7 to 48, even though there were no instances of network status file input error, transmission line binding constraint or energy violation. It was subsequently found that a generation unit of this GRF was represented as connected to an islanded alternate fictional bus in MCE's network status file processing, resulting in the MCE assigning an extremely high price to this MNN. Even though the GRF was not scheduled, this high price episode sent a wrong signal to the market and necessitated Type 5 price reruns for these periods[2].

Offline reruns were conducted for the affected periods by assigning a real bus as the alternate default busbar of the generation unit to discover the correct MNN price. The reruns had minimal impact on other aspects of the overall schedule, specifically:

- There were no changes to the objective values;

- There were no changes to overall system results including USEP, Losses, and quantities scheduled for each product; and

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[1] Except if EMC/RCP/76/2014/323 (Remodelling of Multi-Unit Facility), which has previously been approved by the RCP, is implemented. Under the proposal, if a constituent generating unit of a multi-unit facility (MUF) is islanded but the MUF's remaining constituent generating units are not islanded, the islanded constituent generating unit would not be connected back to the dispatch network by the MCE.
[2] Type 5 price reruns pertain to cases in which the MCE has produced prices which do not reflect their respective locational system marginal price(s) (LSMP).

- For the affected GRF, the nodal price was revised from $4500 to between $136-200. For other GRFs, there were only minor changes in the MNN prices and MW cleared for certain CCGT units due to multi optimality.

In both the original runs and re-runs, this GRF was not scheduled for energy and the reruns were conducted solely to establish correct MNN prices. Nevertheless, such episodes are undesirable as they create the need for price reruns and consequential price uncertainty for the whole market.

Dispatch Network Simplification Process

Upon investigation, it was found that the generation unit in question was islanded as a consequence of the dispatch network simplification process, whereby the MCE processes the network status files from PSO to simplify them into an electrically-equivalent connectivity model.

Specifically, the MCE conducts the following dispatch network simplification steps in sequence by traversing through the whole network status file and:

  i. Determine if each Load Facility is active[3]

  ii. Determine if each Generation Unit is active

  iii. Determine whether each Branch is active at both ends

  iv. Determine if an active Bus is connected directly to another active Bus without any Branch in between. If so, a "Notional Branch" is added between the two buses

  v. Remove any Islanded Buses

  vi. Add in any Bus representing a Market Network Node to generate a price at the MNN; if neither the main or alternate default bus exists, they are added in at this step and the MCE will use them if the generation unit associated with the bus is not synchronised.

During the traversing process, any fictional bus encountered between two active components is "collapsed" to become a connector, essentially removing it from the simplified network.

The procedures above essentially identifies which network elements are active for retention, removes any islanded buses deemed superfluous, then adds back any buses designated the main or alternate default bus for a generation unit for price discovery reasons.

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[3] Connected to a bus.

Dispatch Network Simplification Process on 17 September 2013

Figure 1: Fictional Busbar Simplification leading to Price Separation, 17 Sept 2013

Main Default Busbar = Fictional Busbar 1 (Fic.BB1)
Alternate Default Busbar = Fictional Busbar 2 (Fic.BB2)
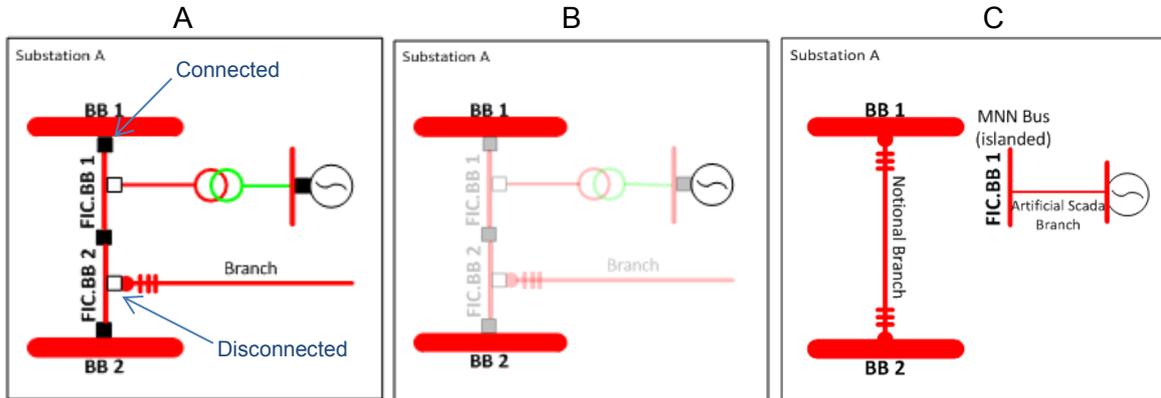
As shown in Figure 1-A above, the generation unit is assigned Fictional Busbars 1 and 2 as its main and alternate default buses respectively. As part of the dispatch network simplification process, the fictional busbars are removed (or "collapsed") and replaced with a Notional Branch (steps iv and v) in Figure 1-B. Finally, since the alternate default Fictional Busbar 1 does not exist, it is added in (step vi); however as it is no longer connected to the network, the generation unit becomes islanded (Figure 1-C). This in turn leads to the erroneous high prices and the need to conduct price reruns.

Revision of Standing Data on 18 September 2013

The standing data for the generation unit was updated on the subsequent day 18 September 2013, which changed the alternate default busbar to a real busbar BB1. In addition, there were changes to the connectivity status as shown:

Figure 2: Fictional Busbar Simplification with Revised Standing Data, 18 Sept 2013

Main Default Busbar = Fictional Busbar 1 (Fic.BB1)
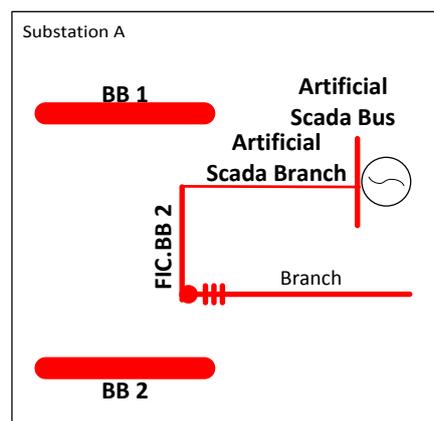Alternate Default Busbar = ~~Fictional Busbar 2 (Fic.BB2)~~ Real Busbar 1 (Real BB1)
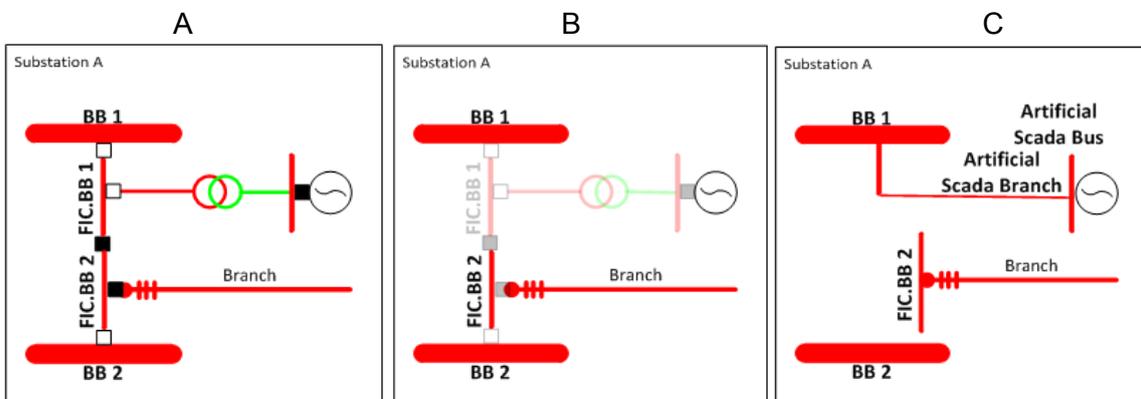
Note: The connections are different compared to Figure 1 and as a result, Fictional Busbar 2 was retained because it was connected to an active Branch. This contrasts with Figure 1 whereby it was removed because it was "collapsed" into one notional branch connecting the two real buses.

Similar to the earlier process, Fictional Busbar 1 was removed through the network simplification process (Figure 2-B). However, as the alternate default bus is a real busbar (BB1) which still existed in the dispatch network, the MCE created an artificial bus and branch to connect the generation unit to BB1 (Figure 2-C). Arising from this, the MNN price for the generation unit reflected prices at BB1.

On a separate note, since Fic.BB2 is connected to a branch in Figure 2A as opposed to being disconnected in Figure 1A, it was not simplified away in the Dispatch Network Simplification Process. As such, even if it were designated as the alternate default busbar in Figure 2A, the generation unit would have been able to connect to it and avoid being being islanded. The connection diagram will thus change from Figure 2C to Figure 2D below:

Figure 2D: Connection Diagram with Foc.BB2 as Alternate Default Busbar

However, the point remains that when both main/alternate default busbar are fictional, there is a chance that both could be simplified away leading to an islanded generation unit.

3.   Analysis

To summarise, the 17 September episode illustrates that islanded bus incidents arising from the handling of fictional busbars[4] could occur if the following conditions ALL occur at the same time:

- Both main and alternate default busbars assigned to a generation unit are fictitious busbars; and

- Both main and alternate busbars are physically connected to the real busbars and therefore will be removed in MCE dispatch model; and

- The generation unit is in a disconnected status (therefore will be connected to fictional main/alternate busbars above).

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[4] There could be other possible causes of islanded busbars although not directly pertaining to the handling of fictional busbars. For example, if BB1 is the main default and FIC.BB1 is the alternate, the islanded busbar incident could occur if the top connector is open.

Based on this potential for re-occurrence, the following solutions are explored:

Option 1: Require at least one of either main or alternate default busbar to be a real one

From the updated standing data episode on 18 September, it can be shown that so long as at least one of the main or alternate default busbars is real, it would definitely not be removed during the network simplification process and the generation unit will consequently not be islanded.

However, in the 17 September episode, there was a good reason for the PSO to assign both fictional busbars as the main and alternate default busbars of the generation unit. Specifically, PSO intended to channel the flow from the generation unit through the connected "branch" out to another substation (not shown in diagram) some distance away from both BB1 and BB2. The contrast between the actual and intended connection is shown in Figure 3 below:

Figure 3: Dispatch Model under Option 1 vs PSO's Intended Physical Connection

	(A) Dispatch Model under Option 1	(B) PSO's Intended Physical Connection for Generation Unit
Main Default	Fictional Busbar 1 (Fic.BB1)	
Alternate Default	Real Busbar 1 (BB1)	Fictional Busbar 2 (Fic.BB2)
Connection after Network simplification		

As shown above, requiring at least one of the main/alternate default busbars to be real may artificially limit the flexibility on the network flow and deviate from PSO's intended flow. In this case, the generation unit will be connected to BB1, where PSO had instead intended for it to be connected through the branch to another substation. If the substation is a significant distance away, the true price (from this substation far away) may differ substantially from the price at BB1, leading to inaccurate price signals. Thus, this option will not be robust enough to resolve the issue.

Option 2: Notionally designate fictional buses assigned as main or alternate default busbars as real buses in the standing data

Alternatively, in the pre-processing stage, EMC could notionally designate fictional busbars assigned as either the main or alternate default busbars as real busbars. In this way, it would neither be removed during the dispatch network simplification process nor lead to islanded buses incidents. It would also not limit main/alternate default busbar assignments by the PSO and ensure flexibility to the network reconfiguration. So long as PSO designates the main/alternate default busbars appropriately, the resulting connections will correctly reflect PSO's intended flow.

Option 3: Change the dispatch Network Simplification Process in the MCE

Finally, system changes could be made to the MCE dispatch network simplification process to treat any fictional busbars assigned as main/alternate default busbars differently and **not** remove them under any condition. The resultant dispatch network connection would be the same as that under Option 2. However, this option will require system changes that require lead time and resources, which may not be justified given that the 17 September incident was an isolated one.

Assessment

A summary of the above options is given below:

Figure 4: Comparison of Various Options

	Option 1 **Designate at least one as real**	**Option 2** **Designate as real in Pre-processing**	**Option 3** **Change network simplification process**
Pros	• No system changes required	• No system changes required • Ensure flexibility to network flow	• Ensure flexibility to network flow
Cons	• Limit flexibility on network flow • Potentially inaccurate price signals		• System changes required

Based on the above assessment, it appears relatively straightforward that Option 2 is a reasonable solution, achieving resolution to the islanded bus issue without incurring any costs associated to system changes while ensuring flexibility to network flow.

If Option 2 is accepted, then EMC will amend our internal procedures such that the relevant buses will be manually denoted in the standing data so that they **will not** be simplified as part of the dispatch network simplification process. This would be a simple, manual solution to an infrequent event, which can be implemented through amendments to EMC's internal processes and the relevant market manual.

4.   Industry Consultation

The concept paper was published for comments on 04 November 2014, and no feedback was received from the industry.

5.   Discussion and Decision at the 77th RCP Meeting

At the 77th RCP meeting, a RCP member enquired on the estimated cost and lead time to implement Option 3 for completeness. Notwithstanding, the Panel unanimously supported

Option 2 and tasked EMC to make changes to the Market Operations Market Manual – Standing Offers, Offer Variations and Standing Data (chapter 6 Market Rules).

6.   Follow-up Actions by EMC Following 77th RCP Meeting

Based on the inputs from the market operations team, the required resourcing are as follows:

Figure 5: Estimated Cost and Lead Time required to Implement Option 3

Time Estimates	Man week(s)	Calendar week(s)
1. Change Requirement Scoping and Analysis	1	1
2. Standing Data/MCE/Settlement Engine Development/Testing	3	2
3. User Acceptance Testing (UAT)	6	6
4. Audit	0	0
5. Parallel MCE/Settlement runs	0.5	1
Total Effort Required	**10.5**	**10**
Total Project Time	**N.A**	**10**
Cost		
1. Internal Power Systems Consultant Resource/EMC Manpower	$49,290	
2. External resource to change Settlement Engine/SD	$0	
3. Audit	$0	
Total Additional Cost Required	**$49,290**	

EMC drafted the changes to the Market Operations Market Manual (MOMM) and sent them for legal review by our external lawyers. The following comments were received from our lawyers:

As discussed, we observe that the proposed insertion of a remark in the MOMM (unlike a substantive provision in the market rules or market manuals) will not have any binding effect on market participants. Further, as there appears to be no detailed description of the dispatch network simplification process in the market rules or the MOMM, the proposed insertion of the remark in the bus form (which is not directly related to the dispatch network simplification process) may lead to confusion as to its purpose/effect.

If the primary objective of inclusion of the remark is to signal the market, an alternative and arguably better approach may be for the EMC to publish the Concept Paper with the necessary revisions to inform market participants/the public of the approach that the EMC will take in respect of designating fictional buses as real buses and to further ensure that its internal documentation on the dispatch network simplification process accurately and comprehensively details the notional designation of fictional buses as real buses.

Based on the above remarks, the required changes will be made through EMC's internal documents governing the dispatch network simplification process. This concept paper will then serve to inform market participants/the public of how EMC will notionally designate fictional buses as real buses in the simplification process, to prevent future recurrence of islanded buses.

7. Recommendations

EMC recommends that the RCP:

- Note that the implementation of Option 2 will entail changes to EMC's internal documents rather than changes to the Market Rules or Market Manual; and

- Note that the proposal will be implemented on 01 April 2015.

8. Deliberation at the 78th RCP Meeting

At its 78th Meeting, the RCP noted and **unanimously supported** EMC's recommendations.