Notice of Market Rules Modification

Paper No.:	EMC/RCP/81/2015/330
Rule Reference:	Market Rules App 6D Sec D.2, D.12, D.13A, D.19 & App 6K Sec K.1
Proposer:	EMC, Market Admin
Date Received by EMC:	12 May 2015
Category Allocated:	2
Status:	Approved by EMA
Effective Date:	28 July 2016

This paper reviews the proposal to extend the revised beginning of period (BOP) test for qualifying regulation offers to qualifying energy and reserve offers from generation registered facilities (GRFs). Earlier, RC303 revised the proxy for a GRF's generation level at the BOP in the BOP test for regulation from StartGeneration to ExpectedStartGeneration. This better ensures that scheduled GRFs are capable of providing the service throughout the dispatch period.

The proposal received prompted EMC to consider the following issues:

Issue 1: Whether Start Generation should be revised to ExpectedStartGeneration as the proxy for a GRF's generation level at the BOP in other constraints; and

Issue 2: Whether BOP tests should be introduced to qualify energy and reserve offers from GRFs as well.

For Issue 1, EMC recommends for the proxy for a GRF's generation level at the BOP in the ramping constraints to be revised, since RC303 has recognized that ExpectedStartGeneration is a better proxy as compared to StartGeneration. For Issue 2, EMC assessed that the current feasibility checks for energy and contingency reserve procured from GRFs are sufficient. As for primary and secondary reserve, EMC analysed the current system-wide reserve availability using historical data to conclude that there is no compelling reason for the BOP tests to be introduced.

At the 80th RCP meeting, the RCP by majority vote did not support Issue 2 which proposes introducing BOP tests for energy and reserve. As for Issue 1, the RCP unanimously supported revising StartGeneration to ExpectedStartGeneration in the ramping constraints and tasked EMC to draft the relevant rule modifications.

The proposed rule modifications were presented at the 27th TWG meeting and the 81st RCP meeting. The TWG (unanimously) and RCP (by majority vote) supported the proposed rule modifications set out in Annex 3. The RCP also by majority vote recommends that the EMC Board **adopt** the proposed rule modifications set out in Annex 3.

Date considered by Rules Change Panel:	14 July 2015
Date considered by EMC Board:	31 July 2015
Date considered by Energy Market Authority:	21 August 2015

Proposed rule modification:

See attached paper.

Reasons for rejection/referral back to Rules Change Panel (if applicable):

Energy Market Company

PAPER NO.	:	**EMC/BD/06/2015/06(b)**
RCP PAPER NO.	:	**EMC/RCP/81/2015/330**
SUBJECT	:	**ELIGIBILITY OF ENERGY & RESERVE OFFERS**
FOR	:	**DECISION**
PREPARED BY	:	**JO ONG ZU ER** **ECONOMIST**
REVIEWED BY	:	**PAUL POH LEE KONG** **EVP, MARKET ADMINISTRATION**
DATE OF MEETING	:	**31 JULY 2015**

Executive Summary

This paper reviews the proposal to extend the revised beginning of period (BOP) test for qualifying regulation offers to qualifying energy and reserve offers from generation registered facilities (GRFs). Earlier, RC303 revised the proxy for a GRF's generation level at the BOP in the BOP test for regulation from StartGeneration to ExpectedStartGeneration. This better ensures that scheduled GRFs are capable of providing the service throughout the dispatch period.

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At the 80th RCP meeting, the RCP by majority vote did not support Issue 2 which proposes introducing BOP tests for energy and reserve. As for Issue 1, the RCP unanimously supported revising StartGeneration to ExpectedStartGeneration in the ramping constraints and tasked EMC to draft the relevant rule modifications.

At the 27th TWG meeting, the TWG unanimously recommended that the RCP support the proposed rule modifications set out in **Annex 3**.

At the 81st RCP meeting, the RCP by majority vote **supported** the proposed rule modifications and recommends that the EMC Board **adopt** the proposed rule modifications set out in **Annex 3**.

1. Introduction

This paper reviews the proposal to extend the revised beginning of period (BOP) test for qualifying regulation offers to qualifying energy and reserve offers from generation registered facilities (GRFs) as well.

2. Background

Current Feasibility Checks for Regulation

The Singapore Wholesale Electricity Market (SWEM) currently uses two tests which check the generation level of a GRF for the scheduling of regulation:

(i) A GRF's generation level at the BOP, as proxied by ExpectedStartGeneration, must be within its regulation range, bounded by its RegulationMin and RegulationMax[1], for its regulation offer to be qualified for use by the Market Clearing Engine (MCE). This test is stated in sections D.13A.1.2 and D.13A.1.3 of Appendix 6D of the market rules and shall herein be referred to as the **BOP test**.

D.13A REGULATION RANGE CONSTRAINTS

D.13A.1 A valid *regulation offer* for a *GRF* for a *dispatch period* shall only be used in the linear program if:

D.13A.1.1 a valid *energy offer* exists for that *GRF* for that *dispatch period* and the sum of the quantities in that *energy offer* is greater than RegulationMin_g for that *GRF*;

D.13A.1.2 the $\text{ExpectedStartGeneration}_g$ of that *GRF* is greater than or equal to RegulationMin_g for that *GRF*; and

D.13A.1.3 the $\text{ExpectedStartGeneration}_g$ of that *GRF* is less than or equal to RegulationMax_g for that *GRF*.

(ii) When the MCE schedule a GRF for regulation provision, it will ensure that the GRF's output when providing both scheduled energy (SE) and scheduled regulation is within its regulation range by applying the constraints stated in sections D.18.1.3 and D.18.1.4 of Appendix 6D of the market rules to the GRF. These constraints shall herein be referred to as the **End of Period (EOP) test**.

D.18.1.3 Mixed Integer Program Based Regulation Max Constraint:

$$\text{Generation}_g + \text{Regulation} - \text{ExcessRegGen} - \text{InfinitePositiveValue} \times (1 - \text{RegulationEligibilitySwitch}) \leq \text{RegulationMax}_g$$

D.18.1.4 Mixed Integer Program BasedRegulation Min Constraint:

$$\text{Generation}_g - \text{Regulation} + \text{DeficitRegGen} + \text{InfinitePositiveValue} \times (1 - \text{RegulationEligbilitySwitch}) \geq \text{RegulationMin}_g$$

[1] The Power System Operator (PSO) controls GRFs to provide regulation through the Automatic Generation Control (AGC) subsystem. RegulationMin and RegulationMax are the minimum output and maximum output, respectively, at which the AGC can operate the GRF to provide regulation.

The objective of these two tests is to ensure that each GRF scheduled to provide regulation has a generation level whereby it is able to provide regulation throughout the dispatch period.

Issues Raised by the Proposal

The proposal to extend the BOP test, revised by RC303, for qualifying regulation offers to qualifying energy and reserve offers raised the following issues:

Issue 1: Whether StartGeneration should be revised to ExpectedStartGeneration as the proxy for a GRF's generation level at the BOP in other constraints; and

Issue 2: Whether BOP tests should be introduced to qualify energy and reserve offers as well.

In the next section, for Issue 1, we will recap why ExpectedStartGeneration is preferred to StartGeneration as the proxy of a GRF's generation level at the BOP. For Issue 2, to determine whether BOP tests for energy and reserve need to be introduced, we will first evaluate the adequacy of current feasibility checks for energy and reserve. We will then further study the current system-wide reserve availability using historical data.

3. Analysis

3.1 Issue 1 – Improve the Proxy for a GRF's Generation Level at the BOP

To recap, StartGeneration values are obtained from the PSO's network status file which captures GRFs' generation levels at **10 minutes before the BOP**. The implication is that the StartGeneration values may deviate significantly from the GRFs' actual generation levels at the BOP, especially when the GRFs are ramping up or down.

In RC303, ExpectedStartGeneration was introduced to replace StartGeneration in the BOP test for regulation because it is a better proxy for a GRF's generation level at the BOP as compared to the StartGeneration. ExpectedStartGeneration values project GRFs' generation levels at the BOP by taking into account their scheduled energy for the prior dispatch period T-1 (SE_{T-1}) and their physical constraints (i.e. StartGeneration and maximum ramp rates). Please refer to **Annex 1** for more details on the derivation of ExpectedStartGeneration values.

Currently, StartGeneration is still used as a proxy for a GRF's generation level at the BOP in other ramping constraints. EMC recommends for the proxy to be revised from StartGeneration to ExpectedStartGeneration in such ramping constraints.

If the RCP supports EMC's recommendation, EMC will further review where else in the market rules StartGeneration should be replaced with ExpectedStartGeneration.

3.2 Issue 2 – Introduce BOP Tests for Energy and Reserve

3.2.1 Energy

Current Feasibility Check for Energy

Currently, to determine how much a GRF will be scheduled for **energy** provision, the following set of energy ramping constraints, as stated in sections D.19.1.1 and D.19.1.2 of Appendix 6D of the market rules, are applied to it in running the MCE.

D.19.1.1 Up Ramp Constraint:

$$Generation_g - ExcessUpRampRate_g \leq GenerationEndMax_g$$

D.19.1.2 Down Ramp Constraint:

$$Generation_g + ExcessDownRampRate_g \geq GenerationEndMin_g$$

These constraints mean that a GRF will be assigned a scheduled energy (i.e. generation) level at the EOP which is within its achievable range bounded by GenerationEndMin and GenerationEndMax, which are determined by its StartGeneration (proposed to be revised to ExpectedStartGeneration in section 3.1) and ramp rates. The constraints thus ensure that the generation level **at the EOP** of each GRF is achievable given its physical ramping limits.

Complementary Roles of Energy and Regulation

In addition to energy being scheduled to meet the forecast demand at the EOP, regulation is also scheduled to cover any variances between forecast and actual demand **throughout the dispatch period**. We thus pay energy and regulation providers, who in combination, are capable of ensuring that actual demand is being met throughout the dispatch period. The consideration of a BOP test for energy is hence unnecessary.

3.2.2 Reserve

Current Feasibility Check for Primary and Secondary Reserve

Currently, to determine if a GRF will be scheduled for **reserve** provision, the following set of Mixed Integer Program (MIP) based reserve constraints, as stated in sections D.17.2.8.1 and D.17.2.8.2 of Appendix 6D of the market rules, are applied to it in running the MCE.

D.17.2.8.1 Mixed Integer Program Based Zero Raw Reserve Constraint:

$$RawReserve - InfinitePositiveValue \times ReserveEligibilitySwitch_g \leq 0$$

D.17.2.8.2 Mixed Integer Program Based Reserve Low Load Constraint:

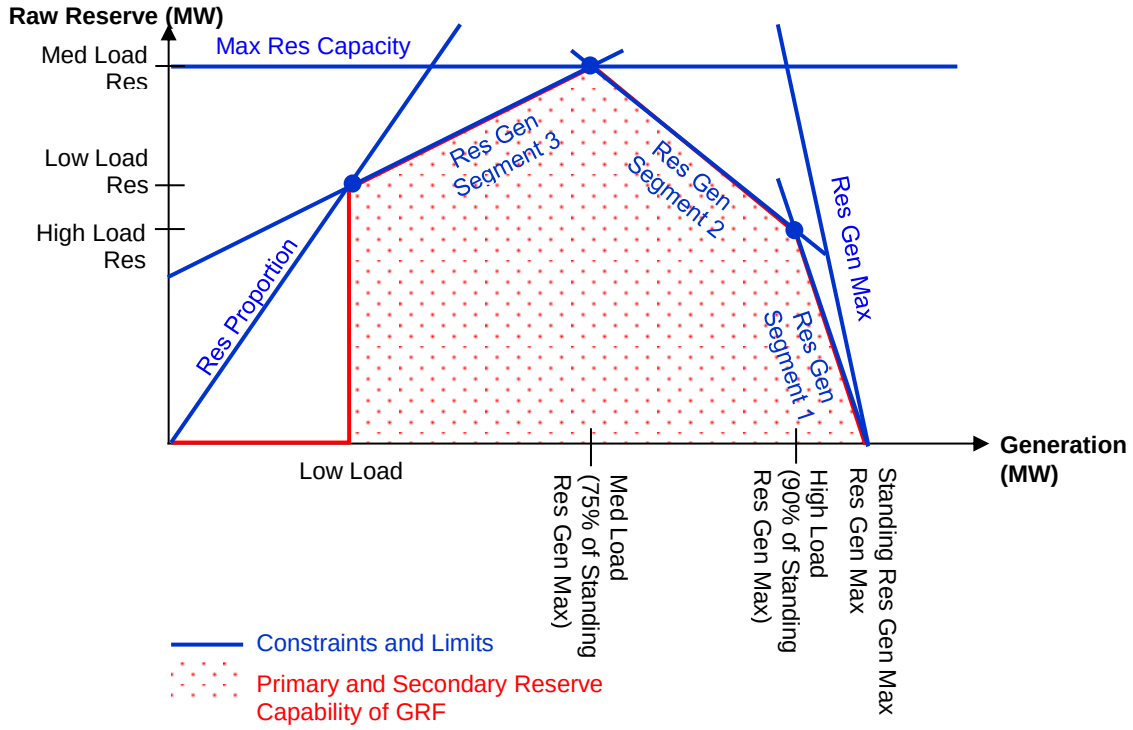
$$Generation_g + InfinitePositiveValue \times (1 - ReserveEligibilitySwitch_g) \geq LowLoad_g$$

These constraints mean that a GRF's scheduled energy i.e. generation level at the EOP must be above its LowLoad for it to be scheduled for primary and secondary reserve provision. GRFs are operationally incapable of providing reserve when their generation levels are below their LowLoad. These constraints thus ensure that each GRF scheduled for reserve provision has its generation level above LowLoad **at the EOP**, so as to be able to respond readily to provide reserve.

A GRF scheduled for provision of contingency reserve is most likely able to ramp up to its LowLoad within the 10-minute reserve response time after activation at any point of time in the dispatch period. Therefore, these EOP constraints **do not apply to contingency reserve**. Similarly, a BOP test (if any) will not apply to contingency reserve as well.

Furthermore, the other constraints and limits of the reserve capability envelope, as shown in Figure 1, is modelled in the MCE and also applied to primary and secondary reserve. These various constraints and limits are described in detail in Table 4 in **Annex 2**. The shaded area forms the current solution space of the primary and secondary reserve capability of a GRF.

Figure 1: Reserve Capability Envelope



EOP Feasibility

We recall from RC303 that it can be argued that EOP feasibility is all that is required for ancillary service provision to be maintained throughout each dispatch period for system security. This is consistent with the dispatch philosophy which sets EOP targets for dispatch variables and rests on the observations that:

- Unless there was an unexpected event, such as a forced outage, the previous period's MCE run should have ensured that **the BOP position is feasible**; and
- Linear ramping between this BOP position and a feasible EOP position should ensure feasibility **throughout the period**.

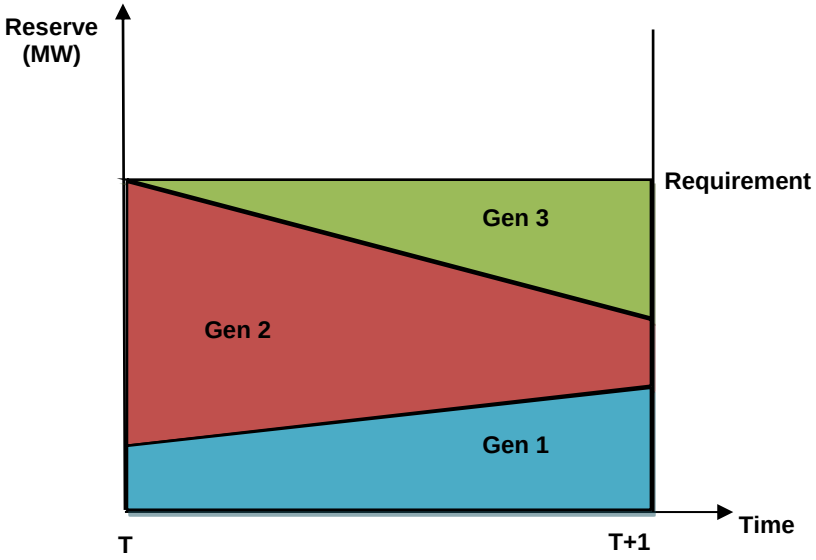
This is valid on the condition that the whole set of GRFs remain in the generation level range within which they can provide the ancillary service throughout the dispatch period i.e. in the case of primary and secondary reserve[2] provision, their generation levels should be above LowLoad from the beginning to the end of the dispatch period.

This is because, when we look at the whole set of GRFs, their aggregate reserve contribution[3] will sum to the reserve requirement at the end of each dispatch period. Suppose the reserve requirement does not change from the previous to the current period, if all GRFs ramp linearly with their reserve contribution also changing linearly, their aggregate reserve contribution will be constant throughout the dispatch period. There will thus be no shortfall in reserve provision for the dispatch period. This is illustrated by Figure 2, where Generator 2 is linearly reducing its contribution, while Generators 1 and 3 increase theirs. Similarly, when the reserve requirement

[2] As earlier mentioned, given the 10-minute response time for contingency reserve, a GRF scheduled for provision of this reserve class is most likely able to ramp up to its LowLoad in time. Subsequent references to 'reserve' in this section and the next therefore **exclude contingency reserve**.
[3] A GRF's reserve contribution is its reserve schedule at the end of each dispatch period and is assumed to change linearly within the dispatch period.

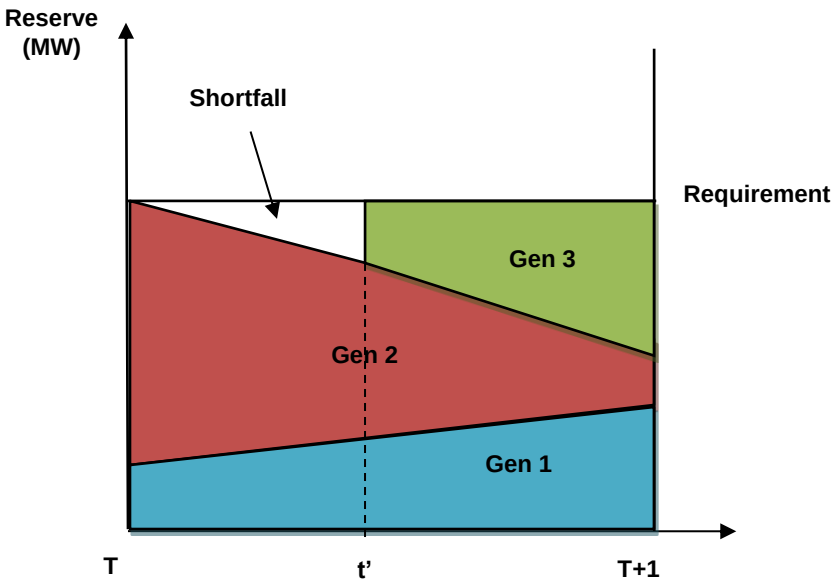
changes from the previous to the current period, the GRFs' aggregate reserve contribution would then ramp linearly within the dispatch period.

Figure 2: No Reserve Shortfall



However, if at some points during the dispatch period there are GRFs whose generation levels are below LowLoad, there could be reserve shortfall for parts of that period. In Figure 3 below, Generator 3 is ramping up from below its LowLoad and is thus not able to provide reserve before its energy output reaches LowLoad at time t'. As a result, there will be this short period of time where there is reserve shortfall.

Figure 3: Reserve Shortfall



To determine whether BOP tests for reserve need to be introduced, we examined the current system-wide reserve availability[4]. The details and results of the study are outlined in the following section.

[4] System-wide reserve availability refers to the aggregate reserve capability of the GRFs in Scenario A or B in the next section.

3.2.3 Study of System-wide Reserve Availability

We conducted a study to examine the current system-wide reserve availability and individual GRFs' reserve capability on a minute-by-minute basis from a random 31-day sample.

Scenarios

We determine the aggregate effective reserve capability for each minute of a dispatch period (30 data points for a half-hour dispatch) for **all GRFs that were scheduled for reserve** in that dispatch period. This is referred to as **Scenario A**. The aggregate effective reserve capability in that minute is then compared with the linearly pro-rated reserve requirement for that minute to determine if there was any effective reserve shortfall for that minute.

All frequency sensitive GRFs that were scheduled for energy and offered reserve in that dispatch period (regardless of whether they are scheduled for reserve in that dispatch period) will respond to the system's needs for reserve. We hence similarly determine the aggregate effective reserve capability for each minute of a dispatch period for all such GRFs and compare it with the linearly pro-rated reserve requirement for that minute to determine if there was any effective reserve shortfall for that minute. This is referred to as **Scenario B**.

Assumptions and Calculations

Using a 31-day period (01 Jul – 31 Jul 2014), our study applies the following assumptions:

For each GRF,

- its energy output at BOP and at EOP are ExpectedStartGeneration and SE_T respectively
- it ramps at its offered ramp rate from ExpectedStartGeneration from BOP and sustain its output at SE_T to EOP
- its reserve capability throughout the dispatch period is sufficiently represented by its reserve capability at each minute of the dispatch period

The following parameters were calculated for **each minute** of a dispatch period, for primary and secondary reserve classes:

- **Effective reserve capability of each GRF**, $EffResCap_{g,t,c}$[5], with respect to the linearly pro-rated energy level of each GRF scheduled to provide energy.

- **System-wide effective reserve availability**, $SystemEffResCap_{t,c}$[6], which is the sum of all the $EffResCap_{g,t,c}$ figures at that minute.

- **System-wide effective reserve shortfall**, $ShortfallEffRes_{t,c}$[7], which is the system-wide effective reserve availability vis-à-vis the linearly pro-rated reserve requirement[8] for that minute.

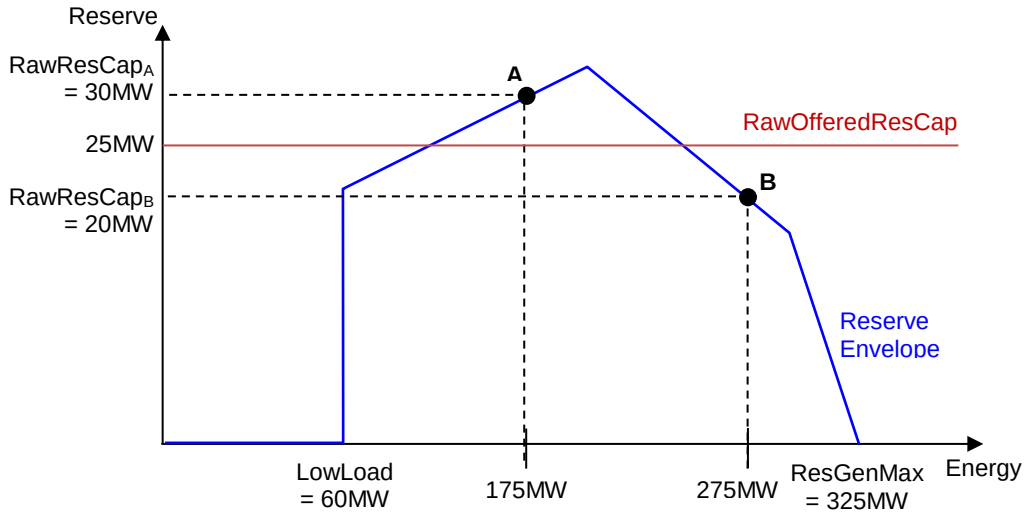
[5] $EffResCap_{g,t,c} = REF_g \times Min(RawResCap_{g,t,c}, RawOfferedResCap_{g,c})$
[6] $SystemEffResCap_{t,c} = \sum EffResCap_{g,t,c}$
[7] $ShortfallEffRes_{t,c} = SystemEffResCap_{t,c} – ReserveRequirement_c$
[8] The reserve requirement is adjusted to be less the effective reserve scheduled from all LRFs.

The effective reserve capability of each GRF is determined by its Reserve Effectiveness Factor (REF) multiplied by the minimum of:

a) its RawResCap, raw reserve capability as derived from its reserve envelope (as shown in Figure 4); and
b) its RawOfferedResCap, maximum reserve capability as declared in its reserve offer quantity[9].

This translates into the formula $EffResCap_{g,t,c} = REF_g \times Min(RawResCap_{g,t,c}, RawOfferedResCap_{g,c})$.

Figure 4: Derivation of Raw Reserve Capability from the Reserve Envelope



For example, in Figure 4 above, for a generator with a REF of 0.85 and a primary reserve offer of 25MW,

At point A, its effective reserve capability is 21.25MW (0.85 x the minimum of RawResCap of 30MW and RawOfferedResCap of 25MW).

At point B, its effective reserve capability is 17MW (0.85 x the minimum of RawResCap of 20MW and RawOfferedResCap of 25MW).

Comparison of Reserve Availability

Table 1 presents the results under Scenarios A and B.

Table 1: Results

	Scenario A		Scenario B	
Reserve Class	**Primary**	**Secondary**	**Primary**	**Secondary**
1. Average number of facilities (includes LRFs) considered to be contributing to reserve provision in each dispatch period	15.38	15.84	16.96	16.96

[9] Reserve offer quantity is used to cap the raw reserve capability with the assumption that the generator's reserve offer quantity should reflect its actual maximum reserve capability.

	Scenario A		Scenario B	
Reserve Class	**Primary**	**Secondary**	**Primary**	**Secondary**
2. Average number of GRFs considered to be contributing to reserve provision in each dispatch period	14.39	14.86	15.98	15.97
3. % of time, in the 31-day period, where there was system-wide reserve shortfall	0	0	0	0
4. Average MW amount of shortfall in all 1-min intervals with system-wide reserve shortfall	0	0	0	0
5. GRF's average % of "under-performing" time[10], **for the GRFs scheduled to provide reserve**	2.38%	1.54%	-	-
6. GRF's average MW amount of shortfall[11], **for the GRFs scheduled to provide reserve**	0.00317MW	0.00528MW	-	-
7. Average system-wide reserve availability cushion in all 1-min intervals	100.59%	83.89%	112.73%	169.75%

We observe that on an individual generator basis, there is an insignificant percentage of "under-performing" time for primary and secondary reserve (2.38%; 1.50%) and an insignificant average MW amount of primary and secondary reserve shortfall (0.00317MW; 0.00528MW). Furthermore, there is no system-wide reserve shortfall at all because the aggregate effective reserve capability of GRFs in both scenarios far exceeds the reserve requirement on a minute-by-minute basis.

Figures 5 and 6 show the period averages for system-wide reserve availability under Scenarios A and B vis-à-vis the reserve requirement. The high percentages of reserve availability cushion, i.e. (reserve availability – reserve requirement) / reserve requirement, which is 100.59% for primary reserve and 83.89% for secondary reserve in scenario A and 112.73% for primary reserve and 169.75% for secondary reserve for scenario B on average, indicate that the system-wide reserve availability is so high beyond the reserve requirement that there is no compelling reason to consider BOP tests for primary and secondary reserves.

[10] % of "under-performing" time for a scheduled GRF = the number of 1-min intervals where the GRF is unable to provide its scheduled quantity of reserve divided by the total number of its scheduled 1-min intervals (i.e. the number of periods it is scheduled to provide reserve x 30)

[11] Average MW amount of shortfall for a scheduled GRF = the total amount of reserve the GRF is unable to provide (i.e. the sum of shortfall amount experienced in each of its scheduled 1-min intervals) divided by the total number of its scheduled 1-min intervals (i.e. the number of periods it is scheduled to provide reserve x 30)

Figure 5: Primary Reserve Availability

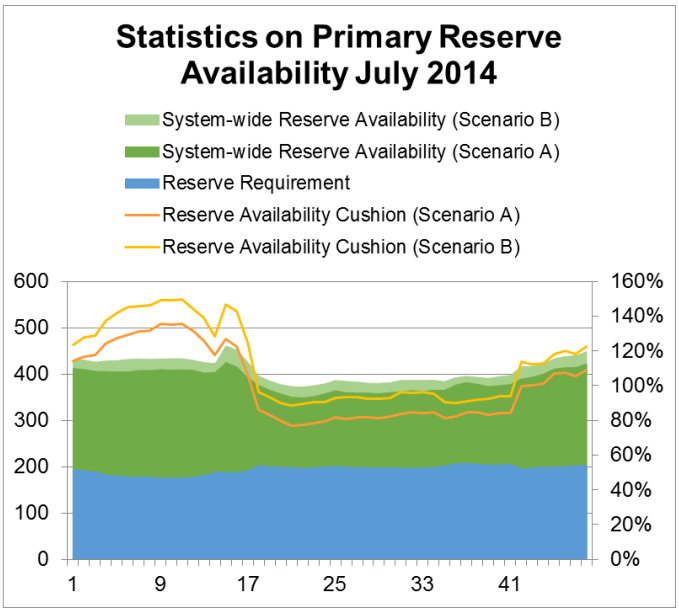
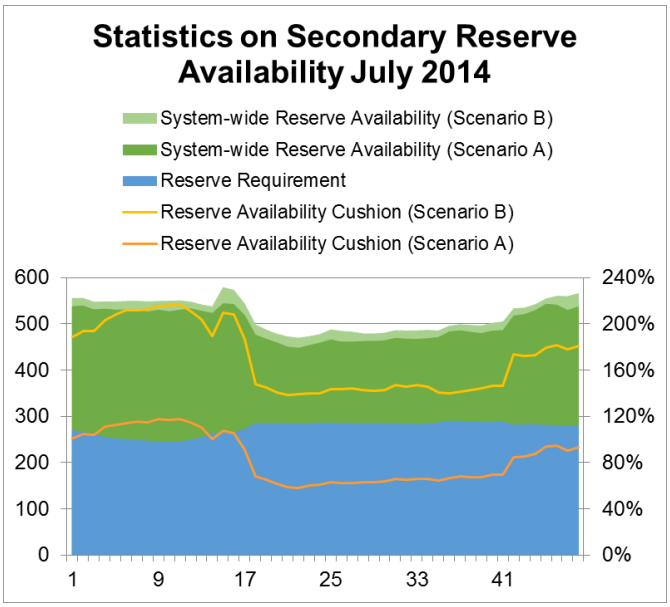


Figure 6: Secondary Reserve Availability



4. Conclusion

In conclusion, for Issue 1, the proposed revision to the proxy of generation level of a GRF at BOP in the ramping constraints ensures consistency in using the better proxy throughout the MCE.

As for Issue 2, evaluation of the current eligibility checks for energy and reserve reveals that only primary and secondary reserves may require BOP tests to prevent reserve availability shortfalls within the dispatch period. A minute-by-minute study of the current individual generators' reserve capability and system-wide reserve availability shows that there is minimal underperformance by individual generators, and high system-wide reserve availability largely in excess of reserve requirement. As such, BOP tests are unnecessary for energy and reserve.

5. Industry Consultation (Concept Paper)

The concept paper was published for industry consultation on 9 April 2015 and no comments were received.

6. RCP's Decision at the 80th RCP Meeting

At the 80th RCP meeting held on 12 May 2015, the RCP **unanimously supported** Issue 1 which proposed revising StartGeneration to ExpectedStartGeneration in the ramping constraints and **tasked** EMC to draft the relevant rule modifications.

The RCP by majority vote **did not support** Issue 2 which proposed introducing BOP tests for energy and reserve. The details of the votes are as follows:

The RCP members who voted not to support:

1. Mr Toh Seong Wah — Representative of EMC
2. Ms Grace Chiam — Representative of Generation Licensees
3. Ms Priscilla Chua — Representative of Generation Licensees
4. Mr Marcus Tan — Representative of Generation Licensees
5. Mr Lim Han Kwang — Representative of Transmission Licensee
6. Mr Sean Chan — Representative of Retail Electricity Licensees
7. Mr Daniel Lee — Representative of Retail Electricity Licensees
8. Mr Luke Peacocke — Representative of Retail Electricity Licensees
9. Mr Lawrence Lee — Representative of Market Support Services Licensee
10. Mr Phillip Tan — Person experienced in Financial Matters in Singapore

The RCP members who voted to abstain:

1. Mr Soh Yap Choon — Representative of PSO

7. Implementation Process

The breakdown of the estimated time and costs for the implementation of the proposal to revise StartGeneration to ExpectedStartGeneration in the ramping constraints is set out in Table 2 below.

Table 2: Estimated Implementation Time and Costs

Time Estimates	**Man week(s)**	**Calendar week(s)**
1) Requirement Scoping and Analysis	2	1
2) Development, Testing, Deployment and Documentation	2	2
3) User Acceptance Testing	2.5	4
Total Project Time	**6.5**	**7**
Cost Estimates		
1) Power Systems Consultant Resource/EMC Manpower	$45,655	
Total Cost	**$45,655 (Within EMC's Budget)**	

Due to the code freeze that EMC has planned for the Demand Response Program (DR) project, the earliest the proposed system changes to the MCE can be implemented is 3 months after the implementation of the DR project, which is targeted to be rolled out in December 2015.

Update: The effective date of the DR project is postponed to 28 April 2016.

8. Proposed Rule Modifications

Arising from the RCP's decision, EMC drafted the proposed rule modifications to implement the proposal to revise StartGeneration to ExpectedStartGeneration in the ramping constraints. The modifications are set out in **Annex 3** and summarised in Table 3.

Table 3: Summary of Proposed Rule Changes

S/N	Chapter/ Section	Proposed Changes	Reasons for Change
1	Appendix 6D Section D.3 Appendix 6K Section K.1.3	Replace "section D.13A.2" with "section D.12.5".	To change the cross-reference to the existing section D.13A.2 to reflect its new section number.
2	Appendix 6D Sections D.12.5 and D.13A.2	Move existing section D.13A.2 to new section D.12.5. Add that the offered ramp rates are set from values for the immediately prior dispatch period.	To move the existing section D.13A.2, where the formulation for the determination of ExpectedStartGeneration is originally defined, to section D.12 where ExpectedStartGeneration is used for the first time. To specify that offered ramp rates used to determine the ExpectedStartGeneration of a GRF for current given dispatch period t, are set from values contained in its valid energy offer for the immediately prior dispatch period.
3	Appendix 6D Sections D.12.6 and D.12.7	Re-number existing sections D.12.5 and D.12.6 as sections D.12.6 and D.12.7 respectively.	To re-number the sections, given the insertion of section D.12.5 above.
4	Appendix 6D Sections D.12.6, D.12.7 and D.19.2	Replace "StartGeneration" with "ExpectedStartGeneration".	To replace StartGeneration with ExpectedStartGeneration in the ramping constraints

9. Legal Sign-Off

The text of the rule modifications in **Annex 3** has been vetted by EMC's external legal counsel, whose opinion is that the modifications reflect the intent of the rule modification proposal as expressed in the third column of the table in **Annex 3**.

10. Industry Consultation (Proposed Rule Modifications)

The proposed rule modifications, as set out in **Annex 3**, were published for industry consultation on 29 May 2015 and no comments were received.

11. TWG's Decision at the 27th TWG Meeting

The proposed rule modifications were presented at the 27th TWG meeting held on 26 June 2015. The TWG unanimously **supported** the proposed rule modifications set out in **Annex 3**.

12. RCP's Decision at the 81st RCP Meeting

The RCP by majority vote **supported** the proposed rule modifications set out in **Annex 3**. The details of the votes are as follows:

The RCP members who voted to support:

1.	Mr Toh Seong Wah	Representative of EMC
2.	Mr Soh Yap Choon	Representative of PSO
3.	Ms Priscilla Chua	Representative of Generation Licensees
4.	Mr Marcus Tan	Representative of Generation Licensees
5.	Ms Grace Chiam	Representative of Generation Licensees
6.	Mr Lim Han Kwang	Representative of Transmission Licensee
7.	Mr Sean Chan	Representative of Retail Electricity Licensees
8.	Mr Luke Peacocke	Representative of Retail Electricity Licensees
9.	Mr Lawrence Lee	Representative of Market Support Services Licensee
10.	Mr Phillip Tan	Person experienced in Financial Matters in Singapore
11.	Dr Toh Mun Heng	Representative for the interests of the consumers of electricity in Singapore

The RCP member who voted to abstain:

1.	Ms Frances Chang	Representative for the interests of the consumers of electricity in Singapore

13. Recommendation

The RCP by majority vote recommends that the EMC Board:

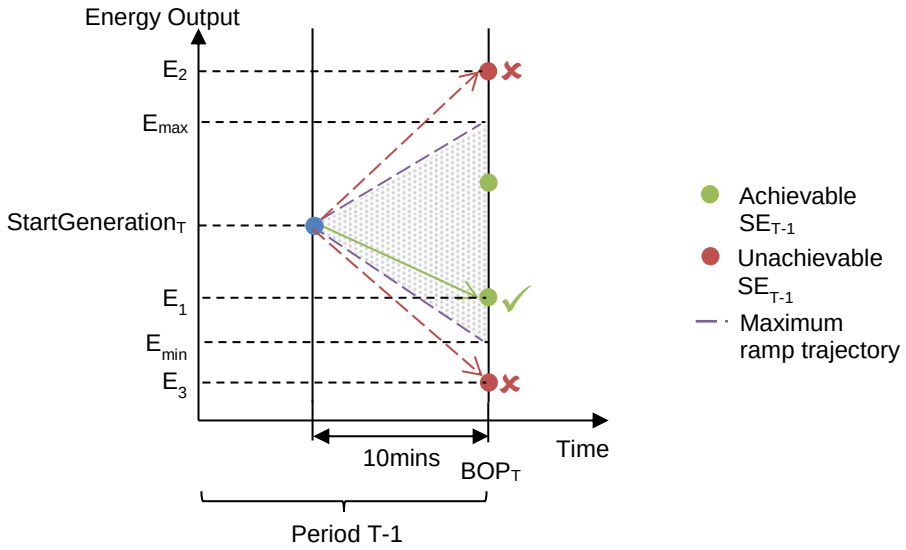
(a) **adopt** the proposed rule modifications as set out in **Annex 3**;

(b) **seek** the EMA's approval of the proposed rule modifications as set out in **Annex 3**; and

(c) **recommend** that the proposed rule modifications come into force **3 months** after the date on which the approval of the Authority is published by the EMC, or **3 months** after the date on which the DR project is rolled out, whichever is later.

Annex 1: Derivation of ExpectedStartGeneration

Figure 7: Derivation of ExpectedStartGeneration



To illustrate, Figure 7 shows how a GRF's ExpectedStartGeneration (to be used for scheduling in the current dispatch period T) is determined:

1. When the GRF's SE_{T-1} is at E_1 which is achievable given its physical constraints, its ExpectedStartGeneration would be its SE_{T-1} at E_1.

2. When the GRF's SE_{T-1} is at E_2 which is unachievable given its physical constraints, its ExpectedStartGeneration will then be E_{max} (constrained by its StartGeneration and maximum ramp-up rate).

3. Similarly, when the GRF's SE_{T-1} is at E_3 which is unachievable given its physical constraints, its ExpectedStartGeneration will then be E_{min} (constrained by its StartGeneration and maximum ramp-down rate).

Annex 2: Reserve Envelope

Table 4: Components in the Reserve Envelope and Corresponding Descriptions and Constraints of a GRF

	Component	Description	Corresponding Modelled Constraints in MCE (If applicable)
1	X-axis (Generation)	Energy Output	N.A.
2	Y-axis (Raw reserve)	Scheduled Reserve	N.A.
3	Maximum Reserve Capacity (MW)	The maximum sustainable amount of reserve that a GRF is capable of providing. This is determined in accordance with Chapter 6, Appendix 6E, E.1.1.5, as part of the GRF's standing capability data.	N.A.
4	Reserve Proportion	The maximum amount of reserve that may be scheduled for a GRF as a ratio of its energy scheduled. This is currently set as part of the GRF's standing capability data under Chapter 6, Appendix 6E, E.1.1.7, but this can be revised as part of reserve offers under Chapter 6, Section 5.3.2.6.	Chapter 6, Appendix 6D D.17.2.3 Reserve Proportion Constraint: $RawReserve_r - ExcessRawReserve_r \leq ReserveProportion_r \times Generation_{g(r)}$ {r ∈ GENRESERVEOFFERS}
5	Reserve Generation Max	The maximum combined capacity of energy, raw reserve and regulation that is offered. This equation allows a GRF to offer a total capacity which is higher than its usual generation capacity (for energy) to take into account reserve provision., as described under the explanatory note in Chapter 6, Appendix 6E, section E.1.1.6.	Chapter 6, Appendix 6D D.17.2.4 Reserve Generation Max Constraint $Generation_{g(r)} + RawReserve_r + Regulation_{l(r)} - ExcessResGen_r \leq ReserveGenerationMax_r$ {r ∈ GENRESERVEOFFERS}

	Component	Description	Corresponding Modelled Constraints in MCE (If applicable)
6	Reserve Generation Segment 1	Reflects the reserve capability of a GRF at energy levels between the standing reserve generation maximum, determined in accordance with Chapter 6, Appendix 6E.1.1.6, and high load.	Chapter 6, Appendix 6D D.17.2.5 Reserve Generation Segment 1 $RawReserve_r$ – $ExcessResGenSegment1_r$ ≤ $HighLoadReserve_r$ + Slope x ($Generation_{g(r)}$ – $HighLoad_{g(r)}$) where: Slope = - $HighLoadReserve_r$/ ($StandingReserveGenerationMax_{g(r)}$ – $HighLoad_{g(r)}$) {r ∈ GENRESERVEOFFERS}
7	Reserve Generation Segment 2	Reflects the reserve capability of a GRF at energy levels between the high load and the medium load.	Chapter 6, Appendix 6D D.17.2.6 Reserve Generation Segment 2 $RawReserve_r$ – $ExcessResGenSegment2_r$ ≤ $MediumLoadReserve_r$ + Slope x ($Generation_{g(r)}$ – $MediumLoad_{g(r)}$) where: Slope = ($HighLoadReserve_r$ - $MediumLoadReserve_r$)/ (HighLoad– MediumLoad) {r ∈ GENRESERVEOFFERS}

	Component	Description	Corresponding Modelled Constraints in MCE (If applicable)
8	Reserve Generation Segment 3	Reflects the reserve capability of a GRF at energy levels between the medium load and the low load.	Chapter 6, Appendix 6D D.17.2.7 Reserve Generation Segment 3 $RawReserve_r - ExcessResGenSegment3_r \leq LowLoadReserve_r + Slope \times (Generation_{g(r)} - LowLoad_{g(r)})$ where: $Slope = (MediumLoadReserve_r - LowLoadReserve_r)/(MediumLoad_{g(r)} - LowLoad_{g(r)})$ $\{r \in GENRESERVEOFFERS\}$
9	Low Load Reserve	Corresponding quantities of reserve (MW) that can be provided by a GRF operating at an energy output of Low Load, Medium Load and High Load.	N.A.
10	Medium Load Reserve		
11	High Load Reserve		
12	Low Load	Lowest load in MW which a GRF can provide reserve such that it meets the requirements of the Transmission Code.	N.A.
13	Medium Load	Energy output of a GRF at the intersection of Reserve Generation Segment 2 and Segment 3. It is expressed as 0.75 of the Standing Reserve Generation Max.	N.A.
14	High Load	Energy output of a GRF at the intersection of Reserve Generation Segment 1 and Segment 2. It is expressed as 0.9 of the Standing Reserve Generation Max	N.A

Annex 3: Proposed Rule Modifications

Existing Market Rules (1 Apr 2015)	Proposed Rules Changes (Deletions represented by strikethrough text and additions represented by double underlined text)	Reasons for rule change
APPENDIX 6D	**APPENDIX 6D**	
D.3 PARAMETERS … ExpectedStartGeneration$_g$ — The forecast generation level at the beginning of a given *dispatch period* of a *generation registered facility* associated with *energy offer g* for that *dispatch period*, which shall be determined in accordance with section D.13A.2. …	**D.3 PARAMETERS** … ExpectedStartGeneration$_g$ — The forecast generation level at the beginning of a given *dispatch period* of a *generation registered facility* associated with *energy offer g* for that *dispatch period*, which shall be determined in accordance with section ~~D.13A.2~~D.12.5. …	To change the cross-reference to the existing section D.13A.2 to reflect its new section number.
D.12 RAMPING CONSTRAINTS … [New Section]	**D.12 RAMPING CONSTRAINTS** … D.12.5 ExpectedStartGeneration$_g$ of a *generation registered facility* associated with an *energy offer g* shall be determined in accordance with the following table: When the *generation registered facility's* StartGeneration$_g$ is greater than its PriorScheduledGeneration$_g$, its ExpectedStartGeneration$_g$ shall be the higher of: a) StartGeneration$_g$ – DownRampRate$_{g,t-1}$ x	To move the existing section D.13A.2 to section D.12 and to insert it as the new section D.12.5. To make further amendments thereto to improve clarity.

Existing Market Rules (1 Apr 2015)	Proposed Rules Changes (Deletions represented by strikethrough text and additions represented by double underlined text)	Reasons for rule change
	RampingTime; and b) PriorScheduledGeneration$_g$. When the *generation registered facility's* StartGeneration$_g$ is less than its PriorScheduledGeneration$_g$, its ExpectedStartGeneration$_g$ shall be the lower of: a) StartGeneration$_g$ + UpRampRate$_{g,t-1}$ x RampingTime; and b) PriorScheduledGeneration$_g$. When the *generation registered facility's* StartGeneration$_g$ is equal to its PriorScheduledGeneration$_g$, its ExpectedStartGeneration$_g$ shall be its PriorScheduledGeneration$_g$. For the purposes of this section D.12.5 only, DownRampRate$_{g,t-1}$ and UpRampRate$_{g,t-1}$, for a given *generation registered facility* for a given *dispatch period t* to which its *energy offer g* relates, shall be determined using the respective values	To specify that the DownRampRate$_{g,t-1}$ and UpRampRate$_{g,t-1}$, used to determine the ExpectedStartGeneration of a generation registered facility for current given dispatch period t, are set from values contained in its valid energy offer for the immediately prior dispatch period. To define DownRampRate$_{g,t-1}$ and UpRampRate$_{g,t-1}$ for this section

Existing Market Rules (1 Apr 2015)	Proposed Rules Changes (Deletions represented by strikethrough text and additions represented by double underlined text)	Reasons for rule change
	contained in its valid *energy offer* for the *dispatch period* immediately prior to *dispatch period t.*	D.12.5 only.
D.12.5 $GenerationEndMax_g = StartGeneration_g + (UpRampRate_g/60 \times RemainingTime)$ { $g \in$ ENERGYOFFERS, $g \notin$ INTERTIEENERGYOFFERS } D.12.6 $GenerationEndMin_g = StartGeneration_g - (DownRampRate_g/60 \times RemainingTime)$ { $g \in$ ENERGYOFFERS, $g \notin$ INTERTIEENERGYOFFERS }	D.12.56 $GenerationEndMax_g =$ ~~$StartGeneration_g$~~ $ExpectedStartGeneration_g + (UpRampRate_g/60 \times RemainingTime)$ { $g \in$ ENERGYOFFERS, $g \notin$ INTERTIEENERGYOFFERS } D.12.67 $GenerationEndMin_g =$ ~~$StartGeneration_g$~~ $ExpectedStartGeneration_g - (DownRampRate_g/60 \times RemainingTime)$ { $g \in$ ENERGYOFFERS, $g \notin$ INTERTIEENERGYOFFERS }	To re-number the existing sections D.12.5 and D.12.6 as sections D.12.6 and D.12.7 respectively, given the insertion of existing section D.13A.2 as section D.12.5 above. To replace $StartGeneration_g$ with $ExpectedStartGeneration_g$.

Existing Market Rules (1 Apr 2015)	Proposed Rules Changes (Deletions represented by strikethrough text and additions represented by double underlined text)	Reasons for rule change
D.13A REGULATION RANGE CONSTRAINTS … D.13A.2 ExpectedStartGeneration$_g$ of a *generation registered facility* associated with an *energy offer g* shall be determined in accordance with the following table: When the *generation registered facility's* StartGeneration$_g$ is greater than its PriorScheduledGeneration$_g$, ExpectedStartGeneration$_g$ shall be the higher of: a) StartGeneration$_g$ – DownRampRate$_g$ x RampingTime; and b) PriorScheduledGeneration$_g$. When the *generation registered facility's* StartGeneration$_g$ is less than its PriorScheduledGeneration$_g$, ExpectedStartGeneration$_g$ shall be the lower of: a) StartGeneration$_g$ + UpRampRate$_g$ x RampingTime; and	**D.13A REGULATION RANGE CONSTRAINTS** … ~~D.13A.2 ExpectedStartGeneration$_g$ of a *generation registered facility* associated with an *energy offer g* shall be determined in accordance with the following table:~~ ~~When the *generation registered facility's* StartGeneration$_g$ is greater than its PriorScheduledGeneration$_g$, ExpectedStartGeneration$_g$ shall be the higher of:~~ ~~a) StartGeneration$_g$ – DownRampRate$_g$ x RampingTime; and~~ ~~b) PriorScheduledGeneration$_g$.~~ ~~When the *generation registered facility's* StartGeneration$_g$ is less than its PriorScheduledGeneration$_g$, ExpectedStartGeneration$_g$ shall be the lower of:~~ ~~a) StartGeneration$_g$ + UpRampRate$_g$ x RampingTime; and~~	To move the existing section D.13A.2 to section D.12 as the new section D.12.5 above.

Existing Market Rules (1 Apr 2015)	Proposed Rules Changes (Deletions represented by strikethrough text and additions represented by double underlined text)	Reasons for rule change
b) PriorScheduledGeneration$_g$. When the *generation registered facility's* StartGeneration$_g$ is equal to its PriorScheduledGeneration$_g$, its ExpectedStartGeneration$_g$ shall be its PriorScheduledGeneration$_g$.	~~b) PriorScheduledGeneration$_g$.~~ ~~When the *generation registered facility's* StartGeneration$_g$ is equal to its PriorScheduledGeneration$_g$, its ExpectedStartGeneration$_g$ shall be its PriorScheduledGeneration$_g$.~~	
D.19 RAMPING … D.19.2 Combined ramping, *reserve* and *regulation* constraints D.19.2.1 Reserve Ramp Constraint: $RawReserve_r + ReserveResponseRatio_r \times (Generation_{g(r)} - StartGeneration_{g(r)}) - ExcessResRamp_r \leq MaxResponse_r$ { $r \in$ GENRESERVEOFFERS, where $ReserveResponsePeriod_{c(r)} >$ CombinedRampThreshold }	**D.19 RAMPING** … D.19.2 Combined ramping, *reserve* and *regulation* constraints D.19.2.1 Reserve Ramp Constraint: $RawReserve_r + ReserveResponseRatio_r \times (Generation_{g(r)} - \sout{StartGeneration_{g(r)}}\ \underline{ExpectedStartGeneration_{g(r)}}) - ExcessResRamp_r \leq MaxResponse_r$ { $r \in$ GENRESERVEOFFERS, where $ReserveResponsePeriod_{c(r)} >$ CombinedRampThreshold }	To replace $StartGeneration_{g(r)}$ with $ExpectedStartGeneration_{g(r)}$.

Existing Market Rules (1 Apr 2015)	Proposed Rules Changes (Deletions represented by strikethrough text and additions represented by double underlined text)	Reasons for rule change
D.19.2.2 Reserve Proportion Ramp Constraint: $RawReserve_r + ReserveResponseRatio_r \times (Generation_{g(r)} - StartGeneration_{g(r)}) - ExcessResPropRamp_r \leq ReserveProportionCombined_r \times Generation_{g(r)}$ { $r \in$ GENRESERVEOFFERS, where $ReserveResponsePeriod_{c(r)} >$ CombinedRampThreshold }	D.19.2.2 Reserve Proportion Ramp Constraint: $RawReserve_r + ReserveResponseRatio_r \times (Generation_{g(r)} - \sout{StartGeneration_{g(r)}}\ \underline{ExpectedStartGeneration_{g(r)}}) - ExcessResPropRamp_r \leq ReserveProportionCombined_r \times Generation_{g(r)}$ { $r \in$ GENRESERVEOFFERS, where $ReserveResponsePeriod_{c(r)} >$ CombinedRampThreshold }	
D.19.2.3 Regulation Ramp Constraint: $Regulation_l + RegulationResponseRatio \times (Generation_{g(l)} - StartGeneration_{g(l)}) - ExcessRegRamp_l \leq MaxResponse_l$ { $l \in$ REGULATIONOFFERS, where RegulationResponsePeriod > CombinedRampThreshold }	D.19.2.3 Regulation Ramp Constraint: $Regulation_l + RegulationResponseRatio \times (Generation_{g(l)} - \sout{StartGeneration_{g(l)}}\ \underline{ExpectedStartGeneration_{g(l)}}) - ExcessRegRamp_l \leq MaxResponse_l$ { $l \in$ REGULATIONOFFERS, where RegulationResponsePeriod > CombinedRampThreshold }	To replace $StartGeneration_{g(l)}$ with $ExpectedStartGeneration_{g(l)}$.

Rules approved by EMA on 05 February 2014 (Effective 27 Aug 2015)	Proposed Rules Changes (Deletions represented by strikethrough text and additions represented by double underlined text)	Reasons for rule change
APPENDIX 6K	**APPENDIX 6K**	
K.1 PURPOSE AND DEFINITIONS … K.1.3 In this Appendix, the following definitions apply: … ExpectedStart Generation$_{g,t}$ = Forecast *generation* level of *GRF* m at the beginning of *dispatch period* t associated with an *energy offer* g for that *dispatch period*, as determined in accordance with section D.13A.2 of Appendix 6D, which is used in the *real-time dispatch schedule* referred to in section 10.5.1.1 of Chapter 6, for *dispatch period* t. …	**K.1 PURPOSE AND DEFINITIONS** … K.1.3 In this Appendix, the following definitions apply: … ExpectedStart Generation$_{g,t}$ = Forecast *generation* level of *GRF* m at the beginning of *dispatch period* t associated with an *energy offer* g for that *dispatch period*, as determined in accordance with section ~~D.13A.2~~D.12.5 of Appendix 6D, which is used in the *real-time dispatch schedule* referred to in section 10.5.1.1 of Chapter 6, for *dispatch period* t. …	To change the cross-reference to the existing section D.13A.2 to reflect its new section number.