APPENDIX J – PRICE LIMITS AND CONSTRAINT VIOLATION PENALTIES

J.1 MAXIMUM AND MINIMUM PRICES

J.1.1 The lower limit on *energy* prices in *standing offers*, *offer variations* and *settlements* shall be:

EnergyPriceMin

J.1.1A The lower limit on *energy* prices in *standing bids* and *bid variations* in respect of *restricted energy bids* shall be:

REBPriceMin

J.1.2 The upper limit on *energy* prices in shall be:

EnergyPriceMax

J.1.2A The upper limit on *energy* prices in *standing bids* and *bid variations* in respect of *restricted energy bids* shall be:

REBPriceMax

J.1.2B The upper limit on *load curtailment prices* shall be:

LoadCurtailmentPriceMax

J.1.2C The upper limit on *energy prices* in *standing offers* and *offer variations* shall be:

EnergyOfferMax

J.1.3 The upper limit on *regulation* prices in *standing offers*, *offer variations* and *settlements* shall be:

RegPriceMax

J.1.4 The upper limit on *reserve* prices for primary *reserve* in *standing offers*, *offer variations* and *settlements* shall be:

ResPriPriceMax

J.1.5 [Deleted and Intentionally Left Blank]

J.1.6 The upper limit on *reserve* prices for contingency *reserve* in *standing offers*, *offer variations* and *settlements* shall be:

ResConPriceMax

Explanatory Note: The lower limit on prices for regulation and all classes of reserve is zero.

J.1.7 Price bound values:

Parameter	**Value**
EnergyPriceMin	0.9 * CDC
REBPriceMin	1.5 * BVP
EnergyPriceMax	0.9 * VoLL
LoadCurtail-mentPriceMax	0.9 * VoLL
EnergyOfferMax	0.9 * VoLL
REBPriceMax	1.00 * VoLL
RegPriceMax	0.06 * VoLL
ResPriPriceMax	0.85 * VoLL
ResConPriceMax	0.65 * VoLL

J.1.7A Price Bound Values that will apply if the *temporary price cap* is in effect:

Parameter	**Value**
EnergyPriceMax	0.9 * CDC
REBPriceMin	1.5 * BVP
EnergyPriceMax	Min [*TPC Energy Multiplier* * *TPC Price Parameter*, 0.9 * VoLL
LoadCurtailmentPriceMax	0.9 * VoLL
EnergyOfferMax	0.9 * VoLL
REBPriceMax	1.00 * VoLL
RegPriceMax	*TPC Regulation Multipler* * EnergyPrice-Max
ResPriPriceMax	*TPC Primary Reserve Multipler* * Ener-

	gyPriceMax
ResConPriceMax	*TPC Contingency Reserve Multiplier* * EnergyPriceMax

Explanatory Note:

"Value of Lost Load" (VoLL) is specified in section J.2.

"Cost of Decommitment" (CDC) is specified in section J.2.

"Base Vesting Price" (BVP) is determined by the MSSL counterparty pursuant to section 2.5.2 of Chapter 7. The rationale for setting the lower bound of the restricted energy bid as such can be found in the Authority's final determination paper on "Implementing Demand Response in the National Electricity Market of Singapore" dated 28 October 2013.

Price bounds are applied at Market Network Nodes.

Energy price bounds should be less than the first block of the violation penalties for deficit energy, by at least the maximum expected marginal loss between any two points in the system. Otherwise load shedding could be recommended by the market clearing engine at some nodes because of the losses between those nodes and the generation facility nodes, even though not all generation capacity has been utilised.

J.2 VoLL AND CDC

The following information will form part of the input data for the *market clearing engine* in accordance with section B.8 of Appendix 6B:

Value of Lost Load (VoLL)	=	$5,000/MWh
Cost of Decommitment (CDC)	=	-$5,000/MWh

J.3 MAPPING OF VIOLATION PENALTIES TO VARIABLES USED IN THE MARKET CLEARING ENGINE FORMULATION

Variable used in MCE formulation	*j*	Violation Penalty Block Prices	Violation Penalty Block Quantities
DeficitGenerationBlock$_{n,j}$ where *n* is a dispatch network node other than those dispatch network nodes added to the dispatch network pursuant to section D.6.5 or section D.8.2 of Appendix 6D.		DeficitGenerationPenalty$_{n,j}$ VoLL	DeficitGenerationBlockMax$_{n,j}$ 10,000 MW
Explanatory Note: **These violation variables do not have the same penalty logic as other violations – any violation blocks are penalised directly in the objective function.** **The purchase bid price is set to a very high level, so that any energy deficit violation will appear in the deficit generation variables, rather than the purchase bid variables.** **Market Max Energy Price/Max Energy Offer Price should be less than the first block of violation penalties for deficit energy, by at least the maximum expected marginal loss between any two points in the system. Otherwise load shedding could be recommended by the market clearing engine at some nodes because of the losses between those nodes and the generation facility nodes, even though not all generation capacity has been utilised.**			
DeficitRegulation	*1*	0.061 * VoLL	2,000 MW
	2	0.6 * VoLL	2,000 MW
DeficitReserve$_c$		**9 Second Class (Primary Reserve):**	
	1	0.062 * VoLL	2,000 MW
	2	0.51 * VoLL	2,000 MW
	3	0.9 * VoLL	2,000 MW
		10 Minute Class (Contingency Reserve):	
	1	0.037 * VoLL	2,000 MW

	2	0.39 * VoLL	2,000 MW
	3	0.7 * VoLL	2,000 MW

Explanatory Note:

A shorter term reserve class is more critical than a longer term reserve class, and should have higher violation penalties. Regulation is less critical than reserve, and is hence given a lower violation penalty.

The Violation Penalty Block Quantities for DeficitRegulation and DeficitReserve will be determined by constraints described in section D.21.4.1 (for regulation) and in sections D.21.3.1 and D.21.3.2 (for reserve) of Appendix 6D.

In general, the violation penalties for DeficitRegulation and DeficitReserve are set such that:

(1) The minimum regulation required constitutes a core requirement. Violation of this requirement will incur the highest violation penalty (i.e. the Violation Penalty Block Price with index j=2) for such DeficitRegulation.

(2) The minimum reserve required for each reserve class constitutes a core requirement. Violation of this requirement will incur the highest violation penalty (i.e. the Violation Penalty Block Price with index j=3) for DeficitReserve for such reserve class.

(3) Energy requirements are met before the fulfilment of the first block of reserve quantities (incurring the least penalty, *j=1*). Hence, the sum of the first block of violation penalties for both classes of deficit reserve is set to be less than the difference between the first block of violation penalties for deficit energy and the highest possible marginal energy offer (i.e. EnergyPriceMax).

Variable used in MCE formulation	**Violation Penalty Block Prices**	**Violation Penalty Block Quantities**
ExcessGenerationBlock$_{n,j}$ where *n* is a dispatch network node other than those dispatch network nodes added to the dispatch network pursuant to section D.6.5 or section D.8.2 of Appendix 6D.	ExcessGenerationPenalty$_{n,j}$ -CDC	ExcessGenerationBlockMax$_{n,j}$ 10,000 MW
ExcessLineFlowForward$_k$ ExcessLineFlowReverse$_k$ DeficitWLineFlow$_k$ ExcessWLineFlow$_k$ where $\{k \in$ LINES, $k \notin$ ARTIFICIALLINES$\}$	2.2 * VoLL	10,000 MW
Explanatory Note: **The recommended violation penalty for line flow is derived from the violation penalties for energy, since line flow or node violations trade-off against each other. Generally the deficiency leading to a line flow violation could alternatively result in a nodal violation – load could be shed at the receiving node rather than violating the flow limits. Assuming the flow limits are hard, then the solution that best matches what will happen in reality is for load to be shed at the receiving end of the line. Hence the price for the line flow violation is the maximum difference between energy prices at each end of the line, VoLL and -VoLL, plus an adder.**		
Variable used in MCE formulation	**Violation Penalty Block Prices**	**Violation Penalty Block Quantities**
ExcessRawReserve$_r$ ExcessResGen$_r$ ExcessResGenSegment1$_r$ ExcessResGenSegment2$_r$ ExcessResGenSegment3$_r$ ExcessResRamp$_r$	20 * VoLL	10,000 MW

$ExcessResPropRamp_r$ $ExcessRegGen_l$ $DeficitRegGen_l$ $ExcessRegRamp_l$ $ExcessUpRamp_g$ $ExcessDownRamp_g$ $ExcessUpRamp_p$ $ExcessDownRamp_p$ $DeficitMulti_s$ $ExcessMulti_s$ $ExcessLineFlowForward_k$ $ExcessLineFlowReverse_k$ $DeficitWLineFlow_k$ $ExcessWLineFlow_k$ where $\{k \in$ ARTIFICIALLINES1$\cup$ ARTIFICIALLINES2$\}$ $DeficitMSL_g$ $ExcessMSL_g$		

Explanatory Note:

Facility constraints should be the most expensive to violate. They comprise constraints on ramping, reserve capability at low loading, total generation plus reserve plus regulation capacity, combined ramping and reserve capability and regulation capability loading levels. These penalty violations should have large values because they relate to the plant capability specified by market participants, who have the best knowledge of the capability of their plant.

All facility groups should have the same violation penalties unless there is some valid reason to discriminate between facilities.

$DeficitGenerationBlock_{n,j}$ and $ExcessGenerationBlock_{n,j}$ where *n* is a dispatch network node added to the dispatch network pursuant to section D.6.5 or section D.8.2 of Appendix 6D.	20 * VoLL	10,000 MW
Explanatory Note: **These artificial nodes are a modelling construct created to support the modelling of an individual facility. It is therefore most appropriate to use the penalty scheme applicable to other facility violation variables, and not the scheme applicable to conventional nodes.**		
Variable used in MCE formulation	**Violation Penalty Block Prices**	**Violation Penalty Block Quantities**
$DeficitSecurity_s$	6 * VoLL	10,000 MW