Market Rule Amendment Proposal

PART 1 – MARKET RULE INFORMATION

Identification No.:	MR-00246-R00			
Subject:	Market Evolution Program			
Title:	Multi-Interval Optimization – Changes to Dispatch Algorithm			
Nature of Proposal:	X Alteration	☐ Deletion	☐ Addition	
Chapter:	7.0	Appendix:	7.5	
Sections:	2.2			
Sub-sections proposed for amending:	2.2.1.10A (new), 2.2.1.11, 2.2.1.15			

PART 2 – PROPOSAL HISTORY

Version	Reason for Issuing	Version Date
1.0	Draft for Technical Panel Review	January 28, 2004
2.0	Submitted for Technical Panel Review	February 12, 2004
3.0	Submitted for Technical Panel Vote	February 25, 2004
4.0	Recommended by Technical Panel and Submitted for IMO Board Approval	March 4, 2004
5.0	Approved by IMO Board	March 26, 2004

Approved Amendment Publication Date:	March 29, 2004
Approved Amendment Effective Date:	June 23, 2004

PART 3 – EXPLANATION FOR PROPOSED AMENDMENT

Provide a brief description of the following:

- The reason for the proposed amendment and the impact on the *IMO-administered markets* if the amendment is not made
- Alternative solutions considered
- The proposed amendment, how the amendment addresses the above reason and impact of the proposed amendment on the *IMO-administered markets*.

Summary

It is proposed to amend the market rules to incorporate the application of Multi-Interval Optimization (MIO) into Appendix 7.5 of the Market Rules. Appendix 7.5 specifies the market clearing and pricing processes used to determine pre-dispatch schedules, real-time schedules, market schedules and market prices.

MR-00246 proposes to:

1) Ensure inputs to the dispatch scheduling and pricing processes may include minimum loading point, forbidden regions, and period of steady operation;

2) Specify that MIO would be used in the real-time constrained schedule to resolve a number of identified real-time dispatch issues. MIO would not be used in the market schedule;

3) Specify that MIO will introduce additional inter-temporal linkages only for the real-time constrained dispatch schedule and that the inter-temporal linkages for all other schedules remain unchanged;

4) Describe the optimization technique at a high level and specify that the IMO has the authority to modify the length of the study period or the number of critical intervals selected in the event that there is a significant improvement or degradation in performance of computer systems or the accuracy of the forecasted demand values;

5) Specify the process of factoring in the unit ramp limits in each of the two optimization steps of the real-time constrained dispatch schedule;

6) Specify that for the real-time constrained schedule dispatch schedule only, the first step of the optimization process will maximize the weighted sum of the net benefits from trades in the dispatch intervals and subsequent advisory intervals.

Background

As part of the Market Evolution Program the IMO has been working with market participants to develop and implement multi-interval optimization (MIO). The MIO project proposes that the existing Real-Time Constrained Dispatch Scheduling Optimizer (RTC DSO) be enhanced such that it employs a formal multi-interval optimization technique rather than the current single interval optimization technique. MIO will determine security-constrained economic dispatch schedules for all resources such that they are optimally utilized over a selected number of intervals.

MIO is intended to result in a lower overall cost dispatch to the market, enhance unit scheduling and reduce dispatch volatility.

The MIO Project is also intended to address the following dispatch issues as identified by generator market participants:

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Reflecting Unit Ramping Capability – The DSO causes a "stutter step" in fossil loading when a unit starts to increase output from either a steady load or a loading rate that is less than the offered rate. This is a result of the snapshot that reflects the unit actual loading when calculating the next interval dispatch instruction. The DSO should account for the initial slow loading characteristic of non-quick start facilities.

Minimum Loading Point - Many facilities have a requirement to operate at or above a minimum loading point. These facilities cannot operate below those levels unless they are either synchronizing or being shutdown. The minimum loading point for specified units could be defined in PLC and be provided by the market participants during the registration process. The DSO should not schedule these units below this minimum output level unless the unit is synchronizing or being shut down.

Period of Steady Operation – Ensure that non-quick start units will not reverse direction without a minimum period (an adjustable variable from zero to two intervals) of steady operation. After the minimum period of steady operation, the unit would be available to be normally dispatched.

Forbidden Region – Hydroelectric generating station units have operating ranges where the units are unable to maintain steady operation without causing equipment damage. The RTC DSO should not schedule facilities in these predetermined operating ranges. The forbidden region should be recorded in PLC for auditing purposes. Multiple forbidden regions for aggregated facilities should be respected, up to a maximum of three. It was identified by the MIO working group that this was sufficient to facilitate the operational requirements of generation facilities.

For further information on MIO please refer to http://www.theimo.com/imoweb/consult/mep_mio.asp.

A related market rule amendment, MR-00245-R00-R03, details the changes to market participant and IMO permissions and obligations necessary to implement MIO and address the identified dispatch issues.

Discussion

MR-00246-R00 proposes to identify the additional inputs that will be used in the real-time constrained dispatch scheduling process in order to implement the Multi-Interval Optimization function and address the identified dispatch issues. The changes proposed for Section 2.2 of Appendix 7.5 are as follows:

Section 2.2.1.10A specifies that inputs to the real time constrained dispatch schedule would include generator start-up and shut-down times to ensure the correct treatment of non-quick start generating facilities. I.e. When a non-quick start unit synchronizes, it must ramp up to its minimum loading point. If the unit is dispatched below its minimum loading point, it must ramp down to zero and be removed from service.;

Section 2.2.1.11 specifies that operating characteristics of generators and dispatchable loads would also include minimum loading point data, forbidden region data and period of steady operation data in the real-time dispatch schedule as applicable for energy offers and offers for operating reserve. Data for minimum loading point, forbidden regions and period of steady operation would be submitted by market participants as part of the facility registration and stored in the IMO's facility registration database (PLC) as detailed in MR-00245-R00-R03; and

Section 2.2.1.15 specifies that limits applied on energy bids and offers and offers for operating reserve would also reflect start-up and shut-down times, minimum loading point, forbidden regions, and period of steady operation.

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Appendix 7.5 – The Market Clearing and Pricing Process

2.2 Inputs

The required inputs to the *dispatch* scheduling and pricing process are:

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2.2.2.10 in respect of the *pre-dispatch schedule* only, daily *energy* limits where specified pursuant to section 3.5.7 of this Chapter;

2.2.1.10A in respect of the *real time* constrained *dispatch schedule* only, the ~~generator~~ start-up and shut-down times for each *generation facility*;

2.2.1.11 the operating characteristics of all ~~*generators*~~ *generation facilities* and *dispatchable loads* including, but not limited to ramp-rate limits and *operating reserve* response parameters and for the *real time* constrained *dispatch schedule* only, the *minimum loading point, forbidden regions* and *period of steady operation*;

2.2.1.12 the operating characteristics of the *IMO-controlled grid* including, but not limited to, the physical flow and loss characteristics and flow limits of *transmission facilities*;

2.2.1.13 the requirements for each *ten-minute operating reserve* that is synchronised to the *IMO-controlled grid*, *ten minute operating reserve* that is non-synchronised to the *IMO-controlled grid* and *thirty-minute operating reserve*, and the area requirements for *ten-minute operating reserve*;

2.2.1.14 security constraints determined by the *IMO* to be applicable;

2.2.1.14A the outage schedules for transmission facilities;

2.2.1.15 the limits to be applied, where applicable, on *energy bids*, *energy offers* and *offers* for *operating reserve*, as the case may be, to reflect:

a. *transmission loading relief constraints;*

b. *generation facility outages;* ~~*and*~~

c. *applicable* contracted *ancillary services* arranged for use outside of the market clearing mechanism*;* and for the *real time* constrained *dispatch schedule* only,

d. start-up and shut-down times*;*

e. *minimum loading point;*

f. *forbidden regions*; and

g. *period of steady operation.*

2.2.1.16 imports or exports between the *IMO-control area* and other control areas required by the *IMO* to meet its obligations under requirements established by all relevant standards authorities and which are outside the normal market *bids* and *offers* including but not limited to inadvertent *intertie* flows and shared activation reserve. These shall be represented as an increase or decrease in *non-dispatchable load*.

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PART 1 – MARKET RULE INFORMATION

Identification No.:	MR-00246-R01			
Subject:	Market Evolution Program			
Title:	Multi-Interval Optimization – Changes to Dispatch Algorithm			
Nature of Proposal:	X Alteration	☐ Deletion	☐ Addition	
Chapter:	7.0	Appendix:	7.5	
Sections:	2.3			
Sub-sections proposed for amending:	2.3.3 (new)			

PART 2 – PROPOSAL HISTORY – PLEASE REFER TO MR-00246-R00

Version	Reason for Issuing	Version Date
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Approved Amendment Effective Date:		

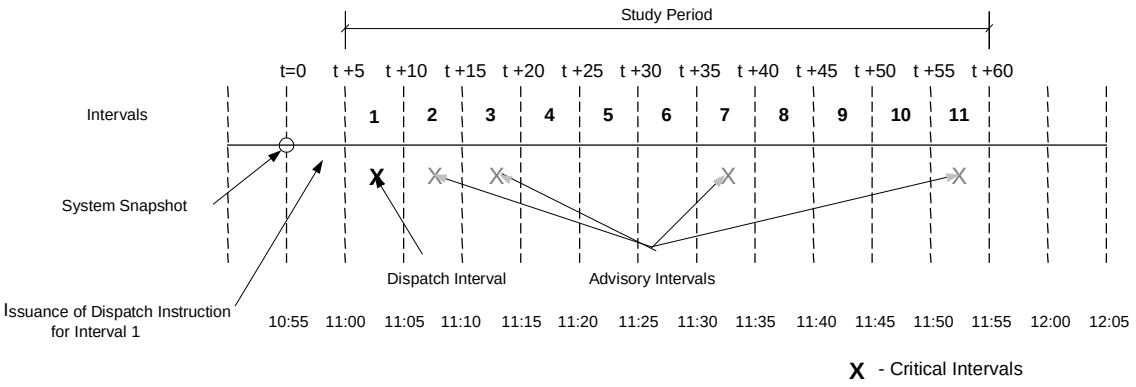
PART 3 – EXPLANATION FOR PROPOSED AMENDMENT

Provide a brief description of the following:

- The reason for the proposed amendment and the impact on the *IMO-administered markets* if the amendment is not made
- Alternative solutions considered
- The proposed amendment, how the amendment addresses the above reason and impact of the proposed amendment on the *IMO-administered markets*.

MR-00246-R01 proposes to amend section 2.3 of Appendix 7.5 by inserting a new sub-section 2.3.3. Section 2.3 deals with the Optimisation Objective. The proposed new section would specify that MIO would only be used in the real time constrained schedule and describes the objective function for the real time constrained dispatch schedule which would use the weighted sum of the economic gain from trade among market participants for the dispatch interval and the advisory intervals within the study period.

A visual representation of study period, critical intervals, and advisory intervals is provided below:



For further information please refer to MR-00246-R00. In addition, for further information on MIO inter-temporal linkages please refer to MR-00246-R02.

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2.3 Optimisation Objective

2.3.1 The *dispatch* scheduling and pricing process shall be a mathematical optimisation algorithm that will determine optimal schedules for each time period referred to in section 2.1.1, given the *bids* and *offers* submitted and applicable constraints on the

use of the *IMO-controlled grid*. Marginal cost-based prices shall also be produced and, for such purpose, *offer* prices shall be assumed to represent the actual costs of suppliers and *bid* prices shall be assumed to represent the actual benefits of consumption by *dispatchable load facilities*.

2.3.2 The *dispatch* scheduling and pricing process shall have as its mathematical objective function maximizing the economic gain from trade among *market participants* as described in sections 4.3.2 and 4.3.3 of Chapter 7.

2.3.3 In respect of the *real time* constrained *dispatch* schedule only, the *dispatch* scheduling and optimization process shall have as its objective function maximizing the weighted sum of the economic gain from trade among *market participants*, as described in section 4.3.2 and 4.3.3 of Chapter 7, for the *dispatch interval* and for advisory intervals within the study period. Critical intervals are those selected from the study period to be used as input to the objective function. The first critical interval is always the *dispatch interval*. The remaining critical intervals are advisory intervals.

PART 5 – IMO BOARD COMMENTS

Market Rule Amendment Proposal

PART 1 – MARKET RULE INFORMATION

Identification No.:	MR-00246-R02			
Subject:	Market Evolution Program			
Title:	Multi-Interval Optimization – Changes to Dispatch Algorithm			
Nature of Proposal:	X Alteration	☐ Deletion	☐ Addition	
Chapter:	7.0	Appendix:	7.5	
Sections:	2.11			
Sub-sections proposed for amending:	2.11.1, 2.11.3 (new), 2.11.4 (new), & 2.11.5 (new)			

PART 2 – PROPOSAL HISTORY – PLEASE REFER TO MR-00246-R00

Version	Reason for Issuing	Version Date
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Approved Amendment Effective Date:		

PART 3 – EXPLANATION FOR PROPOSED AMENDMENT

Provide a brief description of the following:

- The reason for the proposed amendment and the impact on the *IMO-administered markets* if the amendment is not made
- Alternative solutions considered
- The proposed amendment, how the amendment addresses the above reason and impact of the proposed amendment on the *IMO-administered markets*.

MR-00246-R02 proposes to amend section 2.11 of Appendix 7.5 because, for the real-time constrained dispatch schedule only, MIO will introduce additional inter-temporal linkages. It is proposed to amend section 2.11.1 to identify that the MIO function only applies to the real-time constrained dispatch schedule and that the inter-temporal linkages for all other schedules remain unchanged.

It is also proposed to insert three new sub-sections 2.11.3, 2.11.4, and 2.11.5 into section 2.11. Sub-section 2.11.3 describes the optimization technique at a high level and specifies that the IMO has the authority to modify the length of the study period or the number of critical intervals selected in the event that there is an significant improvement or degradation in performance of computer systems or the accuracy of the predicted demand values. Sub-section 2.11.4 specifies the IMO may switch to a single interval optimization in the event of a malfunction of the multi-interval optimization. Sub-section 2.11.5 describes the inter-temporal linkages in the real-time constrained dispatch schedule which would use a two step optimization process over multiple intervals, as opposed to the current single step optimization over a single interval as performed in the real-time unconstrained schedule to establish market prices.

For further information please refer to MR-00246-R00.

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2.11 Inter-temporal Linkages

2.11.1 Except for the *real-time* constrained *dispatch schedule*, ~~T~~the *dispatch* scheduling and pricing process shall solve one *dispatch* period at a time, but shall respect the ramp rate limits applicable to *generation facilities* and *dispatchable load facilities* between *dispatch* periods.

2.11.2 In respect of a *real-time market* scheduling process, the *operating reserve* ramp rates submitted by *market participants* may be increased to levels determined by the *IMO*.

2.11.3 The *real-time* constrained *dispatch schedule* utilizes a two step optimization technique to maximize the weighted sum of the economic gain from trade among *market participants* for a number of critical intervals over a forward looking study period. For each *real time* constrained *dispatch schedule* critical intervals are selected by the *IMO* from the study period based on defined selection criteria. The first critical interval is always the *dispatch interval*, and the remaining critical intervals are advisory intervals. Both the length of the study period and the number of advisory intervals are configurable and may be changed by the *IMO* in the event of significant improvement or degradation of either computer software and hardware performance, the accuracy of the predicted *demand* values or malfunction of the algorithm. Changing the number of critical intervals will affect the number of intervals provided to *market participants* on the *dispatch* advisory reports. The number of critical intervals and the length of the study period will be documented in the applicable *market manuals*.

2.11.4 The *IMO* may switch to a single interval optimization in the event of a malfunction of the multi-interval optimization algorithm.

2.11.5 In respect of the *real-time* constrained *dispatch schedule* only, the *dispatch* scheduling and optimization process shall consist of two steps. The first step considers all of the selected critical intervals together to provide an optimal solution. This uses linearized resource characteristics. The second step solves a set of single interval *dispatch* problems to respect the non-linearities that reflect physical characteristics of resources in accordance with section 6.5.

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Market Rule Amendment Proposal

PART 1 – MARKET RULE INFORMATION

Identification No.:	MR-00246-R03			
Subject:	Market Evolution Program			
Title:	Multi-Interval Optimization – Changes to Dispatch Algorithm			
Nature of Proposal:	X Alteration	☐ Deletion	☐ Addition	
Chapter:	7.0	Appendix:	7.5	
Sections:	4.2			
Sub-sections proposed for amending:	4.2.1			

PART 2 – PROPOSAL HISTORY – PLEASE REFER TO MR-00246-R00

Version	Reason for Issuing	Version Date
Approved Amendment Publication Date:		
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PART 3 – EXPLANATION FOR PROPOSED AMENDMENT

Provide a brief description of the following:

- The reason for the proposed amendment and the impact on the *IMO-administered markets* if the amendment is not made
- Alternative solutions considered
- The proposed amendment, how the amendment addresses the above reason and impact of the proposed amendment on the *IMO-administered markets*.

MR-00246-R03 proposes to amend section 4.2.1 of Section 4 of Appendix 7.5 by specifying that unless otherwise specifically stated the formulation, used in Appendix 7.5, or elsewhere, shall refer only to a single dispatch period or interval.

For further information please refer to MR-00246-R00.

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4. Glossary of Sets, Indices, Variables, and Parameters

4.2 Time

4.2.1 Except where explicitly stated otherwise in Appendix 7.5 or elsewhere, t~~T~~he formulation presented in this Appendix represents a single *dispatch period*~~, except for section 6.5 and 5.0~~.

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Market Rule Amendment Proposal

PART 1 – MARKET RULE INFORMATION

Identification No.:	MR-00246-R04			
Subject:	Market Evolution Program			
Title:	Multi-Interval Optimization – Changes to Dispatch Algorithm			
Nature of Proposal:	X Alteration	☐ Deletion	☐ Addition	
Chapter:	7.0	Appendix:	7.5	
Sections:	4.10			
Sub-sections proposed for amending:	4.10.1, 4.10.1A & 4.10.1B (new) 4.10.2, 4.10.3, 4.10.5 (new)			

PART 2 – PROPOSAL HISTORY – PLEASE REFER TO MR-00246-R00

Version	Reason for Issuing	Version Date
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PART 3 – EXPLANATION FOR PROPOSED AMENDMENT

Provide a brief description of the following:

- The reason for the proposed amendment and the impact on the IMO-administered markets if the amendment is not made
- Alternative solutions considered
- The proposed amendment, how the amendment addresses the above reason and impact of the proposed amendment on the IMO-administered markets.

MR-00264-R04 proposes to amend section 4.10 of Appendix 7.5 to specify the process of factoring in the unit ramp limits in each of the two optimization steps of the real-time constrained dispatch schedule. Pre-processing is the calculation done to establish initial conditions such as operating limits prior to running the linear program. A number of variables relating to the maximum of, and utilization from, each generation and dispatchable load ramping block are defined for use in the DSO algorithm and Generation g start. In sub-section 4.10.3, with respect to $\text{Generation}_{g}^{Start}$, as part of MIO it is necessary to migrate the current single interval Operating Reserve (OR) constraints into the multi-interval and single interval steps of the MIO real-time constrained sequence. $\text{Generation}_{g}^{Start}$ start is the MW energy level associated with the energy offer at the start of a dispatch period.

In addition to these MIO related rule amendments it is also proposed to revise section 4.10.2 by replacing the term “generator” to be consistent with the defined term of “generation facility”.

For further information please refer to MR-00246-R00.

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4.10 Ramping

4.10.1 *Dispatchable load facilities* and *dispatchable generation facilities* have limits on their ability to move from one level of consumption or production to another. Ramping constraints are enforced by constraining the level of consumption or production to be between an upper and a lower limit. These limits are pre-determined ~~by pre-processing~~, based on starting load and generation levels and ~~maximum~~ *bid* and *offer* ramp rates. These limits are applicable to all *pre-dispatch schedules*, *market schedule* intervals, and to the first *dispatch* interval of each *real-time* constrained *dispatch*.

4.10.1A In the first step, of *the real time* constrained *dispatch schedule*, as described in section 2.11.5, the ramp limits are linearized and respected in the optimization.

4.10.1B In the second step, the ramp limits are determined by pre-processing based on *dispatch* load and generation in the critical intervals that precede and follow the interval under consideration. The solution is bounded by:

a) the prior critical interval solution as calculated by the second step and applicable non-linearized ramp rates; and

b) back calculating from the following critical interval solution as calculated from the first step using the applicable non-linearized ramp rates.

In the event that these two sets of bounds do not intersect then a) governs.

4.10.2 Parameters for the optimisation determined by pre-processing

$GenerationEndMax_g$	The maximum ~~generator~~ *generation facility* output level associated with *energy offer* g∈ **OFFERS**, given the corresponding starting ~~generator~~ *generation facility* output level.
$GenerationEndMin_g$	The minimum ~~generator~~ *generation facility* output level associated with *energy offer* g∈ **OFFERS**, given the corresponding starting ~~generator~~ *generation facility* output level.
$PurchaseEndMax_p$	The maximum load level associated with *energy bid* p∈ **BIDS**, given the corresponding starting load level.
$PurchaseEndMin_p$	The minimum load level associated with *energy bid* p∈ **BIDS**, given the corresponding starting load level.

4.10.3 Parameters for Pre-processing

$RampRate_{g,j}^{Up}$	The *energy* ramping up rate in MW per minute associated with the j^{th} block of $GENERATIONRAMPUPBLOCK_g$ for g∈ **OFFERS.**
$RampRate_{g,j}^{Down}$	The *energy* ramping down rate in MW per minute associated with the j^{th} block of $GENERATIONRAMPDOWNBLOCK_g$ for g∈ **OFFERS**.
$Generation_g^{Start}$	The MW *energy* level associated with the *energy offer* at the start of a *dispatch period*. This will be the corresponding $Generation_g$ variable from the previous *dispatch period*

	for the *market schedule* and the constrained *pre-dispatch schedule*, but will be based on operational *metering data* and/or the schedule from the previous *dispatch period* for the *real-time schedule*. If the schedule from the previous *dispatch period* is not available (non-critical intervals in *the real time* constrained *dispatch* schedule) it will be produced by interpolating the *dispatches* from the critical intervals before and after it.
$OperatingReserveRampRate_g$	The single *operating reserve* ramp rate in MW per minute associated with g∈ **OFFERS**.
$RampRate_{p,j}^{Up}$	The *energy* ramping up rate in MW per minute associated with the j^{th} block of $PURCHASERAMPUPBLOCK_p$ p∈ **BIDS**
$RampRate_{p,j}^{Down}$	The *energy* ramping down rate in MW per minute associated with the j^{th} block of $PURCHASERAMPDOWNBLOCK_p$ for p∈ **BIDS**
$Purchase_p^{Start}$	The MW *energy* level associated with the *energy bid* at the start of a *dispatch period*. This will be the corresponding $Purchase_p$ variable from the previous *dispatch period* for the *market schedule* and the constrained *pre-dispatch schedule*, but will be based on operational *metering data* and/or the schedule from the previous *dispatch period* for the *real-time schedule.*
$OperatingReserveRampRate_p$	The single *operating reserve* ramp rate in MW per minute associated with p∈ **BIDS**.
$GenerationRampBlockMax_{g,j}$	The MW component of the jth block of the generator ramp up/down block minus the MW component of the (j-1)th block of the generator ramp up/down block
$PurchaseRampBlockMax_{p,j}$	The MW component of the jth block of the dispatchable load ramp up/down block minus the MW component of the (j-1)th block of the dispatchable load ramp up/down block

4.10.4 Variables Used in Pre-processing

$TimeTrajStart_g^{Up}$	The time, on the ramp up trajectory for the *energy offer*, associated with the $Generation_g$ variable from the previous *dispatch period.*
$RampTraj_g^{Up}$	The ramp up trajectory for the *energy offer*

$TimeTrajStart_g^{Down}$	The time, on the ramp down trajectory for the *energy offer*, associated with the $Generation_g$ variable from the previous *dispatch period.*
$RampTraj_g^{Down}$	The ramp down trajectory for the *energy offer*
$TimeTrajStart_p^{Up}$	The time, on the ramp up trajectory for the *energy bid*, associated with the $Purchase_p$ variable from the previous *dispatch period.*
$RampTraj_p^{Up}$	The ramp up trajectory for the *energy bid*
$TimeTrajStart_p^{Down}$	The time, on the ramp down trajectory for the *energy bid*, associated with the $Purchase_p$ variable from the previous *dispatch period.*
$RampTraj_p^{Down}$	The ramp down trajectory for the *energy bid*

4.10.5 Parameters Determined by Pre-processing and Multi-Interval Optimization

$GenerationRampBlock_{g,j}$	The MW *dispatched* from the jth block of the *generation facility* ramp up/down block
$PurchaseRampBlock_{p,j}$	The MW *dispatched* from the jth block of the *dispatchable load* ramp up/down block

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Market Rule Amendment Proposal

PART 1 – MARKET RULE INFORMATION

Identification No.:	MR-00246-R05			
Subject:	Market Evolution Program			
Title:	Multi-Interval Optimization – Changes to Dispatch Algorithm			
Nature of Proposal:	X Alteration	☐ Deletion	☐ Addition	
Chapter:	7.0	Appendix:	7.5	
Sections:	5.1.1			
Sub-sections proposed for amending:	5.1.1.1			

PART 2 – PROPOSAL HISTORY – PLEASE REFER TO MR-00246-R00

Version	Reason for Issuing	Version Date
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PART 3 – EXPLANATION FOR PROPOSED AMENDMENT

Provide a brief description of the following:

- The reason for the proposed amendment and the impact on the IMO-administered markets if the amendment is not made
- Alternative solutions considered
- The proposed amendment, how the amendment addresses the above reason and impact of the proposed amendment on the IMO-administered markets.

Section 5 of Appendix 7.5 describes the mathematical formulation of the objective function of the dispatch algorithm including the violation variables associated with the various constraints. The objective of the dispatch algorithm is to maximize the economic gain from trade in the unconstrained and constrained sequences.

MR-00246-R05 proposes to amend sub-section 5.1.1 of Appendix 7.5 to specify that, for the real-time constrained dispatch schedule only, the multi interval (first step) optimization will maximize the weighted sum of net benefits from each of the selected critical intervals in the study period. The assignment of weights to the 'critical' intervals is required to account for the relative accuracy of inputs, such as predicted demand, for those intervals further out in the study period. This weighting is only applicable to the real-time constrained dispatch schedule as this is the only schedule which utilizes the MIO functionality and needs to analyse the net benefit for more than one interval at a time.

For further information please refer to MR-00246-R00.

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5. Objective Function

5.1.1 As well as the market terms that are used in the objective function, violation variables associated with the various constraints also appear in the objective function.

5.1.1.1 The NetBenefit is maximised, where:

$$NetBenefit = \sum_{\{j,p \mid j \in \text{PURCHASEBIDBLOCKS}_p, \text{where } p \in \text{BIDS}\}} \text{PurchaseBidPrice}_{p,j} \times PurPF_p \times PurchaseBlock_{p,j}$$
$$- \sum_{\{j,g \mid j \in \text{GENERATIONOFFERBLOCKS}_g, \text{where } g \in \text{OFFERS}\}} \text{GenerationOfferPrice}_{g,j} \times \text{GenPF}_g \times GenerationBlock_{g,j}$$
$$- \sum_{\{j,r,c \mid j \in \text{RESERVEOFFERBLOCKS}_{r,c}, \text{where } r \in \text{RESERVEOFFERS and } c \in \text{RESERVECLASSES}\}} \text{ReserveOfferPrice}_{r,c,j} \times ReserveBlock_{r,c,j}$$
$$- ViolationVariables - TieBreaking$$

In respect of the *real time* constrained *dispatch schedule* only, the first step of the optimization process will maximize the weighted sum of the net benefits

from trades in the ***dispatch interval*** and the advisory intervals. The *IMO* will set the weights for the intervals in the ***real time*** constrained ***dispatch*** study period to account for reduced accuracy of inputs for future intervals. The *IMO* shall establish the process by which weights assigned to non-critical intervals are allocated to the critical intervals.

$$NetBenefit = \sum_{\{c \in allcritical\,\text{int}\,ervals\}} W_c \left[\begin{array}{l} \sum_{\{j,p \mid j \in \text{PURCHASEBIDBLOCKS}_p, \text{where } p \in \text{BIDS}\}} \text{PurchaseBidPrice}_{p,j} \times PurPF_p \times PurchaseBlock_{p,j} \\ - \sum_{\{j,g \mid j \in \text{GENERATION OFFERBLOCKS}_g, \text{where } g \in \text{OFFERS}\}} \text{GenerationOfferPrice}_{g,j} \times \text{GenPF}_g \times GenerationBlock_{g,j} \\ - \sum_{\{j,r,c \mid j \in \text{RESERVEOFFERBLOCKS}_{r,c}, \text{where } r \in \text{RESERVEOFFERS and } c \in \text{RESERVECLASSES}\}} \text{ReserveOfferPrice}_{r,c,j} \times ReserveBlock_{r,c,j} \\ - ViolationVariables - TieBreaking \end{array} \right]$$

Where W_c is the weight assigned to the critical interval c.

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Market Rule Amendment Proposal

PART 1 – MARKET RULE INFORMATION

Identification No.:	MR-00246-R06			
Subject:	Market Evolution Program			
Title:	Multi-Interval Optimization – Changes to Dispatch Algorithm			
Nature of Proposal:	X Alteration	☐ Deletion	☐ Addition	
Chapter:	7.0	Appendix:	7.5	
Sections:	6.5			
Sub-sections proposed for amending:	6.5.2, 6.5.4 (new)			

PART 2 – PROPOSAL HISTORY – PLEASE REFER TO MR-00246-R00

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PART 3 – EXPLANATION FOR PROPOSED AMENDMENT

Provide a brief description of the following:

- The reason for the proposed amendment and the impact on the IMO-administered markets if the amendment is not made
- Alternative solutions considered
- The proposed amendment, how the amendment addresses the above reason and impact of the proposed amendment on the IMO-administered markets.

MR-00246-R06 proposes to amend section 6.5 of Appendix 7.5 by specifying how the variables defined in section 4.10 are used to explicitly enforce the linearized ramp limits in the first step of the multi-interval dispatch problem.

The generator/dispatchable load (purchase) dispatch is the sum of the dispatch (utilization) from each ramping Block. The assumption is made that the unit/purchase will ramp in each of the ramp blocks, using the block ramp rate, for a fraction of the interval time. These fractions must be non-negative and their sum should not exceed the interval time.

For further information please refer to MR-00246-R00.

PART 4 – PROPOSED AMENDMENT

6.5 Ramping

6.5.1 Any change in the output of a *generation facility* or the consumption by a *dispatchable load facility* is subject to up and down ramp rate limits. These constrain the schedule for these *facilities* at the end of the *dispatch period* to be within a band which is set by pre-processing based on knowledge of the schedule at the start of the *dispatch period* and the ramp rates.

6.5.2 Except for the advisory intervals in the *real time* constrained *dispatch*, ~~R~~ramping constraints are expressed as:

6.5.2.1

$$Generation_g \leq \text{GenerationEndMax}_g \qquad \{g \in \textbf{OFFERS}\}$$

6.5.2.2

$$Generation_g \geq \text{GenerationEndMin}_g \qquad \{g \in \textbf{OFFERS}\}$$

6.5.2.3

$$Purchase_p \leq \text{PurchaseEndMax}_p \qquad \{p \in \textbf{BIDS}\}$$

6.5.2.4

$$Purchase_p \geq \text{PurchaseEndMin}_p \qquad \{p \in \textbf{BIDS}\}$$

6.5.3 For purposes of sections 6.5.2.1 to 6.5.2.4, $\text{GenerationEndMax}_g$, $\text{GenerationEndMin}_g$, PurchaseEndMax_p and PurchaseEndMin_p are determined by pre-processing as described in section 8.2.

6.5.4 The ramping constraints for the advisory intervals in the first step of the multi-interval optimization of the *real time* constrained *dispatch* are linearized and included in the optimization as follows:

6.5.4.1

$$Generation_g = \sum GenerationRampBlock_{g,j} \qquad \{g \in \textbf{OFFERS}\}$$

6.5.4.2

$$Purchase_p = \sum PurchaseRampBlock_{p,j} \qquad \{p \in BIDS\}$$

6.5.4.3

$$0 \leq GenerationRampBlock_{g,j} \leq GenerationRampBlockMax_{g,j} \qquad \{g \in OFFERS\}$$

6.5.4.4

$$0 \leq PurchaseRampBlock_{p,j} \leq PurchaseRampBlockMax_{p,j} \qquad \{p \in BIDS\}$$

6.5.4.5

$$-RampRate_{g,j}^{Down} \times T_{g,j} \leq GeneratorRampBlock(i+1th \text{ int } erval)$$
$$-GeneratorRampBlock_{g,j}(ith \text{ int } erval) \leq RampRate_{g,j}^{Up} \times T_{g,j}$$

Where $T_{g,j} \geq 0$ and $\sum T_{g,j} \leq$ Time Interval; and

$T_{g,j}$ is the time that the generator ramps in the $GeneratorRampBlock_{g,j}$; where Time Interval is equal to the length of the *dispatch interval*.

6.5.4.6

$$RampRate_{p,j}^{Down} \times T_{p,j} \leq PurchaseRampBlock(i+1th\,\text{int}\,erval)$$
$$- PurchaseRampBlock_{p,j}(ith\,\text{int}\,erval) \leq RampRate_{p,j}^{Up} \times T_{p,j}$$

Where $T_{p,j} \geq 0$ and $\sum T_{p,j} \leq$ Time Interval; and

$T_{p,j}$ is the time that the purchase ramps in the $PurchaseRampBlock_{p,j}$; where Time Interval is equal to the length of the *dispatch interval.*

PART 5 – IMO BOARD COMMENTS

Market Rule Amendment Proposal

PART 1 – MARKET RULE INFORMATION

Identification No.:	MR-00246-R07			
Subject:	Market Evolution Program			
Title:	Multi-Interval Optimization – Changes to Dispatch Algorithm			
Nature of Proposal:	X Alteration	☐ Deletion	☐ Addition	
Chapter:	7.0	Appendix:	7.5	
Sections:	7.6			
Sub-sections proposed for amending:	7.6.1			

PART 2 – PROPOSAL HISTORY – PLEASE REFER TO MR-00246-R00

Version	Reason for Issuing	Version Date
Approved Amendment Publication Date:		
Approved Amendment Effective Date:		

PART 3 – EXPLANATION FOR PROPOSED AMENDMENT

Provide a brief description of the following:

- The reason for the proposed amendment and the impact on the *IMO-administered markets* if the amendment is not made
- Alternative solutions considered
- The proposed amendment, how the amendment addresses the above reason and impact of the proposed amendment on the *IMO-administered markets*.

MR-00246-R07 proposes to amend the market rules in section 7.6.1 of Appendix 7.5 by specifying that the market constraints for ramping are the same for the dispatch interval in the real-time constrained sequence but not for the advisory intervals.

For further information please refer to MR-00246-R00.

PART 4 – PROPOSED AMENDMENT

7.6 Ramping

7.6.1 The market constraints for ramping are identical to the ramping *dispatch* constraints ~~for~~ ~~ramping~~ used in the *pre-dispatch* and the *dispatch interval* of the *real time* multi-interval *dispatch*, as described in section 6.5.

PART 5 – IMO BOARD COMMENTS