REQUIREMENTS

Power to Ontario On Demand.

Multi-Interval Optimization

Functional Requirements

Issue 3.0

This document defines the functional requirements for Multi-Interval Optimization.

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Document Change History

Issue	Reason for Issue	Date
1.0	Issued for Approval	November 13, 2003
2.0	Updated to include changes resulting from Testing	June 23, 2004
3.0	Change to Retention Period for Dispatch Advisories	June 1, 2005

Related Documents

Document ID	Document Title

Table of Contents

Table of Changes

Reference (Section and Paragraph)	Description of Change
Throughout	Name and logo changed to *IESO*
Section 1.1	Slight changes to Who Should Use This Document to reflect current audience and intent.
Section 2.1.1	Removal of the words “once in service” from the 3rd Bullet regarding the changing of the weighted values used in the MIO calculation
Section 7.2.4	Retention period for Dispatch Advisories reduced from 1 year to 3 months

1. Introduction

This document describes the basic functional requirements for modifications to the Real Time Constrained Dispatch Scheduling and Optimization (RTC DSO) function, to incorporate Multi-Interval Optimization. It also defines modifications to the dispatch that resolve real time dispatch issues.

1.1 Who Should Use This Document

This document was originally used by the MIO Working Group, IESO and vendor staff that may be involved in the development and implementation of Multi-Interval Optimization.

The document is intended to be used by market participants, IESO and vendor staff that may be involved in the development and implementation of potential modifications to Multi-Interval Optimization.

1.2 Scope

This document describes the basic functional requirements for modifications to the functionality of the Real Time Constrained Dispatch Scheduling Optimizer (RTC DSO). Modifications include incorporation of Multi-Interval Optimization and resolution of a number of real time dispatch issues.

1.3 Assumptions

This document describes *changes* to the Real Time Constrained (RTC) sequence. Unless otherwise noted the functionality of the RTC DSO should be maintained and the additional functionality defined should be added.

– End of Section –

2. Multi-Interval Optimization (MIO)

Operating experience with Ontario's market to date suggests that the lack of temporal optimization in the dispatch process may be the cause of difficulties in the scheduling and dispatch of energy-limited and fast-ramping resources within the hour. These difficulties have caused an increased need for the IESO to take actions to constrain on, and to constrain off facilities to maintain the reliability of the IESO-controlled grid. The lack of temporal optimization has also resulted in facility cycling which affects the reliability of generating facilities. The pursuit of Multi-Interval Optimization was initiated to address these concerns. The following objectives have been identified;

Improved Operational Reliability

The optimized solution, based on future interval requirements, efficiently solves reliability issues automatically. By recognizing ramp rate restrictions for future intervals the Dispatch Scheduling Optimizer (DSO) schedules resources in advance of actual requirements to allow ramp rate capability to be utilized to solve for reliability concerns.

Operational Stability

Reduced Unit Cycling **-** A longer optimization period creates a dispatch solution that schedules resources recognizing the requirements over future intervals. This has the effect of smoothing dispatch instructions and reducing the number of start / stop sequences that resources are exposed to. This should result in an increase in overall unit availability due to reduced stress on facilities.

Improved Compliance **-** The addition of Dispatch Advisories to market participants indicating potential future dispatch targets allows market participants to proactively position resources to manage the transition to new dispatch instructions. The overall effect is the reduction of non-compliance with dispatch instructions

Improved Price Transparency

Having the Dispatch Scheduling Optimizer (DSO) automatically solve reliability issues for future intervals reduces the requirement for manual intervention in the dispatch solution.

Improve Market Efficiencies

The optimized solution should improve market efficiencies. Reduced constraint payments caused by limited ramp capability as a result of using a 5-minute optimization period would be one area of improvement.

2.1 Description of MIO

The *MIO* enhancement will be made to the Real Time Constrained Dispatch Scheduling Optimizer (*RTC DSO)* and will have the following aspects:

2.1.1 Computational

- MIO will utilize an accepted and robust formal mathematical technique to perform a linear programming based optimization.
- The optimization objective will be to maximize the gain from trade over an optimization horizon of 1 to 5 critical intervals selected from up to 11 future intervals.
- The objective function will be configurable such that each interval's contribution to the overall optimization has a specific weight. An eleven entry table will store the weights associated with each interval and be initialized to 1.0 starting with the dispatch interval and reduce to 0.5 equally over the 11 intervals (i.e. 1.0, 0.95, 0.9,…..0.5). These values may be changed later to different values based on experience. The weights associated with the critical intervals will be equal to its weight plus half the weights of the non-critical intervals that precede and follow it. The weights of the non-critical intervals that follow the last critical interval will be assumed to be zero.
- The optimization will produce a security-constrained economic dispatch *(SCED)* of all participating resources over the optimization horizon.
- The selection of the optimized intervals will be configurable such that they may be aligned with fixed-length time points, or, they may be aligned with "critical intervals".
- The number of optimized intervals is to be configurable, up to a maximum of 11.
- The frequency of execution will be every 5 minutes.

2.1.2 Critical Intervals

Critical intervals are intervals within the optimization period that provide the most efficient optimized dispatch solution as well as provide most beneficial information to facility operators. The critical intervals are used as input to the MIO calculation, and for preparing the dispatch advisories. Where there is a trade off between both objectives the intervals providing the better optimization have been selected.

Critical intervals are selected in the following order and have been defined as:

- If the first interval is at either xx:10 of xx:15 (where xx is the interval hour), exclude the intervals starting with xx+1:00;
- The dispatch interval;
- The interval five minutes after the dispatch interval;

- If not already selected, xx:05 and or xx:55. If only two intervals have been selected so far (dispatch interval at xx:00), the interval ten minutes after the dispatch interval shall be selected (if not already selected);
- If only three intervals have been selected, including the last interval in the optimization period (dispatch interval at xx:05),), the interval ten minutes after the dispatch interval shall be selected (if not already selected);
- If only three intervals are selected (dispatch intervals at xx:00, xx:50 & xx:55), the last interval in the optimization period shall be selected;
- The final interval shall be selected to meet one of the following conditions (in order):
  1. The interval is a peak or a minimum and falls in the longest gap between selected critical intervals;
  2. The interval is the last interval in the optimization period, and more than one interval is not selected at the end; and
  3. The interval is the mid point of the longest gap between selected critical intervals. Where there are two "longest gaps", the first gap shall be selected.

Table 2-1: Identification of Critical Intervals

Case #	Snapshot	Dispatch Interval	Critical Interval			
			1	2	3	4
1	xx:50	Xx:00	xx:05	xx:10	Use Pk/Min int if between xx:15 and xx:45 OR int xx:30	xx:50
2	xx:55	Xx:05	xx:10	xx:15	Use Pk/Min int if between xx:20 and xx:50 OR int xx:35	xx:55
3	xx:00	Xx:10	xx:15	xx:20	Use Pk/Min int if between xx:25 and xx:50 OR int xx:40	xx:55
4	xx:05	xx:15	xx:20	xx:25	Use Pk/Min int if between xx:30 and xx:50 OR int xx:40	xx:55
5	xx:10	xx:20	xx:25	Use Pk/Min int if between xx:30 and xx:50 OR int xx:40	xx:55	xx:05

Case #	Snapshot	Dispatch Interval	Critical Interval			
			1	2	3	4
6	xx:15	xx:25	xx:30	Use Pk/Min int if between xx:35and xx:50 OR int xx:15	xx:55	xx:05
7	xx:20	xx:30	xx:35	xx:55	xx:05	Use Pk/Min int if between xx:40 and xx:50 OR int xx:20
8	xx:25	xx:35	xx:40	xx:55	xx:05	Use Pk/Min int if between xx:10 and xx:20 OR int xx:25
9	xx:30	xx:40	xx:45	xx:55	xx:05	Use Pk/Min int if between xx:10 and xx:25 OR int xx:30
10	xx:35	xx:45	xx:50	xx:55	xx:05	Use Pk/Min int if between xx:10 and xx:30 OR int xx:35
11	xx:40	xx:50	xx:55	xx:05	Use Pk/Min int if between xx:10 and xx:35 OR int xx:25	xx:40
12	xx:45	xx:55	xx:00	xx:05	Use Pk/Min int if between xx:10 and xx:35 OR int xx:25	xx:45

2.1.3 Output

- The results of the optimization are to be stored in appropriate databases for use by other applications and systems.
- The results for each optimization calculation should be saved and be capable of being reproduced, with re-run limitations as currently exist.
- The resource utilization schedules for the first interval are to be issued to the respective market participants in the form of dispatch instructions.

- The resource utilization schedules for the remaining critical intervals are to be communicated to the respective market participants in the form of *Dispatch Advisories (DA)* [1].

– End of Section –

[1] The method of communication for the *Dispatch Advisories is via a Dispatch Advisory Report using XML technology. Further information on Dispatch Advisories is available in Section 7.*,

3. Dispatch Issues

Market Participants have identified a number of Real Time dispatch issues that result in dispatch instructions that facilities are either unable to physically follow or may cause equipment damage. As a result, a number of modifications have been defined for the RTC DSO in an effort to more accurately reflect the physical characteristics of facilities.

3.1 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 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.

3.1.1 Proposed Implementation to Reflect Unit Ramp Capability

The unit ramp capability will factor in the most limiting of two combinations.

- The last dispatch instruction and the facility's offer ramp rate for the next interval; or
- The facility's actual output at the beginning of the current interval, and its 'effective maximum ramp rate'

Where the effective maximum ramp rate is the lesser of:

- The facility's maximum ramp rate available in the Participant Lifecycle (PLC) as provided to the IESO by the market participant during the registration process; or
- The maximum current offer ramp rate for the facility, multiplied by 1.2

The 1.2 multiplier is being used as the value for the ramp rate multiplier as the first step in a staged implementation. This value may be increased over time by the IESO, in consultation with market participants, until an optimum value is achieved. The optimum value will remove or significantly reduce the 'stutter step', while limiting the impact on other system operation considerations, such as AGC (automatic generation control). The goal is for the intended trajectory for a generator's output to be as close as possible to the output that the generator can reasonably achieve, while at the same time eliminating or reducing the 'stutter step'.

3.2 Minimum Loading Point

Many facilities have a requirement to operate at or above a "minimum" output level or loading point (As defined in the market rules). These facilities cannot operate below those levels unless they are either synchronizing or being shutdown. Units with a minimum loading point will be defined in PLC and will be provided by the market participants during the registration process.

The RTC DSO should not schedule these units below this minimum output level unless the unit is synchronizing or shutting down.

3.3 Start Up and Shut Down Requirements

When a non-quick start unit synchronizes, it must ramp up to its minimum operating point. If the unit is dispatched below its minimum operating point, it must ramp down to zero and be removed from service. After a non-quick start unit synchronizes it must be dispatched to minimum load or above. While on line the unit should never be dispatched below minimum unless predispatch indicates the unit is to be de-committed in the hour. The control room operator must manually approve the de-commitment of a unit (approve dispatching below minimum to begin the shutdown event) in the RTC DSO.

3.3.1 Proposed Implementation of Start Up and Shut Down Requirements

Units will continue to be started and de-committed by the Predispatch Constrained sequence. When predispatch has the unit starting or loaded below the minimum operating point an alarm will be received. The control room must manually approve the starting and de-committing of non-quick start units to allow the DSO to schedule the unit below minimum.

If the previous dispatch was below the minimum operating point and the unit is in service or expected to be in service, its minimum or maximum will be set. The setting of the minimum or maximum will depend on whether the unit is ramping up (going in service) or ramping down (going out of service). If it is ramping up, the unit minimum will be set to the lesser of its minimum operating point and the achievable output based on current output/last dispatch and ramp up rate. If it is ramping down, the unit maximum output will be set the higher of zero and the achievable output based on its current output/last dispatch and ramp down rate.

3.4 Dispatch Trajectory

Ensure that thermal units will not reverse direction without a minimum period (adjustable variable zero to two intervals) of steady operation. After the minimum period of steady operation, the unit is available to be normally dispatched.

3.4.1 Proposed Implementation of Dispatch Trajectory

A thermal unit will be considered in steady operation if the magnitude of the schedule change between the last two intervals is less than an adjustable variable (initialized at 0.1) times the unit offer ramp rate. If the magnitude of the schedule change is higher, the thermal unit will be considered ramping up or down. The minimum and maximum energy output of the unit will be set based on its ramp status as follows:

- If ramping up, the minimum energy output will be set equal to last dispatch. The maximum energy output will be based on its full offer ramp up capability.

- If ramping down, the maximum energy output will be set equal to last dispatch. The minimum energy output will be based on its full ramp down capability.

3.5 Forbidden Regions

Hydraulic 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 predefined forbidden regions. The forbidden region for each facility should be recorded in PLC for auditing purposes. Multiple forbidden regions for aggregated facilities should be respected, up to a maximum of 3.

3.5.1 Proposed Implementation of Forbidden Regions

A post dispatch assessment of the dispatch instruction will be performed. The hydraulic units will be moved up/down depending on where they are within the forbidden regions.

Each forbidden region is to be offered as a separate price segment. Offer validation will be implemented by comparing the price segment and PLC data to identify the forbidden region.

3.6 Operating Reserve Activation (ORA)

During operating reserve activations, “fixed” constraints are applied to facilities that have been activated. A unit “minimum” constraint should be set (instead of the “fixed”) when facilities are activated for operating reserve. This is a change from the current practice of fixing the unit at the operating reserve activation dispatch level.

3.7 Treatment of Self Scheduling Generators (SSG)

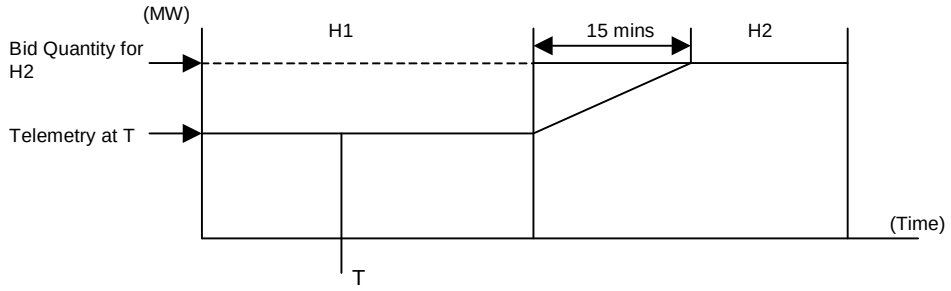
Self-Scheduled Generators (SSG) dispatch shall be set equal to the EMS snap value for current hour intervals. It shall also be set equal to second hour offer for second hour intervals. There will be a transition between the two hours.

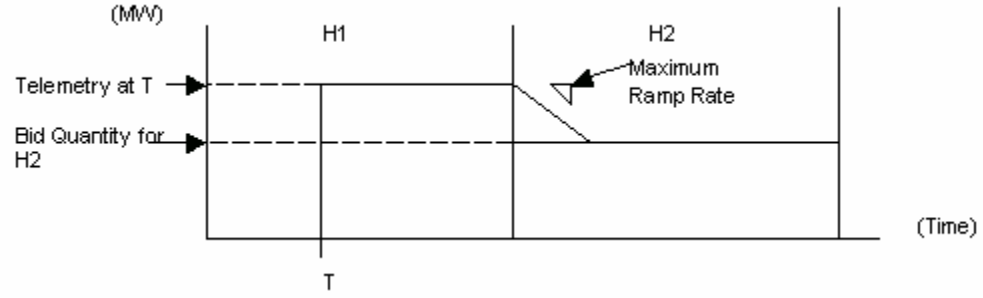
In both Real Time Constrained (RTC) and Real Time Unconstrained (RTU) sequences, all the self-scheduled generators (SSG) will be fixed to per-determined profiles. The profiling for a SSG is based on:

- Its current telemetry value passed from SCADA/EMS (the SE results); and
- Self-submitted bid quantity for the next dispatch hour
- Any outages applied to the SSG during these ramping periods

The DSO shall perform ramping to prevent a sudden jump during the hour crossing. The treatment of the cross-hour ramping will differ slightly depending on the scheduled quantity for the subsequent hour (H2) either being higher or lower than the current schedule. In addition, it also assumes that a SSG will start ramping up or down at the top of the next hour.

This is illustrated in the figures below.





In summary, this approach assumes that the following:

- That the hour-cross ramping can start as early as the EMS snap-shot time.
- For ramping up, the unit will meet its scheduled quantity after 3 intervals, starting at the beginning of the hour.
- For units ramping down, they will ramp down at the maximum ramp rate as stored in PLC.
- In the case of a SSG submitting the same bid quantity for the current hour and next hour, that the SSG schedule for the next hour remains the same as current hour (telemetry value). In other words, DSO will not perform the hour-crossing ramp for this SSG.
- The SSG units will be treated as follows at the crossing of the hour:

  Case 1: Ramp Up, i.e. H1 schedule is less than H2

  - In H1 (including snapshot at H2:00), if telemetry value is below H2 schedule then ramp up starting at H2:00 from the telemetry value to get to the H2 schedule at H2:15. If telemetry is above or equal to the H2 schedule, use the telemetry value.
  - @H2:05 if the telemetry value is below H2 schedule then use H2 schedule for all the interval in the study horizon. If telemetry is above or equal to the H2 schedule use the telemetry value.
  - @H2:10 if the telemetry value is below H2 schedule then, for all intervals in H2, use H2 schedule. If telemetry is above or equal to the H2 schedule use the telemetry value. For interval H3:05, if ramping is required between H2 and H3

and H2 schedule is used for H2 intervals, then the ramping will be done using the H2 schedule and H3 schedule. If the telemetry value is used for H2 intervals, then the ramping will be done using the telemetry value and H3 schedule.

- @H 2:15, use telemetry value for balance of the hour and ramp starting at H3:00 if there is a change between H3 and H2 schedules.

Case 2: Ramp Down, i.e. H1 schedule is greater than H2

- In H1 (including snapshot at H2:00), if telemetry value is above H2 schedule then ramp down starting at H2:00 from the telemetry value to get to the H2 schedule using Max Ramp Rate. If telemetry is below or equal to the H2 schedule use the telemetry value.
- @H2:05 if the telemetry value is above H2 schedule then use H2 schedule. If telemetry is below or equal to the H2 schedule use the telemetry value.
- @H2:10 if the telemetry value is above H2 schedule then, for all intervals in H2, use H2 schedule, If telemetry is below or equal to the H2 schedule use the telemetry value. For interval H3:05, if ramping is required between H2 and H3 and H2 schedule is used for H2 intervals, then the ramping will be done using the H2 schedule and H3 schedule. If the telemetry value is used for H2 intervals, then the ramping will be done using the telemetry value and H3 schedule.
- @H2:15, use telemetry value for balance of the hour and ramp starting at H3:00 if there is a change between H3 and H2 schedules

Case 3: H1 schedule is the same as H2

- Use the telemetry value for H1 and H2.
- @H2:10 for interval H3:05, if ramping is required between H2 and H3, the ramping will be done using the telemetry value.

Notes:

- Since MIO is trying to follow SSG's bid quantity, if a SSG submits an unrealistic profile, MIO may give unrealistic solutions. In this case, the ramp rate constraint will be relaxed to make possible for the SSG to reach its scheduled quantity for the next hour (similar to the insufficient ramp rate problem).
- The IESO has confirmed that there will not be validation rules on the MIM side to verify that the submitted SSG quantities for the adjacent operating hours can be reached within a reasonable amount of time given the PLC ramp rate; and
- During the hour crossing ramp, it is possible that a SSG is scheduled higher than its bid quantity for the current hour. The IESO has confirmed that this will not cause any problems on the other systems (such as Settlements).

3.8 Treatment of Generation Without Offers

Demand for each interval shall be modified due to no offer generators.

For In service (I/S) units without offers:

- If the unit is quick-start, its output will be set to zero;
- If the unit is non-quick start without shut down instruction (no confirmed shut down time before start of study), and above its minimum output (Pmin), its EMS output should be removed from the demand for all intervals; and
- If non-quick start as before, with output below Pmin, the unit shall be ramped up to Pmin using the maximum ramp rate and its output removed from the demand for all intervals.

For non-quick start unit with shut down instruction:

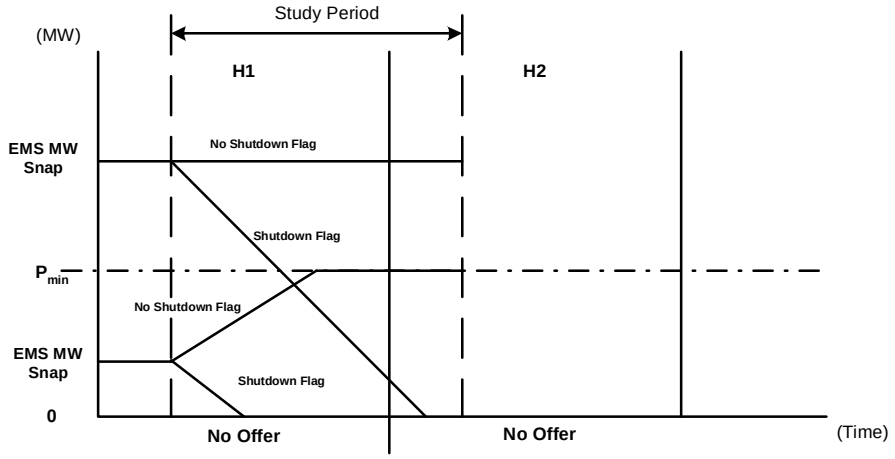
- The unit output shall be ramped down at maximum ramp rate and its output removed from the demand for all intervals.

If a non-quick start unit has start up time before the start of the study and has no offer, an alarm will be issued.

The expected output of units without offer will be subtracted from the total demand. The presence of shut down time and operation below minimum output will be factored in the calculation of expected unit output.

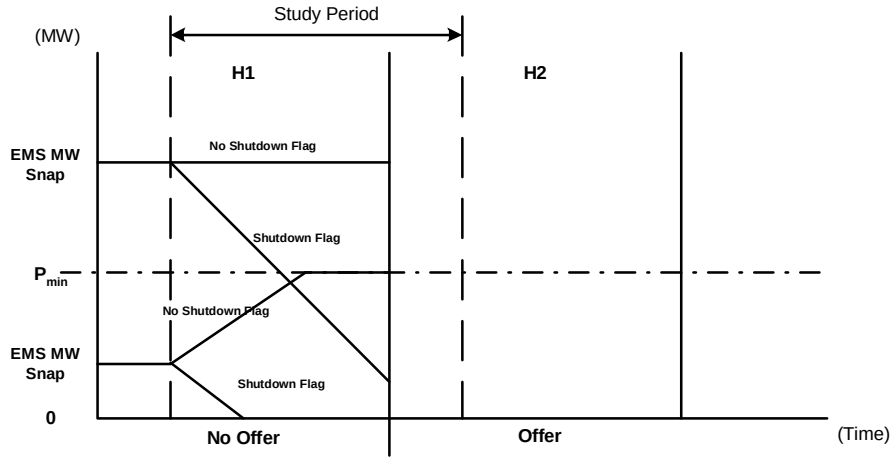
The specific treatment for the following three scenarios is shown in the figures below:

- Scenario 1 - Generator with no offer in current hour (H1) and no offer in the subsequent hour (H2)



Note: Maximum ramp rate will be used.

- Scenario 2 - Generator with no offer in the current hour (H1), but an offer in the subsequent hour (H2)



Note: Offer ramp rate from H2 will be used for H1

- Scenario 3 - Generator with an offer in the current hour (H1), but no offer in the subsequent hour (H2)
    - The unit will be dispatched normally. The high computational penalty associated with the unit output for H2 will force its output towards zero for this hour.

      Note: Dispatch Advisories would be issued for this scenario.

– End of Section –

4. Treatment of Operating Reserve (O/R)

Non quick start facilities should be included in the Operating Reserve calculation during start up and shutdown as follows:

Start Up

- The unit should not be considered for Real Time O/R until the unit reaches minimum;
- During shut down the unit should not be considered for O/R after the unit has been dispatched below minimum
- The unit should be considered available to supply O/R (10S, 10N and 30) only if the unit is at or above minimum load in the advisory time frame.

End of Section

5. Load Predictor (LP)

The LP function provides the forecast demand for each 5-minute interval in the optimization horizon. It is based on historical load pattern and the current load telemetry.

The following items are required for LP function:

- The results should be retained in the Surveillance Data Repository (SDR) for a minimum of 5 years.
- The smoothing capability of LP should be increased to the 2nd order (smoothing is presently available to the 1st order).

End of Section

6. Resource Dispatch (RD)

During operating reserve activations, “fixed” constraints are applied to facilities that have been activated. A unit “minimum” constraint should be set (instead of the “fixed”) when facilities are activated for operating reserve. This is a change from the current practice of fixing the unit at the operating reserve activation dispatch level.

End of Section

7. Dispatch Advisories

Dispatch Advisories will be issued to all dispatchable market participant facilities (equivalent to the Dispatch Instruction set). For each interval, a Dispatch Instruction will be issued plus the addition of up to 4 dispatch advisories for future intervals. There is no change in the requirement of when to issue Dispatch Instructions.

7.1 Functional Requirements

7.1.1 Participant Interface

Dispatch Advisories must be available from the participant dispatch workstation.

7.1.2 Format

Participant specific Dispatch Advisory reports should be available for all participants to view on demand from the participant's workstation. The report should contain the energy and 10S, 10N and 30 OR components of the dispatch advisory and indicate the specific intervals that each component relates to. This report will not contain the Dispatch Instruction.

7.2 Design Requirements

7.2.1 Frequency

Dispatch Advisories for all defined critical intervals will be available every interval.

7.2.2 Participant Acknowledgement

The Dispatch Advisories are for informational purposes only therefore there is no requirement for participants to acknowledge Dispatch Advisories.

7.2.3 Performance Requirements

The following performance requirements apply to the Dispatch Advisories;

- Dispatch Advisory reports defined in sect. 7.1.2 should be available to participants at the start of each dispatch interval;
- The IESO shall monitor the availability of the advisories but will not monitor participant access to the information;

- Dispatch Advisories should be available on time (i.e. at the start of each dispatch interval) 99% of the time. This equates to 87.6 hours a year of unscheduled outages; and
- The issuance of Dispatch Advisories should not have an adverse impact on the issuing of Dispatch Instructions.

7.2.4 Archiving

Dispatch Advisories should be available on line for participants to review for a period of 7 days. All Dispatch Advisories should be retained for 3 months.

7.2.5 Security

Dispatch Advisories should not be available to the general public. Simple security is adequate for this type of information.

– End of Section –

– End of Document –