Guide to Operating Reserve

Training

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Power to Ontario.
On Demand.

Guide to Operating Reserve

AN IESO TRAINING PUBLICATION

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1. Introduction

Operating reserve (OR) is stand-by power or demand reduction that we[1] can call on with short notice to deal with an unexpected mismatch between generation and load.

This guide describes:

- Why we need operating reserve,
- How the Ontario operating reserve market works
- How operating reserve is scheduled and activated
- How we use the Shared Activation of Reserve program

[1] In this document, 'we', 'us' and 'our' refer to the IESO.

2. What is Operating Reserve?

Having enough energy to meet demand is an important part of reliability. Although we always schedule sufficient generation to meet demand, unplanned events can upset the balance of supply and demand. Such contingencies include:

- A sudden, unexpected increase in demand
- A generation loss, or when several generators are unable to follow their dispatch instructions
- The loss of a transmission element, which removes generation or results in a more restrictive operating limit that makes supply unavailable

To help manage situations such as these, we ensure that we have enough stand-by resources in the form of operating reserve (OR). Operating reserve provides us with a supply 'cushion' that we can quickly call upon in the event of an unexpected energy shortfall. If a contingency occurs, operating reserve is activated, quickly re-establishing the balance between supply and demand.

Who determines reserve requirements?

The North American Electricity Reliability Corporation (NERC) and the North East Power Coordinating Council (NPCC) set reliability standards that include operating reserve requirements. These standards describe the amounts of operating reserve required, performance obligations, and the reserve sharing program available to us.

Classes of Operating Reserve

There are three classes of operating reserve, determined by the time required to bring the energy into use and the physical behaviour of the facilities that provide it:

- 10-minute synchronized (spinning)
- 10-minute non-synchronized (non-spinning)
- 30-minute

Total operating reserve is the sum of these three types of reserve.

10-minute reserve

We must have enough 10-minute reserve to cover the largest single contingency that can occur, given the current grid configuration. For example, this might be the loss of Ontario's largest single generation unit. In this case, if the largest generator on the grid is 900 megawatts (MW), we must schedule at least 900 MW of 10-minute operating reserve.

A portion of our 10-minute reserve must be 'spinning' or synchronized to the grid (referred to as 10S). The maximum amount of 10-minute reserve that must be synchronized is 100%, but we are allowed to reduce this percentage (to a minimum of 25%), based on our performance in recovering from contingencies.

We can reduce the synchronized portion of our reserve by 10% in any month that we successfully recover to our pre-contingency supply/demand balance following every reportable event (supply loss > 500 megawatts):

- Because we consistently recover to our pre-contingency supply/demand balance, we normally carry the minimum allowable synchronized reserve (25% of our 10-minute requirement).
- If we fail to successfully recover from a reportable event, our synchronized reserve requirement increases by 20% of the 10-minute reserve total (to 45%). It remains at that percentage until further recovery successes allow us to reduce it, or failures force us to increase it again. We continuously monitor this recovery performance.

The remainder of the 10-minute reserve requirement is non-synchronized (referred to as 10NS). Our non-synchronized portion is normally set at 75%.

30-minute reserve

The 30-minute reserve requirement is equal to the greater of:

- Half of the second largest single contingency, or
- The largest commissioning generating unit (this reflects the increased risk of tripping for a new generator that is still undergoing commissioning tests during initial operation).

This type of reserve does not have to be synchronized and is referred to as 30R in our reports.

3. Operating Reserve Markets

There is a market for each of the three classes of operating reserve, allowing us to efficiently purchase reserve to meet Ontario's needs. Prices and schedules are determined every five minutes, for each reserve class, in conjuction with the energy market. The dispatch algorithm simultaneously determines schedules for both energy and operating reserve through a process called 'joint optimization'. (For details on joint optimization, please see *Quick Take 20: Joint Optimization*, available on the Training web pages.)

Normally, operating reserve requirements are entirely met through the scheduling of resources based on participant offers. We can also use 'control action operating reserve', which reflects our ability to use voltage reductions or forego meeting 30-minute requirements (under specific conditions) to meet operating reserve needs. In the following sections, we consider both types of supply.

Participant-offered operating reserve

Market participants can offer operating reserve to the IESO-administered markets at the same time that they bid or offer energy. Table 1 shows the classes of reserve that each participant type may offer.

Table 1: Participant Eligibility to Offer Reserve

	Dispatchable Loads	Dispatchable Generators	Imports	Exports
10-minute synchronized	√	√	-	-
10-minute non-synchronized	√	√	√	√
30-minute	√	√	√	√

Imports and exports cannot provide synchronized reserve and may only offer on interties where there is agreement with the neighbouring jurisdiction that transactions can be used to supply reserve to Ontario. Note that participants cannot sell reserve from Ontario to another jurisdiction.

To offer operating reserve you must:

- Be able to provide the energy within the time frame specified by the class of operating reserve involved (either 10 minutes or 30 minutes)
- Be able to sustain supplying operating reserve energy for up to one hour - the neighbouring jurisdiction must allow this for import/export providers of reserve

Operating Reserve Offers

You must have a bid or offer in the energy market for an amount greater than or equal to the quantity of your operating reserve offer. Offers:

- Use a price-quantity pair format, as in the energy market, but can have up to 5 price-quantity pairs
- Have one ramp rate – note for import/exports the transaction is always ramped over 10 minutes

Operating Reserve Scheduling & Pricing

The dispatch algorithm builds an offer stack, from lowest to highest price, based on the submitted reserve offers. It can use offered reserve that is not required to satisfy one class to satisfy the requirements for a lower class. This means that if you offered only 10-minute synchronized reserve, you could be scheduled for 10-minute synchronized, 10-minute non-synchronized, 30-minute, or any combination of the three classes of operating reserve.

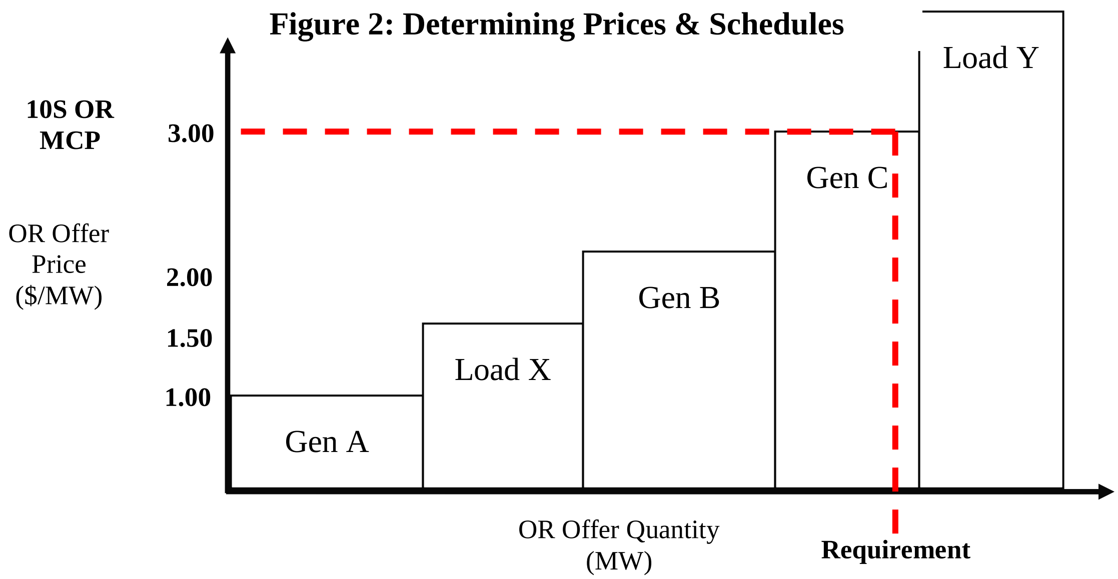
Table 2: Reserve Class Hierarchy

Reserve Class	Satisfy 10S?	Satisfy 10NS?	Satisfy 30R?
10-minute synchronized (10S)	Yes	Yes	Yes
10-minute non-synchronized (10NS)	-	Yes	Yes
30-minute synchronized (30R)	-	-	Yes

Figure 2 shows the operating reserve offers for 10-minute synchronized reserve, stacked according to price. Although only the 10S stack is shown, this calculation is performed for all the operating reserve classes and the energy market at the same time. The point where the reserve requirement meets the offer stack determines the market clearing price (MCP). In this example the MCP is $3.00/MW and Gen A, B, Load X, and part of Gen C are scheduled to provide 10-minute synchronized operating reserve.

Operating reserve prices used for settlement are limited to the range 0 – $2,000 (maximum operating reserve price). In times of a reserve shortfall, the operating reserve price is the greater of the highest priced reserve offer or the energy price for the interval.

Figure 2: Determining Prices & Schedules



Energy versus Operating Reserve

Energy Schedule + OR Schedule ≤ Generator Energy Offer

A facility’s schedule for operating reserve is based on the outcome of the joint optimization process. If a generator offers 200 MW of energy with a corresponding operating reserve offer of 200 MW, they may be scheduled entirely for energy, or operating reserve, or some combination of both, not exceeding 200 MW.

Load Energy Bid ≥ Energy Schedule ≥ OR Schedule

Similarly a load may bid for 150 MW of energy, and offer 150 MW of operating reserve. They may be scheduled for any amount up to their bid quantity and get an operating reserve schedule for any amount up to their energy schedule.

How do I know my operating reserve schedule?

Just as with dispatch instructions for the energy market, we send reserve scheduling dispatch instructions to dispatchable loads and generators at the beginning of each interval. Similar to energy dispatch instructions, new operating reserve schedules are only sent when there is a change from an earlier instruction. Schedules tell participants how much of each class of reserve they are obligated to provide (should we call for it) and are used for settlement.

Importers and exporters receive their energy and operating reserve commitments with the publishing of the hour-ahead pre-dispatch schedules.

Control Action Operating Reserve (CAOR)

When the market cannot provide enough supply to meet forecast demand and reserve requirements (a capacity shortfall), we take a number of out-of-market control actions to manage the shortfall. When the market first opened, using such out-of-market sources of reserve resulted in counter-intuitive prices. Instead of reflecting scarcity, using reserve resources that were not represented in the pricing stack resulted in lower operating reserve prices and prevented market mechanisms from trying to schedule additional supply.

Since 2003, we have used standing offers in the operating reserve offer stack to represent three of the more common control actions. These offers represent our ability to use 3% and 5% voltage reductions or forego meeting 30-minute requirements (under specific conditions) to meet operating reserve needs. They have a pre-defined price and quantity and are always available to the real-time dispatch algorithm.

Voltage Reduction

Taking credit for voltage reductions as operating reserve is a standard industry practice that has been used in Ontario and elsewhere since long before the opening of the IESO-administered markets. By instructing transmitters and distributors to reduce the voltage of distribution systems, the amount of energy being consumed in Ontario is reduced.

Typical voltage reduction is:

- A 3% voltage reduction will lead to about a 1.5% reduction in total energy consumption (for a load of 20,000 MW this represents about 300 MW)
- A 5% voltage reduction will lead to about a 2.6% reduction (for a load of 20,000 MW, this represents about 520 MW)

Considering voltage reductions in the reserve market does not make them unavailable for their other role as an emergency control action. We can use voltage reductions as outlined in the emergency control action list (Market Manual 7.4, Appendix E) to solve local reliablity problems as well as in capacity or energy emergencies.

Control Action (CAOR) OR Offers

The real-time dispatch algorithm uses a set of standing offers from a pair of dummy resources as shown in Table 3.

Table 3: Control Action Operating Reserve Offers

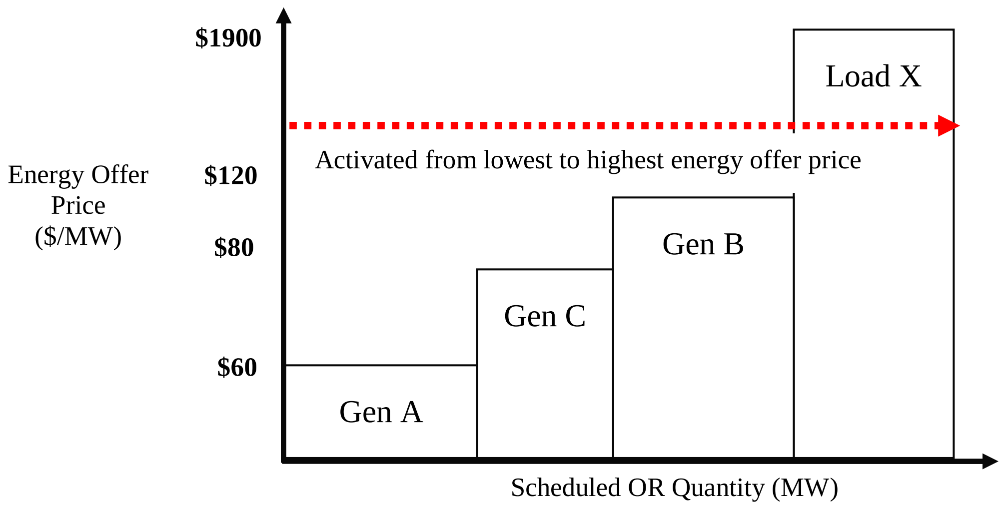
<table>
<tr><th>Resource</th><th>Quantity</th><th>30-minute Offer</th><th>10-minute NS Offer</th><th>Energy Offer</th></tr>
<tr><td>RICHVIEW-230.G_3VR</td><td>400</td><td>$30</td><td>$30.10</td><td>$2000</td></tr>
<tr><td rowspan="2">RICHVIEW-230.G_5VR</td><td>200</td><td rowspan="2"></td><td>$75</td><td>$2000</td></tr>
<tr><td>200</td><td>$100</td><td>$2000</td></tr>
</table>

CAOR has a corresponding energy offer of $2000/MWh (the maximum market clearing price). This ensures that the control action operating reserve is activated after all other scheduled reserve.

4. Activation

Unlike normal energy or scheduled reserve dispatch instructions, activation can happen at any time. We activate reserve based on the energy offer price associated with the resource, not the operating reserve offer price. Figure 3 shows the reordered resources from Figure 2, which we would activate in the order Gen A, Gen C, Gen B, Load X.

Figure 3: Order of Activation



Operating reserve schedules do not take physical limitations on the grid into consideration – i.e., they are not security-constrained. Although we would normally activate as shown in Figure 3, there may be times when we have to skip over a resource in the stack if it cannot be activated due to a transmission limitation. Also, we might not activate all the scheduled operating reserve. Even though we might have scheduled 930 MW of 10-minute reserve, we need only activate 500 MW to cope with the loss of a 500 MW generator.

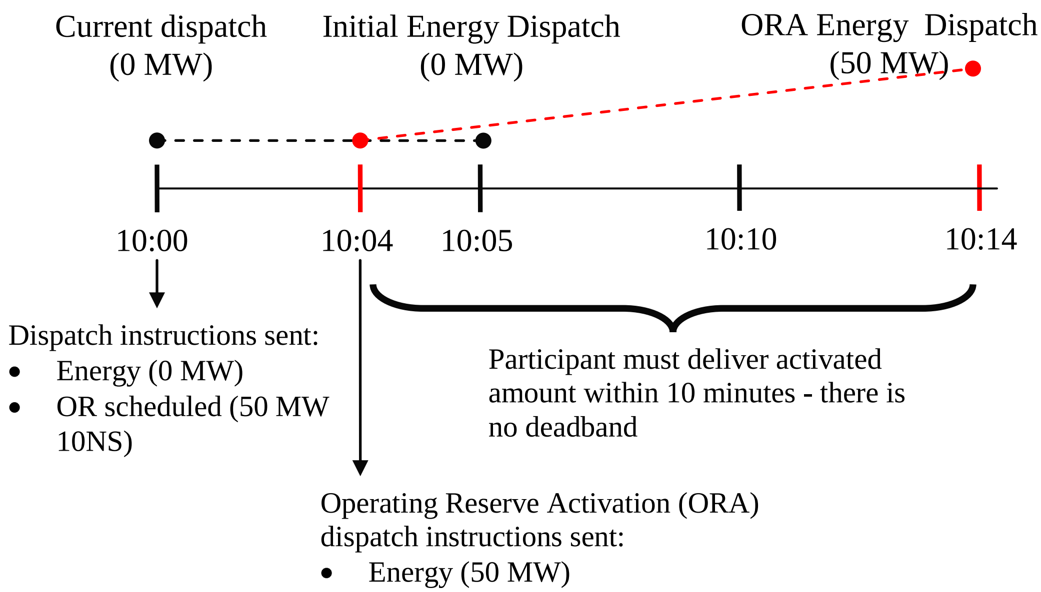
Participant Performance

When scheduled operating reserve suppliers are activated, they must provide the energy within the time period for the product activated:

- If activated for 10-minute reserve, a facility has 10 minutes to provide the energy
- If activated for 30-minute reserve, a facility has 30 minutes to provide the energy

Figure 4 shows a timeline example for a generator scheduled to supply 50 MW of 10-minute non-spinning reserve. Initially we send them a dispatch instruction (at 10:00) with their energy dispatch target of 0 MW and their 10-minute operating reserve schedule of 50 MW. At 10:04 a contingency occurs and we send an operating reserve activation dispatch instruction with their new energy target (50 MW), which they must deliver within 10 minutes.

Figure 4: Scheduling and Activation Timeline



Standards require us to recover to our pre-contingency supply/demand balance within 15 minutes of the initiating contingency. Failure to recover has real reliability implications and can result in increased synchronized reserve requirements and higher costs to the market.

It is essential that activated participants meet their operating reserve activation energy dispatch instruction. We may claw back operating reserve payments if a participant does not provide the energy when called upon. Also, non-performance can lead to a compliance investigation with the potential for sanctions and the possibility of exclusion from further participation in the operating reserve markets.

What happens to the reserve requirement?

When we activate operating reserve, we also reduce our reserve requirement by the amount activated. If we didn't reduce the requirement, the market would continue to schedule resources to satisfy our operating reserve requirements. Standards allow us time to recover our reserve (see below). We deactivate the reserve and increase our requirement back to normal once we have recovered our supply/demand balance. We deactivate and recover our reserve by increasing the operating reserve requirement back up to its normal amount – the dispatch algorithm automatically schedules the necessary amount from the available offers. Depending on the amount of the activation, we may de-activate the reserve in smaller blocks of approximately 250 MW to lessen the ramping impact on participant resources.

Time to Recover Reserve

We must recover our operating reserve within 105 minutes of the initiating event, when the cause is the loss of generation ≥ 500 MW. For all other events requiring activation, we have 90 minutes to recover our operating reserve.

Settlement

Participants with operating reserve schedules receive payment based on their schedule, for each class, and the applicable operating reserve MCP for the interval. Once activated, there are impacts to both the operating reserve and energy market settlement, including congestion management settlement credits (CMSC) payments.

Generators and imports activated to supply reserve receive:

- In the operating reserve market: a constrained-off payment
- In the energy market: the applicable MCP times the quantity produced, plus a constrained-on CMSC if the MCP is less than their energy offer

Loads and exports activated to supply reserve receive:

- In the operating reserve market: a constrained-off payment
- In the energy market: a constrained-off CMSC if their energy bid is higher than the energy MCP

What is One-Time-Dispatch (OTD)?

We use normal market dispatch and automatic generation control to manage routine supply/demand mismatches. We use operating reserve to recover from larger shortfalls. There are other circumstances where quick generation changes are required, such as in response to a security limit violation. In these cases, we use one-time-dispatch. This involves sending dispatch instructions to specific fast-ramping resources. Typically, one-time-dispatch is used when we require quick generation reductions – operating reserve is activated when we need a quick generation increase.

Every day, participants with fast-ramping generators identify which, if any, of their resources are available for one-time-dispatch.

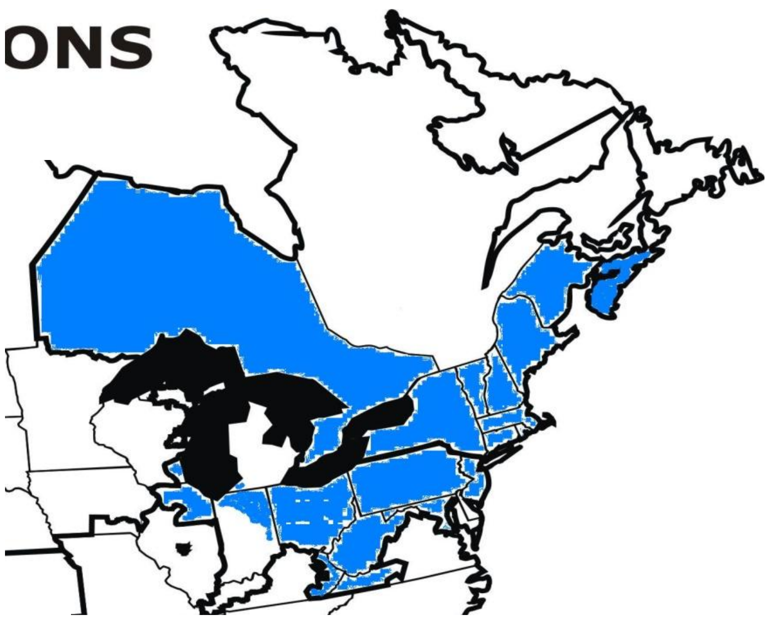
5. Shared Activation of Reserve

The IESO is a member of a group of interconnected system operators who participate in Shared Activation of Reserve (SAR). Participation in SAR is voluntary.

Shared Activation of Ten-Minute Reserve (SAR)

To assist areas in recovering from a sudden supply loss, members of the North East Power Coordinating Council (NPCC) and PJM can participate in the Shared Activation of Ten-Minute Reserve (SAR) program. This voluntary program allows the participating areas' interconnected transmission system to more quickly recover from a significant supply loss (generation or import).

Participants of SAR include: New York ISO (NYISO), ISO-New England (ISO-NE), the Maritimes, Pennsylvania-Jersey-Maryland (PJM) and ourselves. Hydro-Quebec does not participate as they are not synchronously connected to the NPCC region. A geographic representation of SAR participants is shown below.



Any participating area can use this program when they suffer a supply loss (generation or import) of 500 MW or more. The Maritimes, because their capacity is significantly smaller, have a 300 MW threshold to request SAR. Unlike operating reserve, an area cannot activate SAR to manage load/generation imbalances arising for any other reason.

Each participant must notify the SAR coordinator (NYISO) if they are unable to provide SAR energy (typically due to a transmission limitation). When an area requests SAR, NYISO assigns 50% of the loss to the area that suffered the contingency. The remaining 50% is then equally divided amongst the other available participants.

When SAR is implemented, we create an energy export transaction (import if we are receiving SAR) and activate operating reserve to provide our allotment. SAR is sustained until the requesting area no longer wants it, up to a maximum of 30 minutes.

Example:

Assume that the Maritimes can't participate in SAR due to transmission limitations. PJM suffers a 600 MW generation loss and calls NYISO to request SAR. NYISO will then assign the shares as follows:

- PJM = 300 MW (50% of the contingency)
- NYISO = 100 MW *
- ISO-NE = 100 MW *
- IESO = 100 MW *

* The remaining 50% of the contingency divided equally among the participants (300 MW/3 participants)

PJM tells NYISO when they expect to no longer need SAR, and NYISO relays this information to the other contributing areas so that the deactivation is coordinated.

The energy that is transferred during SAR activation is counted as inadvertent energy. Inadvertent energy is the difference between the actual versus scheduled energy that flows between an area and the broader interconnection. Each area maintains a record of their accumulated inadvertent energy and pays it back to the interconnection when a threshold is reached.

Control Actions and SAR

We will not use control actions, such as voltage reduction, to supply other jurisdictions unless they are in a capacity/energy emergency and have taken corresponding actions on their system.

Market Impacts of SAR

SAR has a non-intuitive price impact, as it is not captured in the offer stack used to determine price. When Ontario is receiving SAR energy, the hourly Ontario energy price (HOEP) is suppressed as zero-cost resources are being used to supply demand. There is corresponding upward pressure on the energy price when Ontario is supplying SAR to others.

6. Reports

Table 4 shows the public reports that contain information on operating reserve. Note that:

- Pre-dispatch reports show hourly data, while the real-time reports are based on 5-minute intervals
- 'Constrained' reports are created by the constrained dispatch algorithm, while 'Market' reports come from the unconstrained dispatch algorithm
- 'Operating Reserve in Market' means Control Action Operating Reserve
- The 'Real-time Operating Reserve in Market (C and U)' report is a more viewer-friendly summary of the constrained and market CAOR reports as indicated by the arrows below

Table 4: Reports

Pre-dispatch	Requirements	Scheduled	Prices
Adequacy	Total Operating Reserve	-	-
Pre-dispatch Constrained Totals	-	10S/10NS/30R	-
Pre-dispatch Market Totals	-	10S/10NS/30R	-
Pre-dispatch Market Prices	-	-	10S/10NS/30R

Real-time	Requirements	Scheduled	Prices
Real-time Constrained Operating Reserve in Market	-	Control Action OR	-
Real-time Constrained Totals	-	10S/10NS/30R	-
Real-time Market Operating Reserve in Market	-	Control Action OR	-
Real-time Market Totals	-	10S/10NS/30R	-
Real-time Operating Reserve in Market (C and U)	-	Control Action OR	-
Real-time Market Price Report	-	-	10S/10NS/30R