Stakeholder Engagement Pre-Reading

Calculation Engines – August 27, 2020

The external stakeholder engagement session on August 27, 2020 will cover the structure and functions of the calculation engines, including scheduling and pricing.

The purpose of this document is to provide stakeholders with information on the detailed design for the above topics and set expectations for the session. These materials are required reading for the session.

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1. Session Objective

The detailed design engagement meetings are to be considered technical working sessions. The sessions will focus on specific topics that external stakeholders either expressed an interest in during the high- level design phase or where the IESO has identified the need for further stakeholder input to inform the draft detailed design. Each session will concentrate on the proposed design for one specific aspect of the energy market detailed design.

The IESO is publishing materials for each engagement session no later than two weeks in advance of the session. This information is being shared in advance to provide stakeholders the opportunity to review and consider the potential impacts on their organization. The material should also help stakeholders identify who from their respective organizations may be most appropriate to attend the session and provide feedback. Stakeholders are encouraged to submit questions in advance of the sessions that will be addressed either at or before the session.

Stakeholder feedback, questions or concerns can be sent directly to engagement@ieso.ca.

These sessions will allow for interactive discussions with stakeholders regarding the reading material which will be focused on the questions identified below. They are designed to collect stakeholder feedback in-person and to facilitate a discussion with other stakeholders on that feedback. Following each engagement session, the IESO will publish a brief summary of the discussion and allow for a short window for feedback for those not able to participate.

In the pre-engagement session, the IESO will be asking the following questions:

- What questions do stakeholders have on the proposed design?
- What questions do stakeholders have on the rationale for the proposed design?
- Do stakeholders agree that the proposed design is consistent with the Market Renewal principles? If not, what changes would be required to better align with the principles?

Figure 1 - Principles of Market Renewal

PRINCIPLES				
Efficiency Lower out-of-market payments and focus on delivering efficient outcomes to reduce system costs	**Competition** Provide open, fair, non-discriminatory competitive opportunities for participants to help meet evolving system needs	**Implementability** Work together with our stakeholders to evolve the market in a feasible and practical manner	**Certainty** Establish stable, enduring market-based mechanisms that send clear, efficient price signals	**Transparency** Accurate, timely and relevant information is available and accessible to market participants to enable their effective participation in the market

2. Background

Calculation engines form the heart of electricity market scheduling processes. The IESO utilizes three engines to perform scheduling and pricing in three different timeframes: day-ahead, pre-dispatch, and real-time. Each of these engines uses inputs from market participants and the IESO in order to schedule resources and determine associated market prices. The engines must schedule resources in a manner that maximizes the gains from trade, respects resource operating restrictions and maintains the security of the IESO-controlled grid. This document will describe the function and structure of the day-ahead market, pre-dispatch, and real-time calculation engines that will determine the schedules and locational marginal prices in the renewed markets.

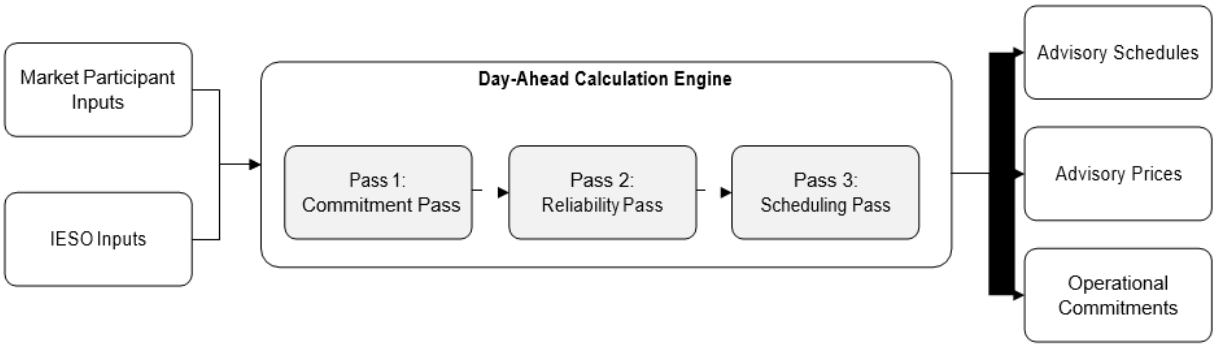
2.1. Day-Ahead Calculation Engine

The IESO's current day-ahead calculation engine (DACE) is a core component of the day-ahead commitment process (DACP). The DACP provides operational commitments and production cost guarantees for eligible non-quick start (NQS) generation units. It also provides day-ahead intertie offer guarantees to eligible imports.

As shown in Figure 2, the DACE uses inputs from market participants and the IESO to run three passes of the calculation engine. Pass 2 and Pass 3 of the DACE also use the outputs from the previous passes as inputs. Each pass has a specific purpose:

- Pass 1 – the Commitment Pass: determines the initial set of commitments for NQS generation facilities and imports required to satisfy the hourly average forecast demand for the next day.
- Pass 2 – the Reliability Pass: checks if the resources committed by Pass 1 are sufficient to satisfy the hourly peak forecast demand. The hourly peak is the highest 5-minute interval of load that the IESO is forecasting within each hour. Pass 2 commits additional resources if required.
- Pass 3 – the Scheduling Pass: uses the commitments made in Pass 1 and Pass 2 to determine the day-ahead advisory schedules of all dispatchable resources to meet the hourly average forecast demand.

Figure 2 - Current Day-Ahead Calculation Engine



The three passes of the DACE are conducted with consideration of resource and system constraints. These constraints include the recognition of each resource's capabilities as well as system constraints, which include operating reserve requirements and transmission limits needed to maintain the security of the IESO-controlled grid.

The DACE produces a set of results in the form of advisory schedules and prices, as well as operational commitments for eligible NQS generation facilities. With the exception of the production cost and intertie offer guarantees, the advisory schedules and prices produced by the DACE are informational and are not used for the settlement of the IESO-administered market.

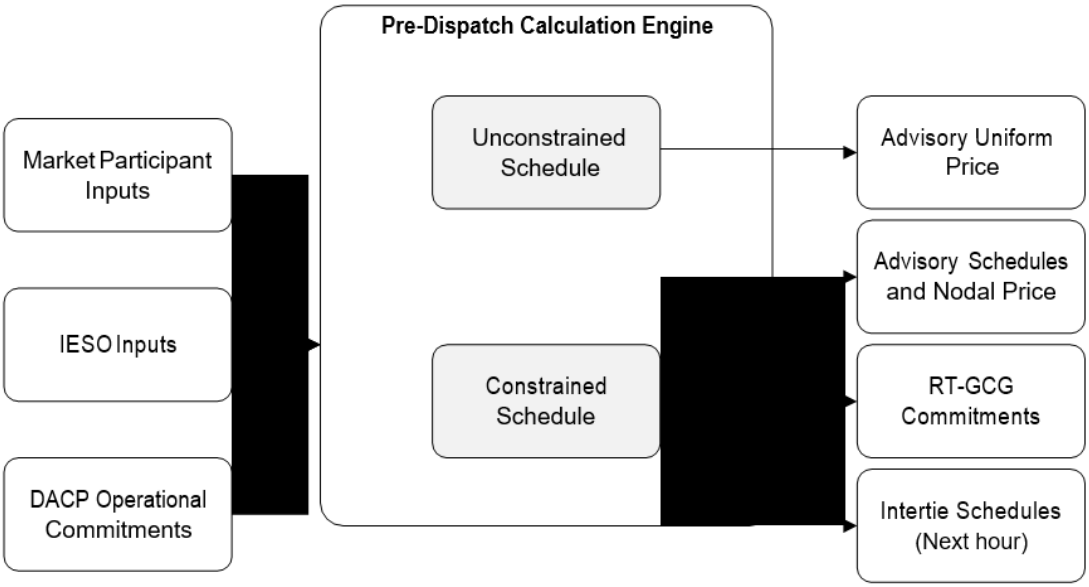
2.2. Pre-Dispatch Calculation Engine

The pre-dispatch (PD) timeframe is the period between the day-ahead timeframe and the real-time dispatch. The IESO's current PD calculation engine provides an indication of future real-time dispatch schedules and associated advisory prices.

The PD calculation engine is run hourly, producing schedules and prices for all hours to the end of the current or next day by optimizing each hour sequentially. The results to the end of the next day are provided for the hourly runs after 15:00 EST when the DACP is complete.

The PD calculation engine receives inputs from both market participants and the IESO. The evaluation is conducted with consideration of system and resource constraints.

Figure 3 - Current Pre-Dispatch Calculation Engine

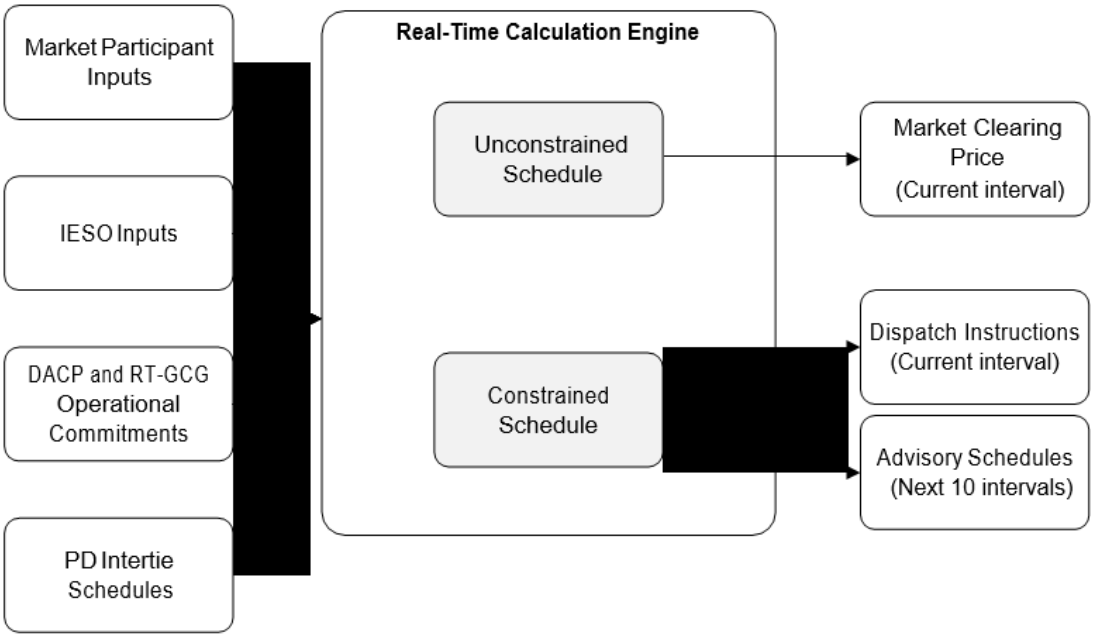


Intertie schedules determined by the final run of pre-dispatch prior to the real-time dispatch hour are used in the real-time dispatch. All internal resource schedules in pre-dispatch are advisory.

2.3. Real-Time Calculation Engine

The real-time market (RT) calculation engine is run every five minutes and utilizes inputs from market participants and the IESO. The evaluation is conducted with consideration of resource and system constraints.

Figure 4 - Current Real-Time Calculation Engine



As illustrated in Figure 4, the RT engine produces a set of results in the form of dispatch instructions for the next five-minute interval and advisory schedules for the next ten intervals for all resources. The five- minute uniform market-clearing price (MCP) is also produced to be used for settlement.

2.4. Prices in the Current IESO-Administered Markets

Currently, the unconstrained schedule of the real-time calculation engine is used to set a single, uniform price across the province every five minutes. This uniform market clearing price is then used to establish the province-wide hourly Ontario energy price for electricity. Because this price doesn't take into account actual system conditions or operational constraints, it does not reflect the real cost of generating or consuming electricity at different locations.

In order to maintain reliability, the constrained schedule, which determines the physical dispatch instructions, does consider all system and operational limitations.

This two-schedule system results in two key challenges for Ontario.

- First, when price and dispatch are not aligned, decisions that make financial sense to market participants may not be efficient or reliable for the market as a whole.
- Second, the differences between price and dispatch require a complex series of out-of-market payments – or congestion management settlement credits (CMSC) – to ensure all market participants follow dispatch instructions to maintain reliability.

The larger the divergences between those two schedules, the more out-of-market payments in the form of CMSC are required to reconcile the difference. Greater divergences also increase the probability of inefficient outcomes, such as higher costs, complex settlements and opportunities for market participants to game the system. CMSC payments are not transparent and as such are not subject to the scrutiny of transparent markets or the pressures of open competition.

3. Calculation Engines

The calculation engines in the future market will remain core components of their respective timeframes, although certain changes will be made. These changes include producing settlement-ready locational marginal prices, implementing multi-hour optimization in the pre-dispatch timeframe, and incorporating ex-ante market power mitigation in the day-ahead market and pre-dispatch calculation engines. The following sections provide further details and describe the basic structure of each engine in the new market.

3.1. Day-Ahead Market Calculation Engine

In the future energy market, the DAM calculation engine will produce the energy and operating reserve schedules and locational prices used to settle the day-ahead market. The DACP and the DACE will be retired. The future DAM calculation engine will be similar to the current DACE in overall structure.

However, there are some important differences between the two, which are described below.

The DAM calculation engine will use largely the same inputs from market participants and the IESO as the DACP, plus some additional ones. New inputs from market participants allow the DAM calculation engine to recognize additional operational characteristics of generation facilities. These inputs include:

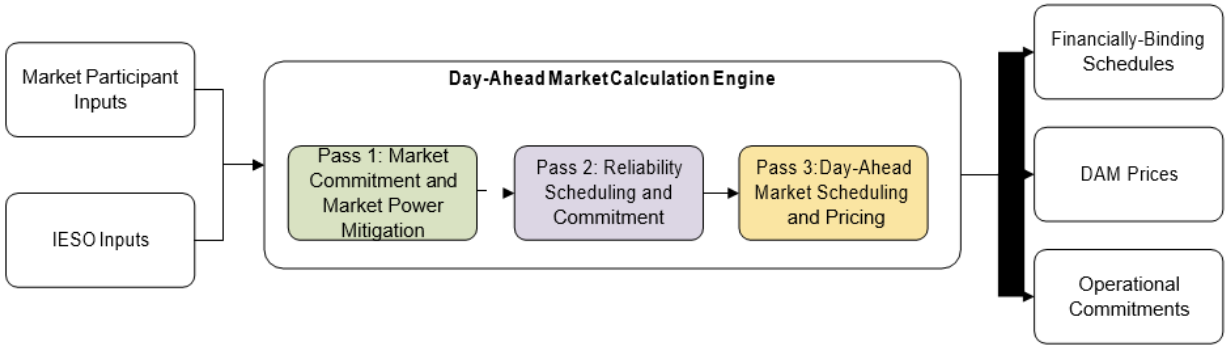
- Hydroelectric Generation Facilities – new inputs that improve the modeling of hydroelectric resource characteristics are minimum daily energy limit (Min DEL), hourly must run (HMR), minimum hourly output (MHO), maximum number of starts per day (MNSPD) and linked resource parameters;
- NQS Generation Facilities - new inputs specifying the number of hours it takes for a resource to reach minimum loading point (MLP) and the energy injected for each of these hours.

New IESO data inputs utilized by the DAM calculation engine include:

- An enhanced network model providing pricing locations for all delivery points associated with dispatchable generation facilities, dispatchable loads, non-dispatchable generation facilities, non-dispatchable loads and price responsive loads;
- New pricing locations for virtual transaction zonal trading entities;
- Ontario demand forecasts produced as the sum of four separate area demand forecasts to better reflect localized weather conditions and consumption patterns for each area.

For a detailed description of the changes to the IESO and market participant inputs, refer to the Offers, Bids and Data Inputs detailed design document.

Figure 5 - DAM Calculation Engine



Similar to the DACE, the DAM calculation engine will consist of three passes (See Figure 5) and is designed to achieve the same reliability-based scheduling outcome as the DACE. Recognizing that the DAM calculation engine is facilitating a day-ahead market, scheduling results will be financially binding for all resources and LMPs will be produced that will be used for settlement. When system constraints create the conditions for the potential exercise of market power, the first pass will also include steps that facilitate ex-ante market power mitigation.

Similar to the existing DACP, the DAM calculation engine will produce operational commitments for NQS resources. However the definition of an operational commitment in the DAM will be different than the DACP. DAM operational commitments will be for the generation unit's minimum generation block as defined by the minimum loading point and the duration of the minimum generation block run-time for that generation unit for each applicable start.

The DAM calculation engine performs three passes, as described in the subsections below.

3.1.1. Pass 1: Market Commitment and Market Power Mitigation

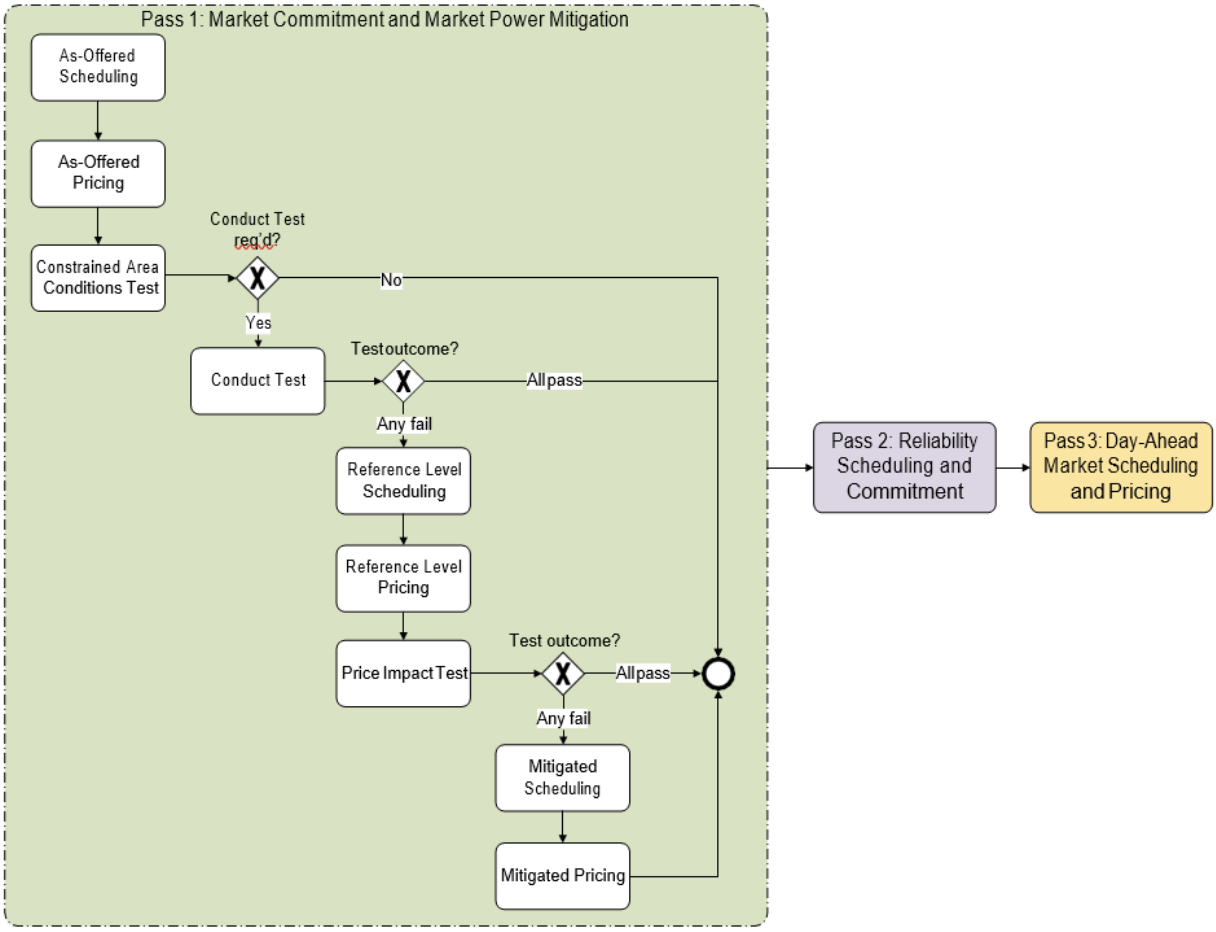
Pass 1 will use market participant and IESO inputs, as well as resource and system constraints, to determine a set of resource schedules and NQS generation unit commitments. These schedules and commitments will be calculated to meet the IESO's average hourly forecast demand and the demand from virtual bids, dispatchable loads, price responsive loads, hourly demand response resources and exports.

Pass 1 will assess whether conditions have been met related to transmission congestion that could limit competition. If such conditions exist Pass 1 will perform the tests related to the ex-ante market power mitigation process.

The schedules, commitments and prices produced by Pass 1 will be used as inputs into Pass 2.

Figure 6 depicts the steps which comprise Pass 1.

Figure 6 - Steps in Pass 1 of the Day-Ahead Market Calculation Engine



The individual steps in Pass 1 are described in further detail below:

- **As-Offered Scheduling:** Determines an initial set of schedules for all market participants as well as commitments for eligible NQS resources. It uses as-offered dispatch data from market participants, IESO data inputs and all resource and system constraints. The IESO data inputs include the constraint violation penalty curves required to meet the IESO's reliability requirements.
- **As-Offered Pricing:** Determines an initial set of prices that also account for all resource and system constraints. It uses the same as-offered dispatch data from market participants and the set of IESO inputs from As-Offered Scheduling with one exception. Instead of the constraint violation penalty curves for reliability, As-Offered Pricing uses the constraint violation penalty curves that are relevant for pricing. It applies the principle for price-setting eligibility which take into account the resource schedules and commitments determined in As-Offered Scheduling. The prices produced are not used for settlement. They may be used as inputs to the ex-ante market power mitigation conduct and price impact tests, if necessary.

- **Constrained Area Conditions Test:** The initiation of the ex-ante market power mitigation process is based on specific conditions corresponding to the constrained area to which a resource belongs. When an area is constrained from being supplied by additional resources, competition is reduced and this creates the potential for the exercise of market power. The constrained area conditions test will use the results of As-Offered Pricing to determine if the conduct test of the ex-ante market power mitigation process needs to be initiated.
- **Conduct Test (if necessary):** If conditions related to the restriction of competition are met, the conduct test will be run. This test will determine if financial dispatch data parameter values submitted by a market participant for a resource differ from its reference levels by more than the relevant conduct threshold. If one or more dispatch data parameter values for any resource fails the conduct test, then Reference Level Scheduling and Reference Level Pricing will occur to facilitate the price impact test. If no financial dispatch data parameter values fail the conduct test, then no further steps in the ex-ante market power mitigation process are necessary.
- **Reference Level Scheduling (if necessary):** Uses nearly all of the same inputs and produces the same outputs as As-Offered Scheduling. The exception is that any dispatch data parameter value that failed the conduct test will be replaced by the reference level value for that dispatch data parameter.
- **Reference Level Pricing (if necessary):** Uses nearly all of the same inputs and produces the same outputs as As-Offered Pricing. However, there are two differences. One difference is that dispatch data parameter values that failed the conduct test will be replaced by the reference level value for that dispatch data parameter. The other difference is that the commitments and resource schedules that are inputs to this step will come from Reference Level Scheduling.
- **Price Impact Test (if necessary):** Compares the prices from As-Offered Pricing to those from Reference Level Pricing. The price impact test is failed if one or more prices in As-Offered Pricing is greater than the corresponding price from Reference Level Pricing by a specified impact threshold. If the price impact test is failed, then Mitigated Scheduling and Mitigated Pricing will occur. If the price impact test does not fail, then no further steps in the market power mitigation process are necessary and the commitments and prices produced by As-Offered Scheduling and As-Offered Pricing will be used as inputs to Pass 2.
- **Mitigated Scheduling (if necessary):** Uses nearly all of the same inputs and produces the same outputs as As-Offered Scheduling. The exception is that when the price impact test failed, each dispatch data parameter value that also failed the conduct test is substituted with the applicable reference level value for that dispatch data parameter.

- **Mitigated Pricing (if necessary):** Uses nearly all of the same inputs and produces the same outputs as the As-Offered Pricing. However, there are two differences. The first difference is that if the price impact test was failed, dispatch data parameter values that also failed the conduct test will be replaced by the reference level value for that dispatch data parameter. The second difference is that the commitments and resource schedules that are inputs to this step will come from Mitigated Scheduling.

  Similar to As-Offered Pricing, the prices produced by Mitigated Pricing are not used for settlement.

Either the results produced by As-Offered Scheduling and As-Offered Pricing or the results produced by Mitigated Scheduling and Mitigated Pricing will be used as inputs to Pass 2.

- If conditions are such that the potential to exercise market power does not exist or the market power mitigation process determines that market power has not been exercised, then the results of As-Offered Scheduling and As-Offered Pricing will be used as inputs to Pass 2.
- If the market power mitigation Conduct Test and Price Impact Test fail, the commitments and prices of Mitigated Scheduling and Mitigated Pricing will be used as inputs to Pass 2.

3.1.2. Pass 2: Reliability Scheduling and Commitment

Similar to Pass 2 of the DACE, Pass 2 of the DAM calculation engine will assess if there are sufficient resources available to satisfy the hourly peak forecast demand. It does this by utilizing primarily the same set of market participant and IESO inputs used in As-Offered Scheduling, or if the price impact test fails, the reference level dispatch data used in Mitigated Scheduling. However, there are some important differences between the inputs used in Pass 1 and those used by Pass 2. These differences are necessary to make sure that the IESO will have adequate supply available to meet peak demand in each hour.

The inputs for this pass include the IESO's centralized forecasts of supply from variable generation facilities and forecasts of demand for all non-dispatchable loads. These forecasts include price- responsive loads and dispatchable loads that have no bid submitted or an entire bid submitted at the maximum market clearing price and exclude virtual bids and virtual offers. Commitments for NQS resources cannot be revoked or reduced between Pass 1 and Pass 2. Import schedules will not decrease and export schedules will not increase from those produced by Pass 1.

Pass 2 uses the inputs described above to conduct a unit commitment and economic dispatch, considering all resource and system constraints, to minimize the cost of additional commitments. To do this, Pass 2 will evaluate whether it can meet hourly peak forecast demand and operating reserve requirements using energy and operating reserve from resources that were committed or available to be scheduled in Pass 1.

If demand cannot be met with the available energy and operating reserve from the set of available resources from Pass 1, then additional NQS resources may be committed.

All NQS commitments that were input into, or created as a result of Pass 2, along with the schedules of imports and exports, will then be used as inputs into Pass 3.

3.1.3. Pass 3: Day-Ahead Market Scheduling and Pricing

Pass 3 will use the same set of market participant and IESO inputs used in Pass 1. It will also use the NQS commitment decisions determined in Pass 1 and Pass 2 to produce a set of financially binding schedules, settlement-ready LMPs and operational commitments.

Pass 3 has two steps, as described below:

- **Day-Ahead Market Scheduling:** Determines the financially binding DAM schedules for all supply and load resources. Import schedules will not decrease and export schedules will not increase from those determined in Pass 2. Day-Ahead Market Scheduling uses the same set of market participant and IESO inputs used in As-Offered Scheduling, or if the price impact test had failed, the reference level dispatch data used in Mitigated Scheduling. This includes the constraint violation penalty curves for meeting the IESO's reliability requirements.

  Day-Ahead Market Scheduling will also produce the energy scheduled for withdrawal at the delivery points for all non-dispatchable loads.

- **Day-Ahead Market Pricing:** Uses the principle for price-setting eligibility to determine a set of settlement-ready LMPs that account for all resource and system constraints. Day-Ahead Market Pricing uses the same set of market participant and IESO inputs used in As-Offered Pricing, or, if applicable the reference level dispatch data used in Mitigated Pricing. This includes using the constraint violation penalty curves that are relevant for pricing.

The resulting LMPs will be used for the settlement of energy and operating reserve markets. Consistent with the current real-time market, the DAM prices for settlement of energy and operating reserve in the future day-ahead market will be no greater than $2,000/MWh and $2,000/MW respectively.

Recognizing that at times there exists the potential for inefficiently low (i.e. much less than $0/MWh) locational prices in certain areas of the grid, the IESO has introduced a settlement floor price for energy of -$100/MWh.

The settlement floor for operating reserve will continue to be $0/MW.

Day-Ahead Market Pricing will use the settlement-ready LMPs to produce the DAM hourly zonal price for the Ontario zone that will be used for the settlement of the Allocated Quantity of Energy Withdrawn (AQEW) by non-dispatchable loads. Day-Ahead Market Pricing will also produce the zonal prices for the settlement of virtual transactions. The schedules and LMPs produced by the DAM calculation engine are utilized by the settlement process to determine settlement outcomes. For more information on how the DAM schedules and DAM LMPs pertain to settlement outcomes, refer to the Market Settlement detailed design document.

3.2. Pre-Dispatch Calculation Engine

In the future market, the current PD calculation engine will be replaced by a redesigned optimization engine that will incorporate several significant changes.

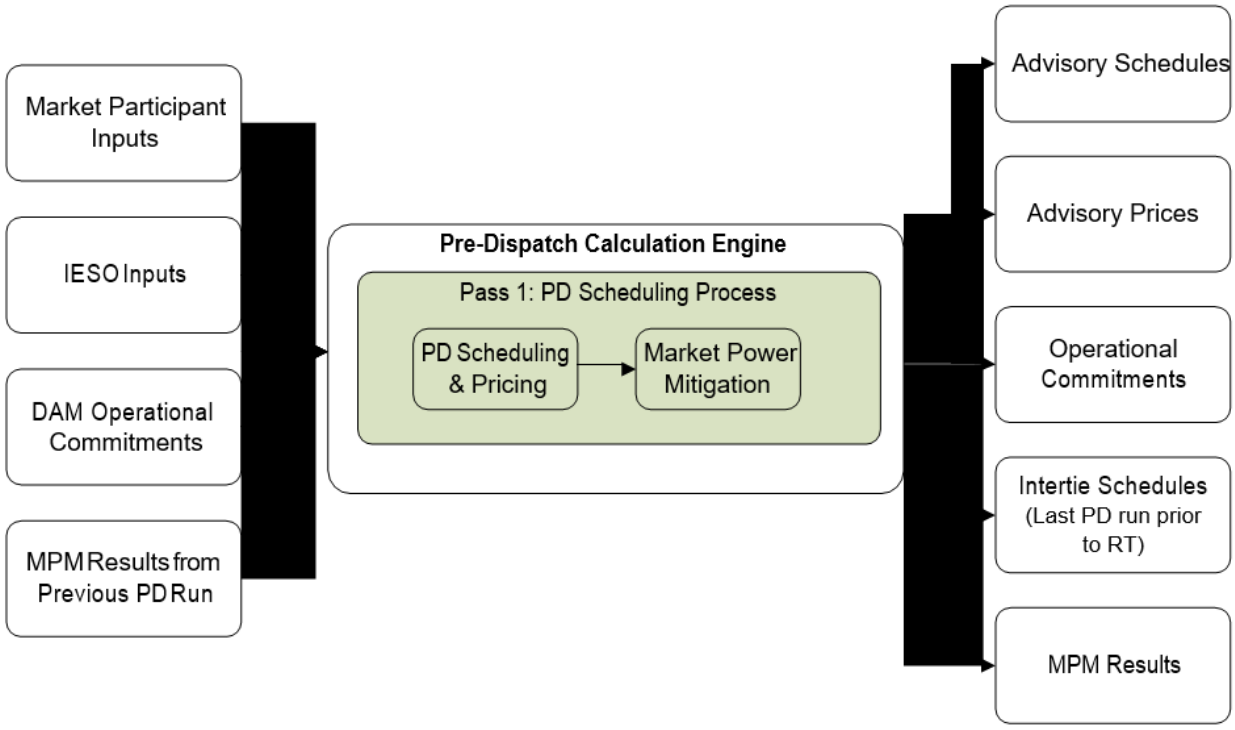
The new PD calculation engine will perform multi-hour optimization over its look-ahead period (LAP) instead of evaluating each hour independently. The LAP will include the remaining hours of the day and at 20:00 EST be expanded to include all the hours of the next day. The PD calculation engine will consider the NQS operational commitments determined by the DAM calculation engine along with revised market participant and IESO data inputs to determine pre-dispatch commitments, schedules and LMPs. These schedules and LMPs will be advisory only and will not be used for settlement.

One exception is for the scheduling of interties. The PD calculation engine will continue to set binding schedules for intertie transactions in the last PD run before a given dispatch hour (i.e. hour T+1). As today, the future PD calculation engine will use updated inputs to re-optimize schedules with each subsequent run of pre-dispatch.

Similar to the day-ahead market calculation engine, additional inputs representing commitment costs of resources will be evaluated, increasing the efficiency of the pre- dispatch schedules as compared to the current pre-dispatch scheduling process. Like the DAM, market power mitigation will also be assessed in the PD calculation engine.

As illustrated in Figure 7, the PD calculation engine consists of one functional pass.

Figure 7 - Pre-Dispatch Calculation Engine



3.2.1. Pass 1: Pre-Dispatch Scheduling Process

Pass 1 will determine NQS commitments, advisory resource schedules and advisory prices for a period of up to the end of the next day.

The first two steps of Pass 1 are described below:

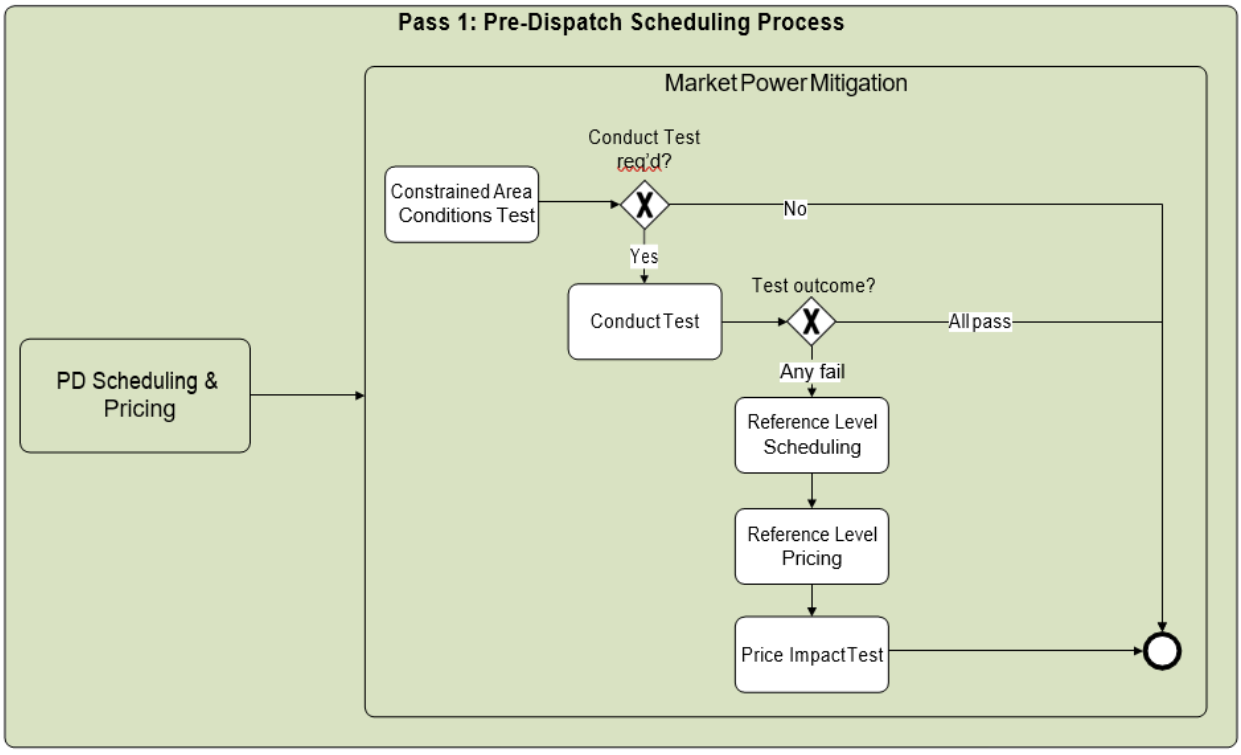
- **Pre-Dispatch Scheduling:** Determines commitments for NQS resources and advisory schedules for all resources, except for T+1 intertie schedules which will be binding. It uses as-offered dispatch data from market participants except for dispatch data that failed the market power mitigation price impact test in a previous run of pre-dispatch. If the price impact test from a previous hour failed, then the applicable reference levels will be used in the subsequent run of Pre-Dispatch Scheduling. IESO inputs, including the constraint violation penalty curves for meeting the IESO's reliability requirements are also used. Any DAM and previously-made PD NQS operational commitments will be respected, and only intertie transactions that cleared the DAM will be evaluated in LAP hours T+2 and beyond. A unit commitment and economic dispatch that maximizes the gains from trade is performed which considers resource and system constraints.

- **Pre-Dispatch Pricing:** Uses the principle for price-setting eligibility to determine LMPs that account for resource and system constraints. It uses the same dispatch data and the set of IESO inputs from the PD scheduling step with one exception. Instead of the constraint violation penalty curves for reliability, this step uses the constraint violation penalty curves that are relevant for pricing. The LMPs produced are advisory and not used for settlement.

3.2.2. Market Power Mitigation

As illustrated in Figure 8, market power mitigation in pre-dispatch consists of up to five steps. Any mitigation results that are produced will be applied in all subsequent runs of the PD calculation engine. This approach is necessary given the run-time constraints for the pre-dispatch calculation engine. PD must produce advisory schedules within 15 minutes while still assessing a full set of resource constraints. Therefore, any failure of the market power mitigation price impact test can only be applied in the subsequent hour's run of pre-dispatch scheduling and pricing.

Figure 8 - Market Power Mitigation in Pre-Dispatch



The steps for market power mitigation in pre-dispatch are consistent with the mitigation steps in Pass 1 of the day-ahead market calculation engine (described in Section 3.1.1 above). The steps include:

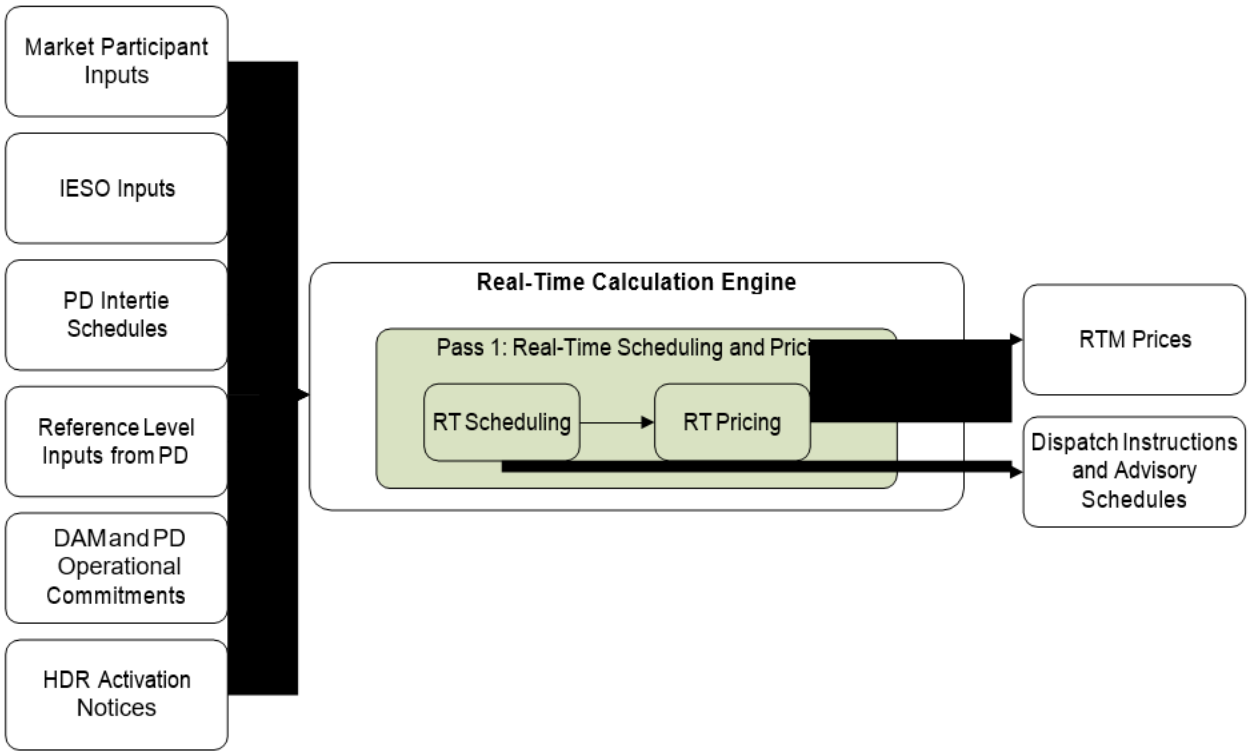
- Constrained Area Conditions Test
- Conduct Test (if necessary)
- Reference Level Scheduling (if necessary)
- Reference Level Pricing (if necessary)
- Price Impact Test (if necessary)

3.3. Real-Time Calculation Engine

Consistent with today's real-time calculation engine, the future real-time calculation engine will continue to determine five-minute dispatch instructions and advisory schedules for all resources, using similar inputs as today. There are two main differences. The first is that settlement-ready LMPs will be produced by the RT engine. The second is that market participant financial dispatch data will assessed for market power through the pre-dispatch calculation engine.

As illustrated in Figure 9, the RTM calculation engine consists of a single functional pass.

Figure 9 - Real-Time Calculation Engine



3.3.1. Pass 1: Real-Time Scheduling and Pricing

Real-time dispatch and pricing in the future real-time market will be driven by a RT calculation engine composed of a single pass, Real-Time Scheduling and Pricing, that calculates both dispatch schedules and settlement-ready LMPs for the next interval. Advisory schedules and LMPs will be produced for the subsequent 10 intervals. This pass includes the following steps:

- **Real-Time Scheduling:** Determines dispatch and advisory schedules for all resources. This is done by performing an economic dispatch that considers resource and system constraints to maximize the gains from trade. It uses the dispatch data set from the previous hour's pre- dispatch. This set will include market participant bids and offers, as well as any reference levels that were applied as a result of a failure of the market power mitigation price impact test in pre- dispatch. IESO inputs, including the constraint violation penalty curves for meeting the IESO's reliability requirements, are also used.
- **Real-Time Pricing:** Uses the principle for price-setting eligibility to determine settlement-ready LMPs, again accounting for resource and system constraints. It uses the same dispatch data and the set of IESO inputs from RT Scheduling with one exception. RT Pricing uses the constraint violation penalty curves that are relevant for pricing instead of the constraint violation penalty curves for reliability. The LMPs for the next interval are used for RT settlement; the LMPs for the subsequent 10 intervals are advisory.

4. Price-Setting Eligibility

Background

In Ontario's renewed wholesale electricity market, locational marginal prices (LMPs) will reflect the cost of meeting additional demand at each location on the IESO-controlled grid. With more granular prices, resources will be better able to make decisions that will improve efficiencies and reduce total system costs. Locational prices will align with schedules by accounting for transmission congestion and line losses from the supply resource. These prices will be used for settlement in the day-ahead and real-time markets and will provide advisory prices to participants in the pre-dispatch.

The marginal price at each location is set by the offer or bid that is able to supply the next increment of demand at a given locale. Suppliers are able to meet that demand when they can be scheduled without restriction due to a system constraint or an operational constraint of a resource. Examples of operational constraints include minimum output, maximum output, ability to ramp up or down and constraints related to safety or regulatory concerns.

In general, a resource is unable to set price whenever its operational constraint(s) limits its ability to meet the next increment of demand. This is the principle that drives the capability for resources to set price regardless of fuel type. The same principle holds true in the constrained schedules of the current market. Nodal prices[1] currently calculated and published from the IESO's day-ahead commitment process and the pre-dispatch and real-time constrained schedules all reflect the cost of meeting incremental demand from a supplier who has the ability to serve it.

As its name suggests, the IESO's current unconstrained uniform pricing system does not consider resource constraints. As a result resources are not restricted from being the marginal resource to set the uniform price. This difference in price-setting eligibility between the current constrained and unconstrained schedules drives a systematic difference between schedules and prices. The result is a need for an expensive set of uplift payments to promote efficient offers and maintain system reliability. The intent of the single schedule market is to resolve this misalignment between schedules and prices.

The following sections will describe the constraints that will impact a given resource's ability to meet incremental demand and therefore its ability to set locational marginal prices. The constraints are organized by resource type and, unless otherwise noted, apply to the day-ahead, pre-dispatch, and real- time timeframes.

[1] In the current IESO-administered markets, nodal prices are commonly referred to as shadow prices.

4.1. Maximum Daily Energy Limit for Generation Resources

Maximum daily energy limit represents the maximum amount of energy that a generation resource can be scheduled to supply within a dispatch day. Generation resources offers will not be eligible to set energy or operating reserve prices above their maximum daily energy limit.

4.2. Ramping Constraints for Dispatchable Resources

Dispatchable resources submit ramp rates describing the rate at which its resource can physically increase or decrease its production/consumption.

Resources that are ramping up or down at their maximum or minimum capability are not eligible to set price.

4.3. Non-Quick Start Resources

Non-quick start (NQS) resources need at least 60 minutes before they are able to respond to energy and operating reserve dispatches. They also must be scheduled to at least their minimum loading point (MLP) for their minimum generation block run time (MGBRT) prior to being dispatched offline.

Online/Offline

An NQS resource is considered online in a given hour when it is committed and scheduled to at least its MLP. An NQS resource is considered offline when it has not been committed and is therefore unable to be scheduled in a given hour. NQS resource offers will not be eligible to set energy or operating reserve prices below the resource's MLP or when the resource is offline.

Ramping to/from MLP

NQS resources are not dispatchable below MLP, including when they are ramping up or down from MLP. NQS resources ramping up to, or down from, MLP will not be eligible to set price.

4.4. Quick-Start Resources

Quick-start resources are able to respond to energy and operating reserve dispatch within 5-minutes.

4.5. Dispatchable Hydroelectric Resources

Dispatchable hydroelectric resources have unique operating characteristics that impact how they are scheduled. The following subsections describe how specific dispatch data parameters that are considered in scheduling will affect their ability to set marginal prices.

Minimum Hourly Output

The minimum hourly output parameter represents the minimum amount of energy that a dispatchable hydroelectric resource must, if economic, produce in any one hour to prevent the registered facility from operating in a manner that would endanger the safety of any person, damage equipment, or violate any applicable law. Hydroelectric resource offers at or below the minimum hourly output will not be eligible to set energy or operating reserve prices.

Hourly Must-Run

The hourly must-run parameter represents the minimum amount of energy that a dispatchable hydroelectric resource must produce in any one hour to prevent the registered facility from operating in a manner than would endanger the safety of any person, damage equipment, or violate any applicable law. This parameter must be respected in the hour, regardless of the offered price of the energy.

Hydroelectric resource offers at or below the hourly must-run will not be eligible to set energy or operating reserve prices.

Minimum Daily Energy Limit

Minimum daily energy limit parameters represents the minimum amount of energy that a dispatchable hydroelectric resource must be scheduled to supply within a dispatch day to prevent the registered facility from operating in a manner that would endanger the safety of any person, damage equipment, or violate any applicable law. Hydroelectric resource offers at or below the minimum daily energy limit will not be eligible to set energy or operating reserve prices.

Maximum Number of Starts Per Day

The maximum number of starts per day parameter represents the maximum number of times a generation resource can be started within a dispatch day. A start is counted when the resource is scheduled above a minimum MW quantity, known as the start indication value.

The start indication value acts as a partition in a hydroelectric resource's offer curve in terms of price- setting eligibility. When a resource is scheduled below the start indication value, its offers will not be eligible to set energy prices above the start indication value. When a resource is scheduled at or above the start indication value, its offers will not be eligible to set energy prices below the start indication value. Maximum number of starts will not limit a hydroelectric resource's ability to set prices in the operating reserve market.

Forbidden Regions

Forbidden regions are operating ranges where a hydroelectric resource cannot maintain steady output without causing equipment damage. Hydroelectric resource offers will not be eligible to set price for outputs within their forbidden region(s).

Linked Resources, Time Lag and MWh Ratio

Linked resources, time lag and MWh ratio are three new daily dispatch data parameters that will be used to represent the energy production and time lag relationship between hydroelectric generation resources on a hydroelectric cascade river system. The energy produced by upstream resources require a proportional amount of energy to be produced by downstream resources after a period of time.

When a cascade relationship applies to a hydroelectric resource, its offers will not be eligible to set energy prices outside of a range, defined as follows:

- The lower limit of the range will be equal to the highest of the following values:
    - The resource's scheduled quantity minus an infinitesimal amount;
    - 0 MW; or
    - The resource's minimum operating limit.
- The upper limit of the range will be equal to the lowest of the following values:
    - The resource's scheduled quantity plus an infinitesimal amount;
    - The resource's maximum offer quantity; or
    - The resource's maximum operating limit.

Cascade dependencies will not limit a hydroelectric resource's ability to set price in the operating reserve market.

4.6. Imports and Exports

Consistent with today's DACP, in the day-ahead market import schedules from Pass 3 can be no less than they were scheduled to from Pass 1 or Pass 2. Therefore import offers are not eligible to set energy or operating reserve prices for schedules below their schedule from Pass 2. Export bids will not be eligible to set energy or operating reserve prices for outputs above their schedule from Pass 2.

Consistent with today's market, import offers and export bids will not be eligible to set energy or operating reserve prices in the real-time market.

4.7. Active Loads

When an active load[2] submits a $2,000/MWh energy bid lamination, it will be deemed non-dispatchable in that particular timeframe. Non-dispatchable loads are not eligible to set price.

4.8. Virtual Supply/Virtual Load

Virtual supply and load are eligible to set price over their entire offer/bid curve.

[2] Active loads include dispatchable and price responsive loads.

4.9. Manual Resource Constraints

From time-to-time the IESO will take actions that are responsive to market participant requests for generation unit constraints related to safety, legal, regulatory, environmental or equipment damage or that are deemed necessary to maintain the reliability of the IESO-controlled grid. The following list describes the restrictions that such constraints place on price-setting:

1. A minimum constraint which requires a resource to be at an energy scheduling point that is at or above the stated MW restriction. To maintain alignment with scheduling, the resource will be ineligible from setting price based on offer laminations below the stated MW restriction.
2. A maximum constraint which requires the total of the energy and operating reserve scheduling points to be at or below the stated MW quantity. To maintain alignment with scheduling, the resource will be ineligible from setting price for energy and/or operating reserve on any offered laminations above the stated MW restriction.
3. A fixed constraint which requires a resource to be at an energy scheduling point that is equal to the stated MW restriction. To maintain alignment with scheduling, the resource cannot increment/decrement and will be ineligible from setting price.

4.10. Intertie Curtailments

The IESO may be required to curtail intertie transactions in order to maintain reliability, adequacy or in response to requests from external control areas. Intertie transactions that are curtailed in pre-dispatch will not be eligible to set energy or operating reserve prices.

5. Settlement Floor

At the technical session on February 13th, 2020, the IESO received feedback from stakeholders regarding the issue of locational prices that can be substantially less than $0/MWh. The issue with substantially negative locational prices is that they may not provide efficient market price signals. These substantially negative prices are best described as outcomes of meeting water management regulations and are not necessarily associated with the marginal cost of producing power. The IESO's proposed solution to this issue was to introduce a settlement floor of -$20/MWh. An import offer floor of -$20/MWh was also proposed.

In consideration of stakeholder feedback the IESO has updated its proposal. Specifically, the IESO reviewed two main aspects of the proposal to evaluate if they achieve market renewal principles:

1. Whether a settlement floor effectively handles the issue of substantially negative prices while maximizing efficient trade and market transparency.
2. The most efficient settlement floor price.

The IESO continues to believe a settlement floor is required to enhance the efficiency of the market and provide transparent market signals. The IESO determined that a price of -$100/MWh will provide an efficient price signal.

The IESO's initial proposal of a -$20/MWh settlement floor price reflected the highest price at which the settlement floor does not interact with existing participant offers, including those of must-run resources. However, stakeholders raised a concern that the proposed settlement floor price may not provide the proper incentives for suppliers or consumers in an oversupplied area. A price below

-$20/MWh would likely provide a better incentive for suppliers to, if possible, limit production, and for consumers (including exports if available) to increase production during times of oversupply.

Stakeholders also suggested that there could be situations where transactions could be efficient below -$20/MWh, and imposing a settlement floor higher than these efficient offers would reduce the competitiveness and efficiency of the market.

The IESO has revised the design for the settlement floor to -$100/MWh. The -$100/MWh settlement floor level was determined with consideration from the insights of stakeholders mentioned above and the historical offers of non-hydro baseload supply (e.g. nuclear) and resources respecting regulatory requirements.

The minimum price at which market participants may offer will remain at -$2,000/MWh. Ontario has baseload supply that requires enough offer price separation in the negative price range in

order to provide a reliable dispatch order. The IESO relies upon this order to manage surplus conditions and meet its reliability requirements.

5.1. Removal of the Proposed Import Offer Floor

A settlement floor of -$100/MWh also removes the need for an import offer floor. An import offer floor was proposed to reduce the incentive to offer imports at prices lower than the settlement floor. Imports could have paid -$20MWh for the import, but offered the supply at much lower prices, potentially leading to inefficient trade. This is less of a concern with a settlement floor of -$100/MWh. Therefore the IESO has removed the proposed import offer floor.

6. Conclusion

In preparation for the engagement session, stakeholders are encouraged to submit any questions or requests for clarification in advance of the interactive session.

For questions or feedback, please email engagement@ieso.ca.