Stakeholder Engagement Pre-Reading

Hydroelectric Dispatch Data – November 14, 2019

The external stakeholder engagement session on November 14, 2019 will cover the following topic(s):

- Hydroelectric Dispatch Data

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

Contents

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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.

Stakeholders may also submit written feedback after the session if they choose to do so. However, these engagement sessions are designed to collect stakeholder feedback in-person and to facilitate a discussion with other stakeholders on that feedback. The IESO will use the input from these sessions to inform the detailed design decisions. 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

Hydroelectric resources have unique operating constraints that can impact the amount of energy and operating reserve they are able to provide. Some operating constraints are physical equipment limitations, while others are determined by safety, regulatory and environmental requirements. These constraints should be considered, to the extent possible, when evaluating resource offers within the market optimization. Failing to do so could result in market prices and schedules that are less efficient and potentially infeasible. By better modelling the operating constraints of hydroelectric resources, the IESO and market participants will benefit from greater certainty as real-time approaches.

During high-level design, stakeholders representing dispatchable hydroelectric resources expressed concerns regarding feasible DAM schedules and associated real-time balancing risk. Under the current Day-Ahead Commitment Process (DACP), few operating constraints associated with dispatchable hydroelectric resources are considered. While sub-optimal, this shortcoming has had limited market impact given the non-financially binding nature of the current DACP.

Left unchanged, under a DAM this gap could similarly result in instances where a market participant receives a day-ahead schedule that may not be operationally possible. However, unlike the DACP, the financially binding two-settlement of the DAM could result in the market participant potentially having a balancing amount to account for differences in real-time quantities delivered. This balancing amount may be positive or negative depending on both the delivered volume and real-time market prices relative to day-ahead results. The uncertainty and possible financial risk associated with these balancing amounts due to infeasible schedules could impede efficient market participation from these resources.

In response to these concerns, the IESO committed in the DAM high-level design to examine ways to implement several hydroelectric operating constraints within the DAM and pre-dispatch (PD) engines. The goal of modelling additional operating constraints is to produce schedules that better reflect physical resource capabilities. From the participant perspective, these improvements should greatly reduce the financial risk associated with misalignment between financial day-ahead schedules and feasible physical real-time operation. From the IESO perspective, these improvements help to improve efficient resource scheduling and produce more accurate market price signals.

Introducing new operating constraints into the DAM and PD optimization engines for dispatchable hydroelectric resources brings some consistency with the operating constraints that are submitted as dispatch data for non-quick start resources. While not identical, they are similar in that they also restrict the resource's operating capabilities for safety, regulatory and environmental reasons. Operating constraints are not intended to achieve an economic preference to operate within a certain range. These preferences are instead reflected through the resource's offers as price/quantity laminations.

Market optimization engines mathematically evaluate operating constraints that are defined in temporal and electrical terms, such as hours and megawatts. These terms allow the optimization engine to evaluate the offers from market participants within the operating capabilities of resources. At its core, market optimization engines will maximize the economic "gains from trade" (producer and consumer surplus) by accepting bids and offers subject to the specified physical system and resource constraints. For hydroelectric resources, constraints can vary by hour or apply to all hours of the day, such as total energy available to be scheduled.

Market optimization engines have not been designed to manage a resources' fuel. For instance, market participants with thermal resources are responsible for procuring and managing their fuel supply, and adjust their offers accordingly. Similarly, market participants with dispatchable hydroelectric resources that also have capability to control water flows are expected to manage their water in conjunction with their offers. Decisions on managing ponding or forebay levels are entirely at the participants' discretion, impacting the volume of energy that is made available to the market from its facility or facilities. This strategic management of fuel is outside of IESO's visibility, control, or expertise. Moreover, the management of fuel requires estimation of opportunity cost, which is dynamic and influenced by a participants' own view on financial risk.

While perfect alignment between physical resource operation and the operating constraints considered by market optimization engines is ideal, it is impractical to achieve when considering operating constraints can change on even a minute to minute basis. As a result, constraints considered in market optimization engines are almost always an approximation. This is true for a market participant's resource constraints and transmission constraints imposed by the system. Other approximations may arise where constraints are simplified, or in cases where the complexity to properly account for the constraint may be impractical.

When the day-ahead market produces its market prices and schedules, it will be the best estimate of real-time operation based on the inputs provided. To the extent any system or resource constraints are not fully captured in the DAM, this can result in a potentially infeasible day-ahead schedule. This does <u>not</u> mean resources will be actually dispatched to run in a way that compromises safety, regulatory or environmental requirements. While the DAM is financially binding, it is not a physical obligation to operate in real-time in accordance to the DAM schedule.

Following the publication of the DAM schedule, market participants are able to update their bids and offers throughout the day as real-time approaches and intra-day conditions change. Multi-hour optimization through PD will provide visibility to the participant regarding the impact of those offer changes. This feature allows participants to ultimately adjust their real-time schedules via their offers in order to achieve a feasible dispatch. Experience in other North American markets by participants that offer dispatchable hydroelectric facilities in day-ahead have found this to be manageable.

As noted previously, this approach is not without a financial impact to the participant. Updating offers to achieve feasible real-time schedules that differs from day-ahead may result in a balancing amount. The "direction" of the infeasibility may result in DAM schedule that is higher or lower relative to real-time. Depending on the changes in system conditions after the day-ahead market clears, the real-time market price may be higher or lower in the affected hours. Therefore, the net impact of the imperfect set of operating constraints for the dispatchable hydroelectric resource may be positive or negative. Experience in other North American day-ahead markets from dispatchable hydroelectric participants has found this to be approximately net neutral.

These observations do not diminish the need to improve the dispatch data capability that is currently provided under the existing Ontario market. Dispatch data parameters that are used to reflect operating constraints are made available to market participants with hydroelectric resources in other North American markets. Adoption of similar constraints in the Ontario market would greatly improve alignment with real-time operation, and thus significantly reduce the magnitude of balancing amounts associated with infeasible day-ahead schedules. Improving how well the Dispatch and Scheduling

Optimization (DSO) is able to consider resource operating constraints will minimize the offer changes that market participants need to make in order to refine their schedule as real-time approaches.

The IESO remains committed to working with market participants to determine how operational constraints will be integrated in the DAM and PD optimization engines.

3. Hydroelectric Operating Constraints

The following subsections outline the hydroelectric operating constraints that the IESO committed to exploring as new dispatch data for the DAM and PD optimization processes. Each subsection includes a description of the operating constraint and the IESO's proposal for the dispatch data required to satisfy the operating constraint.

3.1. Minimum Hourly Output

Some hydroelectric resources have minimum hourly must run conditions that apply to one or more hours of a dispatch day. These requirements are governed by safety, regulatory and environmental restrictions that can vary on a daily, weekly or seasonal basis.

In the current market, market participants offer lower prices to reflect hourly must run conditions. In the absence of local transmission constraints or extreme surplus conditions, this strategy is an effective way for a hydroelectric resource to receive a minimum hourly schedule. In the presence of these conditions, hydro resources may receive partial schedules that come real-time may require spill conditions to pass the minimum amount of water required to respect other safety, regulatory or environmental restrictions, but prevent the resource from providing any of its partial energy schedule.

Under a financially binding DAM, a partial hourly schedule that results in a real-time spill condition that prevents the resource from providing any energy exposes the market participant to a real-time balancing charge.

During the high level design, stakeholders recommended that hourly must run requirements should be reflected in the DAM and PD calculation engines as non-dispatchable, rather than allowing the resource to be scheduled to 0 MW if uneconomic. Stakeholders noted that under normal operating conditions, a subset of their resources have constant hourly must run MW quantities applicable for all hours of the day where these resources are unable to respond to dispatches below these levels. It was also noted that exceptions can be made during emergency operating conditions.

Other jurisdictions provide their market participants with the ability to specify their hourly minimum energy requirements. If applicable, these minimum hourly energy requirements are typically registered as a single value well in advance during market registration and cannot be updated on a daily basis as dispatch data. This single value is used for every hour of the dispatch day. While this approach helps market participants reduce the risk of receiving schedules below their minimum hourly requirements, it is quite static in nature when considering that hydroelectric minimums in practice can vary hourly from one day to the next. Other jurisdictions address this variability through mechanisms such as intraday outage requests and manual constraints by ISO operators. This design utilizes the supplementary mechanisms that reduce the overall effectiveness that static registration parameters provided market participants compared to dynamic values that can be updated regularly.

The IESO considered the possibility for market participants to submit non-dispatchable hourly quantities for hydroelectric resources into the DAM and PD calculation engines. However, enforcing an above zero schedule could cause a security limit such as a thermal rating on a transmission line to be violated if the resource could not be scheduled to 0 MW to respect the transmission line rating.

It is for this reason even non-dispatchable resources can receive 0 MW schedules in the current day-ahead and PD timeframes. Non-dispatchable resources submit hourly schedules at a price at which they expect to reduce their output to zero. If these conditions were to materialize in the PD schedule prior to real-time, the non-dispatchable resource would be expected to reduce its output to 0 MW.

Instead, the IESO proposes using an approach that would allow hydroelectric resources to be evaluated in a similar manner to today's non-dispatchable resources. A new parameter called Minimum Hourly Output (MHO) will define the minimum amount of energy that a hydroelectric resource must be scheduled to for a specified hour of a dispatch day. The DAM and PD calculation engines would not schedule a hydroelectric resource between 0 MW and the submitted MHO value. MHO is also analogous to the minimum loading point parameter currently used for non-quick start (NQS) resources. Like minimum loading point, the DAM and PD calculation engines would not schedule a hydroelectric resource between 0 MW and the submitted MHO value. Another similarity to a NQS resource's minimum loading point is that hydroelectric resources could continue to be scheduled for operating reserve above their MHO values.

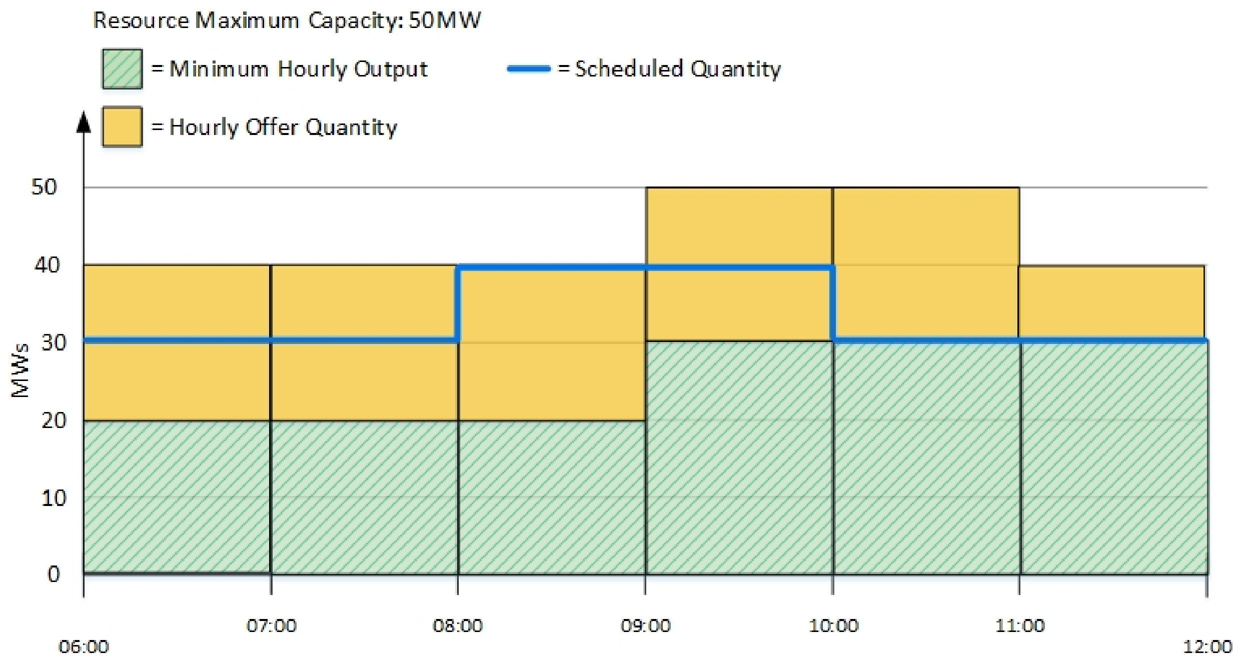
Market participants may submit MHO values as part of their dispatch data. The following data validation rules will apply when the market participant submits an MHO value:

- MHO value of greater than 0 MW must be accompanied with an energy offer;
- Submitted MHO value cannot exceed the maximum quantity of the energy offer;
- If no MHO value is submitted for a given hour, the MHO value will be assumed to be 0 MW; and
- The sum of all submitted MHO quantities must not exceed the submitted daily energy limit for the specified resource for same dispatch day.

An MHO parameter would allow market participants to continue to offer lower prices to reflect must run conditions but with greater assurance that they will not receive a partial schedule between 0 MW and the MHO threshold. While they could still receive a 0 MW schedule if market conditions required it, this would send an appropriate day-ahead market price signal that emergency-like conditions may be required for next day operations. This price signal would inform a market participant that their offer prices in the day-ahead market may have been too high. The market participant could respond to this by lowering its offers in the pre-dispatch timeframe to drive the desired outcome. If day-ahead offer prices were already very low, the day-ahead price signal would inform the market participant that preparations for potential spill conditions or regulatory approvals may be required to deviate from normal operations if day-ahead conditions were to materialize in real-time.

As illustrated by the example in **Figure 2** below, the DAM and PD calculation engines will schedule hydroelectric resources to at least the MHO in each hour, if the resource is economic to generate in that hour. The calculation engines may also schedule additional MWs up to the maximum offered quantity, if it is economic to do so.

Figure 2 - Example: Minimum Hourly Output



3.2. Multiple Daily Energy Limits

Hydroelectric resources can have minimum requirements for how much energy they must produce within a dispatch day, and maximum limits on how much energy they can produce within a dispatch day.

3.2.1. Maximum Daily Energy Limit

To manage the maximum limits for energy a hydroelectric resource can produce within a dispatch day, market participants currently submit to the IESO a single maximum daily energy limit (DEL) with their hourly offers. The market participant need not worry about limiting the amount of energy they offer in any given hour because the submitted DEL will ensure the sum of hourly energy schedules produced will not violate the DEL.

DEL parameters are a common form of dispatch data used in the DAMs of other jurisdictions. A DEL allows the optimization engine to maximize the gains from trade over the course of a dispatch day while providing market participants assurance that their resources will not be scheduled to produce more energy than they expect to have available.

In the current Ontario market, DEL is respected by the DACP's multi-hour optimization engine but limited to single hour optimization in the PD calculation engine. The DACP may hold off scheduling a hydro resource in earlier hours to make use of it in later hours of the day. However, the myopic nature of the PD optimization means the very first run of PD can distort DACP results by scheduling the same resource in the earlier hours rather than the later hours, even if forecast conditions remain the same. The PD can therefore exhaust the DEL much sooner than what was initially intended by DACP. Since PD results influence real-time dispatch, the resource's DEL can actually be exhausted sooner than expected. The hydroelectric resource's future hour DACP schedule in effect becomes infeasible because of the PD single hour optimization.

If the PD were to remain single hour optimization under a financially binding DAM, a hydroelectric resource's DAM schedule in a future hour might not be feasible in real-time if the PD exhausted the DEL sooner. If system conditions did not change day-ahead to real-time, real-time prices would likely be higher relative to day-ahead prices assuming the hydro-electric resource is no longer available with its DEL exhausted. This would result in a negative two-settlement for the participant.

To address this shortcoming in the future market, during high level design the IESO determined that DEL will be respected in a multi-hour fashion by both the DAM and PD calculation engines. This will provide system operators and market participants with schedules and price signals that better reflect anticipated operating restrictions and reduce negative two-settlement risk for market participants.

Market participants will continue to submit DEL as part of their dispatch data. The following data validation rules will apply:

- DEL must continue to be between 0.0 and 999999.9; and
- DEL must be greater than or equal to the submitted Minimum Daily Energy (MDE) value (described next).

3.2.2. Minimum Daily Energy Requirement

Some hydroelectric resources have minimum daily flow requirements that must be met by the end of a dispatch day to meet regulatory and environmental requirements. Today, market participants manage this requirement by submitting low energy offers. While this approach increases the likelihood that hydroelectric resource schedules will satisfy the minimum amount of energy that must be scheduled within a dispatch day, hourly schedules can sum up to less than the minimum requirement in the absence of the optimization engine recognizing the constraint. To manage this risk, market participants could offer more of their energy at even lower prices.

Maintaining the current approach of submitting low offers in the future market would still be an effective way for the market participant to ensure their hydroelectric resource schedules meet the minimum daily energy requirement. If this strategy did not satisfy the minimum daily energy requirement in the DAM, the market participant could offer more energy at lower prices to meet the requirement as real-time approaches. This strategy would not introduce negative two settlement risk as the resource would be scheduled in real-time to generate more than their DAM schedule. While the increase in lower energy offers would appropriately send lower price signals for the hours required to meet the daily minimum energy required, lower prices signaling an artificial surplus condition could result in hours not actually required to meet the daily energy requirement.

The IESO will introduce a new parameter called Minimum Daily Energy (MDE) to define the minimum amount of energy a hydroelectric resource must produce within a dispatch day. Market participants will submit a single MDE value as part of their dispatch data and the MDE will be respected by the DAM and PD calculations. The market participant will need not worry about increasing the amount of energy they offer in any given hour because the submitted MDE will ensure the sum of hourly energy schedules produced will at least meet the MDE. The DAM and PD calculation engines will generate hydroelectric resource schedules that most economically satisfy the MDE based on the hourly offers submitted by the market participant. The MDE will be respected even if one or more of the offers for hydroelectric resources are not economic. This approach provides the DAM and PD calculation engines with the ability to maximize the gains from trade while respecting the safety, regulatory or environmental restrictions for hydroelectric resources.

The following validation rules will apply when the market participant submits MDE as dispatch data:

- MDE must be less than or equal to the submitted DEL; and
- MDE must be less than the sum of all hourly energy quantities submitted with the energy offer for a given dispatch day.

3.2.3. Shared DELs

Currently, market participants submit a separate DEL for each of their hydroelectric resources. While effective for most resources, there are some resources that draw water from the same forebay where the single DEL per resource parameter may create challenges. The DEL is a measure of how much energy is available from one or more resources that may have the same physical location along a river system. If there was only one resource, then the DEL would be an equal measure of how much energy the resource can provide; with multiple resources this may not always be the case.

For example, consider two hydroelectric resources that have the same physical location along a river system but have two different connection points on the electricity system. The two resources share the same total available energy of 1000 MWh. In this case, the market participant would have to forecast how much energy they expect will be used on each resource despite having the same DEL. For instance, they may submit a 500 MWh DEL for each resource to provide assurance that the sum of their schedules will not exceed the 1000 MWh. In the absence of any electricity system constraints, the resources could be scheduled up to 500 MWh each.

However, if an electricity system constraint prevents one hydroelectric resource from being fully scheduled but not the other, the unconstrained resource could only be scheduled for up to 500 MWh even though another up to 500 MWh is still available. In this scenario, the total energy available is not exhausted however the resource is precluded from being scheduled for more energy than is actually available.

This scenario assumes the market participant is not aware of the constraint to begin with. Once they were aware of the constraint they could assign a higher DEL to the unconstrained resource. Under the current market, there is limited financial impact to the participant as long as these adjustments are made prior to real-time.

In the future market, however, if a similar transmission constraint occurred that the participant was unaware of, this would have different financial repercussions. The unconstrained resource would be scheduled for less energy than if the DAM calculation engine understood the DEL from the constrained resource could be used. While the market participant can continue to redistribute its DEL value for the unconstrained resource after the DAM, the absence of recognizing the resources share a DEL can create inefficiencies.

To address this limitation, the IESO will provide market participants with the option to identify resources that share a DEL. This relationship will be captured through facility registration, and the DAM and PD calculation engines will be enhanced to use the registration data to ensure that schedules produced for those resources respect the same DEL and MDE constraints.

3.3. Maximum Starts Per Day

Maximum starts per day is a parameter currently available for NQS resources to reflect the number of times that they can start up and shut down within a given day to avoid equipment failure. These are known as start-up cycles. Similar to Non-Quick Start (NQS) resources, hydroelectric resources have start-up cycle restrictions but have no equivalent parameter to submit.

The absence of this operating constraint can result in a hydroelectric resource being scheduled in hours after the maximum number of starts are exhausted. Market participants currently manage this risk with lower offers in hours they would like to start up and higher offers or no offers in hours they would like to shut down based on their own estimate of which hours yield favourable prices. The market participant can follow this strategy as real-time approaches to increase their assurance of getting the best prices for the energy they can provide within the maximum number of starts they have.

In a financially binding DAM, the hydroelectric market participant's offer strategy remains effective in managing two-settlement outcomes for the starts but reduces their assurance of getting the best two-settlement outcomes for energy they can provide within the maximum number of starts they have. Unlike today where the market participant has many opportunities to adjust its offers to get the best real-time price, they only have one opportunity to get their best day-ahead schedule. They could have received a better day-ahead schedule in hours they weren't targeting to manage their starts if the starts were respected by the DAM engine. This behavior would be less efficient than if a constraint were respected and the market participant focused its offers on optimizing its use of fuel rather than also having to consider starts.

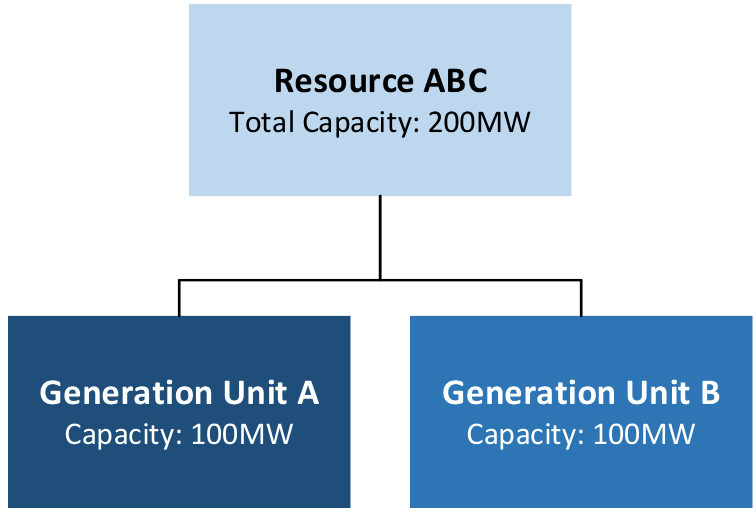
In the absence of a max starts per day parameter, managing two-settlement outcomes for hydroelectric resources would be further complicated since they are often represented as an aggregate of multiple generation units with start-up cycles that are independent of one another. As a result, hydroelectric resource offers would also have to account for individual unit starts within many offer laminations rather than a single lamination.

The IESO is proposing that the maximum starts per day parameter currently available for NQS resource will be expanded to hydroelectric resources. Additionally, the DAM and PD calculation engines will be enhanced to respect the maximum starts per day for each generation unit where they are aggregated under one resource.

The proposed approach uses both dispatch data and registration data provided by the market participant. As with NQS resources, maximum starts per day will be submitted for the hydroelectric resource as dispatch data. During facility registration, the market participant will register the quantity of MWs that correspond to the start of one or more generation units within an aggregated hydroelectric resource. These registered MW quantities will be referred to as start indication values. A description of how the DAM and PD calculation engines will work with both data is described in the following example.

The hydroelectric resource 'Resource ABC' in **Figure 3** represents an aggregated resource with two generation units, each with a maximum capacity of 100MW. This examples assumes each generation unit within the aggregated resource has a maximum number of three starts per day which translates to a maximum of six starts per day for the resource.

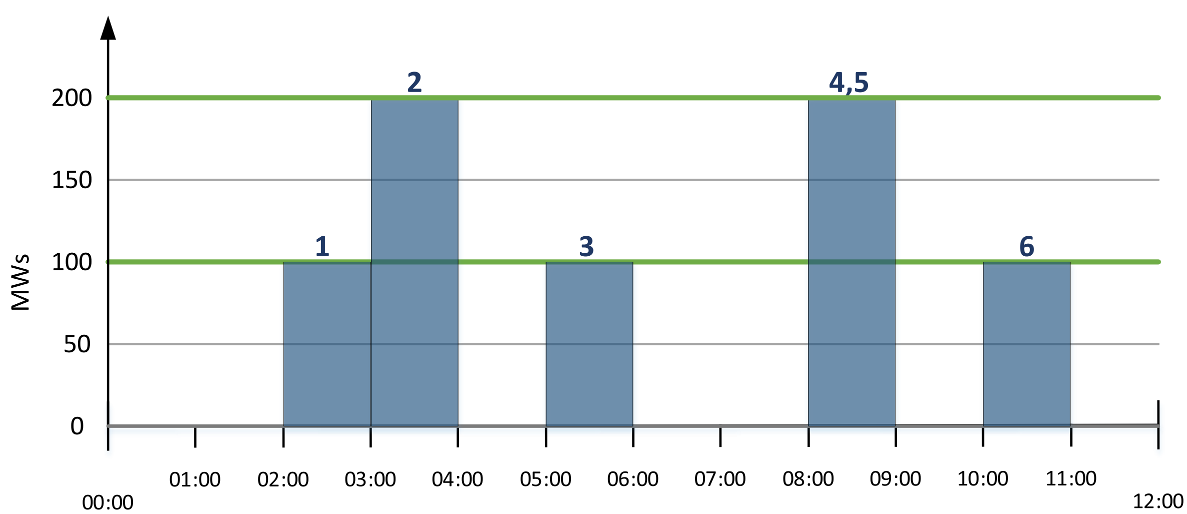
Figure 3 - Example: Aggregated Hydroelectric Resource



Continuing the example from **Figure 3**, the market participant could register start indication values to reflect that starts would occur at 100 MW and 200 MW. As dispatch data, the market participant would submit a maximum number of six starts per day.

When Resource ABC is scheduled, the engine would be capable of counting the number of starts that occur based the number of times the resource schedule crosses a registered start indication value during the dispatch day. An example of a schedule that Resource ABC could receive is included in **Figure 4** below.

Figure 4 - Example: Scheduled Starts for Aggregated Hydroelectric Resource



3.4. Forbidden Regions

Forbidden regions are operating ranges where a hydroelectric resource cannot maintain steady output without causing equipment damage. If a hydroelectric resource were to receive a schedule within this range, the market would be scheduled short of energy because the resource would not be able to meet that schedule. Other resources would not have been scheduled to fill the energy gap.

To mitigate this risk, the IESO provides market participants with the ability to register forbidden regions for their hydroelectric resources and respects these constraints in the real-time market. Forbidden regions are currently not respected by the DACP or PD engines since there is no physical or financial impact of not modelling these constraints.

However, under a financially binding DAM, not modelling these constraints would introduce two-settlement risk for the participant. This is because a financially binding DAM schedule within a forbidden region would be considered infeasible in real-time and the market participant would be at an increased risk of balancing their DAM schedule in real-time at a loss. For this reason, forbidden regions will be respected by the DAM engine. They will also be respected by the PD calculations to drive greater consistency between the DAM and real-time market.

During high level design, stakeholders recommended the IESO explore the following additional improvements to the existing forbidden region design:

- Removing the existing requirement for offer quantities to be aligned with the upper and lower limits of each forbidden region registered; and
- To expand the number of forbidden regions currently available to register.

3.4.1. Forbidden Region Offer Structure Alignment

Market participants must structure their offers such that price-quantity pairs include quantities equal to the registered upper and lower limits of each forbidden region within the offer range. This offer structure requirement may reduce the flexibility a market participant has to vary their offer quantities and manage other operating constraints or even the opportunity costs associated with a resource.

For example, a hydroelectric aggregate resource representing many generation units may utilize the majority of the 19 non-zero quantities it can currently submit to manage other constraints such as minimum hourly output requirements, start-up cycles and dependencies between cascade resources. Market participants also use the price-quantity laminations to reflect different opportunity costs across the capability of the resource. If three of the 19 quantities are already used for forbidden regions, the market participant may be limited in their ability to effectively manage the constraints and opportunity costs associated with the many generating units represented by the resource.

The IESO proposing to remove the requirement for market participants to align their price-quantity pairs with the registered upper and lower limits of forbidden regions to have them respected. The DAM and PD engines will only require the registered forbidden region values registered by the market participant to respect the forbidden regions.

3.4.2. Additional Forbidden Regions

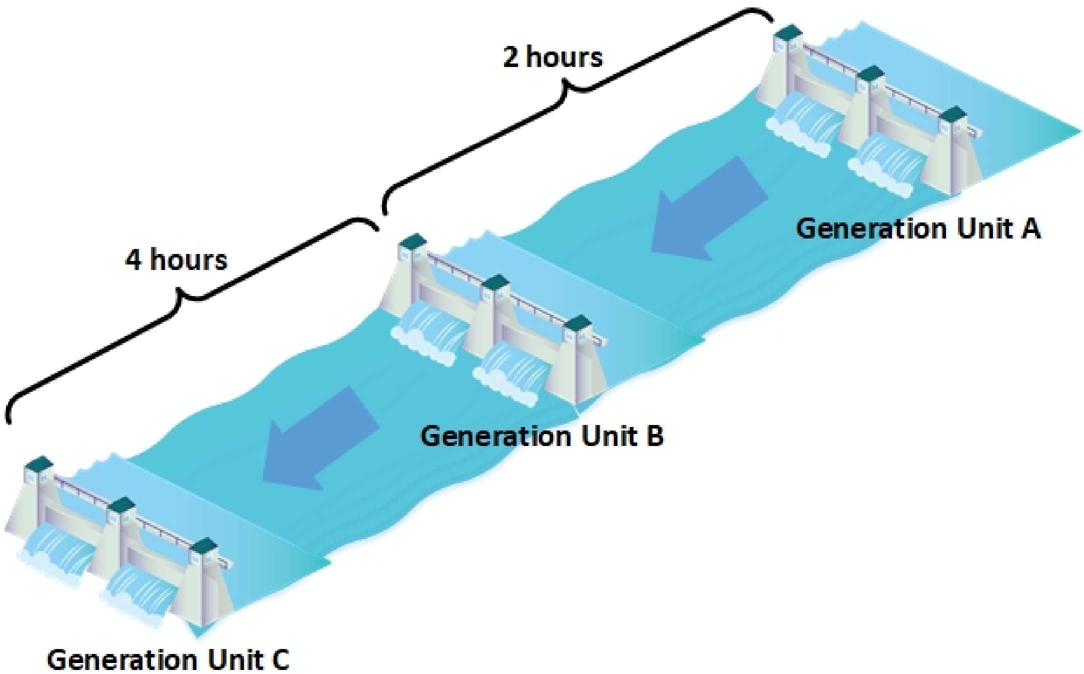
In the current market, hydroelectric resources are limited to registering three forbidden regions, a standard feature included in the initial market software. Stakeholders noted that for aggregated resources, three forbidden regions are not enough to cover the forbidden regions that actually exist for each generating unit in the aggregate. For example, an aggregate resource consisting of four generation units each with its own forbidden region is unable to register a forbidden region associated with the fourth generation unit.

The IESO proposes to explore the feasibility of expanding the number of forbidden regions for aggregate resources.

3.5. Intertemporal Dependencies on a Cascade River System

Hydroelectric resources on the same river system are known as cascade hydroelectric resources. Cascade hydroelectric resources have time-lag dependencies related to how long it takes water to pass between them, as illustrated in **Figure 5** below. These time lags can vary between different resources on the same river system. If an upstream resource generates in one hour, one or more downstream resources may need to generate in subsequent hours to pass the water that the upstream resource passed while it was generating. The physical constraint here is the intertemporal nature of the fuel, and is particularly relevant for a cascade system that have forebay or ponding capability.

Figure 5 - Cascade Hydroelectric Resources



In the above example, the market participant will target producing at each of the three units to maximize the total market revenue. The market participant will identify the most profitable combination of hours (t, t+2, t+6) based on its forecast of market conditions.

Under the current market, in order to try to achieve economic schedules for Units A, B, and C in hours t, t+2 and T+6 respectively, the participant will typically submit low prices offers in those targeted hours.

This offer strategy is intended to both shape the use of water in the most profitable manner, but also to achieve feasible schedule throughout the cascade.

Despite best efforts by the participant, the offer strategy may fail to produce a feasible schedule in day-ahead or early pre-dispatch runs. For example, if unit A and C were economic in the correct hours, but unit B was not. This may come about because system conditions may not match exactly to the participant's forecast. Local demand, supply or transmission congestion can result in one or more of the facilities on the cascade not to be scheduled. In the event that not all of the units successfully achieve an economic schedule that matches this plan, the participant has some choices.

If one or more of the resources on the cascade are uneconomic, the participant can update their offers for the unit(s) to improve the likelihood of being scheduled. Continuing the example, reducing offer prices for unit B in hour t+2 could help to achieve the feasible schedule. Alternatively, the participant may instead to raise the offer prices of units A and C in order to avoid getting an infeasible schedule for the cascade. The approach used is dependent on the relative size of the units, the expected market prices and the opportunity cost of water if able to be stored for future use.

Under the future day-ahead market, this same approach of updating offers after day-ahead can be employed in order to receive a feasible real-time schedule. An infeasible day-ahead schedule may be produced, based upon the participant's forecast of market prices through the day that differs than actual day-ahead market results. The participant is able to adjust its offers through pre-dispatch in order to achieve a feasible real-time schedule. However, unlike under the current DACP this would also trigger a balancing amount for the difference between day-ahead and real-time schedules.

As noted in the background section, this is not ideal from either the participant or IESO perspective. The intertemporal dependency between resources is a real physical constraint that will be ultimately respected in real-time. Failing to do so in day-ahead can result in market results that do not completely reflect system capability. An important clarification is that the constraint being considered is the intertemporal relationship of unit availability. This does not impact over which hours the cascade will be utilized; this is entirely determined by the participant via their offer strategy.

Stakeholders identified that market participants should be provided the option of establishing scheduling dependencies between two or more resources such that all, some, or none of the resources on the cascade could be economically scheduled in any given hour. Stakeholders identified these scheduling dependencies could be expressed in temporal and electrical terms between the resources in MW quantity relationships, lag times and offer prices. Stakeholders also noted that scheduling dependencies should be able to be added or removed during the pre-dispatch hours after the DAM clears.

It should be noted that market participants in other North American markets with cascade hydroelectric resources do not have any registration or dispatch data available to them to manage these interdependencies. While at times participants' view of day-ahead markets result in an offer strategy that produces an infeasible day-ahead schedule, this feasibility can be corrected using updated offers. Associated balancing payments incurred are considered to be infrequent, as the participant becomes familiar with typical local conditions.

As this parameter may be a unique feature to Ontario, the ability for the DAM and PD calculation engines to adequately recognize these inter-dependencies between resources across hours has yet to be determined. While conceptually (relatively) easy to understand, the inter-temporal nature of these constraints may create optimization challenges that could potentially be too cumbersome to generate a solution within the required processing time. The IESO will continue to investigate the potential options and keep stakeholders updated as more information becomes available.

4. 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.