Enhanced Real-Time Unit Commitment High-Level Design

Executive Summary

Independent Electricity System Operator

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Description of Core Concepts

Pre-Dispatch

The timeframe between clearing of the day-ahead market until real-time operations, during which optimization of bids and offers is performed to address changes in system conditions.

Multi-Hour Optimization

The evaluation of all bids/offers and operating restrictions over multiple hours, optimizing all hours at the same time, in order to determine the lowest-cost resources to meet demand.

Minimum Loading Point

The minimum output of energy that can be produced by a generator under stable conditions without ignition support.

Minimum Generation Block Run-Time

The number of hours that a generator must be operating at or above its minimum loading point, in accordance with the technical requirements of the facility.

Lead Time

The amount of time between the initiation of the start-up sequence and the time at which a generator is able to reach its minimum loading point, which depends on the technical requirements of the facility. Lead time determines the amount of notice a generator needs to respond to a start-up instruction.

Non-Quick Start Resource

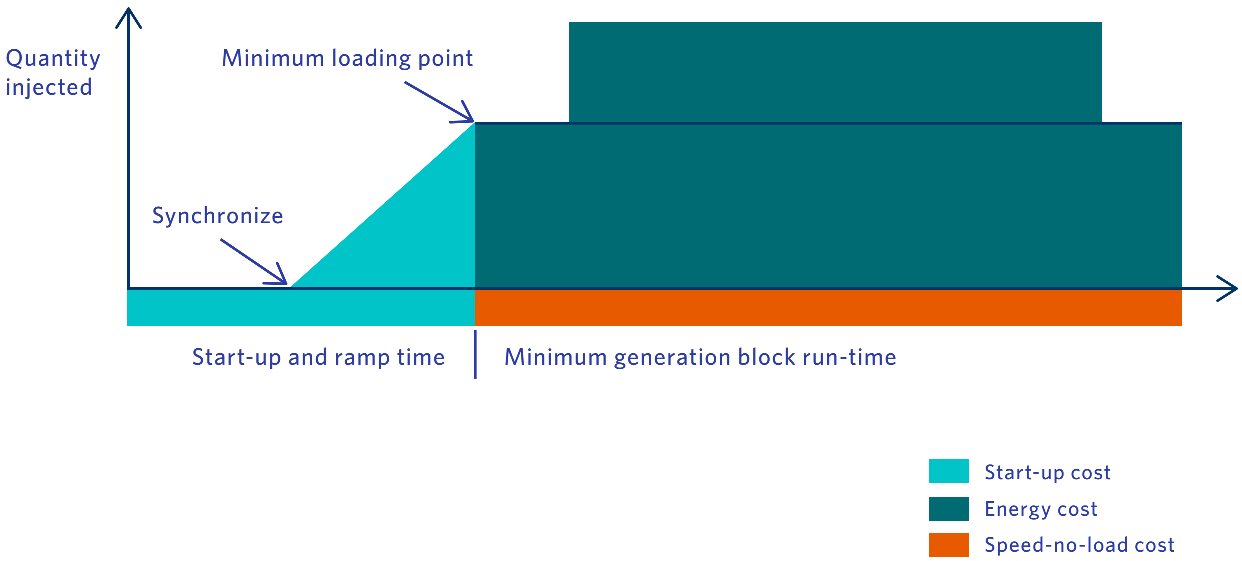
A generator with a lead time of at least one hour, and that must remain operating at its minimum loading point for its minimum generation block run-time.

Commitment

The process of deciding when and which non-quick start resources should come online in order to maintain reliability and meet demand at lowest overall cost. Operational constraints are applied such that a non-quick start resource will not be required to operate below its minimum loading point or to come offline before its minimum generation block run-time has been completed, and the non-quick start resource will be guaranteed to recover its as-offered costs.

Three-Part Offer

A resource offer into the energy market that comprises three parts: start-up cost, speed-no-load cost and energy cost. Start-up cost is the cost for a generator to come online and reach MLP. Speed-no-load cost is the cost to maintain a generator synchronized with zero net energy injected into the system. Energy cost is the cost to generate energy.



1. Executive Summary

Designing the Electricity Market of the Future

Every minute of every day, the Independent Electricity System Operator (IESO) is responsible for ensuring the reliability of the province's electricity grid, administering Ontario's electricity markets, and providing businesses, communities and consumers with the power they count on to meet their needs. Achieving these objectives is complicated by the fact that our existing electricity markets have not kept pace with the dramatic sector-wide developments – technological advances, an evolving operating and regulatory environment and a more diverse supply mix – that are continuing to transform the energy landscape.

Market Renewal: The Rationale For Change

In May 2002, the opening of transparent, wholesale competitive electricity markets in Ontario marked a shift from large, centralized and publicly owned bodies providing services to passive customers to one where buyers and sellers connect to cost effectively supply more engaged consumers with the electricity they need.

While the IESO has made incremental changes to market design to ensure system reliability, the consensus has been clear for some time: the markets require foundational and wide-reaching reforms. That is where the IESO's market renewal program (MRP) comes into play.

Part of our broader efforts to continually rethink the way we do business, this redesign will address persistent, costly design flaws in the current system, and prepare us to more effectively manage future change. In the end, the IESO will deliver more efficient markets, ensuring that all Ontarians have a stable and reliable supply of electricity at the lowest cost.

To lay the groundwork for market renewal, in 2016 the IESO committed to a made-in-Ontario approach by establishing an internal market renewal team supported by an external Market Renewal Working Group, a representative stakeholder forum to advise and inform the IESO on important strategic, policy and design issues affecting the program's success.

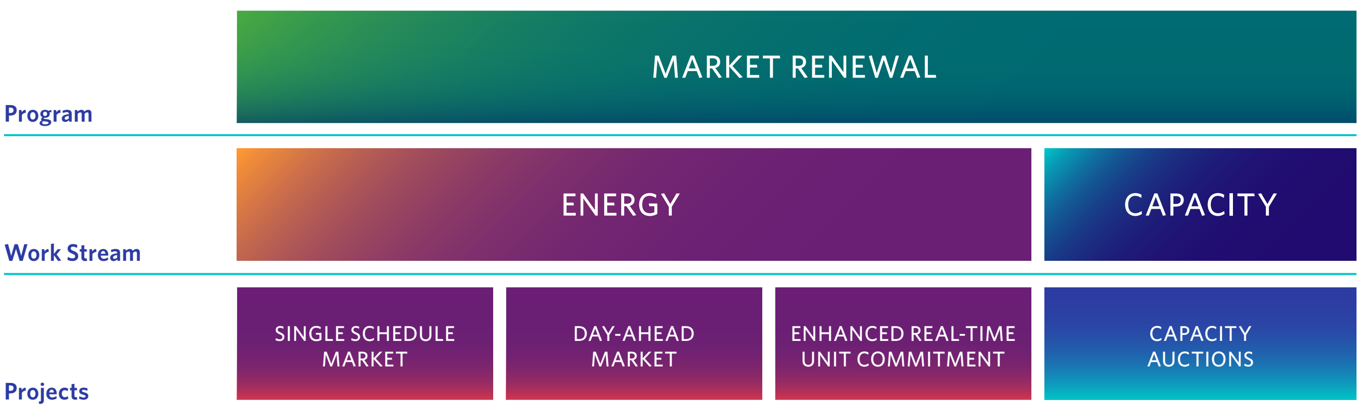
In the two years since, this collaborative effort has delivered a compelling benefits case study, a comprehensive market renewal engagement framework founded on agreed-upon principles, and general consensus on important high-level design decisions that will shape Ontario's new marketplace.

Market Renewal Initiatives

To deliver on its mission to enhance the efficiency of Ontario's wholesale electricity markets, the MRP will:

- Replace the two-schedule market with a **single schedule market** (SSM) that will address current misalignments between price and dispatch, eliminating the need for unnecessary out-of-market payments
- Introduce a **day-ahead market** (DAM) that will provide greater operational certainty to the IESO and greater financial certainty to market participants, which lowers the cost of producing electricity and ensures we commit the resources required to meet system needs
- Reduce the cost of scheduling and dispatching resources to meet demand as it changes from the day-ahead to real-time through the **enhanced real-time unit commitment** (ERUC) project
- Improve the way Ontario acquires the resources to meet longer-term supply needs by implementing capacity auctions that will drive down costs by encouraging greater competition and reducing barriers to ensure we have an efficient way to acquire the resources to meet system needs and customer demands at the lowest cost

FIGURE 1: MARKET RENEWAL PROGRAM WORK STREAMS



Developing a Balanced Market Design: Incorporating Stakeholder Input

At the outset, we recognized that our success in creating a market that better meets the needs of suppliers and consumers would depend, in part, on the broad support of stakeholders who were prepared to invest time and effort in developing solutions that will work for the sector and the IESO.

With this in mind, the IESO committed to designing the new energy markets collaboratively and established a comprehensive consultation framework. Built on agreed-upon principles –efficiency, competition, implementability, certainty and transparency – this framework reinforces the importance of giving interested parties an opportunity to provide feedback.

While each of the MRP initiatives addresses specific needs, they all follow the same design process shown in Figure 2.

FIGURE 2: PROJECT DESIGN PROCESS

Enhanced Real-Time Unit Commitment

An Efficient Transition from Day-Ahead to Real-Time

Electricity markets require a mechanism to cost-effectively transition from day-ahead scheduling to real-time operations. While a day-ahead market can efficiently schedule resources to meet the following day's expected demand, conditions can and typically do change after the day-ahead scheduling process is complete. There may be changes in Ontario demand due to weather conditions or changes in supply from variable generators, such as wind. Electricity markets evaluate bids and offers from all resources between the clearing of the day-ahead market until real-time operations, known as the pre-dispatch timeframe. This evaluation addresses deviations between day-ahead and real-time in order to reliably meet real-time demand at the lowest possible cost. For most resources, the pre-dispatch process does not produce any form of financial guarantee. Instead it provides information on how they are likely to be dispatched, so they can prepare for real-time operation.

However, certain generators – like non-quick start (NQS) resources – require unique treatment in the pre-dispatch process. NQS resources incur three types of costs: the cost of providing energy (energy costs), the cost of starting up to be available to provide energy (start-up costs), and the cost of operating at a minimum level required to inject power to the grid without generating any output (speed-no-load costs). Further, once started, these NQS facilities must remain online and provide a certain amount of power for a minimum period of time prior to shutting down, to avoid damaging their equipment. Without the appropriate market design, these resources may not make themselves available until they are certain they will be able to recover their costs in the real-time market.

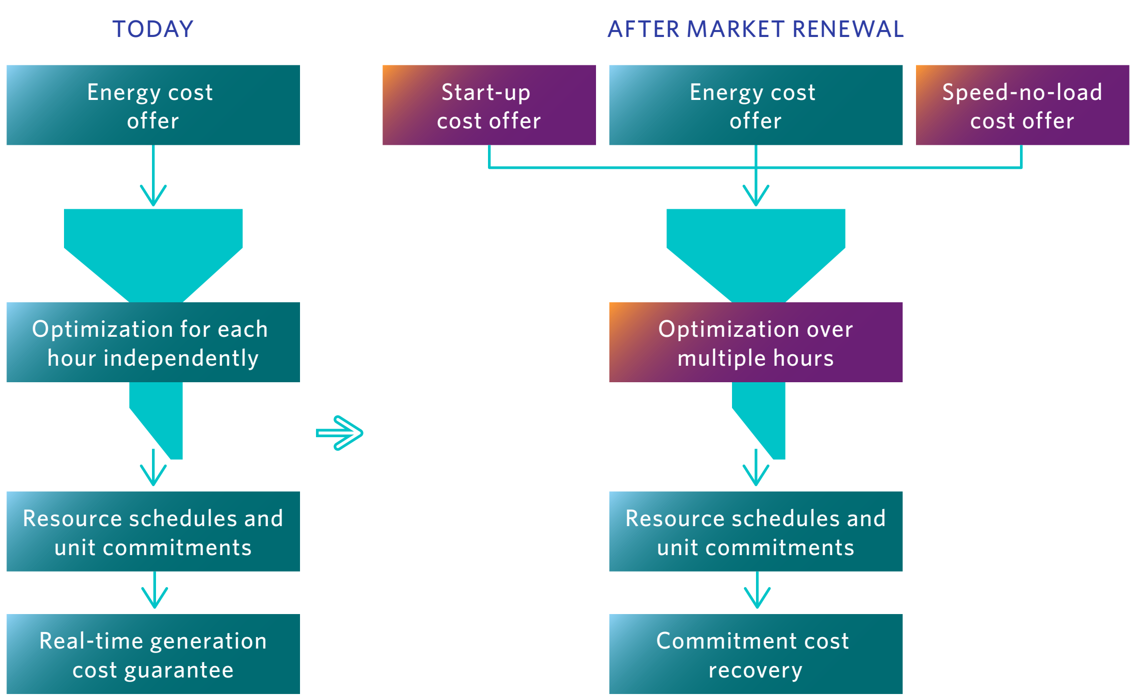
Unit commitment is an important element of the pre-dispatch process. It is the mechanism through which electricity markets ensure that cost-effective NQS resources are available in real-time. Once committed, an NQS resource is guaranteed to be scheduled in accordance with its physical requirements (including the minimum amount of time it must remain online and the minimum amount of energy it must produce). Typically, the unit commitment process is accompanied by a financial guarantee, which ensures the resource will not have to operate at a loss, even if conditions change in real-time.

A unit commitment process in pre-dispatch was not included in the province's electricity markets at opening because real-time energy prices were expected to offer sufficient incentive to ensure that resources would be online when needed. However, as Ontario's generation mix evolved to include more NQS resources, it became apparent that this approach would no longer suffice. To better integrate NQS resources, the IESO introduced a unit commitment process and accompanying financial guarantee in 2003. The program has evolved over time and is known today as the Real-Time Generation Cost Guarantee (RT-GCG) program.

While the RT-GCG program is an important tool for meeting reliability needs, market renewal provides opportunities to improve both the program and the pre-dispatch scheduling process it supports. That is why the IESO is engaging with stakeholders on the ERUC initiative, which will replace both the current pre-dispatch process and the RT-GCG program.

In particular, ERUC will result in pre-dispatch schedules and unit commitments that better reflect the total cost of NQS supply and that are based on a longer, more efficient optimization timeframe. When implemented, ERUC will help to ensure that when changes in system needs arise in the pre-dispatch time frame, the most cost- effective set of resources will still be available to meet demand in real-time.

FIGURE 3: CHANGES TO UNIT COMMITMENT PROCESS



Today, unit commitment decisions are made based on energy costs alone, while start-up and speed-no-load costs are not taken into account. This means a resource with lower energy costs but higher overall costs may be committed instead of a resource with lower total costs. In other words, because RT-GCG decisions do not account for all costs, they may result in inefficient outcomes.

ERUC will address this issue by introducing three-part offers into the unit commitment process. NQS resources will have to submit offers for their energy, start-up and speed-no-load costs. Considering all these costs in making commitment decisions will increase transparency and competition within the commitment process, resulting in lower costs for consumers.

In today's unit commitment process, costs are evaluated separately for each hour, without taking into consideration the minimum level of output that NQS resources must provide and the minimum amount of time they must remain online. This results in inefficient scheduling decisions as only the following hour is considered. For example, a resource that has lower costs over a particular hour may get dispatched, though it has a higher cost overall because it must remain online for a longer period of time.

ERUC will improve the efficiency of commitment decisions by optimizing over multiple hours rather than solving for each hour independently.

In addition to addressing issues with the existing pre-dispatch unit commitment process, ERUC will also work effectively alongside the other the energy work stream initiatives. The SSM will enable the IESO to improve scheduling decisions by laying the foundations for DAM and ERUC.

The DAM will produce financially binding day-ahead schedules for all participants, including NQS resources based on three-part-offers. If an NQS resource is scheduled in the DAM, the resulting day-ahead commitments will be transferred to ERUC. ERUC will then make additional scheduling and unit commitment decisions to address deviations between DAM and real-time, ensuring reliability is maintained cost-effectively. However, ERUC will not "de-commit" an NQS resource with a DAM financially binding schedule.

Since the first ERUC stakeholder meeting in October 2017, in-depth consultation has taken place on all aspects of ERUC design, including the applicability for Ontario of different options for each of the proposed design elements. The process has considered how design decisions may affect stakeholders and reflects the collective stakeholder feedback received. While collaboration does not necessarily signal agreement on every detail, the design decisions have been extensively discussed, and provide a strong foundation for the detailed work required to implement ERUC.

To manage the scope and complexity of the ERUC initiative, the IESO focused the design work and engagement with stakeholders, separating the project into 13 design elements. These elements were grouped into four categories: Engine Parameters and Output, Market Power Mitigation, Participation and Input Data, and Settlement. The following sections focus on the most material design elements in each category.

Engine Parameters and Output at a Glance

The design elements in this category focus on the internal workings of the optimization engine used to produce schedules and determine dispatch, including unit commitment decisions.

The optimization engine will run on an hourly basis using multi-hour optimization to make improved scheduling, dispatch and commitment decisions. During each hourly run, the optimization engine will assess offers to sell energy, bids to buy energy and hourly forecasts (e.g., for demand) for all remaining hours of the operating day. By taking a longer view, ERUC will deliver more efficient schedules for all resources.

Improved modelling of both NQS resources and hydroelectric resources will be incorporated into the optimization engine for the pre-dispatch timeframe, and this will be consistent across all timeframes, day-ahead to real-time. NQS resources have scheduling dependencies between units within the same facility, resulting in operational restrictions. These dependencies can be recognized by using "pseudo-units" that model the relationships between resources, as currently done in the Day-Ahead Commitment Process (DACP). The IESO is also committed to modelling additional hydroelectric operating characteristics to the extent feasible within the DAM and pre-dispatch engines, as outlined in the DAM high-level design document. Hydroelectric resources have operational restrictions, including but not limited to must-run requirements, a limited number of daily starts, and scheduling dependencies with upstream or downstream hydroelectric resources. Improved modelling in the pre-dispatch timeframe will recognize that NQS and hydroelectric resources have operational restrictions that limit their ability to generate, and will optimize the scheduling of these resources in all timeframes.

After the DAM, the ERUC optimization engine will produce additional binding start-up instructions for NQS resources, as required. Advisory schedules, which indicate if, when and to what extent resources are likely to be required to meet system needs in future hours, will be produced for all other resources.

Market Power Mitigation at a Glance

Market power mitigation is an important element of deregulated wholesale electricity markets. A market thrives when there is effective competition among many resources. When competition is restricted, market participants can exercise their "market power" by either economically or physically withholding energy from the market to increase the price.

The IESO has always had a framework to address the potential exercise of market power. Under the current system, however, market power mitigation is carried out after it occurs, and so is based on actual values rather than estimates.

While the approach to market power mitigation will be consistent across the three initiatives within the energy work stream, there are some specific market power mitigation considerations for commitment of NQS resources in the pre-dispatch and DAM timeframes.

In pre-dispatch, as in other timeframes, to address economic withholding, energy offers from all resources will be tested to see if they deviate from expected costs based on pre-defined levels known as conduct thresholds. In cases where energy offers violate a conduct threshold, resulting in a material impact on price that could distort market outcomes, offers will be adjusted to pre-determined reference levels before schedules are produced. In cases where a cost guarantee is impacted, the guarantee payment may be adjusted after-the-fact.

Restrictions to offer changes will also be placed on NQS resources that are committed in DAM and pre-dispatch, in order to maintain a level playing field. For example, once committed in pre-dispatch, NQS resources will not be allowed to increase their offer prices. These limitations will help to ensure that committed resources are not able to use their commitment to influence market prices.

Participation and Input Data at a Glance

Broad participation in the IESO's electricity markets drives competitive behaviour which typically results in efficient market outcomes. Participation and input data design elements focus on what data will be required and evaluated by the optimization engine, when they will be submitted, and under what circumstances they may be revised. These design elements also explore the physical characteristics required for a resource to be eligible for a cost guarantee.

To be eligible for cost guarantee payments, resources will have to qualify as NQS resources. Then they will need to have registered values for: the minimum loading point (MLP), the minimum generation block run-time (MGBRT), and a registered elapsed time to dispatch, i.e., minimum lead time, that is greater than one hour.

Market participant data will either be generally static or subject to relatively frequent variation. For example, MLP and MGBRT data, which are connected to the physical attributes of a resource, are relatively static but may change on occasion. Other data such as three-part offers which are driven by fuel costs will change more frequently. Market participants will provide operating parameter data during the market registration process and, since this data can change, generators will also have the opportunity to make updates on a daily basis.

Settlement Topics at a Glance

In its settlement processes, the IESO will determine the cost guarantee payments for NQS resources. The IESO will evaluate all as-offered energy, start-up, speed-no-load and operating reserve (OR) costs up to maximum offered quantity against all revenues earned in the energy and OR markets during the commitment period.[1] Cost guarantee payments will typically be made if revenues earned are less than the costs incurred. In making this determination, the IESO will examine other factors, such as whether resources synchronize on schedule and inject energy for the expected length of time. The calculation of the cost guarantee payment for pre-dispatch NQS commitments will not overlap with the financially binding DAM schedule for that resource. During the DAM scheduled hours, the NQS resource will receive a DAM make-whole payment, if applicable.

Unit commitment is about ensuring reliability can be met effectively. In cases when an NQS resource fails to meet its pre-dispatch commitment for reasons that are within its control or influence, system reliability might be impacted, and the IESO will apply a failure charge. The magnitude of this charge will depend on how much energy the resource failed to deliver and whether any additional costs have been incurred to secure a replacement resource.

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[1] The commitment period begins at synchronization and includes all hours that the NQS resource is operationally constrained at minimum load point.

Conclusion

The ERUC high-level design addresses existing issues with the current pre-dispatch and unit commitment processes. ERUC will improve competition and produce more efficient market outcomes by taking all relevant costs into account when making commitment decisions. Further, costs will be optimized over multiple hours and the physical constraints of NQS resources, such as minimum output and run-time, will be factored into the pre-dispatch optimization process. With these enhancements, the IESO will be better positioned to schedule the lowest-cost resources to satisfy reliability needs in real-time.

Building on months of extensive consultation with stakeholders, this document is both a comprehensive summary of the decisions that will enable the introduction of an enhanced pre-dispatch model, and a stepping-off point for engagement on the detailed design decisions that will need to be addressed before implementation.

This high-level design is part of a series of changes intended to fundamentally transform the province's electricity markets to deliver electricity to consumers at lowest cost and to better prepare the IESO and market participants for future market evolution.

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