ERUC: Overview and Design Elements

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FTI

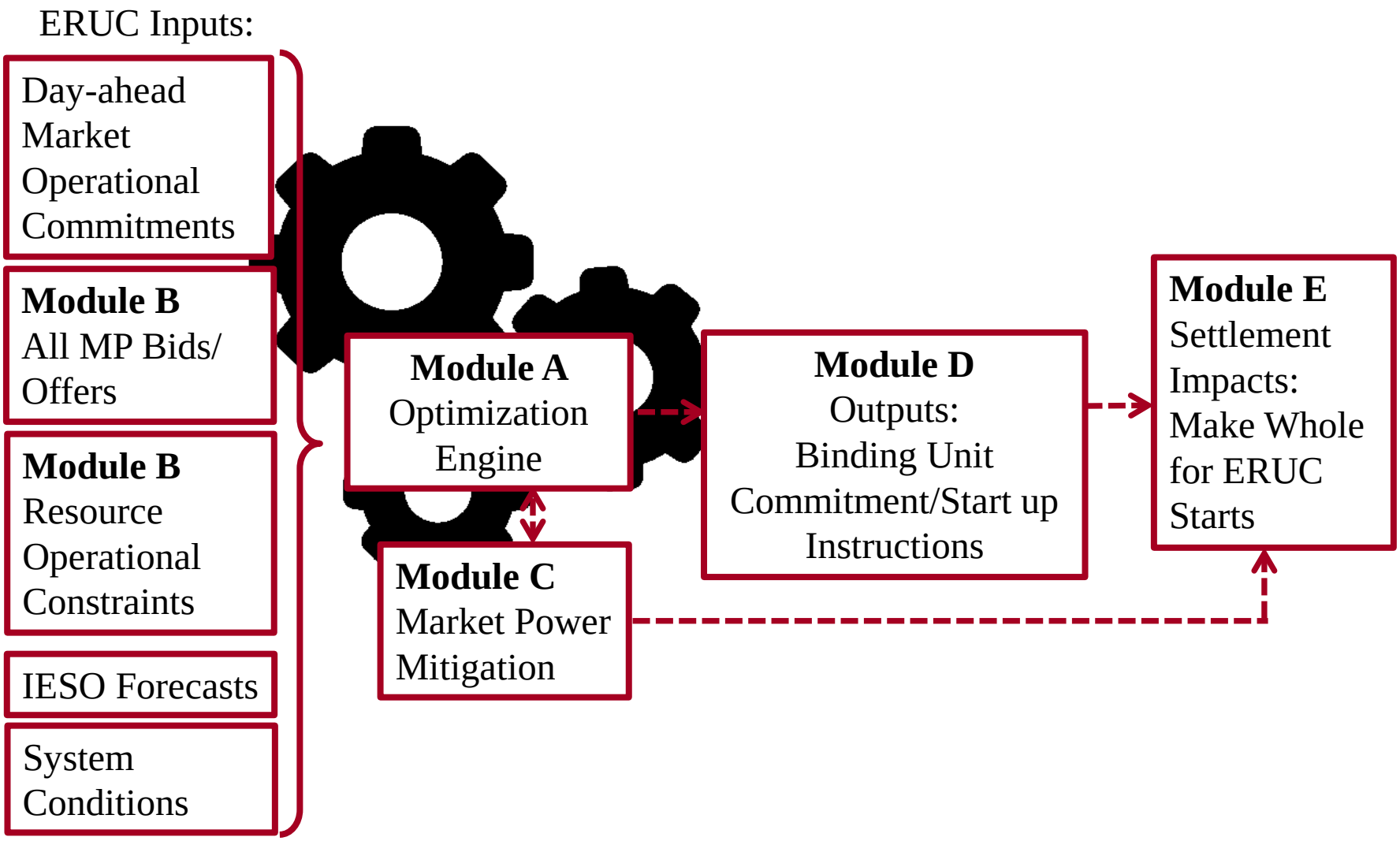
Agenda

- ERUC Overview (Key Concepts)
- Design Elements
  - Module A – Optimization Engine Parameters
  - Module B – Participation and Input Data
  - Module C – Market Power Mitigation
  - Module D – Outputs
  - Module E – Settlement Impacts

- Optimization
- Other North American ISOs
- Inputs and Outputs
- Market Power Mitigation
- Outputs and Settlement

ERUC Overview

Key Concepts



The ERUC engine will utilize multi-hour security constrained unit commitment and dispatch to jointly optimize energy and operating reserves, similar to the DACP.

ERUC will allow the IESO to more efficiently evaluate the need for unit commitments between the time when the day-ahead market schedules are published and the real-time dispatch.

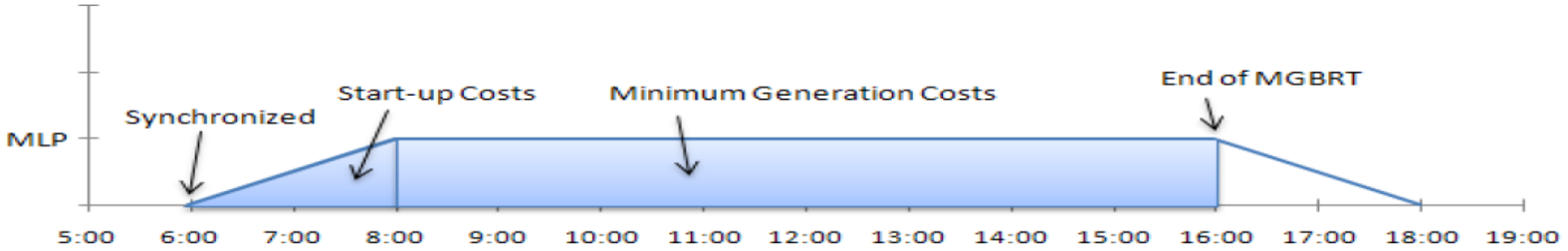
The engine will consider bids and offers from dispatchable loads, dispatchable generators and intertie transactions to determine the optimal mix of resources to meet net load; this may include commitment of a non-quick start resource.

ERUC's optimization engine will differ from the current pre-dispatch engine in several important respects:

- It will be based on three-part offers (incremental energy, start-up and speed-no-load costs).
- It will take account of resource operational constraints (e.g. minimum run time, minimum loading point, time required to start-up and ramp rates).
- It will conduct an evaluation of unit commitment over the minimum run time of the resource or longer.
- It will produce binding start-up/commitment notifications.

ERUC's economic evaluation of intra-day commitment decisions will enhance competition and improve market efficiency by accounting for both commitment and incremental energy costs:

- Commitment costs are the energy, start-up and speed-no-load costs to operate at the minimum loading point for the minimum generation block run-time.



- Incremental energy costs are energy costs incurred to increase output over a unit's minimum loading point.

It is envisioned that ERUC will differ from the post DAM unit commitment engines used by other North American ISOs which:

1. rely on load serving entities and virtual buyers to submit demand bids in the DAM and take responsibility for their own forecast error; and
2. typically have a much larger number of gas-fired resources that can be started in an hour or less allowing for the use of short-term unit commitment analyses (looking ahead no more than a few hours) to manage most intra-day commitment analysis.

ERUC requires a look-ahead period longer than North American ISO short-term unit commitment engines to:

1. Allow economic evaluations (overall production cost minimization) for commitment decisions required throughout the operating day based on IESO net load forecasts; and
2. Address the characteristics of the current Ontario generation resource mix:
   - Many non-quick start resources are part of gas-fired combined cycle facilities that require several hours to start-up and have multi-hour minimum run times.
   - There is a large and growing group of renewable resources with uncertain hourly production profiles.

Inputs

- Day-ahead market - operational commitments only
- All market participant bids/offers
- Resource operational constraints
- IESO load and net load forecasts
- System conditions
  - Transmission outages
  - Generation outages and deratings
  - Interchange curtailments

Inputs

ERUC inputs will:

- Ensure that ERUC is aware of day-ahead market operational commitments.
- Ensure the ERUC considers all available resources and commits only if the non-quick start resource is the lowest cost option.
- Account for net load forecast uncertainty.
- Allow the IESO operators to account for outages and other changes affecting the availability of supply.

ERUC will include market power mitigation to ensure that unit commitment decisions are not impacted by the exercise of market power and that make-whole payments are constrained by competition.

- Incremental energy costs will be subjected to market power mitigation as determined in the SSM work stream.
- The ERUC work stream will determine the market power mitigation design for the commitment cost and non-price bid/offer parameters.
- ERUC will also include rules governing bid/offer price changes between the day-ahead market and ERUC and between ERUC and real-time.

ERUC's main output is unit commitment decisions:

- Commitment in ERUC means that a resource receives a operational commitment to start-up and run at minimum output for at least its minimum generation block run-time, and that it will be eligible for a make whole payment if applicable.
- A resource may be "notionally" included in the schedules of several ERUC runs but only receive a commitment instruction when it needs to commence start-up.

DESIGN ELEMENTS

Optimization Engine — Module A

- Duration of look ahead period
- Functional passes
- Timing and frequency of runs
- Time step of optimization

Duration of look ahead period:

- Timeframe over which the engine optimizes, impacting economic efficiency of the commitment.
- Establishes extent to which commitment of resources with longer start-up, minimum run times, and use-limit constraints can be evaluated.

Functional passes:

- Each pass will jointly optimize energy and operating reserves to generate a solution based on inputs unique to that pass.
- Multiple engine passes will be required for the implementation of market power mitigation.
- Additional passes may be used to account for differences in hourly average versus peak load and net load forecast uncertainty.
- Additional passes will increase ERUC solution time.

Timing and frequency of runs:

- Establishes when the ERUC will be run.
- Establishes how often the engine will run (e.g., every hour).
- More frequent ERUC runs allow for commitment of resources in a timely manner to address changing system conditions.

Time step:

- This is the interval (e.g., hour, 30 or 15 minutes) used for the optimization, which determines the duration and precision of the schedule increments.
- The precision of the ERUC commitment decisions and the coordination with interchange scheduling impacts market efficiency.
- Smaller time steps increase the software run time.
- ERUC could use more than one time step, such as smaller time steps for near term pre-dispatch hours and longer time steps for future periods.

Participation and Input Data — Module B

- Intertie transactions
- Must offer requirement
- Eligibility for commitment
- Market participant data

Intertie transactions:

- Intertie transactions with a DAM schedule are incentivized to offer in real-time and will be accounted for by ERUC.
- Need to consider whether or not to incorporate intertie bid/offers that were not cleared in the DAM and which may therefore be less certain.
  - A longer ERUC look ahead period increases forecast uncertainty and can result in evaluation of import offers and export bids that may not be available in real-time.
  - Import and export schedules rely on interactions with adjacent ISOs which can change significantly throughout the operating day.

Must offer requirement:

- ERUC requires sufficient resources be available to support a competitive and efficient commitment analysis.
- ERUC may include requirements for certain resources to offer their capability into ERUC which could protect against the exercise of market power and reduce reliability concerns that may arise due to changes in system conditions in real-time.

Eligibility for commitment and make whole payment:

- Establish which resources evaluated by ERUC are eligible for commitment instructions and make whole payments.

Market participant data:

- Specifies market participant offer data and non-price bid/offer parameters which enable the optimization to make efficient choices.

Market Power Mitigation Module C

- Commitment cost market power mitigation design
- Bid/offer changes

Commitment cost market power mitigation design:

- Mitigation to address the impact of economic or physical withholding of supply through commitment cost bids and offers and non-price bid/offer parameters will be determined in the ERUC work stream.
- Market power mitigation for incremental energy will be applied in ERUC using the framework developed in SSM.

Bid/offer changes:

- Since ERUC will be carrying out its optimization over a period stretching a number of hours into the future, there is a potential for bid/offer price changes after the ERUC optimization.
- Bid/offer prices changes submitted after ERUC has made commitment decisions could allow the exercise of market power as well as leading to inefficient commitment decisions.
- The ERUC work stream will therefore consider rules governing bid/offer prices changes by resources committed in ERUC.
- ERUC will also consider restrictions on changes in commitment cost bid/offer prices and non-price bid/offer parameters between the day-ahead market and ERUC.

Binding start-up instruction and operational schedule:

- This is the key ERUC output which supports efficient commitment.
- Instructions for non-quick start resources to commence start-up and operate at minimum load point will be communicated to the resource's operator.
- Commitment for an operational schedule beyond MGBRT will be considered; need to balance forecast uncertainty for a longer commitment versus its potential efficiency benefits.
- Unit dispatch instructions above MLP will be determined in real-time dispatch.

Calculation of Make-whole Payment:

- These payments will ensure that real-time revenues are sufficient to recover as-offered costs of resources committed by ERUC.

Failure Charge:

- This is a potential charge so that generators respond to ERUC commitment instructions in real-time, in order to ensure reliability, efficiency and reduced uplifts.

Topic Schedule - Fundamentals

- **October 31, 2017 - Stakeholder Engagement Session**
  - ✓ Module A – Optimization Engine
  - ✓ Module B – Participation and Input Data
- **November 29, 2017 - Stakeholder Engagement Session**
  - ✓ Module C – Market Power Mitigation
  - ✓ Module D – Outputs
  - ✓ Module E – Settlement Impacts