Stakeholder Engagement Pre-Reading

Pseudo-Units - February 27, 2020

The external stakeholder engagement session on February 27, 2020 will cover the following topic:

- Pseudo-Units

The purpose of this document is to provide stakeholders with information on how combined cycle plants will be modeled, scheduled and settled in the day-ahead market and the real-time market. These materials are required reading for the session.

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Disclaimer

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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 about the proposed design?
- What questions do stakeholders have about 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

In high-level design stakeholders identified complexity relating to scheduling and financially committing combined cycle plant (CCP) resources, which are a type of non-quick start (NQS) generator.

Today, the IESO models physical resource unit relationships through simplified pseudo-units (PSUs) in the day-ahead (DA) scheduling timeframe only. Stakeholders expressed concerns that the inconsistent use of PSU models from day-ahead into real-time (RT) could result in undue financial penalties. Under day-ahead market (DAM) financially-binding schedules and binding pre-dispatch (PD) commitments for NQS resources, CCP resources may be exposed to greater financial risk if models are not accurately applied in all timeframes to achieve feasible physical resource schedules.

To address these concerns, the IESO determined that combined cycle modelling will be implemented in all timeframes (i.e., DA, PD, and RT) to improve schedule feasibility and reduce financial impacts to market participants.

Table 1: Comparison of Current and Future CCP Modelling

	Use of Combined Cycle Modelling		
Design	**DA**	**PD**	**RT**
Current	✓		
Future	✓	✓	✓

The combined cycle modelling approach that will be implemented in all timeframes is described in this document.

Consistent modelling in all market timeframes will enable more feasible schedules, commitments, and dispatch instructions for CCP generation facilities. CCP modelling in all timeframes will also impact settlement in the DA and RT markets.

2.1. Non-Quick Start Facilities and Combined Cycle Plants

The current energy supply mix in Ontario includes a large number of NQS generation facility resources. NQS facilities cannot, due to equipment limitations, synchronize and output energy to the grid in five minutes or less to accommodate RT dispatch instructions from the IESO.

NQS generation facilities have the following characteristics:

- The minimum loading point (MLP) is greater than zero[1];
- The minimum generation block run-time (MGBRT) is greater than one hour[2]; and

[1] MLP is the minimum output of energy that can be produced by a generation facility under stable conditions without ignition support.

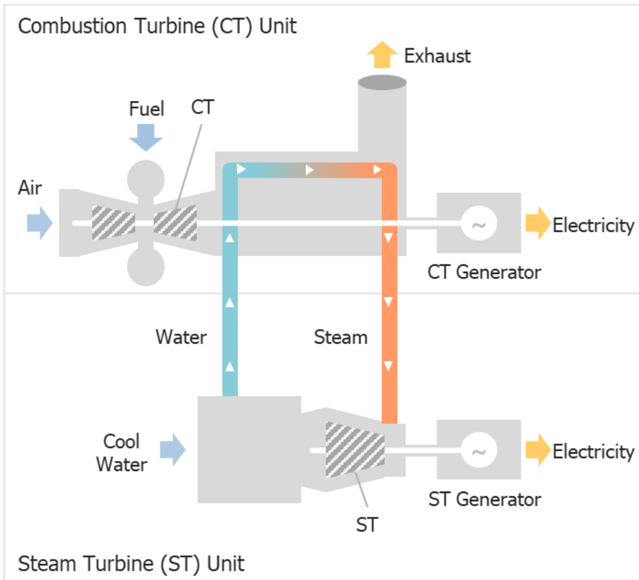
[2] MGBRT is the number of hours that a generation facility must be operating at MLP in accordance with the technical requirements of the facility.

- The elapsed time to dispatch is greater than one hour[3].

Description of Combined Cycle Plants

A CCP is a type of NQS generation facility. As depicted in **Figure 2**, a CCP has one or more fuel-fired (typically gas) combustion turbine (CT) generation units and a single steam turbine (ST) generation unit. A CCP uses waste heat created by the CTs to heat water until it turns to steam. The steam is then used to fuel the ST generator.

Figure 2: Combined Cycle Plant (CCP)



Dependency Between CT and ST Units within a Combined Cycle Plant

The dependency between CT and ST units creates unique challenges for scheduling and dispatching CCPs to generate electricity. Each CT within the CCP has a defined contribution to the ST and the output of an ST is dependent on the output of its associated CTs.

CT units can be scheduled based on submitted values for the physical unit (PU), similar to scheduling other NQS resources. However, the ST unit must be scheduled with respect to both the schedules of the associated CT units and the contribution of each CT to the ST.

CCPs have three operating ranges: MLP, dispatchable above MLP, and duct-firing. Duct-firing is an operating method unique to the ST unit, whereby the unit operator can inject extra fuel to increase the ST to its maximum output.

2.2. Current Market

This section describes combined cycle plants and their interdependencies in greater detail, specifically in how CCPs are currently modelled, offered, scheduled and settled.

[3] Elapsed time to dispatch is the minimum amount of time, in minutes, between the time at which a start-up sequence is initiated for a generation unit and the time at which it becomes dispatchable by reaching its MLP.

Pseudo-Unit Models
The IESO introduced PSU modelling in 2011 as part of enhancements to the Day-ahead Commitment Process (DACP). This modelling facilitates the commitment of combined cycle resources. The modelling schedules each PSU independently, where a CT and part of the ST is scheduled in parallel and proportioned according to a fixed ratio of energy output between the gas and steam resource.

Parallel scheduling between the CT and ST allows both resources to receive commitments from the DACP, reflecting the operational interdependencies between resources at a combined cycle facility. Proportional scheduling mimics the mutual energy loading levels on a physical unit (PU) level, which then facilitates security assessments. This allows for grid security to be verified based on the physical representation in which a PSU energy schedule will be delivered.

Offers and Schedules in Day-Ahead
Today, the IESO only uses PSU modelling in the DACP to provide commitments to generators for at least their MGBRT hours at MLP.

Today, if a market participant elects to use the PSU model in DACP, they must submit two sets of offers:

- Offers on the PSU so that the calculation engine provides more feasible commitments for the PU for both energy and operating reserves and;
- Offers on the PU resources that comprise the PSU to be used by the pre-dispatch scheduling process.

In DACP, NQS generation facilities may provide three-part offers including the start-up offer, speed no-load offer and energy offer. The day-ahead calculation engine (DACE) optimizes the PSU schedule with respect to the economics of the PSU offers. The DACE translates the PSU schedule into PU schedules to perform a security analysis. Operating reserves offered on a PSU basis are jointly optimized with energy, and scheduled at the PSU level based on remaining CT and ST capacity.

The DACP publishes energy and operating reserves schedules for each of the PSUs (i.e., PSU1, PSU2, PSU3) and energy and operating schedules for each of the PUs (i.e., CT1, CT2, CT3, and ST) associated with a PSU.

Offers and Schedules in Pre-Dispatch and Real-Time
Participants use the PUs to offer in the PD and RT timeframes. While PSUs are used in DACP, pre-dispatch and real-time PU models do not consider feasible CCP operating ratios/dependencies that are captured by PSUs.

Settlement
The Day-Ahead Production Cost Guarantee (DA-PCG) is the only settlement amount in the current market impacted by PSU modelling. Since dispatch instructions, metering, and settlement all take place on a PU basis, it is necessary to derive PU energy offer curves from the PSU energy offer curves. The PU offers are required to calculate the as-offered cost for the DA-PCG on a PU basis.

The energy offer derivation is achieved through formulation of the Derived Interval Price Curve (DIPC). The portion of the day-ahead ST energy schedule that is eligible for cost recovery is achieved through formulation of the Derived Interval Guarantee Quantity (DIGQ). The DIPC and DIGQ formulation methodology is outlined in Appendices B and C, respectively, of Market Manual 9.5.

Based on PU relationships, the IESO derives CT and ST energy offers from the DA PSU energy offers. The determination of the PU energy offer is achieved by decomposing PSU offers into DIPC, which applies to both the CTs and ST. The DIGQ is the sum of the ST portion of the day-ahead PSU schedules from all PSUs where the associated CT is injecting energy in that interval.

While participants submit PSU offers into DACP for both energy and OR, the IESO does not use the PSU OR offer to derive PU OR offers for settlement purposes. Instead, the IESO uses a simplified approach that has minimal impact on accuracy. The real-time PU OR offer submitted by the participant after the DACP is used to calculate the as-offered cost on a PU basis.

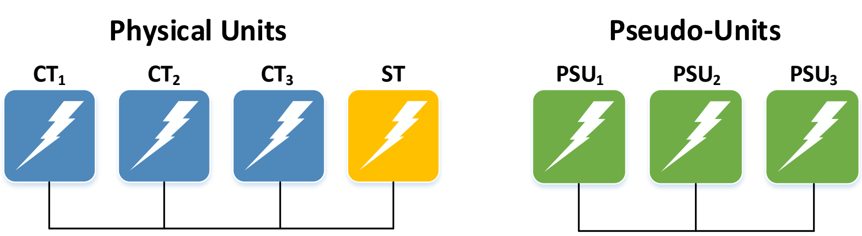
3. Pseudo-Unit Operation

The IESO will continue to use PSUs as the modelling approach for CCPs, and will utilize this model across all timeframes.

As noted in **Section 2**, PSU modelling recognizes the relationship between the CTs and ST in scheduling and dispatch, specifically that the capability of the ST is dependent on the output of the CT units.

As illustrated in **Figure 3**, each PSU represents the capacity of one CT combined with a proportional amount of the ST's capacity. Market participants register the Steam Turbine Share (%) for each PSU, which is used to assign the ST capacity to corresponding PSU. PSU modelling examples discussed in this material assume an equal contribution of each CT to the ST.

Figure 3: PSU Model for a 3CT x 1ST Configuration



$PSU_1 = CT_1 + 1/3\ (ST)$
$PSU_2 = CT_2 + 1/3\ (ST)$
$PSU_3 = CT_3 + 1/3\ (ST)$

Scheduling energy and operating reserve will be conducted on a PSU basis, largely consistent with the existing methodology under DACP. Some enhancements will be provided for operating reserve scheduling to ensure that reserve is scheduled proportionally on the physical units. Operating reserve schedules are explained further in **Section 3.4.3**.

The Pseudo-Unit approach will be discussed in terms of:

- Registering Pseudo-Units;
- Modelling Pseudo-Units;
- Offering Pseudo-Units; and
- Scheduling Pseudo-Units.

3.1. Registering Pseudo-Units

Consistent with the current process, market participants will register each PU within a CCP during facility registration. Market participants will register the technical parameters of each PU, as well as the relationship between the units.

Table 2: Comparison of Current and Future PSU Registration

Area	Design	
Registration	Current	PU with PSU election
	Future	PU with PSU election[4]

Technical parameters include data such as MLP and MGBRT. Market participants will also submit many of these parameters as daily or hourly dispatch data.

During facility registration, the market participant will indicate if they are electing to register for PSU scheduling, or if they would like to be scheduled based on PU. If they elect to be scheduled as PU, the CCP will be scheduled in all timeframes as they are today in real-time, with no relationship recognized between the CT and ST.

3.2. Modelling Pseudo-Units

The PSU model is important because it defines the boundaries for PSU schedules and the relationship between CT and ST for each operating region. PSU schedules are translated to PU schedules using the proportional relationship established by the model for each operating range. PU operational limitations are mapped back to the PSU using the same linear relationship.

The PSU model used in DACP today will be carried forward into the new market.

Table 3: Comparison of Current and Future PSU Modelling Timeframes

		Timeframe		
Area	Design	DA	PD	RT
Modelling	Current	PSU, PU	PU	PU
	Future	PSU, PU	PSU, PU	PSU, PU

The IESO will continue to calculate technical parameters for each PSU based on the corresponding CT and ST data. Parameters for the operating ranges of the PSU will be calculated using a blend of CT and ST data, as illustrated in **Figure 4** and outlined below.

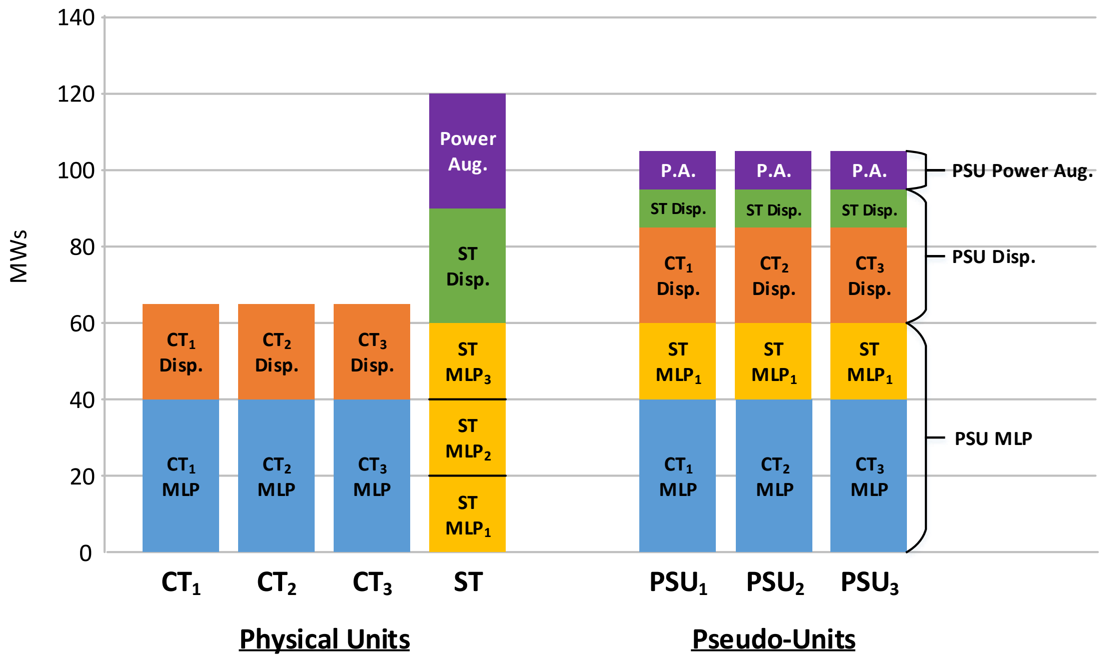
Mapping Operating Ranges of PU to PSU

CTs have two operating ranges: MLP and dispatchable above MLP. STs have three operating ranges: MLP, dispatchable above MLP, and duct firing. PSUs are modelled to include all three operating ranges. The MLP operating range of a PSU is calculated by adding the MLP of the corresponding CT unit to a portion of the ST's MLP. ST units have multiple MLP values based on how many CT units are online. For

[4] If a market participant chooses to be a PSU or PU in registration they will be one for all timeframes in the future market. Unlike other registration data which turns into dispatch data (that can be updated through the day), the selection of PSU/PU only happens once.

example, the MLP of the ST may be 40 MW if one CT is online (1x1) and 60 MW if two CTs are online (2x1). PSU scheduling does not consider if other PSUs at the facility have been scheduled, so each PSU is modelled using the (1x1) ST MLP (e.g. MLP_1).

Figure 4: Mapping Operating Ranges of CTs and ST to PSUs (3x1)

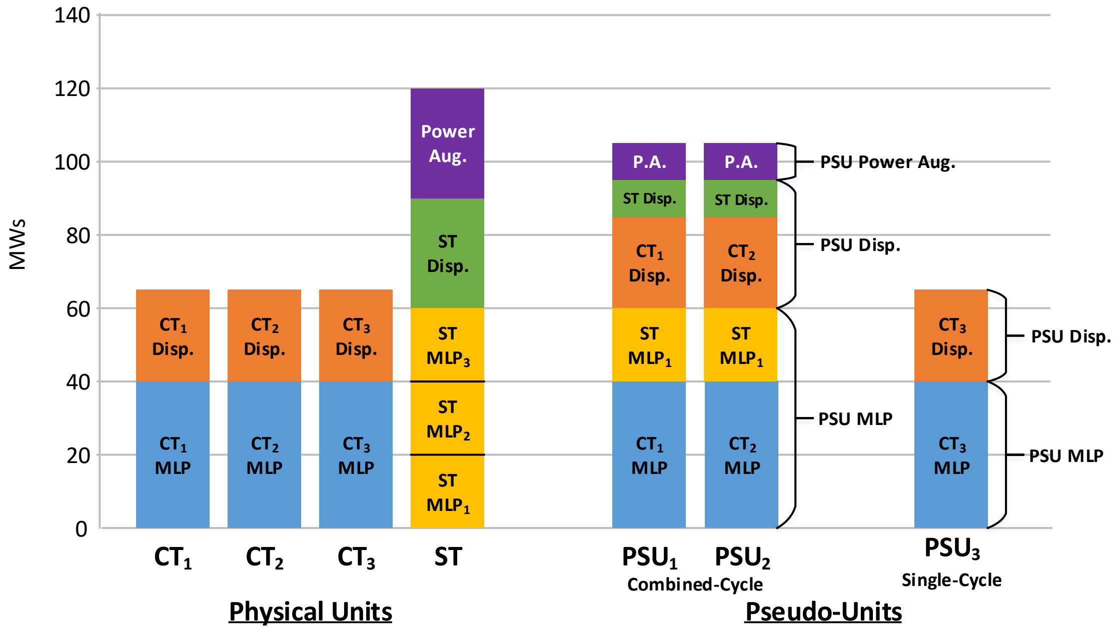


The dispatchable operating range of the PSU above MLP is calculated by adding the dispatchable range of the corresponding CT to a proportional quantity of the ST's dispatchable range. For example, if a CCP has three CTs and each PSU is registered with an equal Steam Turbine Share, each PSU would be modelled with a third of the ST's dispatchable range.

The duct firing range of the PSU is calculated by taking a proportional quantity of the ST's duct firing range. Similar to the dispatchable range, if there are three PSUs and each is registered with an equal ST share, each one would be modelled with a third of the ST's duct firing range.

If a PSU is operating in single-cycle mode, the ST's contributions to the operating ranges are dropped. In other words, in single-cycle mode the operating ranges of the PSU are equal to the operating ranges of the corresponding CT. See **Figure 5** for an illustration of single-cycle mode mapping.

Figure 5: Mapping Operating Ranges in Single-Cycle mode



3.3. Offering Pseudo-Units

Today, market participants can elect to offer both energy and operating reserves (OR) on a PSU basis or as individual physical CT and ST units in the DACP. In the future market, this option will still be available. If a market participant has elected to operate as a PSU, they will offer into the market on a PSU basis only.

Table 4: Comparison of Current and Future PSU Offers

		Timeframe		
Area	**Design**	**DA**	**PD**	**RT**
Offers	Current	PSU	PU[5]	PU
	Future	PSU		

PSU offers into the DAM will be carried forward in PD and RT and can be revised within applicable offer revision timelines.

Market participants with CCP facilities will be responsible for providing additional dispatch data to enable PSU model evaluation by the DAM, PD, and RT calculation engines. The dispatch data that market participants would submit for their PSUs and their PUs is included in **Table 5**.

[5] PU offers are submitted into the day-ahead timeframe for use in PD.

Table 5: Dispatch Data for PSU Modelling

Data Input	Description	PSU/PU
Energy Offer	Price-quantity pairs for energy	PSU
OR Offer	Price-quantity pairs for OR	PSU
Start-up Offer	The cost to bring an offline generation unit through start-up procedures to reach its MLP	PSU
Speed-no-load Offer	The cost to operate a generation unit that is synchronized to the grid while injecting no energy	PSU
Ramp Data	Ramp rate to specify the speed at which a PSU can increase or decrease its output for energy and OR, including break point quantities	PSU
Maximum Daily Energy Limit	Optional maximum energy amount that a generation unit can be scheduled to supply in a dispatch day	PSU
Single-cycle Mode	Flag to indicate if CT is operated in a mode without the ST contribution to its corresponding PSU	PU (CT)
MLP	Minimum output that a CT or ST unit must maintain to remain stable	PU (CT & ST)
MGBRT	Minimum number of consecutive hours a CT unit must be scheduled to at least its MLP	PU (CT)
Minimum Generation Block Down Time	Minimum time in hours between the last time a resource was at MLP before de-synchronization and when it can be scheduled back to its MLP after re-synchronizing the CT, based on its current operating state (e.g. cold, warm, hot)	PU (CT)
Maximum Number of Starts Per Day	Maximum number of times that a CT unit can physically be started in a dispatch day	PU (CT)
Lead Time	Minimum time in hours for CT unit to start-up and reach its MLP from an offline state, depending on the thermal operating state of the generation unit (e.g. cold, warm, hot)	PU (CT)
Ramp up Energy to MLP	Number of hours required to ramp each CT and ST unit to MLP and the average MWs for each ramping hour	PU (CT & ST)

3.4. Scheduling Pseudo-Units

The future day-ahead, PD, and RT calculation engines will generate schedules and prices on a PSU basis for energy and OR. Subsequently, the engines will translate PSU schedules to PU schedules for the CT and ST units. PU schedules are required for security analysis and settlements.

Table 6: Comparison of Current and Future PSU Schedules

		Timeframe		
Area	**Design**	**DA**	**PD**	**RT**
Schedules	Current	PSU → PU	PU	PU
	Future	PSU ←→ PU	PSU ←→ PU	PSU ←→ PU

In the above table the bi-directional arrow ←→ means that in the future scheduling will be on PSU, but the scheduling engines will need to translate PSU to PU and vice versa.

In this section, the following scheduling topics will be discussed:

- Schedule notifications
- Pseudo-unit commitments
- Operating reserve schedules
- Scheduling DAM and PD ramp to MLP
- Scheduling RT ramp to MLP
- Dispatch instructions
- Operational limitations
- Single cycle operation

3.4.1. Schedule Notifications

In all timeframes, the PSU schedule will provide information on how the market participant has been scheduled given their PSU offer, and the PU schedule will be based on the translation of their schedule from the PSU to PU.

The DAM will publish confidential energy and operating reserves schedules for each of the PSUs (i.e., PSU1, PSU2, PSU3), which will also be translated into schedules for each of the physical resources (i.e., CT1, CT2, CT3, and ST) associated with a PSU.

Similarly, throughout the PD scheduling process, PD will publish energy and operating reserves schedules for each of the PSUs, and schedules for each of the physical resources associated with a PSU.

The RT scheduling process will produce PSU dispatches that will be translated into PU dispatches on the CT and ST. PU dispatches will be sent to the dispatch workstation. PSU dispatches will be available for informational purposes, in order to reconcile PSU offers and scheduling outcomes.

3.4.2. Pseudo-Unit Commitments

The DAM and PD scheduling process will produce commitments for PSUs, as it does for other NQS resources. PSU commitments will be translated into PU commitments on the CT and ST. These commitments will be used as an input into subsequent PD and RT scheduling processes. Like the commitments produced in DACP today, the ST commitment will reflect the configuration-based MLP depending on the number of CTs committed.

3.4.3. Operating Reserve Schedules

Currently, operating reserve (OR) scheduling uses a different modelling approximation than is used for energy schedules. Energy and reserve are co-optimized and scheduled on the PSU. Energy schedules on the PSU are translated into energy schedules on the PU using the proportional relationship defined by the PSU model. Operating reserve schedules on the PSU are allocated to the PU based on available capacity on the CT and ST; they are not necessarily assigned with the same proportional relationship as used for energy. This modelling approach can lead to:

- PU operating reserve schedules that are not feasible since they do not respect proportional loading of CT and ST;
- Operating reserve schedules which overstate the actual capability of the PSU; and
- A lack of consistency in how operating reserve schedules are allocated from PSU to PU, which adds complexity to the settlement of operating reserve schedules.

While this was an acceptable modeling approximation with PSU scheduling in the DACP only, in the future market where PSU will also be scheduled in real-time, reserve schedules must reflect actual capabilities. This is imperative so that DAM financially binding operating reserve schedules are viable and in real-time satisfies IESO's reliability requirements by being fully deliverable by market participants.

In the future market, scheduling engines will evaluate the PSU offer, PU derates, and the proportional relationship between the CT and ST to determine the effective operating region of the PSU. This evaluation will be used to limit scheduling of both energy and operating reserves for the PSU. PSU 10-minute and 30-minute operating reserve schedules will be translated to PU operating reserve schedules using proportional allocations just as they are for energy. This will ensure that all PSU energy and reserve schedules are viable.

3.4.4. Scheduling DAM and PD Ramp to MLP

Market participants will submit a new parameter for NQS facilities called 'Ramp up Energy to MLP' to describe their ramp profile. This parameter defines the quantity of energy they will inject in each hour from the time they synchronize to the time they reach MLP. Ramp up Energy to MLP will be used to schedule NQS facilities for ramp hours up to MLP in the DAM and PD scheduling process. The ramp to MLP will be financially binding in DAM.

For combined cycle plants offering as PSU, market participants will submit Ramp up Energy to MLP for the CT and the ST for each thermal state. The Ramp up Energy to MLP for the ST will represent its ramp profile in a 1x1 configuration, where there is only one CT online. The DAM and PD calculation engines will combine the Ramp up Energy to MLP for the CT and ST to determine the PSU ramp profile. This calculated PSU Ramp up Energy to MLP will be used to schedule the PSU in the DAM and PD scheduling processes.

Example of PSU and PU Ramp Schedules for 1x1 Configuration

For example, assume a market participant submits the parameters in **Table 7** as part of its daily dispatch data for the PUs in a 1x1 PSU configuration:

Table 7: Example - PU Ramp Schedules (1x1)

Parameter	CT	ST
Number of hours ramping	2	2
Quantity for Hour 1	50 MW	0 MW
Quantity for Hour 2	70 MW	30 MW

The DAM/PD calculation engine would construct the PSU ramp profile by adding the ramp profile data submitted for the CT and ST:

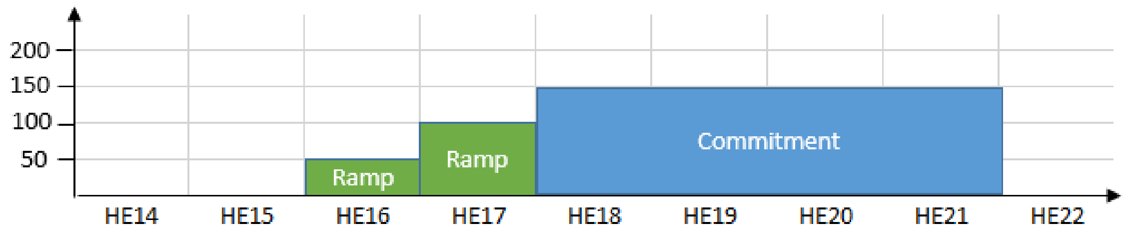
PSU_1

PSU_1 Ramp Hour 1 $= CT_1\ Ramp_{Hour\ 1} + ST\ Ramp_{Hour\ 1}$
$= 50\ MW + 0\ MW$
$= 50\ MW$

PSU_1 Ramp Hour 2 $= CT_1\ Ramp_{Hour\ 2} + ST\ Ramp_{Hour\ 2}$
$= 70\ MW + 30\ MW$
$= 100\ MW$

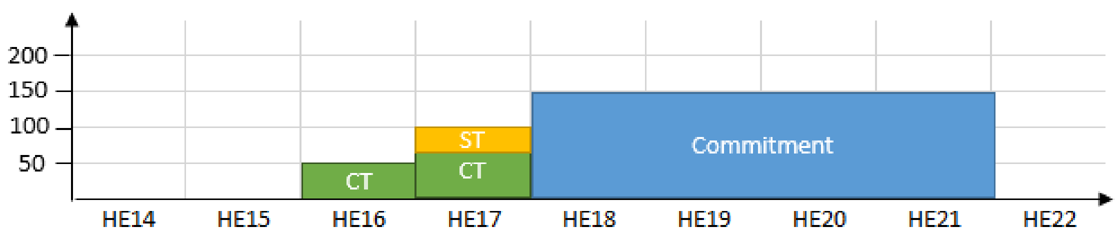
The DAM/PD calculation engine would schedule the PSU ramp hours based on the PSU ramp profile. An example of a schedule the PSU could receive is included in **Figure 6**.

Figure 6: Example: PSU_1 Ramp Schedule (1x1)



After determining the PSU schedule, the calculation engine would translate the PSU schedule back to individual PU schedules. For this example, the PU ramping schedules would match the submitted ramp profile on the CT and ST, as shown in **Figure 7**.

Figure 7: Example: PU Ramp Schedules for PSU_1 Ramp



3.4.5. Scheduling RT Ramp to MLP

Ramping to MLP in real-time will be scheduled on an interval basis by the RT engine based on offered ramp rates, not the hourly ramp profile used in DAM and PD. Today, CT and ST are dispatched up to their respective MLP based on ramp rates provided on the CT and ST. In the future, the IESO will dispatch PSUs to the PSU MLP based on PSU ramp rates. PSU ramp rates will be submitted by the market participant in their hourly offer and will reflect the combined ramp capability of both the CT and ST.

Like today, the market participant will provide synchronization times for both the CT and the ST. Synchronization times are used to inform RT scheduling for dispatch advisory intervals. Dispatch advisories are provided to market participants to indicate how their resources will likely be dispatched in future intervals. The CT synchronization time will be used to indicate when the PSU will be considered synchronized and dispatchable. The dispatch advisory will show PSU schedules starting at the CT synchronization time with the entire schedule assigned to the CT. Advisory intervals after the ST synchronization time will show the PSU schedule translated to both CT and ST schedules.

Also like today, a dispatch instruction will not be sent to either the CT or the ST until their respective sync breaker is closed and the generating unit is synchronized to the grid. As soon as the CT sync breaker closes, the RT engine will assume the PSU is in-service and will dispatch the PSU up to its MLP using the

PSU ramp rates. The RT engine will assign the entire PSU dispatch to the CT until the ST sync breaker has closed. Once both units are synchronized to the grid, the PSU dispatch will be translated to CT and ST dispatches based on their proportional relationship in the MLP operating range.

3.4.6. Dispatch Instructions

Today, dispatch instructions for the CT and the ST are sent to market participant dispatch workstations. In the future market, the RT calculation engine will economically schedule the PSU. The PSU dispatch will be translated into PU dispatch instructions based on the proportional relationship between the CT and ST. Market participants will continue to receive the dispatch instruction for the CT and the ST on their dispatch workstation. The PSU dispatch will be provided for informational purposes to assess scheduling outcomes.

Table 8: Comparison of Current and Future PSU Dispatches

		Timeframe		
Area	**Design**	**DA**	**PD**	**RT**
Dispatches	Current	-	-	PU
	Future	-	-	PU, PSU

3.4.7. Compliance to Dispatch

There will be no changes to compliance aggregation or compliance deadbands. CCP facilities registered as a compliance aggregate will continue to be assessed for compliance to dispatch based on the combined dispatch and output of all generating units at the station. CCP facilities that are not registered as a compliance aggregate will continue to be assessed for compliance to dispatch based on the PU output and dispatch.

In situations where unit-specific dispatch is required for reliability, the IESO may revoke compliance aggregation like it does today. When this occurs, each generating unit will need to follow the PU dispatch to each CT and ST. Similarly, there are situations where the IESO may require a change in output for reliability and will verbally dispatch resources up or down to new dispatch targets. The IESO may continue to issue verbal dispatch instructions on the station and/or specific generating units, not on the PSU.

3.4.8. Operational Limitations

Market participants will continue to report outages and derates on their PU. In the future, outages will be translated back to the PSU in all timeframes so that the scheduling engine has the latest information.

Likewise, if a generating unit must generate at a specific minimum output to prevent endangering the safety of any person, equipment damage or the violation of an applicable law (SEAL), market participants will communicate the need to the IESO for the affected PU. The IESO will apply the minimum generation constraints on the PU. The calculation engines will translate the PU outage/derate/constraint to a physical limitation back to the PSU using the proportional relationship established by the model. This will be used in subsequent scheduling to produce PSU and PU schedules that respect operational limitations of physical equipment.

Table 9: Comparison of Current and Future PSU Outages, Constraints, and Verbal Dispatches

Area	Design	Timeframe DA	PD	RT
Outages	Current	PU → PSU	PU	PU
	Future	PU → PSU	PU → PSU	PU → PSU
Constraints, verbal dispatches	Current	PU	PU	PU
	Future	PU→ PSU	PU→ PSU	PU→ PSU

3.4.9. Single Cycle Operation

Today, CCP facilities registered as PSU can opt to be evaluated in DACP[6] as running in single-cycle mode (without the associated steam turbine). This election is indicated through the Single-Cycle Mode flag as part of the daily generator data. In the future market, this flag will be used by scheduling engines in all timeframes.

Market participants can elect to be evaluated by the DAM engine as operating in either single or combined cycle mode. Market participants may have the ability to change their operating mode post-DAM, but there may be restrictions on changing modes and the timing of changes to prevent gaming or the exercise of market power. At any point, the PSU can change from combined to simple cycle operation due to a forced outage of the steam turbine.

4. Pseudo-Unit Settlement

Facilities operating under the PSU model will continue to be settled on a PU basis. The IESO explored settlement on a PSU basis for facilities operating under the PSU model and determined that it is not currently feasible due to Measurement Canada regulations.

Table 10: Comparison of Current and Future PSU Settlement Treatment

Topic	Design	Timeframe DA	PD[7]	RT
Settlement Price	Current	-	-	PU
	Future	PU	-	PU
Settlement Quantity	Current	-	-	PU
	Future	PU	-	PU

4.1.1. DAM Two-Settlement

There is no impact or additional complexity for DAM two-settlement for PU operating under the PSU model. For NQS generators operating under the PSU model, the settlement of the DAM will be based

[6] PSU's are only in DACP today. In PD the CT and ST are evaluated independently. There is no concept of single or combined cycle in the PD scheduling process. Market participants may receive a CT schedule and no ST schedule. They can elect to bring the ST on with a SEAL constraint or run single cycle.

[7] Although NQS facilities may be committed in the PD timeframe, settlement is based on price and quantity in the DAM and Real-Time Market (RTM).

upon the standard first settlement and second settlement. A PSU-specific variant is not required for DAM two-settlement.

Figure 8: DAM Settlement Equation for Resources Submitting their Own Bids/Offers

Equation 1 – DAM Settlement for Resources that Submit Their Own Bids/Offers

$$\text{DAM Settlement} = Q_{DA}^{m} \times P_{DA}^{m}$$

Equation 2 – RT Balancing Settlement for Resources that Submit Their Own Bids/Offers

$$\text{RT Balancing Settlement} = (Q_{RT}^{m} - Q_{DA}^{m}) \times P_{RT}^{m}$$

Where:

Q_{DA}^{m} **is the day-ahead quantity of energy or operating reserve scheduled at *wholesale meter or intertie metering point* 'm' for a given settlement hour.**

P_{DA}^{m} **is the day-ahead LMP of energy or operating reserve at *wholesale meter or intertie metering point* 'm' for a given settlement hour.**

Q_{RT}^{m} **is the real-time quantity of energy generated or consumed, or operating reserve scheduled at *wholesale meter or intertie metering point* 'm' for a given settlement hour.**

P_{RT}^{m} **is the real-time LMP of energy or operating reserve at *wholesale meter or intertie metering point* 'm' for a given settlement hour.**

The two-settlement system requires DAM PU quantities and real-time market (RTM) PU quantities, as well as DAM and RTM PU locational marginal prices (LMPs).

- Quantity ("Q"): energy and operating reserve quantities for the PU resources associated with the PSU.
- Price ("P"): energy and operating reserve LMPs for the PU resources associated with the PSU.

The DAM and RTM calculation engines will produce all settlement inputs except the metered quantities for each PU which will be known after the fact. The PU LMPs and PU quantities will be used for DAM two-settlement for the PU associated with a PSU.

4.1.2. Other Settlement Amounts

In order to calculate other settlement amounts, PU offers will continue to be derived from PSU offers in a manner consistent with the existing methodology. For example, make-whole payment settlement amounts require a comparison of cost and revenues to determine whether a cost recovery payment is required.

The implied offers, i.e. Derived Interval Price Curve (DIPC), for the PU establish the cost side of providing energy, which is compared to the market revenues for the PU in order to accurately calculate any payment for each PU. Since PSUs do not offer on a PU basis, the PU energy and OR offers will be derived from PSU energy and OR offers, achieving a derived interval price curve for each PU, to represent the cost. The DIPC is further described in **Section 4.2**.

As a result of settling on a PU basis, the calculations will be more complex for make-whole payments; however, the resulting settlement will be largely the same as if settlement was performed on the PSU[8].

PSU modelling will impact guarantees and make-whole the following future settlement amounts:

- DAM guarantee/make-whole payment (MWP);
- RT guarantee; and
- RT MWP.

The DAM guarantee/MWP will provide compensation when revenues are insufficient to recover as-offered costs during the DAM financially binding schedule. In addition, the IESO will continue to have a RT guarantee based on as-offered costs for NQS generators that are committed in the PD timeframe to meet changing system conditions. Finally, the RT MWP will provide the incentive to follow dispatch instructions to a facility that has been dispatched up or dispatched down, and this settlement amount will also be impacted by PSU modelling.

The PU will recover any revenue shortfall on its share of the PSU as-offered costs. There is no difference in the eligibility conditions for recovery of as-offered costs for a CT whether it is operating as part of a PSU or not. The CT will recover its share of the PSU offered costs if it meets all eligibility conditions (e.g. completing MGBRT). The ST will recover its share of the PSU offered costs for each PSU whose associated CT meets all eligibility conditions.

4.2. Derived Interval Price Curve and Derived Interval Guarantee Quantity

Derivation of PU offer curves from PSU offer curves will continue as today, but will be required across all timeframes in the future. The Derived Interval Price Curve (DIPC) and Derived Interval Guarantee Quantity (DIGQ) formulation methodology under the renewed market will be very similar to that under DACP:

- The DIPC is the PU offer curve that is constructed by decomposing PSU offers. In the current market, the DIPC applies only to generation units associated with a combined-cycle plant using the PSU model in DACP. Refer to Appendix B of Market Manual 9.5 for explanation of DIPC formulation under the current market.

- The DIGQ is the portion of the ST energy schedule eligible for cost recovery. In the current market, this is the sum of the ST portion of the day-ahead PSU schedules from all PSUs where the associated CT is injecting energy in that interval. Refer to Appendix C of Market Manual 9.5 for explanation of DIGQ formulation under the current market.

In the future market, DIPC and DIGQ formulation will be required to calculate settlement amounts for the PU associated with a PSU.

4.2.1. Energy Market

Since there will be PSU modelling in all timeframes, it will be necessary to derive PU offer curves from the PSU offer curve for any calculation that requires PU offer curves.

[8] Performing settlement on a PU basis could result in a different settlement amount than if performed on the PSU because each PU guarantee/MWP will have a minimum of zero.

The DIPC will continue to derive CT and ST energy offers from PSU energy offers based on PU relationships, by decomposing PSU offers. The DIGQ will continue to be the portion of the ST schedule eligible for cost recovery, which will be the sum of the ST portion of the PSU schedules from all PSUs where the associated CT is eligible for the MWP/guarantee in question.

These formulations will allow comparison of all as-offered costs against actual revenues in the energy market for the PU. Market manuals will outline the formulation of each DIPC and DIGQ. At a high level:

- The DIPC and DIGQ for DAM guarantee/MWP will be calculated using the DAM PSU offer curves and the DAM scheduled quantity, as well as the eligibility requirements.
- The DIPC and DIGQ for RT guarantee will be calculated using the RT PSU offer curves and the RT economic operating point (EOP) of each PU.[9] The formulation steps will incorporate the eligibility requirements specific to the RT guarantee.
- The DIPC and DIGQ for a CT associated with a PSU for RT MWP will be calculated using the RT PSU offer curves and the RT EOP of the CT. The RT MWP calculation for a ST associated with a PSU will require two unique sets of DIPC and DIGQ, one based on EOP and the other based on RT schedules.

Table 11: Overview of Formulation of DIPC and DIGQ

Specific Use	DAM guarantee/MWP	RT guarantee	RT MWP
Timeframe of PSU Offer Curves	DAM	RT	RT
Quantity Variable	DAM schedule	EOP	EOP and RT schedule

4.2.2. Operating Reserve Market

Implied PU operating reserve offers will be derived from PSU OR offers across all timeframes. OR settlement in the current market avoids the need for such a translation by simply using the RT PU OR offer. However, the RT PU OR offer will not be available in the future when we have only PSU OR offers in all timeframes.

In order to determine as-offered OR costs on a PU basis, the model will construct an OR offer DIPC for each class of reserve in a manner that is similar to the energy offer DIPC. The difference is due to the fact that OR offers, unlike energy offers, are not tied to any particular output level or operating region. As a result, the OR offer curves may have different underlying CT:ST shares depending on the schedules for energy and other classes of OR. The PSU offer curves will not change based on energy and OR scheduling, except when curtailed to respect maximum capacities. However, the resulting CT and ST DIPCs will depend on which operating regions the OR offer curves occupy.

Since a PSU must be committed to at least MLP in order for any OR to be scheduled, the OR offer curves may only occupy the dispatchable and duct-firing regions, which further simplifies the OR DIPC formulation. Since there will be PSU modelling in all timeframes, it will be necessary to derive PU OR offer curves from the PSU OR offer curve for any calculation that requires PU OR offer curves.

[9] The implementation of a single schedule market will introduce a new concept of the economic operating point. The EOP indicates the profit-maximizing operating point of a facility that is implied by the RTM LMPs for energy and OR.

5. Next Steps

In preparation for the engagement session, stakeholders are encouraged to submit any questions or requests for clarification that they would like to discuss in the session.

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