Combined Cycle Plant Modelling

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Agenda

Generators have provided feedback that the IESO needs to address combined cycle modelling under the MRP HLD. This presentation will provide an overview of CCP modelling, requirements for the future, and next steps.

Agenda:

- What is a combined cycle plant (CCP)?
- Current IESO modelling approach for CCPs
- Jurisdictional scan – common methods and timeframes
- Issues with the current IESO CCP modelling approach
- Discussion of future CCP modelling approach
- Detailed Design – Next Steps

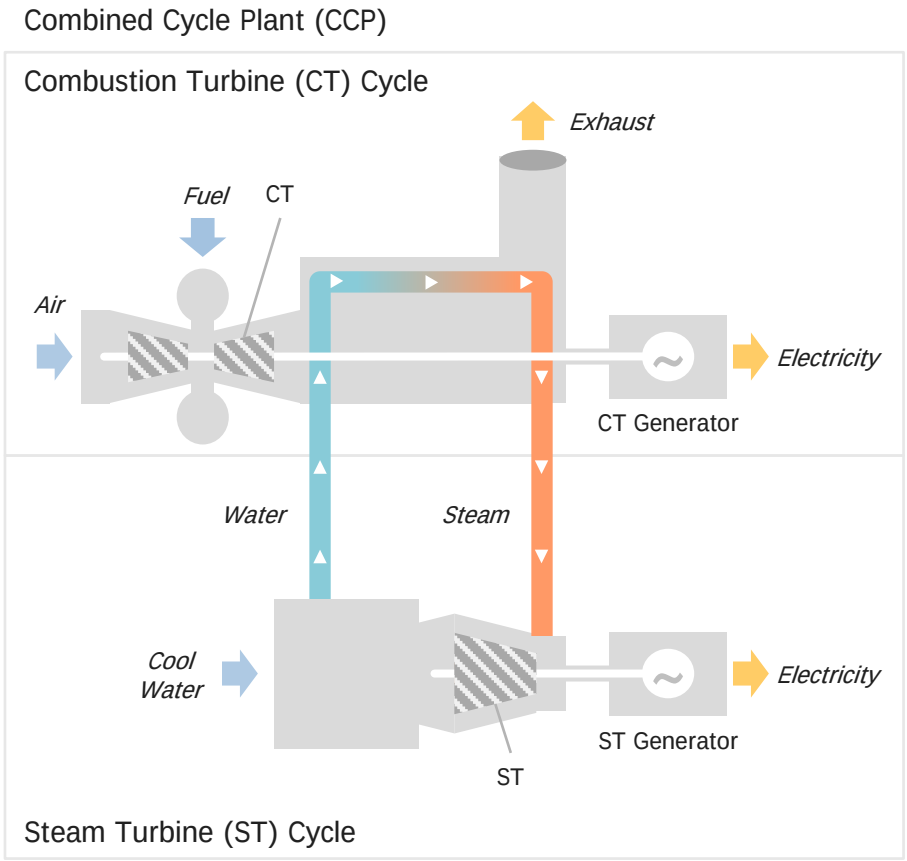
What is a Combined Cycle Plant?

Combined Cycle Plant (CCP):

- Consists of 1 or more fuel fired combustion turbine (CT) and 1 steam turbine (ST)
- Routes waste heat from CTs to ST, generating extra power through converting water to steam
- Produces up to **50%** more electricity from same fuel compared to traditional simple cycle (CT only)

CCPs have 3 operating ranges:

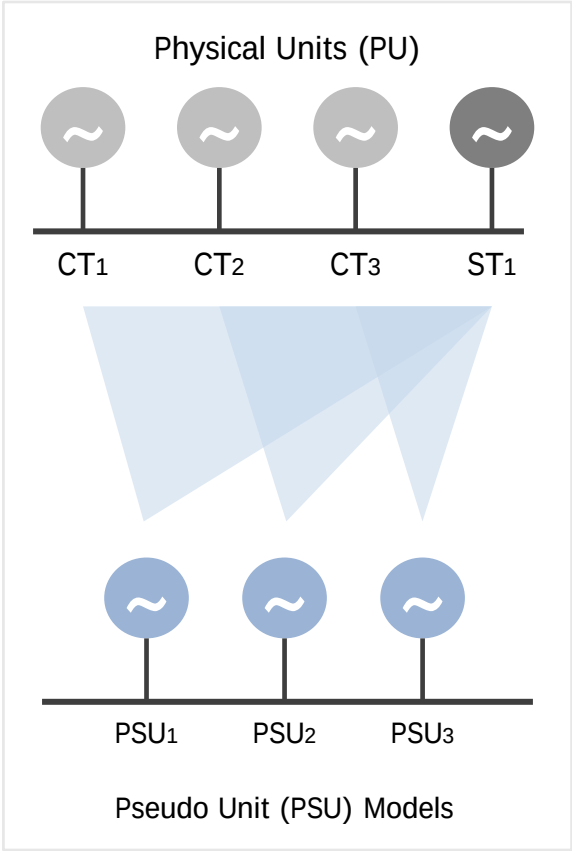
- MLP
- Dispatchable above MLP
- Duct-firing: At 100% CT utilization, ST can provide additional capacity from fuel injections



IESO CCP Modelling Approach – Overview

Pseudo Unit (PSU) Model:

- ✓ Allows market participants to offer energy into DACP using "pseudo units" (i.e., PSU_1, PSU_2, PSU_3) on a voluntary basis
- ✓ Reflects CCP operational dependencies for appropriate DA energy commitments
- ✓ Varies with different CCP configurations, where PSUs can have up to **4** MLP values
- ✓ Translates DA **energy** schedules from PSUs to ST/CTs based on physical unit (PU) relationships and loading proportions
- ✓ IESO schedules DA **operating reserve** on a PSU basis while translation to PUs uses remaining capacity on CTs & ST for OR



3x1 CT-ST Configuration

IESO CCP Modelling Approach – Examples

Example 1: Total ***capacity*** (including Duct Firing) from a 3x1 CCP configuration is represented by 3 PSU formulas:

- $PSU_{1,Max} = CT_{1,Max} + \frac{ST_{1,Max}}{3}$
- $PSU_{2,Max} = CT_{2,Max} + \frac{ST_{1,Max}}{3}$
- $PSU_{3,Max} = CT_{3,Max} + \frac{ST_{1,Max}}{3}$

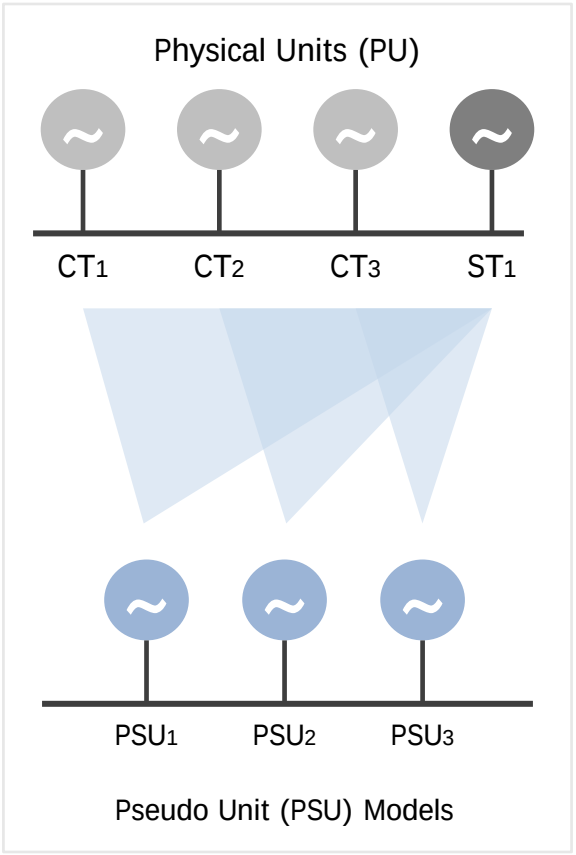
Example 2: Depending on the number of CTs online, ST ***output*** varies according to submitted data. For example*, Resource A @ MLP:

$CT_{1,2,3\ @\ MLP}$ = 50 MW

$ST_{1,2,3\ @\ MLP}$ = 1x1) 25 MW, 2x1) 55 MW, or 3x1) 85 MW

$PSU_{1,2,3\ @\ MLP}$ = 75 MW

**for illustrative purposes*



3x1 CT-ST Configuration

Jurisdictional Scan – Common Approaches

Today, **three main CCP modelling methods** are used across other jurisdictions with slight variations for increased model accuracy and / or simplified market procedures:

#	CCP Model	High Level Description	High Level Pros & Cons
1	**Aggregate Model**	• Accepts offers from / dispatches **entire CCP** as single generation resource	➢ **Pro:** Simplifies offers and settlement ➢ **Con:** Reduces operational efficiencies & incentives to offer at cost
2	**Pseudo Unit (PSU) Model**	• Represents **each CT and the associated portion of ST capacity** as individual generation resources	➢ **Pro:** Increases ST/CT dependency modelling accuracy ➢ **Con:** Does not model all configurations and transitions between them
3	**Configuration Based Model (CFBM)** *i.e. Combined Cycle Trains (CCT)*	• Represents different **operating states / cycles and corresponding physical units** as mutually exclusive generation resources	➢ **Pro:** Most accurate for transition dependencies, incremental energy costs, ramping rate changes, etc. ➢ **Con:** Costly to implement, performance issues, challenge to perform CBA

IESO Today? *PSU modelling in DACP.*

Jurisdictional Scan – Timeframe Consistency

Other jurisdictions use various CCP models **consistently across market timeframes**. The IESO uses pseudo unit modelling but only in the DA timeframe; it was not necessary to implement across all timeframes with DACP – no financially binding schedules.

#	CCP Model	Other Jurisdictions	Timeframes
1	**Aggregate Model**	1. MISO 2. PJM 3. NYISO 4. XM (Columbia)	✓ *All market timeframes*
2	**Pseudo Unit (PSU) Model**	1. NE-ISO 2. NYISO 3. *PJM Prototype*	✓ *All market timeframes*
3	**Configuration Based Model (CFBM)** *i.e., Combined Cycle Trains (CCT)*	1. ERCOT 2. SPP 3. CAISO 4. *MISO Prototype* 5. *PJM Review*	✓ *All market timeframes*

IESO Today? *Differs as PSU model only in DA timeframe.*

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IESO CCP Modelling Approach – Key Issue

The PD and RT models don't consider feasible CCP operating ratios / dependencies captured by DACP PSU modelling, impacting PD & RT schedules:

- DACP publishes schedules for each physical resource associated with a PSU, and participants use the physical resources to offer in PD & RT
- Generators try achieving feasible CT/ST dispatch by submitting CT & ST offers
- When PD and RT scheduling does not reflect CCP dependencies, generators must contact the CRO to intervene in the physical unit scheduling
- ST duct firing operations further impacts PD and RT schedules
- DA operating reserve is scheduled on a PSU basis with translation to PUs using remaining capacity on CTs & ST for OR, which may result in infeasible OR schedules

CCP Modelling by Market Timeframe:

		Day-Ahead	Pre-Dispatch	Real-Time	Post-Operations
Modelling Approach	**CCP Data Type**	Energy Offers / Sched	Energy Offers / Sched	Energy Offers / Sched	Metering / Settlements
Modelling in 1 Timeframe: DACP Only	Modelled Unit	✓			
	Physical Unit	✓	✓	✓	✓

Future CCP Modelling Approach

With a future DAM, generators will be subject to financially binding schedules, where inconsistencies between DAM & RT result in financial impacts. Therefore, CCP modelling will be applied across all 3 timeframes.

Expected Benefits:

- ✓ Improve feasibility of dispatch schedules, reducing CRO intervention
- ✓ Allow generator offers to reflect operating costs without implicating feasibility constraints in PD & RT
- ✓ Allow generators to more effectively manage two settlement under DAM

CCP Modelling by Market Timeframe:

		Day-Ahead	Pre-Dispatch	Real-Time	Post-Operations
Modelling Approach	**CCP Data Type**	Energy Offers / Sched	Energy Offers / Sched	Energy Offers / Sched	Metering / Settlements
Modelling in 3 Timeframes: DAM, PD, & RT	Modelled Unit	✓	✓	✓	
	Physical Unit	✓	✓	✓	✓

Detailed Design – Next Steps

In order to apply CCP modelling across all timeframes, detailed design will require significant stakeholder involvement, and will include the following:

1. Assess alternative CCP models, considering Ontario requirements:
   - For example, what is the impact of a longer PD look-ahead & commitment timeframe on alternative CCP model effectiveness?
2. Determine operational requirements for managing CCP configuration changes in RT (e.g. due to unit outages, de-rates)
3. Review model data conversion requirements relative to Measurement Canada regulations on whole meter data for settlement
4. Address impacts on internal processes for operations and settlement for energy and operating reserve markets

Stakeholder feedback is requested by August 17.