# Overview/Update on Implementation of Enhanced Combined Cycle (ECC) Model

Keyur Patel
Sr. Lead Market Design Specialist
Market Design

Combined Cycle Modeling Education Workshop

October 20, 2022

# Agenda

1. Background of Previous Groups' work related to Enhanced Combined Cycle (ECC) model
2. Performance impact with Market Clearing Engine (MCE) multi-schedule model in current production vs nGEM ECC model
3. Consideration of multi-schedule model in MCE optimization in current production model vs. nGEM ECC model
4. Comparison of implementation of ECC model in various ISOs/RTOs
5. Next Steps

# Previous Group's Key Work Activities

| | | | |
|---|---|---|---|
| Review the work of prior groups addressing the model of combined cycle units | Promote understanding of generating plants and their need for a more flexible model | Identify market rules/mechanisms to integrate generation resources into PJM's markets such that their operating characteristics and capabilities are understood, are properly modeled and adequately compensated | Identify necessary changes to the OA, Tariff and manuals needed to implement any new model |

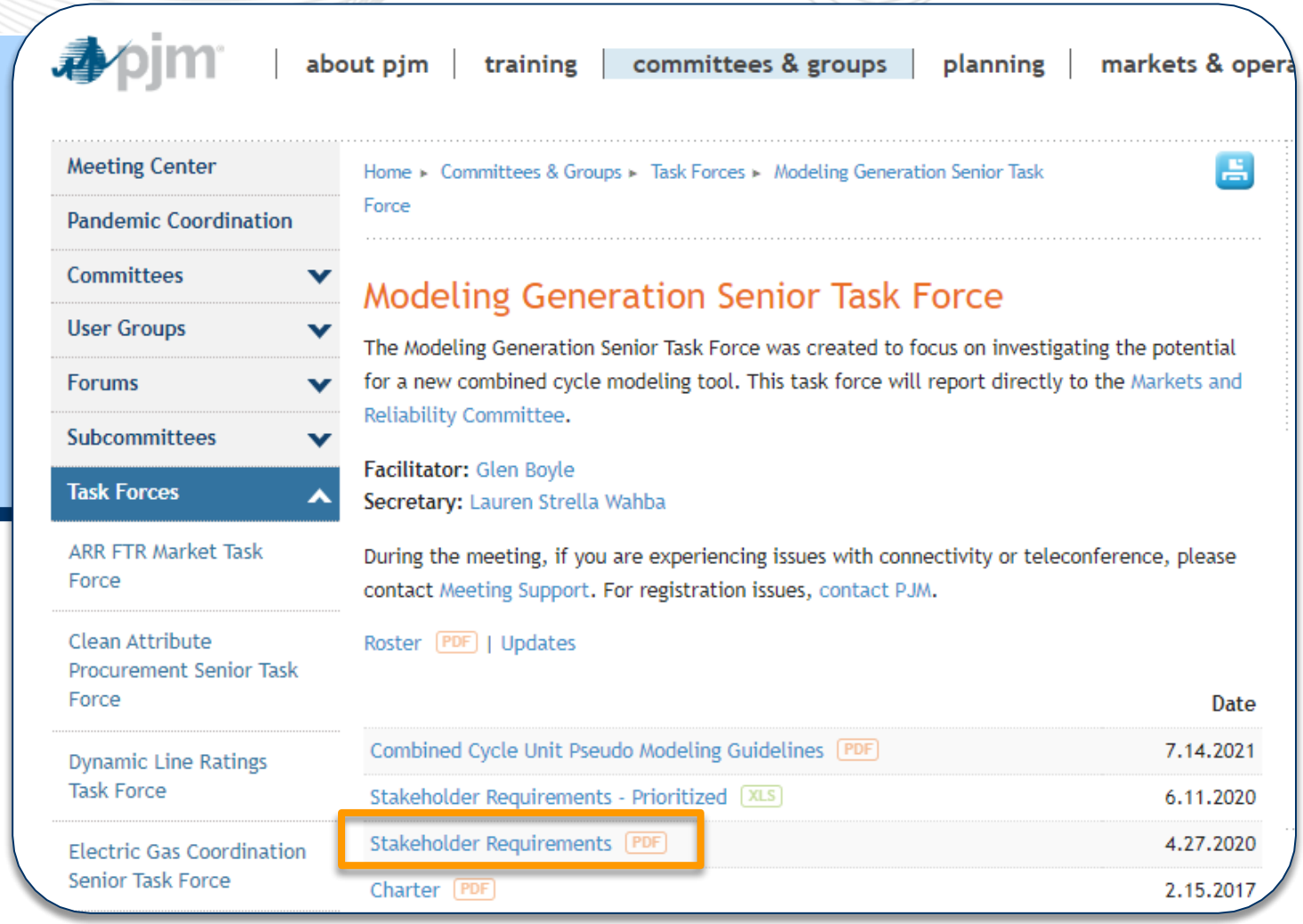
# Recommendations of Previous Group

| Stakeholder requirements document created for ECC model | Hourly segmented ramp rates | Additional offer segments | Soak Time |
|---|---|---|---|
| • Shared with GE<br>• Will guide nGEM implementation | Implemented | Implemented | Failed vote at MGSTF |

# Stakeholder Requirements for ECC Model

**The stakeholder requirements document** for the ECC model can be found under Committees & Groups > Task Forces > Modeling Generation Senior Task Force (MGSTF) meeting materials on PJM.com.

The document identifies requirements that are included in the base product, require customization or are not included in the current implementation plan. This may change when PJM starts developing detailed requirements.



# Summary of Requirements

## Requirements which need customization for PJM

- The transition time for each significant component/configuration of the plant including MW quantity – Modeling of MW quantity requires customization.
  - DA will provide an award during transition based on “from” configuration parameter.
  - RT will fix output at SE MW during transition.
- Modeling of Soak Time in Day-Ahead Market – PJM has modified the startup cost definition to include soak cost; therefore, PJM is not planning to implement this customization.
- Multi-schedule model (price-based offers and cost-based offers) in MCE.

***Note:*** *Requirements that are included in base product are not included here. Please refer to the previous slide for location of requirement document for more detail.*

## Requirements Not in Current Implementation Plan

**Ability to:**

- Model the transition matrix as state dependent, schedule dependent, fuel dependent and ambient-temperature dependent
- Handle both cost-based and price-based transitions
- Consider hourly differentiated Minimum Run Time in Day-Ahead Market
- Model any change in unit's operating mode that requires hold time/transition time modeled as X number of fixed segments of output (in incremental offer curve) or ramp rate
- Model pipeline switching, fuel switching, firm or non-firm fuel transport
- Model offline state as valid configuration

# Current Performance Impact With Multi-Schedule Model

| | |
|---|---|
| **Impact With Multi-Schedule Model in MCE** (During HWA/CWA/Max Gen Alert) | Each schedule of a resource is essentially modeled as a logical resource in MCE. |
| | If a resource has two schedules then, from MCE perspective, there are two logical resources. |
| | The day-ahead commitment software solution time increases by approximately 10 times compared to a normal operating day.<br>• This Performance Impact due to multi-schedule model in MCE is still manageable with the current 2.5-hour day-ahead solution time window. |
| | Real-time uses preferred schedule based on predefined formula. |

# Performance Impact of ECC Model With Multi-Schedule

| | |
|---|---|
| **Performance Impact With Multi-Schedule Model in MCE** (During HWA/CWA/Max Gen Alert) **+** **ECC Model** | Each configuration of a combined cycle plant is essentially modeled as a logical resource in MCE. |
| | A typical 2X1 combined cycle plant has six configurations. Hence, there will be six logical resources for a combined cycle plant per schedule in MCE. For two schedules, there will be 12 logical resources for MCE for six configurations with two schedules. |
| | Schedule specific transition matrix will further add additional constraints, complexity and solution time. |
| | As solution time is not linearly proportional to number of resources, we expect the solution time to drastically increase for commitment software. |

# Base nGEM ECC Model

**Cheapest schedule selection will be outside of optimization.**

- There will be only one schedule fed to the optimization engine.
- Multiple schedule model in optimization makes the model more complex, and MCE performance will be the biggest concern.

**No schedule specific transition matrix**
(i.e., transition matrix from "from" configuration to the "to" configuration will be at unit level or plant level).

Schedule specific transition matrix makes optimization formulation more complex and creates additional performance impact for MCE.

# Comparison of ECC Model in Various ISOs/RTOs

| | No. of Configurations | Multi-Schedule Model | No. of Combined Cycle Resources | Vendor | DA Clearing Window (Hours) |
|---|---|---|---|---|---|
| **SPP** | • Limited to three<br>• Must be able to start and stop when committed | No concept of Multi-Schedule model in MCE optimization | ~13 | GE | 3.5 |
| **ERCOT** | • No restrictions on number of configurations | | ~65 | ABB | 7.5 |
| **CASIO** | • Limited to six without any limitation on transition matrix<br>• If greater than six, limit eligible transitions between configurations for upward and downward transitions to two | | ~20 | Siemens | 3 |
| ***MISO** | • Limited to seven | | ~50 | GE | 3 |
| **PJM** | • TBD | Multi-Schedule model | ~100 | | 2.5 |

** MISO is not planning to implement ECC model in production until nGEM implementation.*

# Comparison of ECC Model in various ISOs/RTOs cont..

| | |
|---|---|
| **ERCOT<br>SPP<br>CAISO** | Implemented scaled back version of ECC model to reduce complexity and software performance impact. |
| | Multiple delays in implementation of ECC model. |
| | Experienced software performance impacts in implementation of ECC model despite having single set of parameters and incremental energy offers in MCE. |

# Issues With Other Future Models

**Current MCE doesn't have concept of different operating modes for Energy Storage Resource (ESR) model.** Commitment software solution time is unaffected by current self-scheduled ESR model.

- **nGEM ESR model** is a configuration-based model to accommodate all characteristics of Energy Storage Resource, which current model does not have. nGEM hybrid model will be the extension of ESR model.

- **Multi-Schedule model** in optimization for nGEM ESR model will impact the performance depending upon how many units participating in that model.

# Next Steps

Solicit additional topic for **Next meeting**.

**Discuss potential path forward** to minimize performance impact of ECC model.