Combined Cycle Resources in ERCOT Nodal Market

April 28, 2010

Introduction

Bob Spangler

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Workshop Agenda

Topic	Presenter	Time
Introduction & Overview	Bob Spangler / Bill Blevins	9:30 – 10:00
Registration	Art Deller	10:00 – 11:00
Break		11:00 – 11:10
Management & Operations Activities	Bill Blevins	11:10 – 12:10
Lunch Break		12:10 – 12:50
MMS / DAM / ASM / RUC / SCED Applications	Resmi Surendran	12:50 – 1:50
Break		1:50 – 2:00
Settlement & Billing Overview	Pam Shaw	2:00 – 3:00
Closure / Q & A	Bob Spangler	3:00 – 3:30

Historical Background

2007 – 2010

- Conceptual work was accomplished to allow Combined Cycle Trains (CCT) to offer each configuration of the train as separate Generation Resources into the Day-Ahead Market.
  - IDA 003 White Paper: Combined Cycle Unit Modeling in the Nodal Design
  - SIG 0003 Combined Cycle Plants
  - SIG 0022 Transmission Constrant Model for RT CCP Dispatch
- The optimization packages provided by the MMS vendor, ABB, are unitized at the individual Resource level. This necessitates the need for a logical link between a CCT configuration and an individual Generation Resource.
- All DAM, Adjustment Period and Real Time, and Settlement and Billing systems were reviewed
- The MMS and Commercial Systems Functional Requirement documents have been updated to include the Combined Cycle design implementation.
- April 23, 2010 ERCOT submitted NPRR 228 to revise Nodal Protocol requirements to encompass Combined Cycle Resources.

Protocol Subsections Impacted by the CCT Implementation

5 Protocol Sections affected as follows:

- 2.1 Definitions
- 3.8 Special Considerations for Split Generation Meters
- 3.9.1 Current Operating Plan
- 4.5.1 DAM Clearing Process
- 4.6 DAM Settlement
- 4.6.1 Day-Ahead Settlement Point Prices
- 4.6.2.3.1 Day-Ahead Make-Whole Payment
- 4.6.4.1.1 Regulation Up Service Payment
- 4.6.4.1.2 Regulation Down Service Payment
- 4.6.4.1.3 Responsive Reserve Service Payment
- 4.6.4.1.4 Non-Spin Reserve Service Payment
- 5.7.1 RUC Make-Whole Payment
- 5.7.1.1 RUC Guarantee
- 5.7.1.2 RUC Minimum-Energy Revenue
- 5.7.1.3 RUC Revenue Less Cost Above LSL During RUC-Committed Hours
- 5.7.1.4 Revenue Less Cost During QSE Clawback Intervals
- 5.7.2 RUC Clawback Charge
- 5.7.3 Payment When ERCOT Decommits a QSE-Committed Resource
- 5.7.4 RUC Make-Whole Charges
- 5.7.4.1 RUC Capacity-Short Charge
- 5.7.4.1.1 Capacity Shortfall Ratio Share
- 5.7.5 RUC Clawback Payment
- 5.7.6 RUC Decommitment Charge
- 6.5.5.2 Operational Date Requirements
- 6.6 Settlement Calculations for Real-Time Energy Operations
- 6.6.1 Real-Time Settlement Point Prices
- 6.6.3.1 Real Time Imbalance Payment or Charge at a Resource Node
- 6.6.5.1.1 Base Point Deviation Charge for Over Generation
- 6.6.5.1.2 Base Point Deviation Charge for Under Generation
- 6.6.5.4 Base Point Deviation Payment
- 6.6.6.1 RMR Standby Payment
- 6.6.6.2 RMR Payment for Energy
- 6.6.6.3 RMR Adjustment Payment
- 6.6.6.4 RMR Charge for Unexcused Misconduct
- 6.6.6.5 RMR Service Charge
- 6.6.7.1 Voltage Support Service Payments
- 6.6.8.1 Black Start Capacity Payment

Combined Cycle Train Protocol Definitions

Section 2, Definitions

- Generation Resource
  - A generator capable of providing energy or Ancillary Service to the ERCOT System and is registered with ERCOT as a Generation Resource. The term “Generation Resource” used by itself in these Protocols does not include a Non-Modeled Generator.
- Combined Cycle Train
  - The combinations of gas turbines and steam turbines in an electric generation plant that employs more than one thermodynamic cycle. For example, a Combine Cycle Train refers to the combination of gas turbine generators (operating on the Brayton Cycle) with turbine exhaust waste heat boilers and steam turbine generators (operating on the Rankin Cycle) for the production of Electric Power. In ERCOT Combined Cycle Trains are registered as a plant that can operate as a Generation Resource in one or more Combined Cycle Generation Resource configurations.
- Combined Cycle Generation Resource
  - A specified configuration of physical Generation Resources (Gas and Steam Turbines), with a distinct set of operating parameters and physical constraints, in a Combined Cycle Train registered with ERCOT.

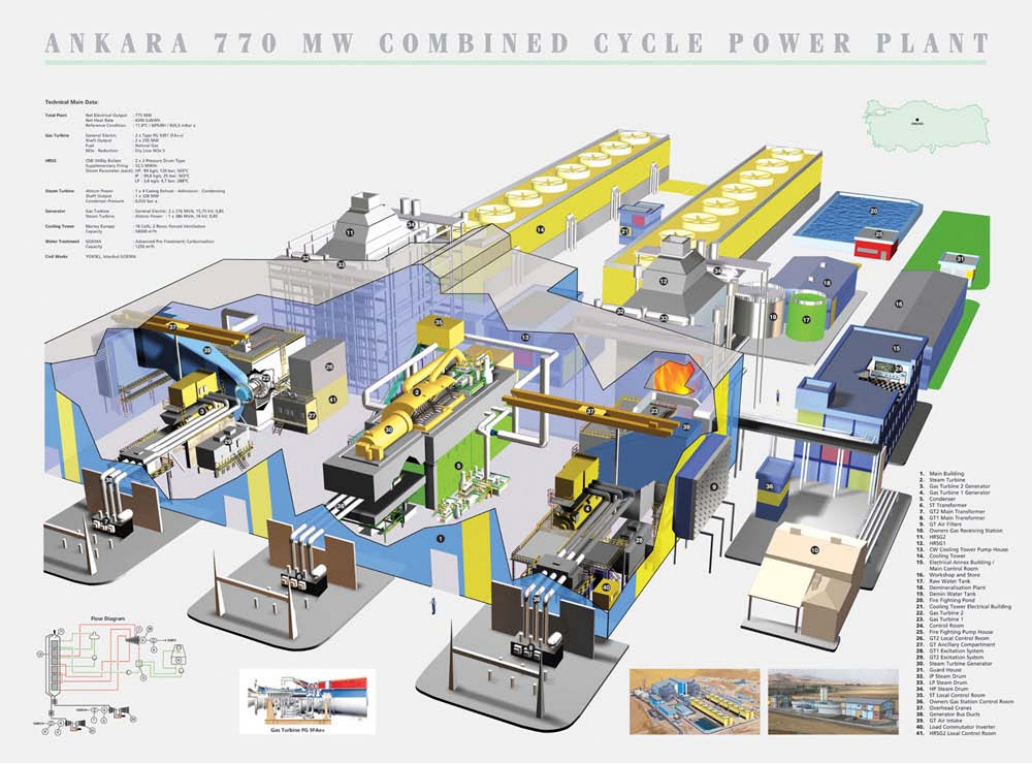
Modified

Added

Overview

Bill Blevins

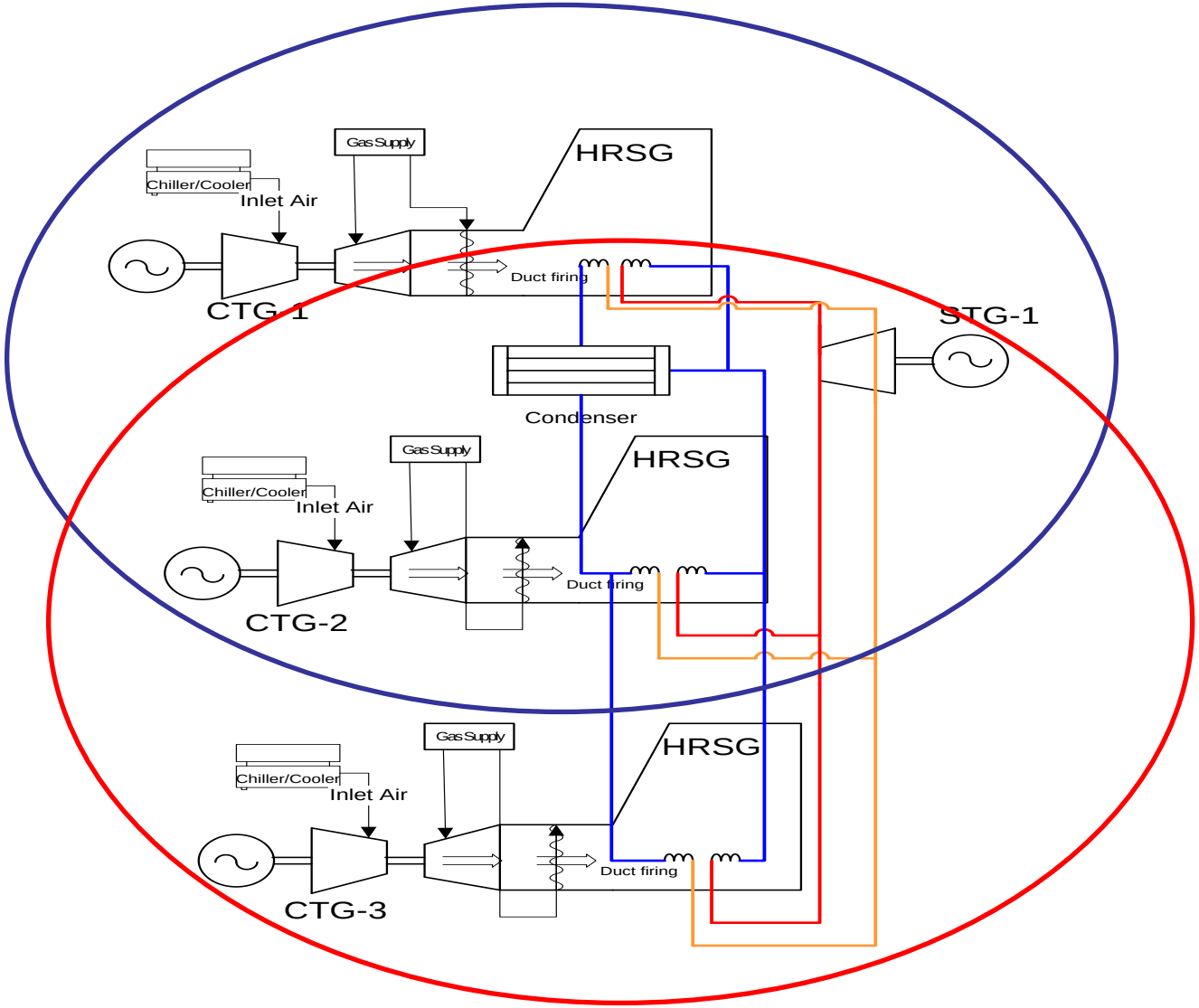
Typical Combined Cycle Train



Example Combined Cycle Train & Operating Configurations

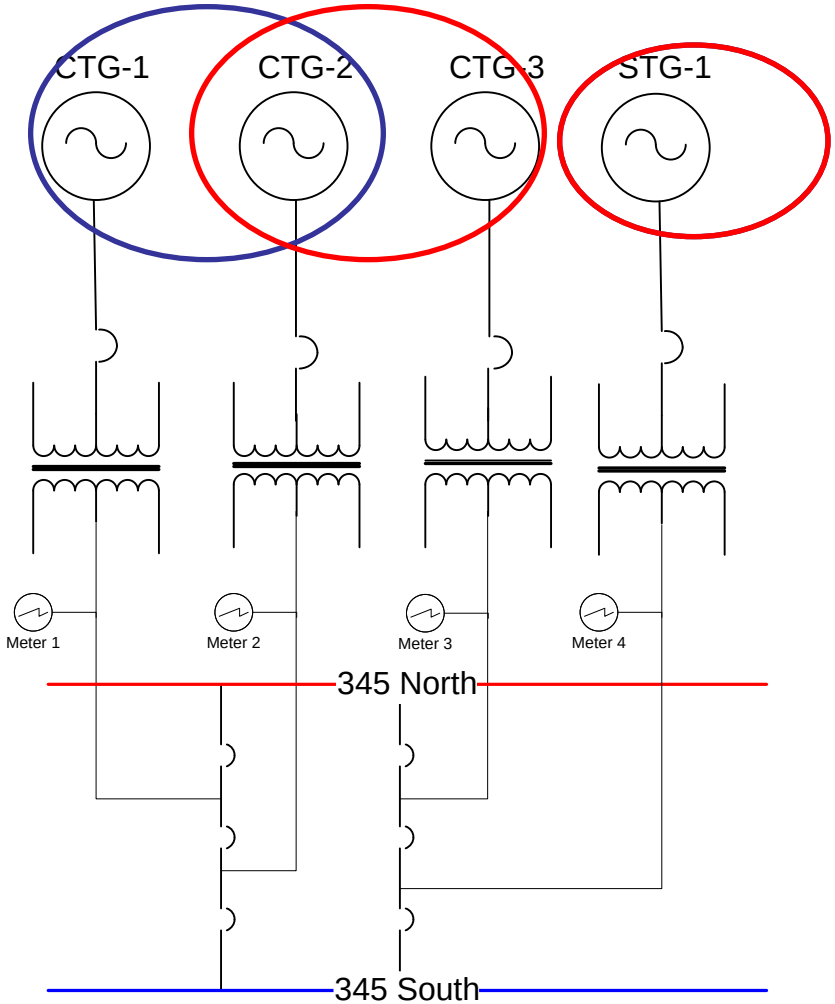
2 X 1

2 X 1

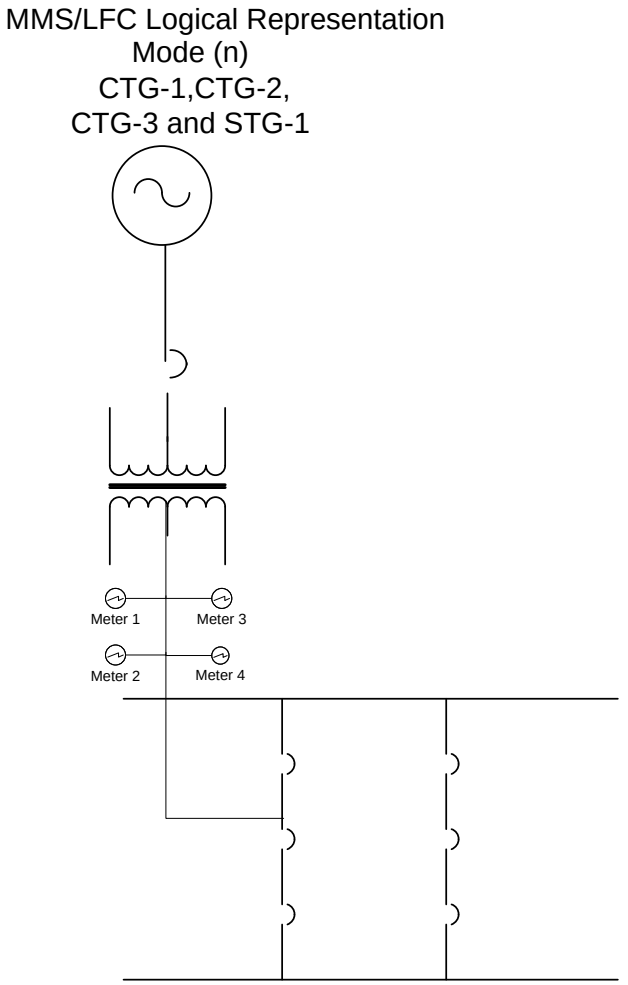


Physical Plant Configuration

Model for Market Application & Energy Management System



Physical EMS Model



Logical Resource =

Combined Cycle Generation Resource

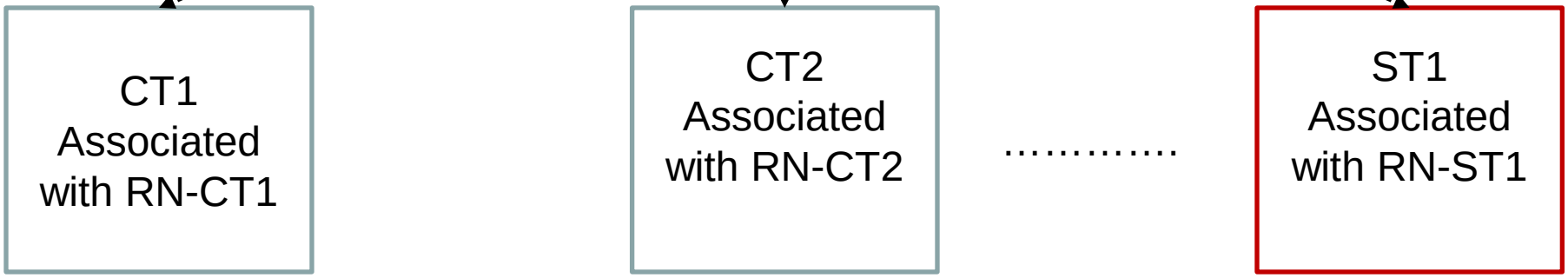
ERCOT Systems Combine Cycle Conceptual Description

CCT logical Resource Node (RN)

- May be used only for 3PO and AS Offer Settlement
- Represents each registered CCGR as an aggregated representation of the underlying CT and ST elements
- DAM/SASM/SCED/RUC optimization is based on the CCGR representation at the logical RN

Dis-aggregate down to the physical representation

Aggregate up to the CCGR representation



- All Network modeling is at the generation unit level
- Each CT and ST in the CCT must be registered with ERCOT
- RT Telemetry must be provided for each CT and ST in the CCT

Takeaways: ***Registration***

Use RARF to Register Combined Cycle Train (CCT)

- Each registered CCGR requires the QSE to submit COP entries in accordance with the requirements in Protocol Section 3.9.1
- Each CCT is assigned one logical Resource Node as a Settlement Point used only for CCGR specific 3PO's struck in the DAM and AS offers that are struck in the DAM or a SASM.

Register all physical generation units in the CCT

- Registration entries are required for each CT and ST in the CCT
- Includes: Resource Parameters such as HRL values, temporal constraints, ramp rates, etc per the RARF instructions.

Register each CCGR configuration that will be offered into DAM/RT

- Includes Resource Parameters such as temporal constraints & ramp rates that are values for the aggregated CCGR representation.

Takeaways: ***Day-Ahead Market***

Three-Part Offers

- Submit Three-Part Offers for CCGRs
- May include Start-up Offers, Minimum Energy Offers & Energy Offer Curves (EOC)
- Aggregated representation of the underlying CT and ST in the CCGR.

Ancillary Service Offers

- CCGR AS Offers may be made inclusive or exclusive of the 3PO.

DAM utilizes Outage Scheduler (OS) Information to:

- Select between primary and alternate CT and ST when calculating the weight factors used
  - to aggregation up from the CT and ST to the logical Resource Node for the CCGR, or
  - to disaggregate down from the logical Resource Node for the CCGR to the CT and ST.

Takeaways: *Day-Ahead Market (cont')*

Special Instructions for QSEs with CCT Resources during Market Trials Phases 4 and 5:

In DAM, *limit total number of CCGR Three-Part Offers* per CCT to less than or equal to total number of units registered in the CCT

Total number of CCGR Three-Part Offers	Included	Not Included
Exclusive Online AS Offers	X	
Inclusive Online AS offers		X
Offline AS Offers		X

Takeaways: ***Reliability Unit Commitment / Adjustment Period***

Three-Part Offers not struck in DAM

- RUC optimization utilizes unexpired CCGR Three-Part Offers not struck in DAM

COP Statuses

Special Instructions for QSEs with CCT Resources during Market Trials Phases 4 and 5:

limit COP Resource Status entries in each hour to:

- No more than one CCGR with an On-line Resource Status + Additional CCGRs with OFF Resource Status to <= the total # of units in the CCT.
- All other CCGR in the CCT should be “OUT” (unavailable)

Takeaways: ***Real-Time Operations***

QSE Telemetry

- Must include ICCP points for each CT and ST
- Must include ICCP points for the On-line CCGR

(Source: ICCP Handbook)

SCED calculates Base Point for the On-Line CCGR

- SCED has no affect on CCGR configuration
- No SCED Base Points are calculated for the CT and ST in the CCT
- The UDBP is calculated for the CCGR
- Base point deviation charges are determined by comparing the expected CCGR production to the total metered energy injection by the CT and ST units during each SCED Interval.

Registration

Art Deller

Objectives

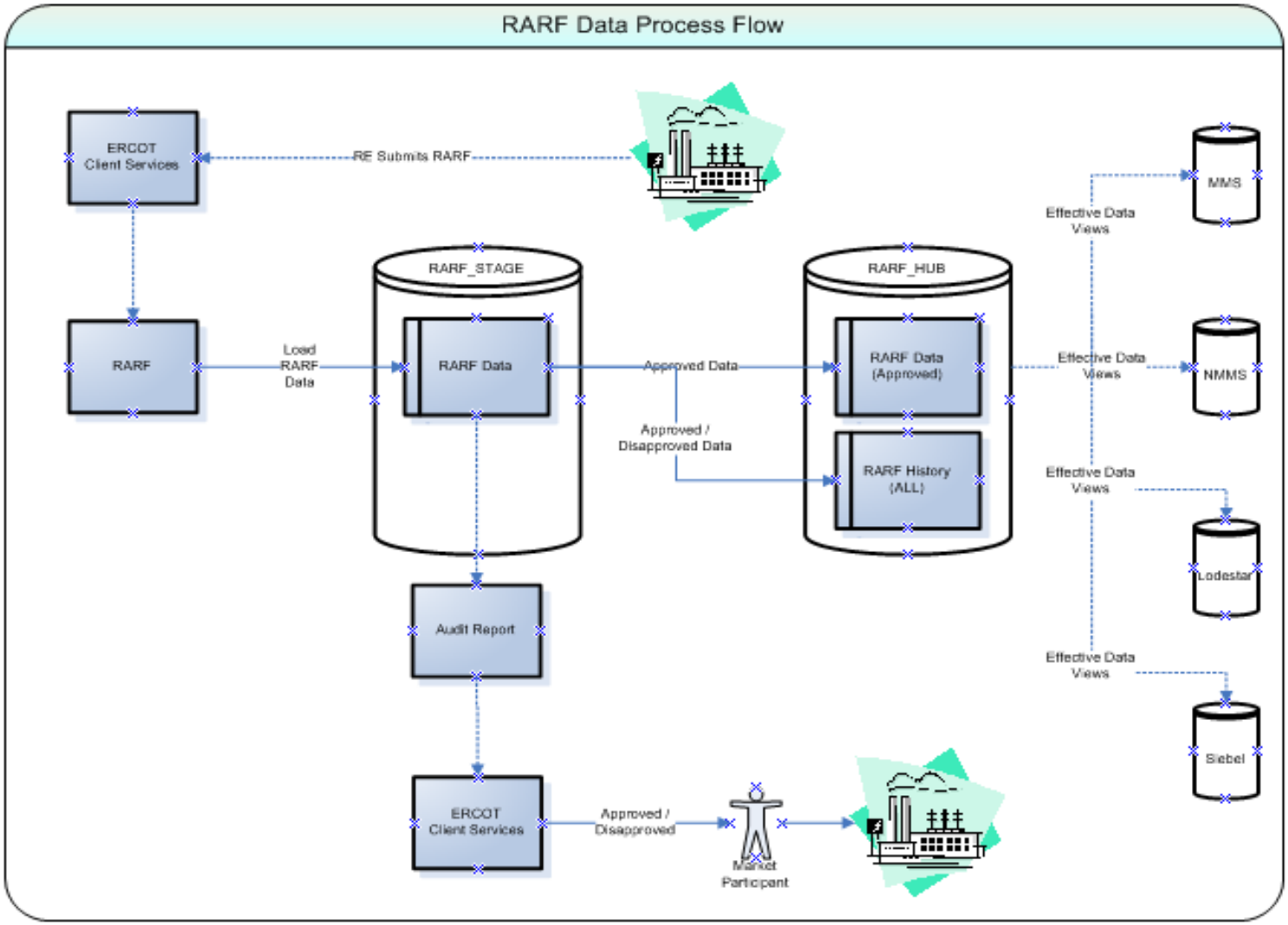
- Understand the unique parameters required for each CCT configuration (e.g., HRL; allowable configuration-to-configuration transitions; operational temporal limitations etc)
- Understand how the values you set for these parameters will be used in the ERCOT systems.

3.7 Resource Parameters

1. “A Resource Entity shall register Resource Parameters for its Resources with ERCOT.”

- Submitted to ERCOT via the Resource Asset Registration Form (RARF)
  - Found on the ERCOT website
  - Used for updating parameters

RARF Process



Registration of Combined Cycle Generation Resources

- Define Combined Cycle Generation Resources (configurations)
- Register both the Physical Units and Combined Cycle Generation Resources
- Register Resource Parameters for both physical units and CCGRs
- Define the mapping between Physical and CCGRs
- May identify units as Primary or Alternate
- Register Reactive Capability Curves for physical units

Unique Issues

- Cannot be a Split generation Resource
  - A train may not be split among multiple owners

- Train must contain one or more configurations
  - Offline is a required (default) configuration
  - Every configuration must have a **To** and a **From** configuration (no orphaned configurations)

- Configurations may contain alternate units
- Registered transition parameters will be honored

Unique Issues (cont.)

- Register all operationally unique configurations

- Power augmentation methods must be made available as a part of one or more of the registered configurations

  Augmentation includes:

  – Combustion turbine inlet air cooling (CTIAC)

  – Duct firing

  – Other ways of temporarily increasing output

  6.5.5.2 (9) Operational Data Requirements

Unique Issues (cont.)

- Resource Category set by largest single Combustion Turbine in the train
  - Combined Cycle > 90MW
  - Combined Cycle <=90 MW
    (Real Power Rating)
- Operational Parameters given by CCGR (Config)
  - Min On Line Time
  - Min Off Line Time
  - Hot, Cold Intermediate Start Times
  - Max Weekly Starts
  - Max On Line time
  - Normal and Emerg Ramp Rate curves

Parameters – CC Resource

HRL (by unit) – Used for calculation of DASPP, Disaggregation of energy Schedules and Aggregation of Shift factors

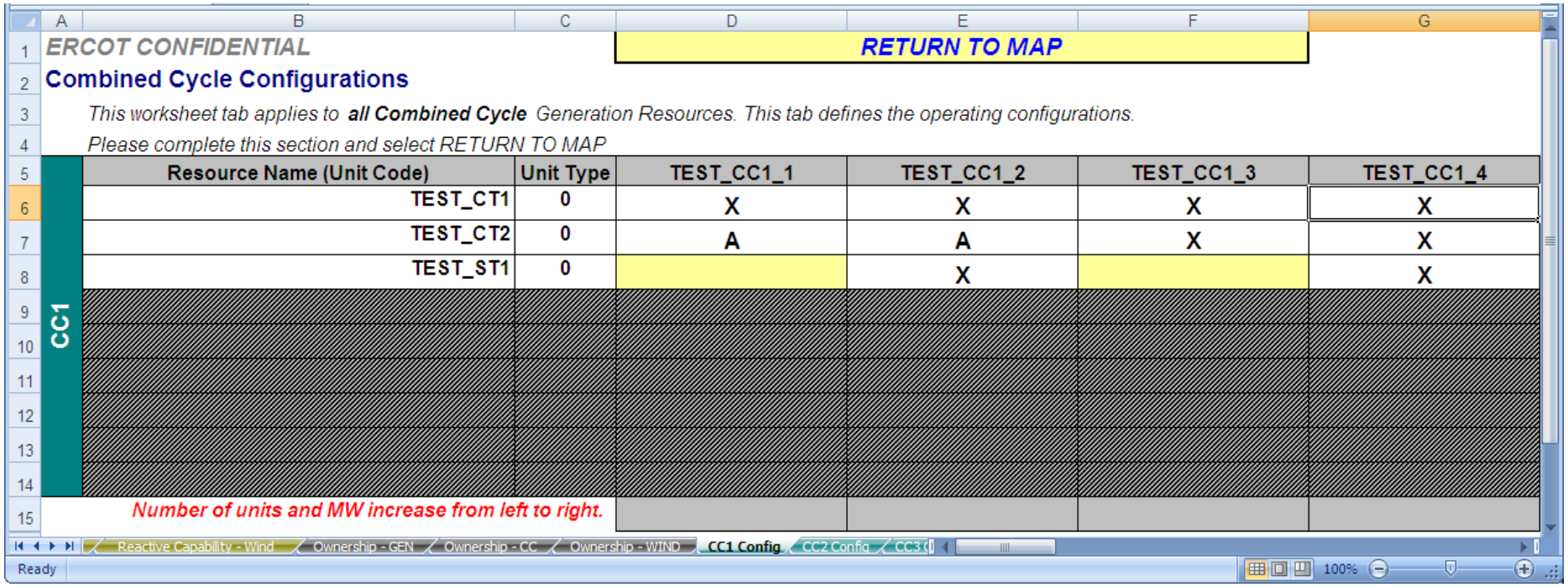
	A	B	C	D	E
1		*ERCOT Confidential*		***RETURN TO MAP***	
2		**Resource Parameters**			
3		*This worksheet tab provides resource parameters for **Combined Cycle** generation resources. This tab is UNIT specific for **all CC**.*			
4		*Please complete this section and select RETURN TO MAP*			
6	CC GENERATION RESOURCES CC1	**Reasonability Limits**	**Labels**	**TEST_CT1**	**TEST_CT2**
7		High Reasonability Limit	MW		
8		Low Reasonability Limit	MW		
9		High Reasonability Ramp Rate Limit	MW/min		
10		Low Reasonability Ramp Rate Limit	MW/min		
12		**Seasonal Ratings**	**Labels**	**TEST_CT1**	**TEST_CT2**
13		Seasonal Net Max Sustainable Rating - Spring	MW		
14		Seasonal Net Min Sustainable Rating - Spring	MW		
15		Seasonal Net Max Emergency Rating - Spring	MW		
16		Seasonal Net Min Emergency Rating - Spring	MW		
17		Seasonal Net Max Sustainable Rating - Summer	MW		
18		Seasonal Net Min Sustainable Rating - Summer	MW		
19		Seasonal Net Max Emergency Rating - Summer	MW		
20		Seasonal Net Min Emergency Rating - Summer	MW		
21		Seasonal Net Max Sustainable Rating - Fall	MW		
22		Seasonal Net Min Sustainable Rating - Fall	MW		
23		Seasonal Net Max Emergency Rating - Fall	MW		
24		Seasonal Net Min Emergency Rating - Fall	MW		
25		Seasonal Net Max Sustainable Rating - Winter	MW		
26		Seasonal Net Min Sustainable Rating - Winter	MW		
27		Seasonal Net Max Emergency Rating - Winter	MW		
28		Seasonal Net Min Emergency Rating - Winter	MW		

Unit Info - CC | Unit Info - Wind | Parameters - GEN | **Parameters - CC** | Parameters - CFG | Parameters - WIND

Ready

CC1 Config

* Must fill in the configurations tab before you can fill in the parameters for a configuration



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RETURN TO MAP

Combined Cycle Configurations

*This worksheet tab applies to **all Combined Cycle** Generation Resources. This tab defines the operating configurations.*

Please complete this section and select RETURN TO MAP

	Resource Name (Unit Code)	Unit Type	TEST_CC1_1	TEST_CC1_2	TEST_CC1_3	TEST_CC1_4
CC1	TEST_CT1	0	X	X	X	X
	TEST_CT2	0	A	A	X	X
	TEST_ST1	0		X		X

Number of units and MW increase from left to right.

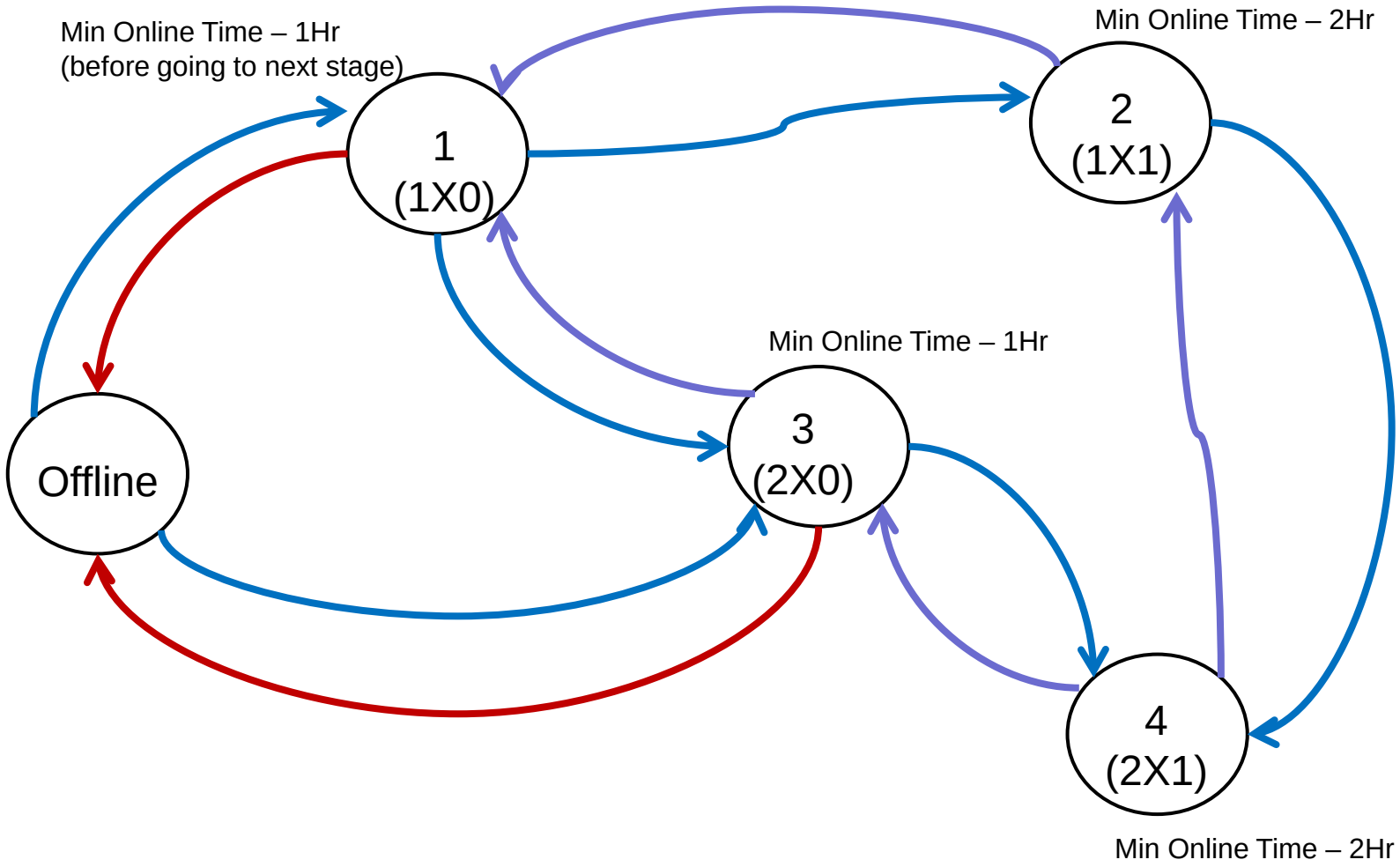
Reactive Capability - Wind | Ownership - GEN | Ownership - CC | Ownership - WIND | CC1 Config | CC2 Config | CC3

Ready

X – Indicates a Primary Unit for this configuration

A – Indicates an Alternate Unit for this configuration

Configurations are numbered from lowest output to greatest.



CCT Transitions

This transition map and the time parameters for each transition determines the limits that ERCOT will use in committing Combined Cycle Generation Resources (Configurations) through the DAM and RUC processes.

ERCOT CONFIDENTIAL — RETURN TO MAP

Combined Cycle Transitions

*This worksheet tab applies to **all Combined Cycle** Generation Resources. This tab defines the operating transitions.*

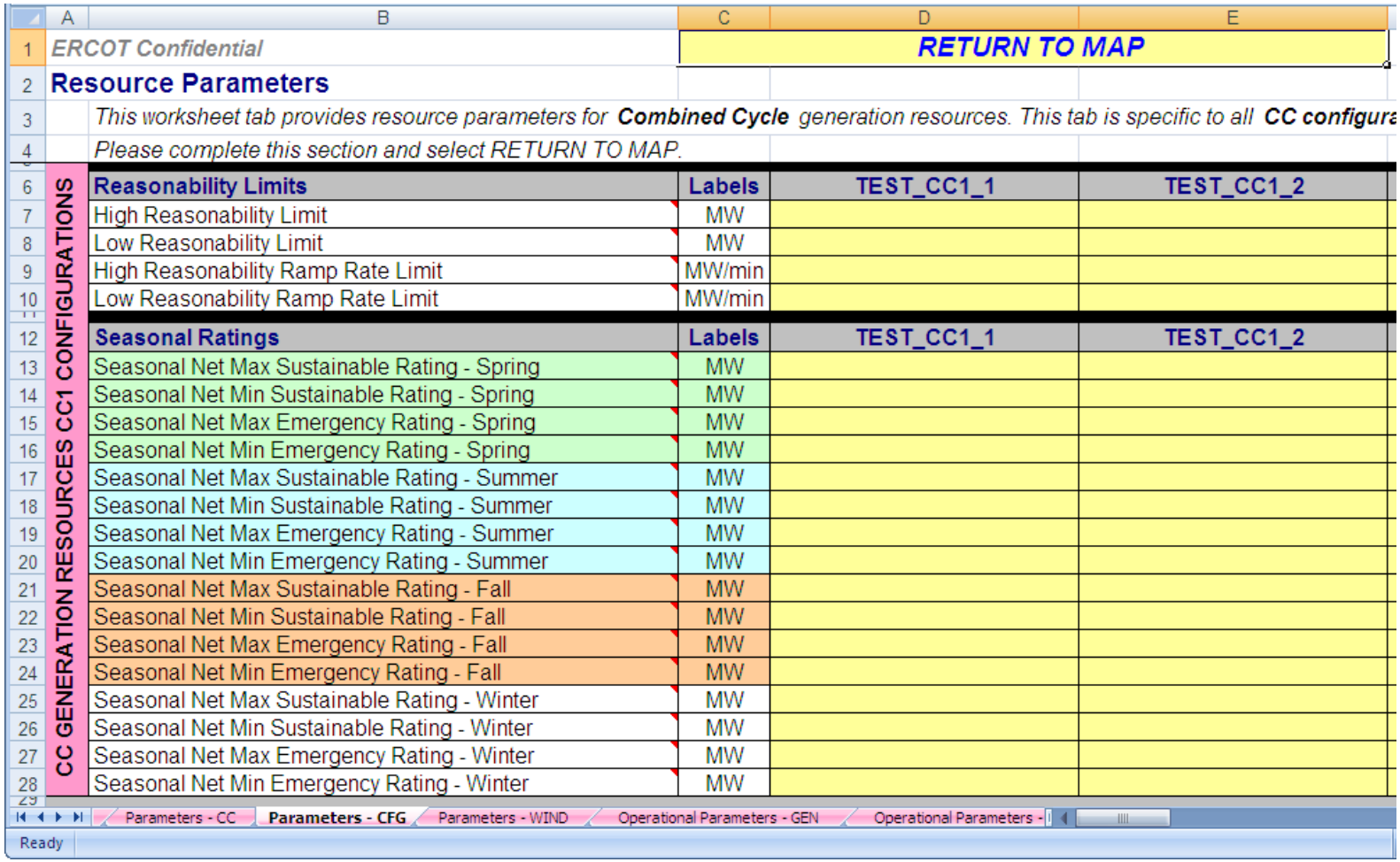
Please complete this section and select RETURN TO MAP

From \ To	Offline	TEST_CC1_1	TEST_CC1_2	TEST_CC1_3	TEST_CC1_4
Offline		X		X	
TEST_CC1_1	X		X	X	
TEST_CC1_2		X			X
TEST_CC1_3	X	X			X
TEST_CC1_4		X		X	
TEST_CC1_5					

CC1 Config | CC2 Config | CC3 Config | **CC1 Transitions** | CC2 Transitions | CC3 Transitions | Planning - GEN | Planning

Ready

HRL (by configuration) – Used to validate Offers



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RETURN TO MAP

Resource Parameters

*This worksheet tab provides resource parameters for **Combined Cycle** generation resources. This tab is specific to all **CC configura***

Please complete this section and select RETURN TO MAP.

CC GENERATION RESOURCES CC1 CONFIGURATIONS

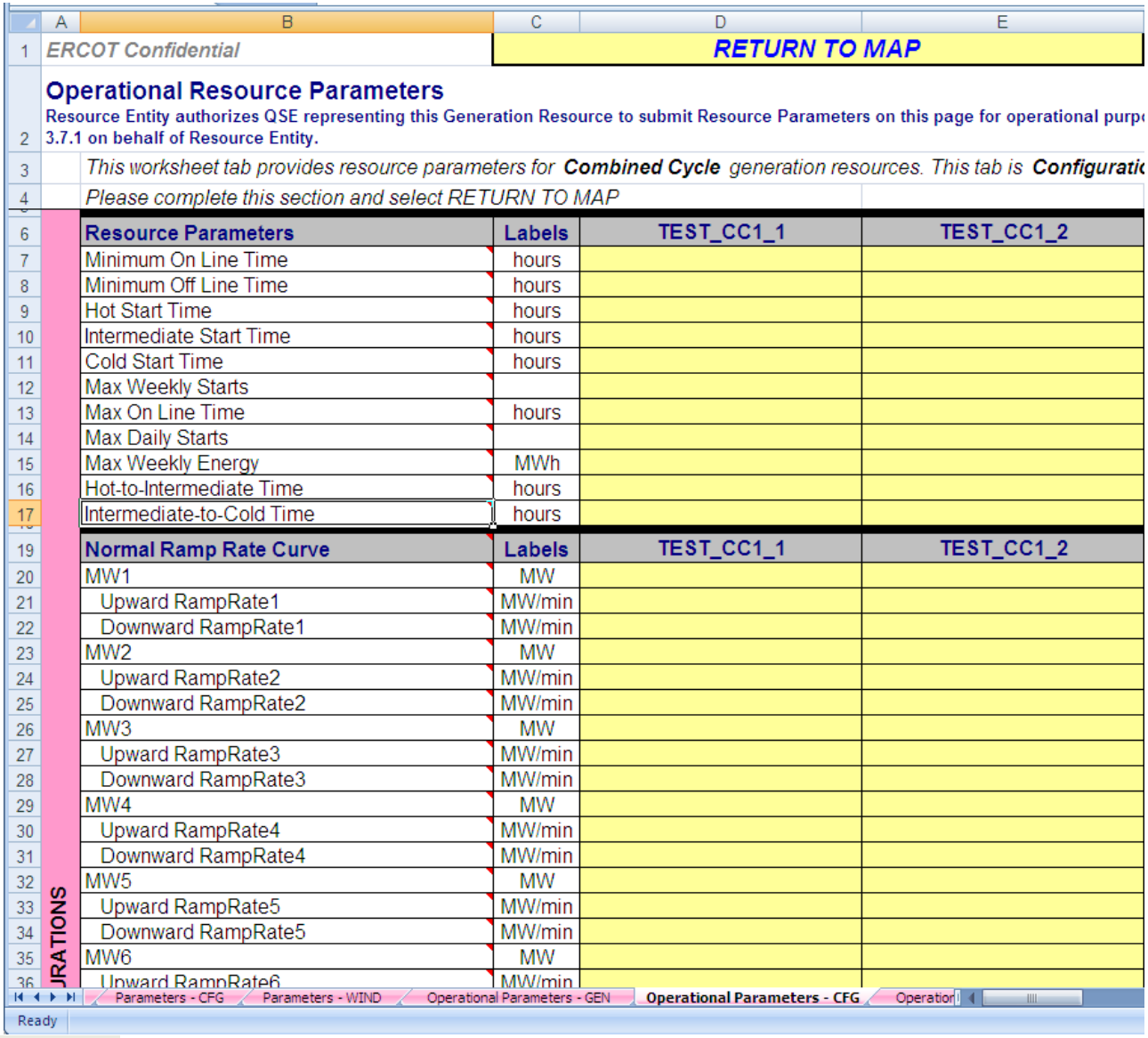
Reasonability Limits	Labels	TEST_CC1_1	TEST_CC1_2
High Reasonability Limit	MW		
Low Reasonability Limit	MW		
High Reasonability Ramp Rate Limit	MW/min		
Low Reasonability Ramp Rate Limit	MW/min		

Seasonal Ratings	Labels	TEST_CC1_1	TEST_CC1_2
Seasonal Net Max Sustainable Rating - Spring	MW		
Seasonal Net Min Sustainable Rating - Spring	MW		
Seasonal Net Max Emergency Rating - Spring	MW		
Seasonal Net Min Emergency Rating - Spring	MW		
Seasonal Net Max Sustainable Rating - Summer	MW		
Seasonal Net Min Sustainable Rating - Summer	MW		
Seasonal Net Max Emergency Rating - Summer	MW		
Seasonal Net Min Emergency Rating - Summer	MW		
Seasonal Net Max Sustainable Rating - Fall	MW		
Seasonal Net Min Sustainable Rating - Fall	MW		
Seasonal Net Max Emergency Rating - Fall	MW		
Seasonal Net Min Emergency Rating - Fall	MW		
Seasonal Net Max Sustainable Rating - Winter	MW		
Seasonal Net Min Sustainable Rating - Winter	MW		
Seasonal Net Max Emergency Rating - Winter	MW		
Seasonal Net Min Emergency Rating - Winter	MW		

Parameters - CC | Parameters - CFG | Parameters - WIND | Operational Parameters - GEN | Operational Parameters -

Ready

Configuration Operational Parameters



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RETURN TO MAP

Operational Resource Parameters

Resource Entity authorizes QSE representing this Generation Resource to submit Resource Parameters on this page for operational purp
3.7.1 on behalf of Resource Entity.

*This worksheet tab provides resource parameters for **Combined Cycle** generation resources. This tab is **Configurati***

Please complete this section and select RETURN TO MAP

Resource Parameters	Labels	TEST_CC1_1	TEST_CC1_2
Minimum On Line Time	hours		
Minimum Off Line Time	hours		
Hot Start Time	hours		
Intermediate Start Time	hours		
Cold Start Time	hours		
Max Weekly Starts			
Max On Line Time	hours		
Max Daily Starts			
Max Weekly Energy	MWh		
Hot-to-Intermediate Time	hours		
Intermediate-to-Cold Time	hours		

Normal Ramp Rate Curve	Labels	TEST_CC1_1	TEST_CC1_2
MW1	MW		
Upward RampRate1	MW/min		
Downward RampRate1	MW/min		
MW2	MW		
Upward RampRate2	MW/min		
Downward RampRate2	MW/min		
MW3	MW		
Upward RampRate3	MW/min		
Downward RampRate3	MW/min		
MW4	MW		
Upward RampRate4	MW/min		
Downward RampRate4	MW/min		
MW5	MW		
Upward RampRate5	MW/min		
Downward RampRate5	MW/min		
MW6	MW		
Upward RampRate6	MW/min		

Parameters - CFG | Parameters - WIND | Operational Parameters - GEN | **Operational Parameters - CFG** | Operatior

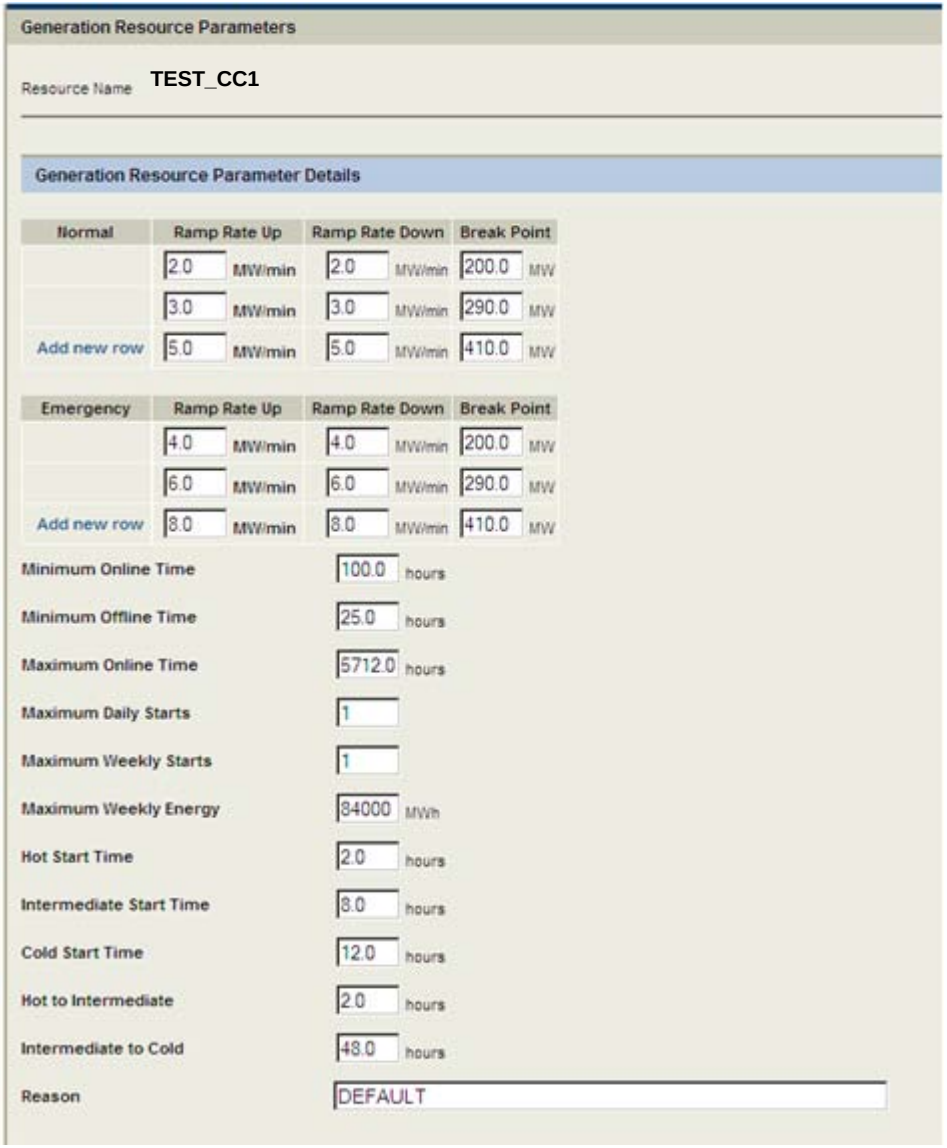
Ready

These are default values, all of these parameters are editable on the Market Manager, Resource Parameters Tab

Market Manager Resource Parameters

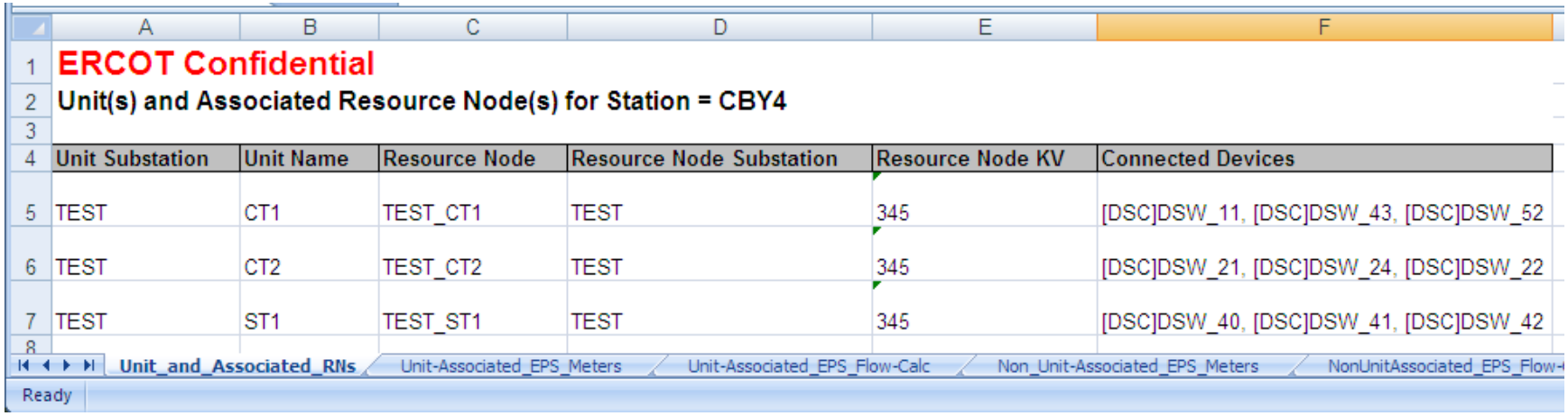
Normal and Emergency Ramp Rates

CCGR Parameters



GENMAP (Generation Node and Meter Mapping)

- Resource Entity signs verification indicating agreement with the mapping of the Resource Nodes in accordance with “Procedures for Identifying Resource Nodes”
- The Resource Nodes will be used in all associated ERCOT models, applications and processes and Settlements
- Resource Entity also confirms agreement with EPS Meter Mapping



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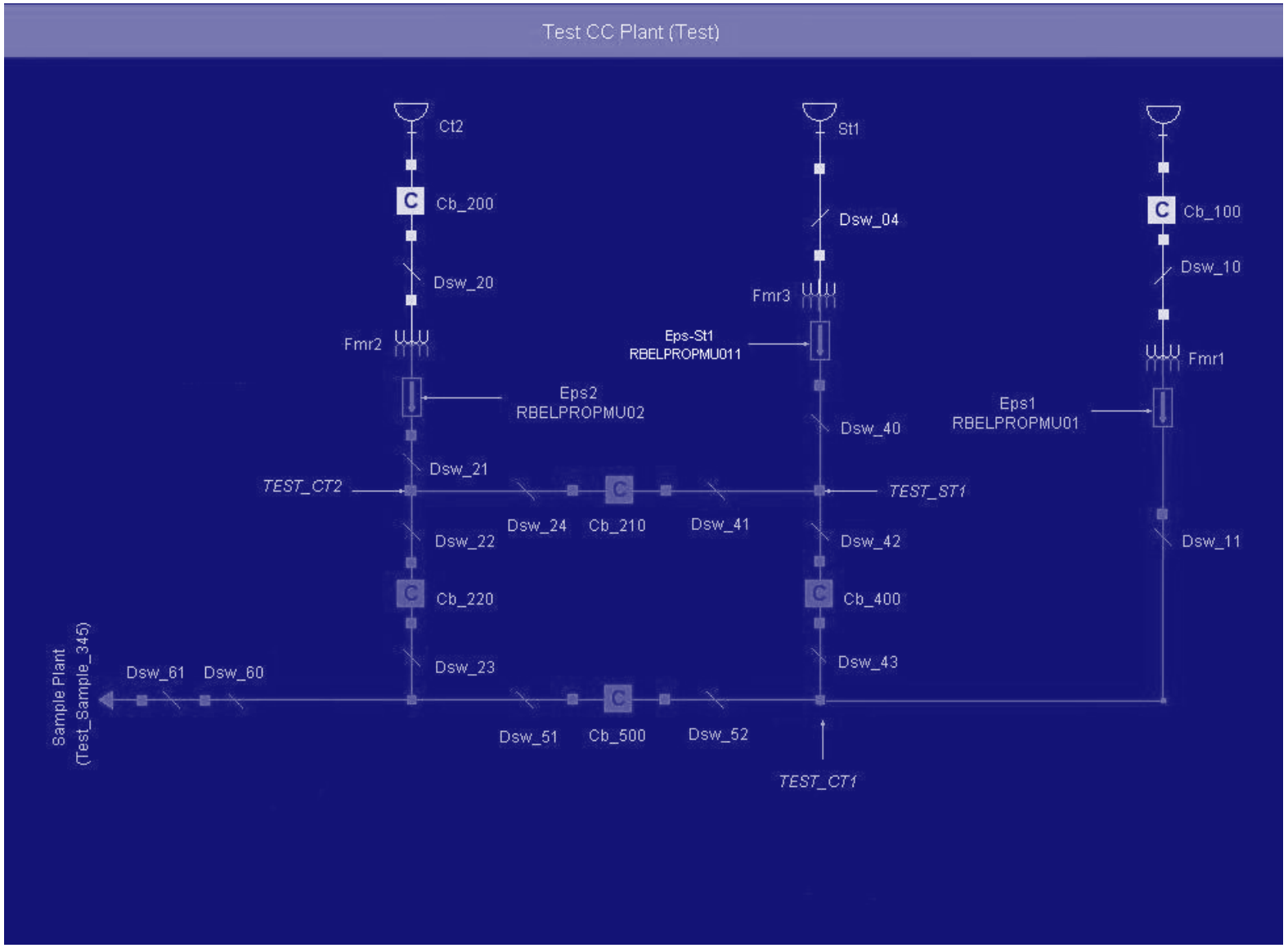
Unit(s) and Associated Resource Node(s) for Station = CBY4

Unit Substation	Unit Name	Resource Node	Resource Node Substation	Resource Node KV	Connected Devices
TEST	CT1	TEST_CT1	TEST	345	[DSC]DSW_11, [DSC]DSW_43, [DSC]DSW_52
TEST	CT2	TEST_CT2	TEST	345	[DSC]DSW_21, [DSC]DSW_24, [DSC]DSW_22
TEST	ST1	TEST_ST1	TEST	345	[DSC]DSW_40, [DSC]DSW_41, [DSC]DSW_42

Resource Genmap



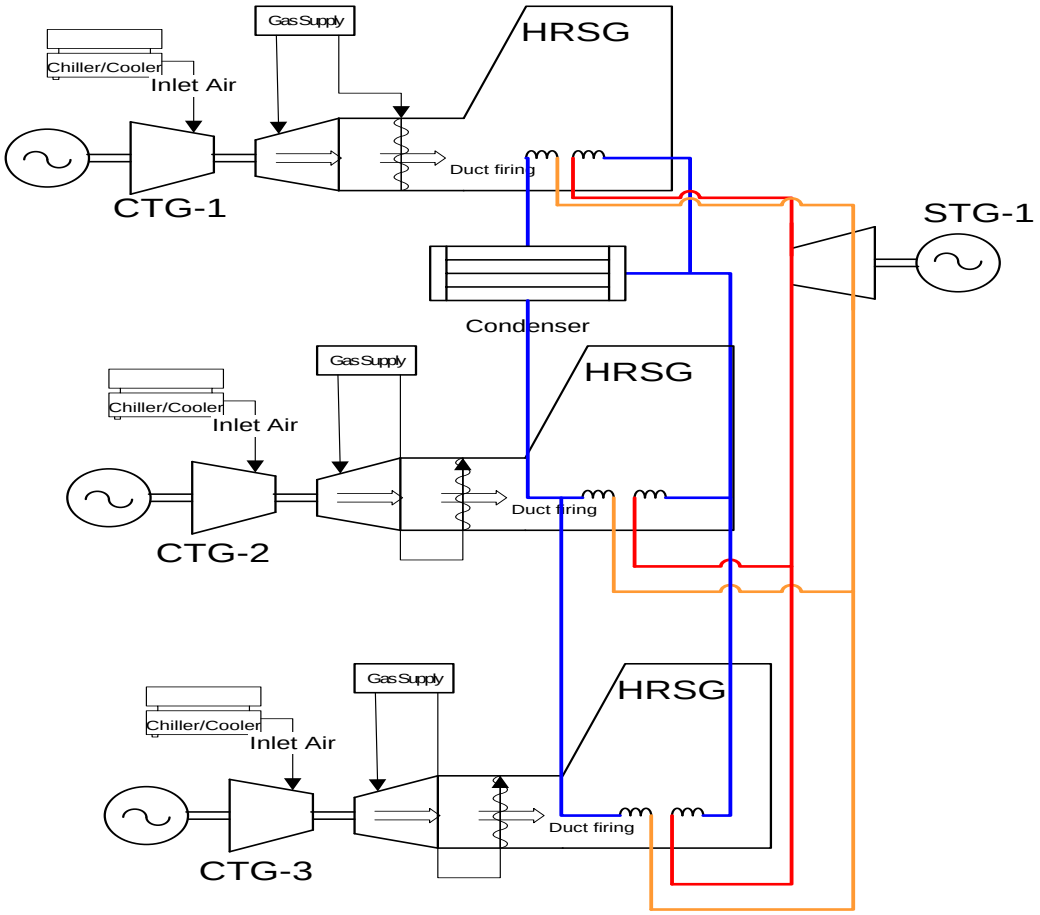
Management & Operations Activities

Bill Blevins

Management Activities for the ERCOT Systems

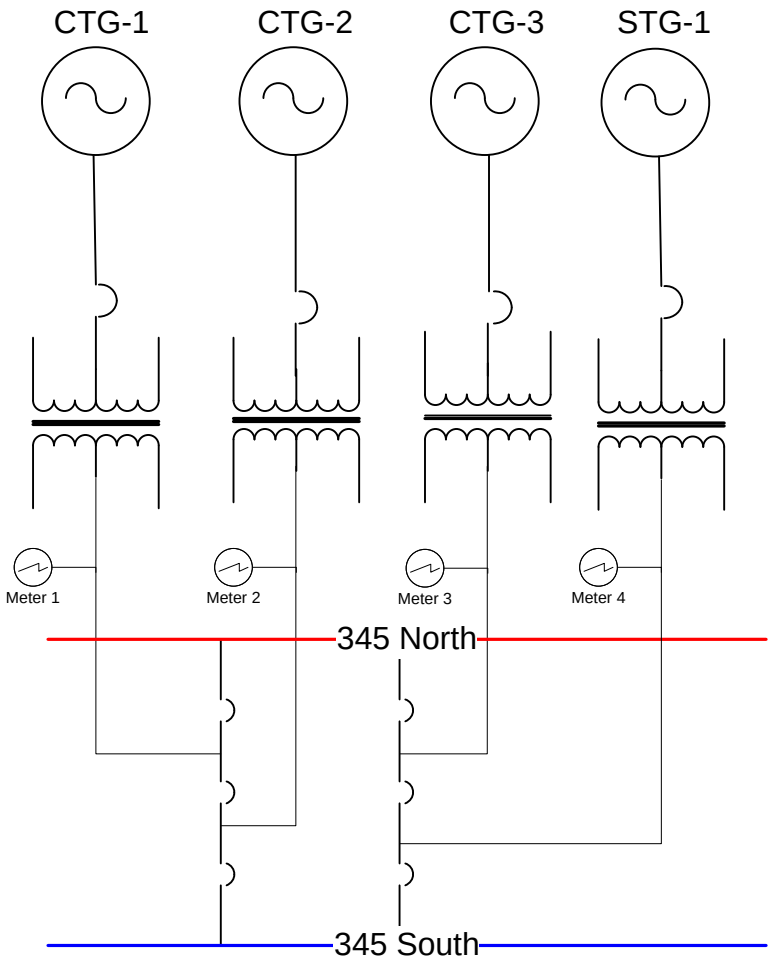
- **Current Operating Plan**
  - Resource Status for On-line and Off-line (available; unavailable) Combined Cycle Generation Resources
- **Outage Scheduler**
  - Generation unit outages
  - Off-line Non-Spin Ancillary Service Offers
- **Real Time Market Security Constrained Economic Dispatch**
  - All market transactions are at the logical Resource Node
    - Energy Offer Curve/Economic Base Points
    - Real Time Settlement Point Price
    - Base Point Deviation Penalties
    - Voltage Support Service
    - AS deployment and associated performance measures

Example Combined Cycle

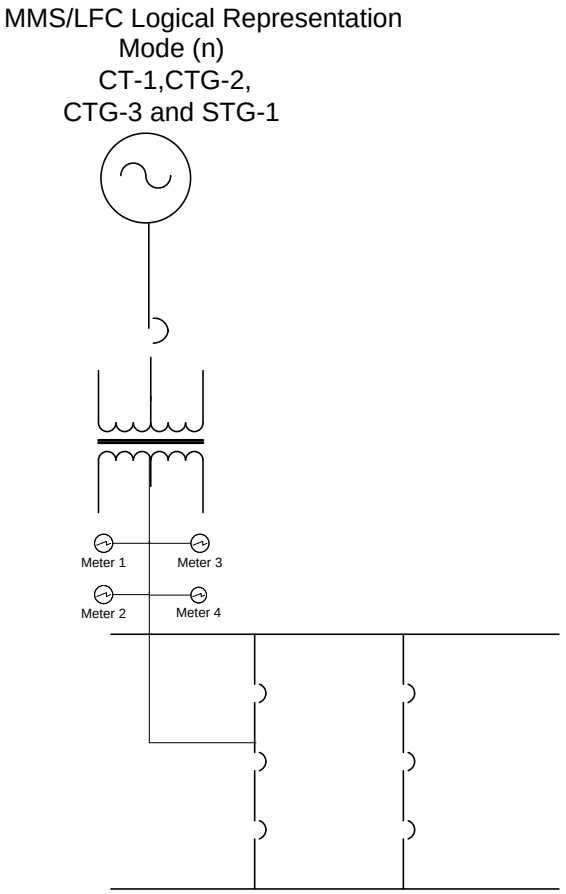


Physical Plant Configuration

Logical model for Market Application



Physical EMS Model



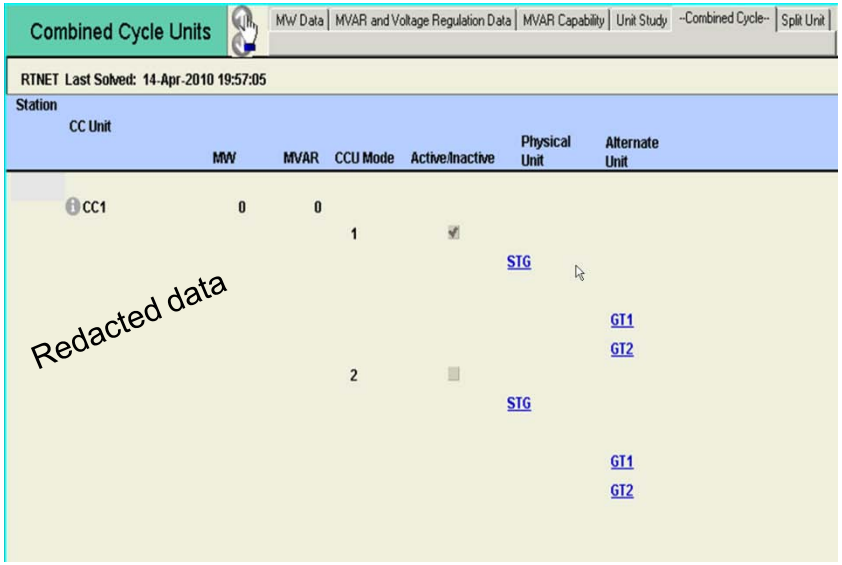
Logical Configuration

EMS will Map Physical Units to the logical Units for Network studies

Device Type	Device Name	ID	Value	Data Quality	Inhibit Alarm	Not in Service
UN	GT1	MW	68.49	Replaced		
UN	GT1	MVAR	-2.20	Good		
UN	GT1	GMW	94.30	Good		
UN	GT1	GMV	7.10			
UN	GT1	AVR	ON			
UN	GT2	MW	71.11	Replaced		
UN	GT2	MVAR	14.30	Good		
UN	GT2	GMW	97.90	Good		
UN	GT2	GMV	25.40	Good		
UN	GT2	AVR	ON	Good		
UN	ST1	MW	79.90	Replaced		
UN	ST1	MVAR	14.80	Good		
UN	ST1	GMW	110.00	Good		
UN	ST1	GMV	14.80	Good		
UN	ST1	AVR	ON	Good		
UN	CC1	EOCV	ON	Suspect		
UN	CC1	LBST	OPEN	Replaced		
UN	CC1	RBST	OPEN	Replaced		
UN	CC1	NDPL	OFF	Suspect		
UN	CC1	LASL	151.00	Good		
UN	CC1	HDL	314.50			
UN	CC1	BP	164.31			
UN	CC1	UDBP	164.31	Good		
UN	CC1	SCBP	164.31	Good		
UN	CC1	LMP	61.62	Good		
UN	CC1	DSRS		Suspect		
UN	CC1	LDL	151.00	Good		
UN	CC1	HASL	597.62	Good		

Physical Unit Telemetry

Configuration Telemetry



Network Mapping of Logical to Physical Resources for Network Analysis

SCADA from QSE for Real-Time

SCED uses the limits based on the telemetry for the Logical Unit

RLC Unit Input Data

Nodal EMS » Real-Time » Generation » RLC » Input Data

Invoke EECP | Emergency Base Point: | Generation 33447 | GTBD 33447.3 | Load 33736 | Frequency 59.993 | Log | Output | SCADA | Parm

QSE	Substation	Unit ID	HEL	HSL	Gen	LSL	LEL	AS Responsibilities				AS Schedule			
								Reg-Up	Reg-Down	RRS	NSRS	Reg-Up	Reg-Down	RRS	NSRS
		CC1	350.00	350.00	0.00	140.00	140.00	0.00	15.00	20.00	0.00	0.00	0.00	20.00	0.00
		CC1	875.00	875.00	849.51	445.00	445.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		CC1	510.00	510.00	478.00	285.00	285.00	50.00	50.00	10.00	5.00	0.00	0.00	10.00	5.00
		CC2	510.00	510.00	474.00	265.00	265.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		CC1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		CCG1	15.00	30.00	11.72	10.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		CC1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		CC1	491.00	491.00	437.63	282.00	282.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		CC2	494.00	494.00	438.55	282.00	282.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		CC1	610.00	610.00	222.10	151.00	151.00	0.00	0.00	11.77	0.62	0.00	0.00	11.77	0.62

QSE & Station redacted

SCADA for the logical Resource (CCGR) is then supplied to RLC

RLC Unit Output Data

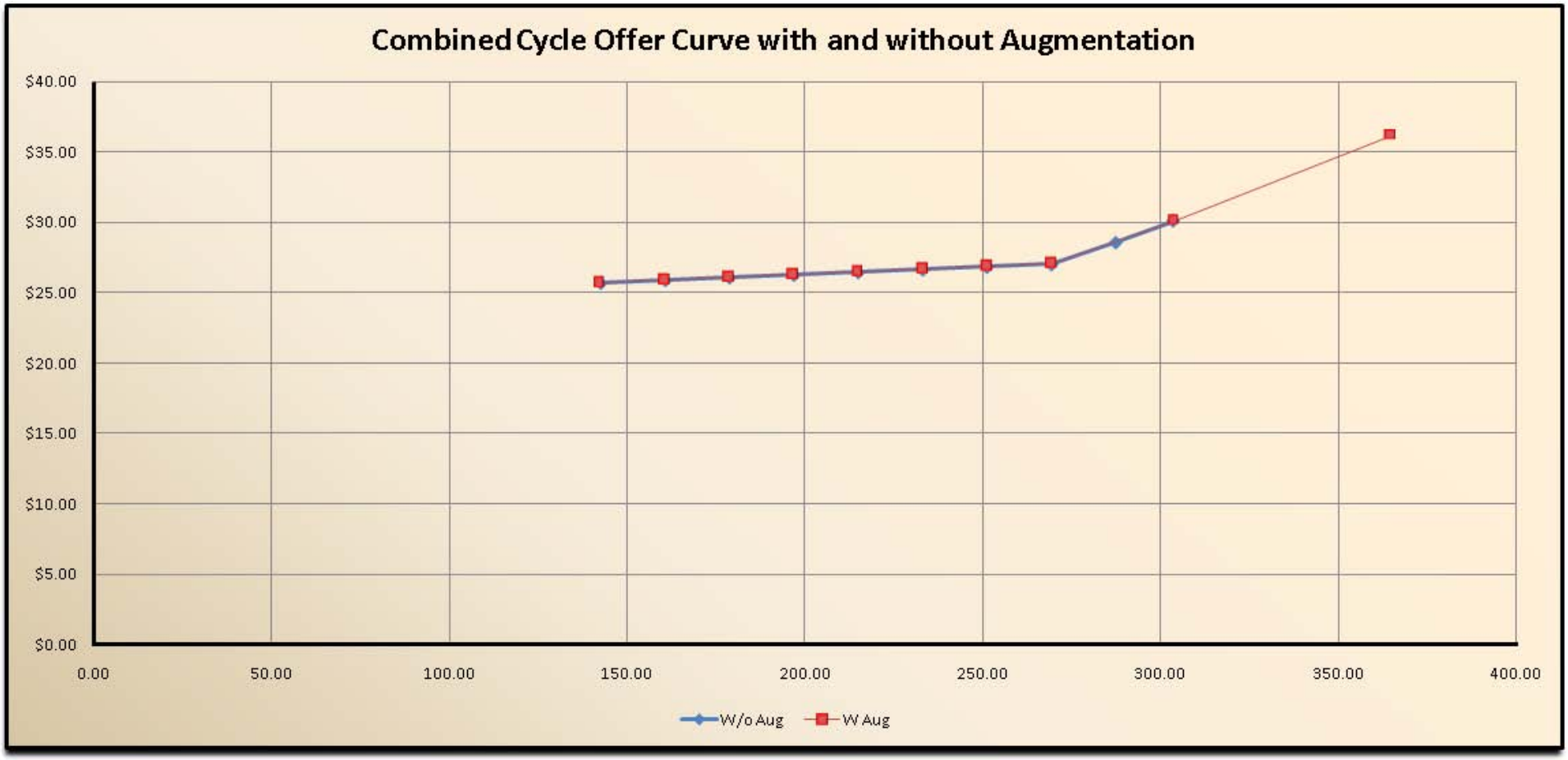
Nodal EMS » Real-Time » Generation » RLC » Ouptut Data

Invoke EECP | Emergency Base Point: | Generation 32738 | GTBD 32737.7 | Load 32966 | Frequency 60.039

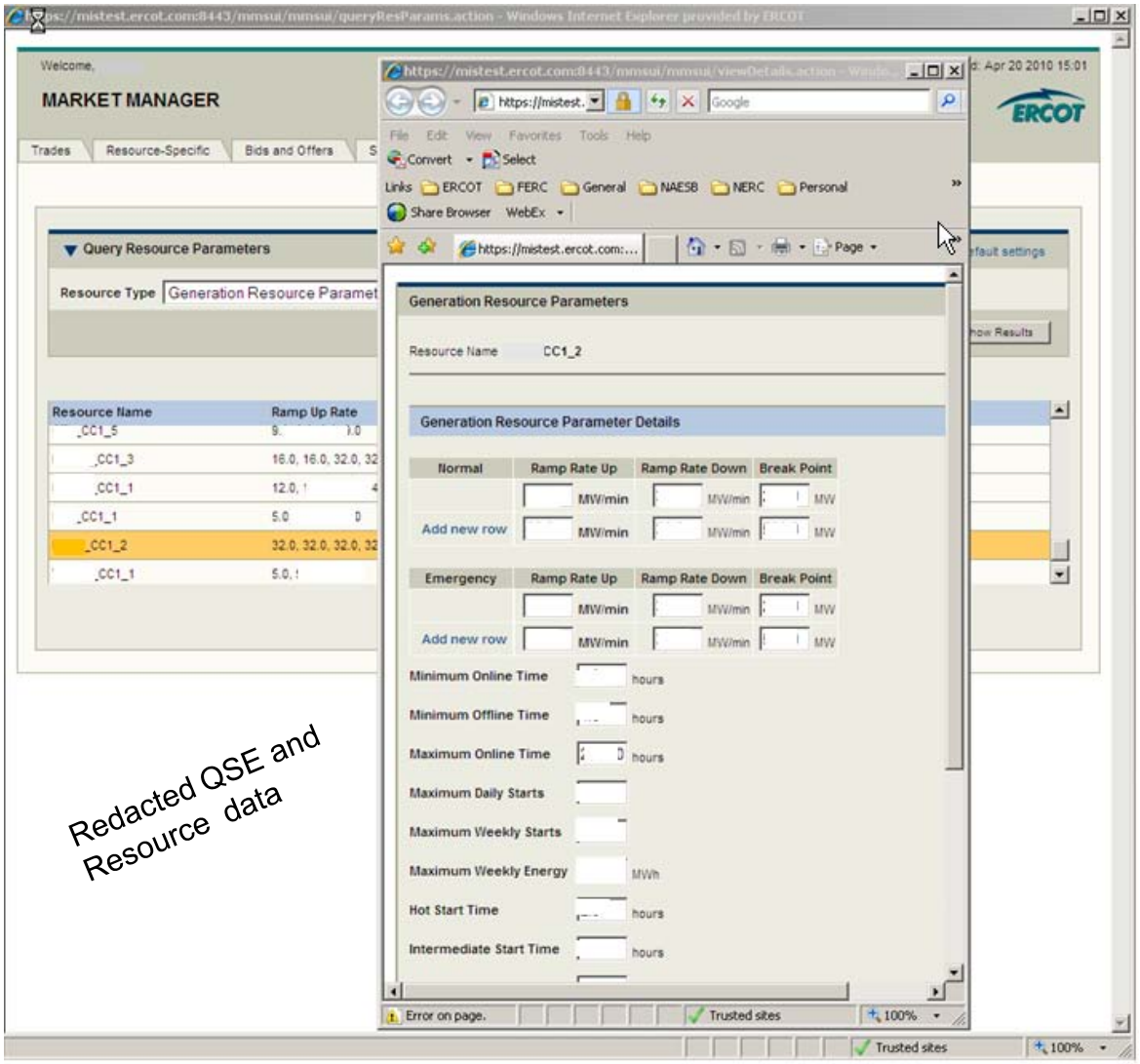
QSE	Substation	Unit ID	HASL	HDL	Gen	LDL	LASL	Unit Status	LMP		Base Point			Ramp Ra
									REF	Cur	SCED	MAN	MAN Flag	
		CC1	330.00	0.00	0.00	0.00	155.00	OFF	0.00	56.17	0.00		☐	[RAMP]
		CC1	875.00	720.31	720.31	720.31	445.00	ON	0.00	56.17	721.36		☐	[RAMP]
		CC1	445.00	475.00	475.00	475.00	335.00	ONREG	0.00	56.17	475.00		☐	[RAMP]
		CC2	510.00	482.00	467.00	452.00	265.00	ONREG	0.00	56.17	476.00		☐	[RAMP]
		CC1	0.00	0.00	0.00	0.00	0.00	OFF	0.00	56.17	0.00		☐	[RAMP]
		CCG1	30.00	11.24	11.24	11.24	10.00	ONREG	0.00	56.17	11.29		☐	[RAMP]
		CC1	0.00	0.00	0.00	0.00	0.00	OFF	0.00	56.17	0.00		☐	[RAMP]
		CC1	491.00	491.00	389.30	282.00	282.00	ON	0.00	56.17	491.00		☐	[RAMP]
		CC2	494.00	494.00	413.51	293.51	282.00	ON	0.00	56.17	494.00		☐	[RAMP]
		CC1	597.46	313.10	218.10	151.00	151.00	ON	0.00	56.17	155.23		☐	[RAMP]

QSE & Station redacted

Combined Cycle Augmentation



Update Resource Parameters



Redacted QSE and Resource data

SCED_LFC Deployment

QSE	Plant	Unit	Unit Status Code Text	Output MW	Base Point SCED	Base Point UDBP	Base Point Paused	Base Point EMG	HDL	LDL	Avail Cap	CTRL Block UP	CTRL Block DN	CTRL Block NT
QSE & Station redacted		CC1	ON	217	215	215		0	217	196	0			
		CC1	ON F	52	51	51		0	52	52	0			
		CC2	ONOSREG	9 F	9	9		0	9	9	0			
		CC1	OUT F	0 F	0	0		0	0	0	0		F	
		CC1	ON	276	273	272		0	270	251	0			
		CC1	ON	183	200	200		0	238	200	0			
		CC1	ON	116	90	90		0	90	90	0			✓
		CC1	ON	562	421	421		0	582	422	0			✓
		CC1	ONREG	426	418	418		0	479	304	0			
		CC1	ON	677	620	621		0	777	577	0			✓
		CC1	ONREG	406	455	455		0	517	324	0			
		CC1	ON	484	365	364		0	519	364	0			✓
		CC2	ON	482	362	362		0	519	362	0			✓
		CC1	ON	518	428	429		0	603	433	0			✓
		CC1	ON	107	157	157		0	157	110	0			✓
		CC1	ON	174	133	133		0	219	129	0			✓
		CC1	ON	532	473	473		0	592	472	0			✓
		CC1	ON	224	166	166		0	319	151	0			✓
		CC1	OFF	0	0	0		0	0	0	0			
		CC1	ON	37	37	37		0	37	37	0			
		CC1	OFF	0	0	0		0	0	0	0			
		CC1	ON	462	461	461		0	461	352	0			
		CC1	OFF	0	0	0		0	0	0	0			

Regulation “Frequency Control”

QSE	Plant	Unit	Resource Status Code	Output MW	Reg-Up Resp	Reg-Up Deploy	Reg-Up Remain	Reg-Up Part Factor	Reg-Down Resp	Reg-Down Deploy	Reg-Down Remain	Reg-Down Part Factor	CTRL Block UP	CTRL Block DN	CTRL Block NT
QSE & Station redacted		CC1	ON	230	30.0	0.0	0.0	1.00	9.7	0.0	0.0	1.00			
		CC1	ON F	51	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.00			
		CC2	ONOSREG	9 F	10.0	0.0	0.0	0.00	10.0	0.0	0.0	0.00			
		CC1	OUT F	0 F	0.0 F	0.0	0.0	0.00 F	0.0 F	0.0	0.0	0.00 F	F	F	
		CC1	ON F	287 F	0.0 F	0.0	0.0	0.00 F	0.0 F	0.0	0.0	0.00 F	F	F	
		CC1	ON	183	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.00			
		CC1	ON	115	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.00			✓
		CC1	ONREG	560	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.00			✓
		CC1	ON	446	9.0	0.0	0.0	0.50	38.5	0.0	0.0	0.50			
		CC1	ON	677	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.00			✓
		CC1	ON	441	9.0	0.0	0.0	0.50	38.5	0.0	0.0	0.50			
		CC1	ONREG	483	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.00			✓
		CC2	ONREG	480	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.00			✓
		CC1	ONREG	519	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.00			✓
		CC1	ON	107	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.00			✓

Regulation will be deployed to a QSE every 4 seconds.

Responsive Reserve

QSE	Plant	Unit	Resource Status Code	Output MW	Responsive Reserve Service		
					Responsibility	Deployed	Schedule
QSE & Station redacted		CC1	ON	231	52	0	52
		CC1	ON F	51	0	0	0
		CC2	ONOSREG	9F	15	0	15
		CC1	OUT	0	0	0	0
		CC1	ON	284F	0	0	0F
		CC1	ON	181	12	0	12
		CC1	ON	114	12	0	12
		CC1	ON	562	12	0	12
		CC1	ONREG	440	12	0	12
		CC1	ON	676	12	0	12
		CC1	ONREG	441	12	0	12
		CC1	ON	483	12	0	12
		CC2	ON	482	12	0	12
		CC1	ON	518	12	0	12
		CC1	ON	107	12	0	12
		CC1	ON	174	12	0	12
		CC1	ON	533	12	0	12
		CC1	ON	221	12	0	12
		CC1	OFF	0	0	0	0
		CC1	ON	35	0	0	0
		CC1	OFF	0	0	0	0
		CC1	ON	460	0	0	0

Why, What and How of COP DATA

COP

Submit Id	Transaction Id	Resource Name	Participant Name	Delivery Date	Delivery Hour	Resource Status	Reg Up	Reg Down	RRS	NSPIN	High Sustained Limit	Low Sustained Limit	High Emergency Limit	Low Emergency Limit
6,635,519	4iZSYWpC	SOME_CC1_1	QSE1	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	185.000	70.000	185.000	70.000
6,635,522	4iQSYWpB	NEW_CC1_1	QSE2	12/31/2012	16	ON	0.000	0.000	0.000	0.000	80.000	50.000	80.000	40.000
6,635,522	4iQSYWpB	NEW_CC1_2	QSE2	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	96.000	58.000	96.000	58.000
6,635,522	4iQSYWpB	NEW_CC1_3	QSE2	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	160.000	100.000	160.000	100.000
6,635,522	4iQSYWpB	NEW_CC1_4	QSE2	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	192.000	108.000	192.000	108.000
6,635,523	4iXSYWp5	ANOTHER_CC1_1	QSE3	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	325.000	130.000	325.000	130.000
6,635,523	4iXSYWp5	ANOTHER_CC1_2	QSE3	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	325.000	130.000	325.000	130.000
6,635,523	4iXSYWp5	ANOTHER_CC1_3	QSE3	12/31/2012	16	ON	0.000	0.000	0.000	0.000	655.000	200.000	655.000	200.000
6,635,523	4iXSYWp5	TYPICAL_CC1_1	QSE3	12/31/2012	16	OUT	0.000	0.000	0.000	0.000	300.000	50.000	300.000	50.000
6,635,526	4i3SYWpA	COMPLEX_CC1_1	QSE4	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	225.000	60.000	225.000	60.000
6,635,526	4i3SYWpA	COMPLEX_CC1_2	QSE4	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	450.000	120.000	450.000	120.000
6,635,526	4i3SYWpA	COMPLEX_CC1_3	QSE4	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	700.000	145.000	700.000	145.000
6,635,526	4i3SYWpA	COMPLEX_CC1_4	QSE4	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	675.000	180.000	675.000	180.000
6,635,526	4i3SYWpA	COMPLEX_CC1_5	QSE4	12/31/2012	16	ON	0.000	0.000	0.000	0.000	975.000	205.000	975.000	205.000
6,635,526	4i3SYWpA	GUESSWHO_CC1_1	QSE4	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	325.000	85.000	325.000	85.000
6,635,526	4i3SYWpA	GUESSWHO_CC1_2	QSE4	12/31/2012	16	ON	0.000	0.000	0.000	0.000	650.000	155.000	650.000	155.000
6,635,526	4i3SYWpA	FUN_CC1_1	QSE4	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	205.000	45.000	205.000	45.000
6,635,526	4i3SYWpA	FUN_CC1_2	QSE4	12/31/2012	16	ON	0.000	0.000	0.000	0.000	240.000	85.000	240.000	85.000
6,635,526	4i3SYWpA	SAD_CC1_1	QSE4	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	207.000	73.000	207.000	73.000
6,635,526	4i3SYWpA	SAD_CC1_2	QSE4	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	403.000	78.000	403.000	78.000
6,635,526	4i3SYWpA	SAD_CC1_3	QSE4	12/31/2012	16	ON	0.000	0.000	0.000	0.000	610.000	151.000	610.000	151.000
6,635,526	4i3SYWpA	BLUE_CC1_1	QSE4	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	232.000	90.000	232.000	90.000
6,635,526	4i3SYWpA	BLUE_CC1_2	QSE4	12/31/2012	16	ON	0.000	0.000	0.000	0.000	300.000	110.000	300.000	110.000
6,635,526	4i3SYWpA	COMPLICATED_CC1_1	QSE4	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	130.000	60.000	130.000	60.000
6,635,526	4i3SYWpA	COMPLICATED_CC1_2	QSE4	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	135.000	64.000	135.000	64.000
6,635,526	4i3SYWpA	COMPLICATED_CC1_3	QSE4	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	165.000	90.000	165.000	90.000
6,635,526	4i3SYWpA	COMPLICATED_CC1_4	QSE4	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	219.000	126.000	219.000	126.000
6,635,526	4i3SYWpA	COMPLICATED_CC1_5	QSE4	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	250.000	120.000	250.000	120.000
6,635,526	4i3SYWpA	COMPLICATED_CC1_6	QSE4	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	262.000	135.000	262.000	135.000
6,635,526	4i3SYWpA	COMPLICATED_CC1_7	QSE4	12/31/2012	16	OFF	0.000	0.000	0.000	0.000	300.000	170.000	300.000	170.000

Resource Status Determination

Based on
- COP
- Telemetry

EMS Current Commitment Status

Resource Name	Status
AMISTAD_AMISTAG1	OFF
AMISTAD_AMISTAG2	ON
AMOCOOIL_CC1_3	ON
AMOCOOIL_CC2_5	ON
APD_APD_G1	ON
ATKINS_ATKINSG3	OFF
ATKINS_ATKINSG4	OFF
ATKINS_ATKINSG5	OFF
ATKINS_ATKINSG6	OFF
ATKINS_ATKINSG7	OFF
AUSTPL_AUSTING1	ON
AUSTPL_AUSTING2	ON
AZ_AZ_G1	OFF
AZ_AZ_G2	OFF
AZ_AZ_G3	OFF
AZ_AZ_G4	OFF
BASTEN_CC1_1	ON
BBSES_UNIT1	OFF
BBSES_UNIT2	ON
BOSQUESW_CC1_1	OFF
BOSQUESW_CC2_4	OFF
BRAUNIG_CC1_2	OFF
BRAUNIG_VHB1	OFF
BRAUNIG_VHB2	ON
BRAUNIG_VHB3	OFF
BRAUNIG_VHB6CT5	OFF
BRAUNIG_VHB6CT6	OFF
BRAUNIG_VHB6CT7	OFF

Simulated data

Logical Unit Summary

Unit | Logical Unit | Line | Transformer | Load | B | Inhibit Alarm | Resource Code ... | QKNET | REALTIME | TOP DONE

Station	Unit	CCU?	SGR?	Resource Status	COP Status	TOP Dev	COP Dev	Inhibit Alarm? Temp	Inhibit Alarm? Perm	Last Alarm Time
KMCHI	CC1	☑	☐	13	13	☑	☐	☐	☐	14-Apr-2010 14:45:48
KMCHI	CC2	☑	☐	13	11	☑	☑	☐	☐	14-Apr-2010 14:45:48
TNSKA	CC1	☑	☐	13	13	☑	☐	☐	☐	14-Apr-2010 14:45:48
LPCCS	CC1	☑	☐	2	3	☑	☑	☐	☐	14-Apr-2010 14:45:48
LPCCS	CC2	☑	☐	2	3	☑	☑	☐	☐	14-Apr-2010 14:45:48
FREC	CC1	☑	☐	2	2	☐	☐	☐	☐	14-Apr-2010 18:50:28
FREC	CC2	☑	☐	2	2	☐	☐	☐	☐	14-Apr-2010 18:50:28
SILASRAY	CC1	☑	☐	13	13	☐	☐	☐	☐	14-Apr-2010 15:01:38
B_DAVIS	CC1	☑	☐	3	0	☐	☑	☐	☐	14-Apr-2010 14:45:48
CCEC	CC1	☑	☐	2	2	☐	☐	☐	☐	14-Apr-2010 18:50:28
LGE	CC1	☑	☐	2	13	☐	☑	☐	☐	14-Apr-2010 14:45:48
NEDIN	CC1	☑	☐	3	3	☐	☐	☐	☐	14-Apr-2010 18:32:28
FRONTERA	CC1	☑	☐	3	13	☐	☑	☐	☐	14-Apr-2010 14:45:48
DUKE	CC1	☑	☐	3	3	☐	☐	☐	☐	14-Apr-2010 18:50:28
INGLCOSW	CC1	☑	☐	2	3	☐	☑	☐	☐	14-Apr-2010 18:02:58
NUECES_B	CC1	☑	☐	3	3	☐	☐	☐	☐	
OECCS	CC1	☑	☐	3	13	☐	☑	☐	☐	14-Apr-2010 15:32:38
OECCS	CC2	☑	☐	3	13	☐	☑	☐	☐	14-Apr-2010 15:32:38
QALSW	CC1	☑	☐	13	13	☑	☐	☐	☐	14-Apr-2010 14:45:48
QALSW	CC2	☑	☐	13	13	☑	☐	☐	☐	14-Apr-2010 14:45:48
FLCNS	CC1	☑	☐	13	13	☑	☐	☐	☐	14-Apr-2010 14:45:48
WFCOGEN	CC1	☑	☐	13	13	☐	☐	☐	☐	14-Apr-2010 14:45:48

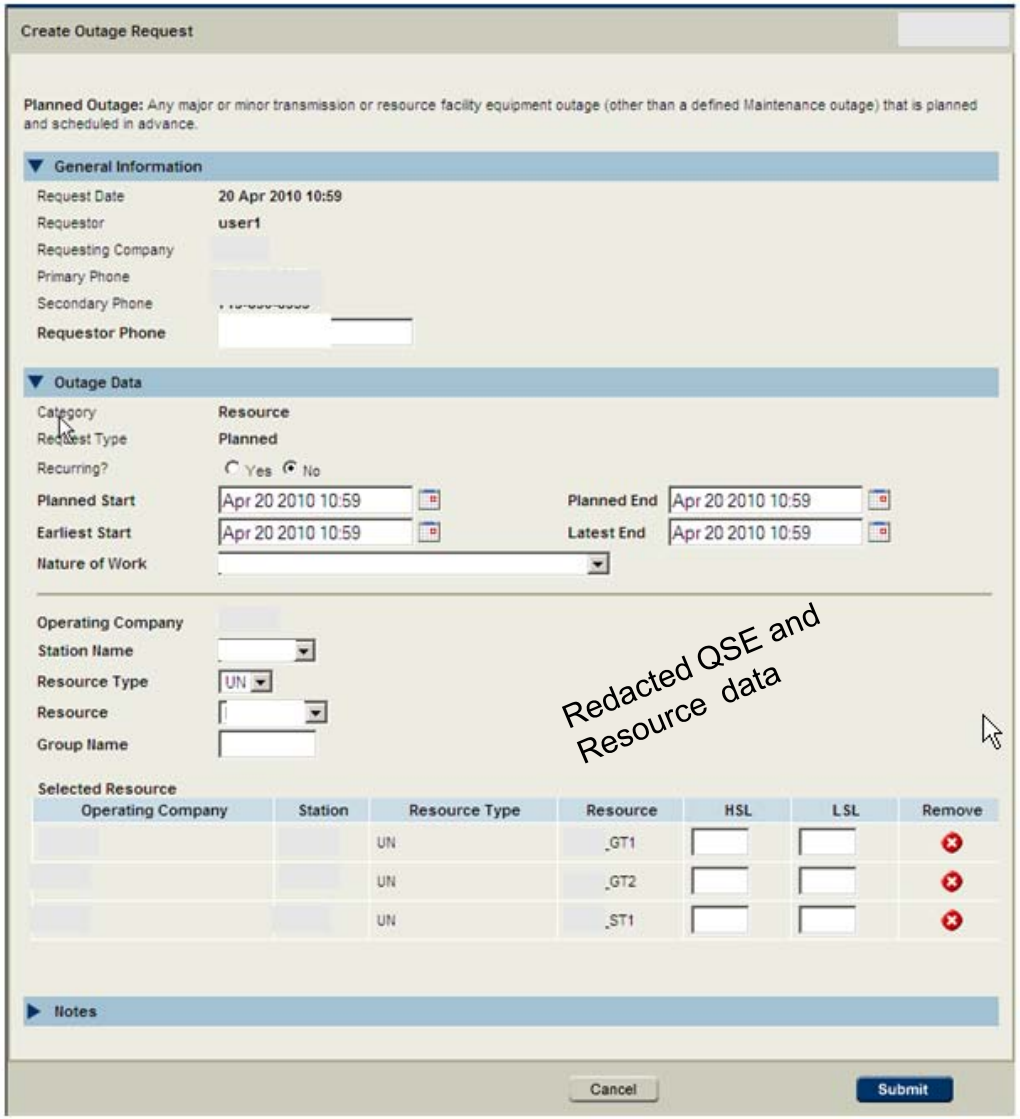
Simulated Forced Outage Detection data

EMS History Commitment Status

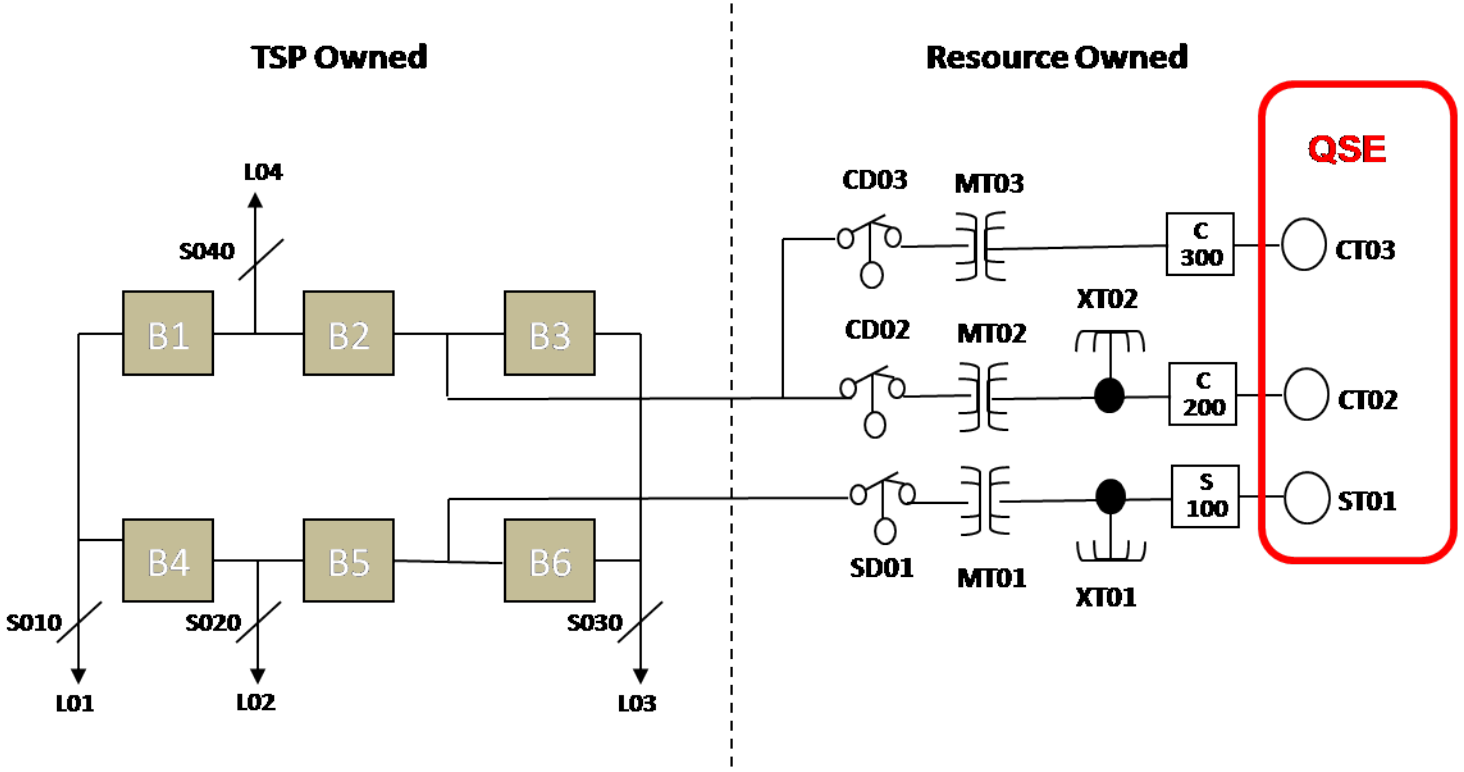
Resource Name	Online Hours	Offline Hours	No. Startups
AMISTAD_AMISTAG1	0	6	2
AMISTAD_AMISTAG2	2	0	1
AMOCOOIL_CC1_1	0	1	9
AMOCOOIL_CC1_2	0	27	0
AMOCOOIL_CC1_3	27	0	0
AMOCOOIL_CC1_4	0	27	0
AMOCOOIL_CC2_1	0	1	9
AMOCOOIL_CC2_10	0	27	0
AMOCOOIL_CC2_2	0	27	0
AMOCOOIL_CC2_3	0	27	0
AMOCOOIL_CC2_4	0	27	0
AMOCOOIL_CC2_5	1	0	1
AMOCOOIL_CC2_6	0	27	0
AMOCOOIL_CC2_7	0	27	0
AMOCOOIL_CC2_8	0	27	0
AMOCOOIL_CC2_9	0	27	0
APD_APD_G1	1	0	44
ATKINS_ATKINSG3	0	27	0
ATKINS_ATKINSG4	0	27	0
ATKINS_ATKINSG5	0	27	0
ATKINS_ATKINSG6	0	27	0
ATKINS_ATKINSG7	0	27	0
AUSTPL_AUSTING1	2	0	2
AUSTPL_AUSTING2	11	0	1
AZ_AZ_G1	0	27	0
AZ_AZ_G2	0	27	0

Simulated data

Outage Scheduler

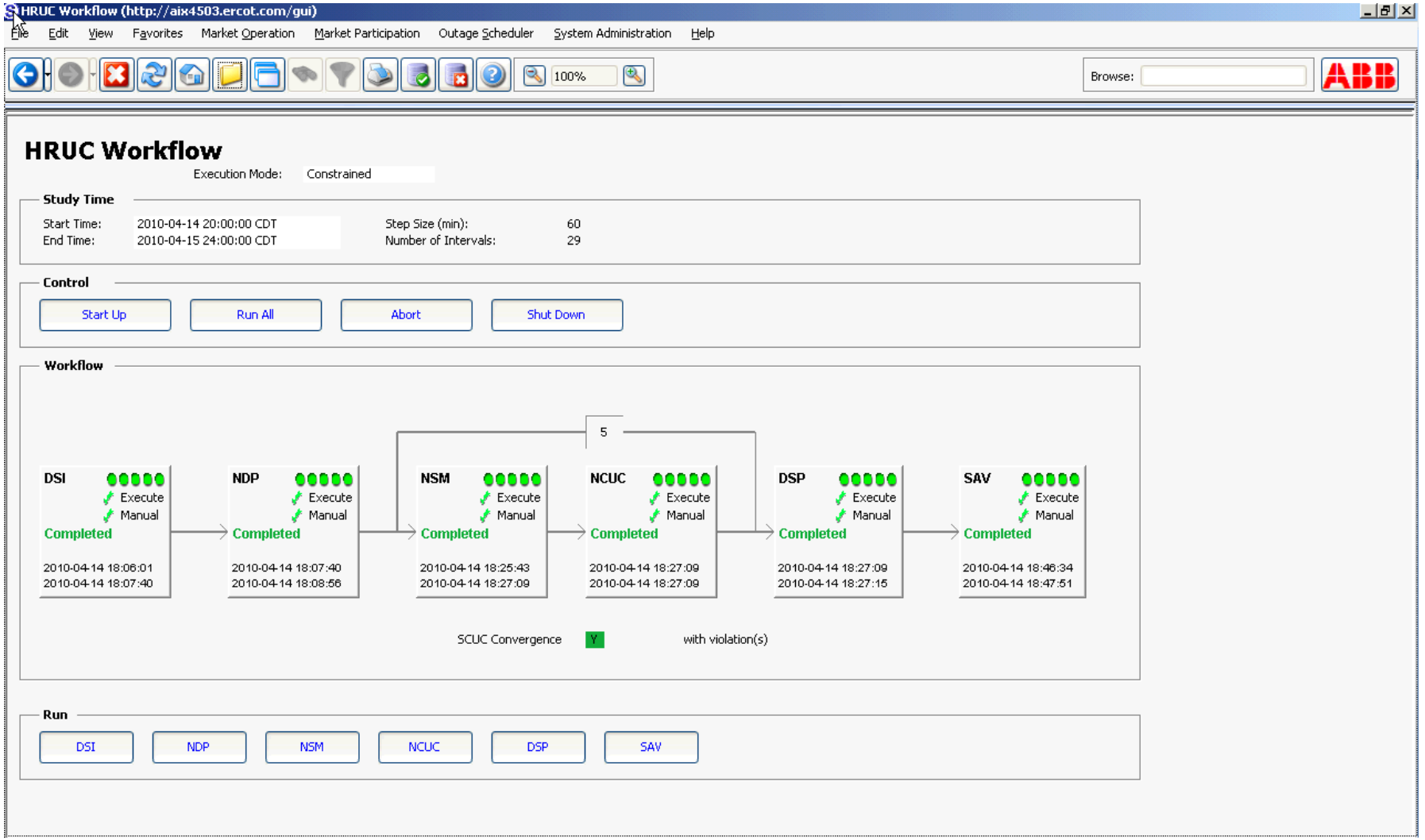


Outage Scheduler entries are by CCT Generation Unit



If the CCGR includes a primary generation unit that is subject to an outage, then MMS DAM/RUC applications uses the alternate unit for the outaged unit in the CCGR

Data is used to Commit / Decommit Resources in RUC



MMS Applications

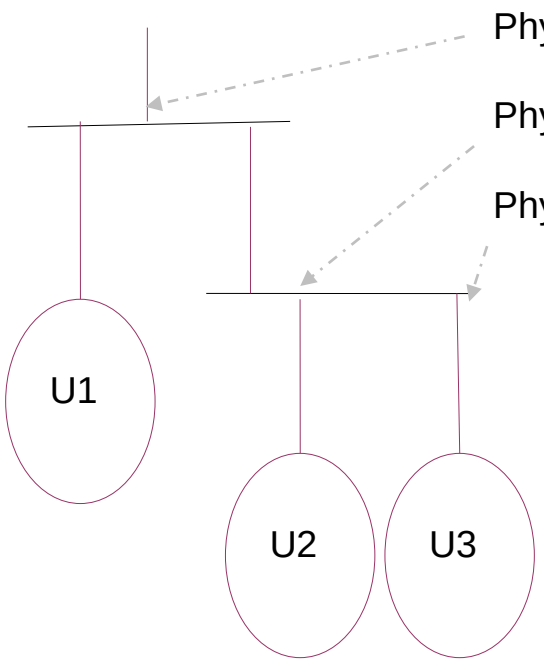
Resmi Surendran

Sub Topics

Topics we'll cover:

- Resource Node types for Combined Cycle (Logical & Physical)
- Market submissions guidelines
- Combined Cycle Modeling
- Aggregation and Disaggregation between the logical Resource Node and the physical generation Resource Nodes
- Resolving missing or conflicting COP Resource Status
- Identifying active Resources for each Combined Cycle Generation Resource (primary/alternate RARF designations)
- Modeling startup and transition

Definition



Logical RN for CC1

Mapped to
CC1_1
CC1_2
CC1_3
CC1_4

CCGR

CCT

CCU

			CC1_1	CC1_2	CC1_3	CC1_4
CC1		**HRL**	**1X0**	**2X0**	**1X1**	**2X1**
Unit 1	CT	100	X	X	X	X
Unit 2	CT	100	A	X	A	
Unit 3	ST	100			X	X
		300	**100**	**200**	**150**	**300**

Combined Cycle Train Resource Nodes

Logical Resource Nodes

- Defined for each Combined Cycle Train (CCT) & mapped to All CCGRs within the CCT
- Abstract in network model, i.e., not mapped to any Electrical Bus
- Resource specific submissions (3PO & AS offer) for the CCGRs are optimized and settled at the logical Resource Node for the CCT
- Used in NCUC and SCED

Physical Resource Nodes

- Defined for each generation unit in a CCT
- Mapped to an EB (Electrical Bus) in the Network model
- Could be Settlement Point for
  - CRR offer
  - DAM Energy only offer/bid,
  - PTP Obligation bids, and
  - QSE to QSE trades
- Used in NSM

Market Submissions Guidelines

- 3PO and online reserves can be submitted for each CCGR separately.

- CRR offer, DAM Energy only offer/bid, PTP Obligation bids, QSE to QSE trades **cannot** be submitted at logical Resource Node.

- Offline Non-Spin offer can be submitted only for CCGR that are registered as a startup mode.
  - If multiple Offline Non-Spin offers exist from different CCGR within the same CCT, then the offer from for the CCGR with max HSL capacity is selected as the only valid offer.

COP Verification

- COP for any CCGR is not cross validated with COP for other CCGRs in the CCT at the time of submission.
- Warning messages are sent out every hour to the QSE if there is any conflicting submission.
- Ancillary Service Responsibility check will check the COP status and will count only the Ancillary Service from CCGR with highest HSL.

CCT Modeling in MMS

- Each CCGR of a CCT is modeled as a separate Resource in the optimization.

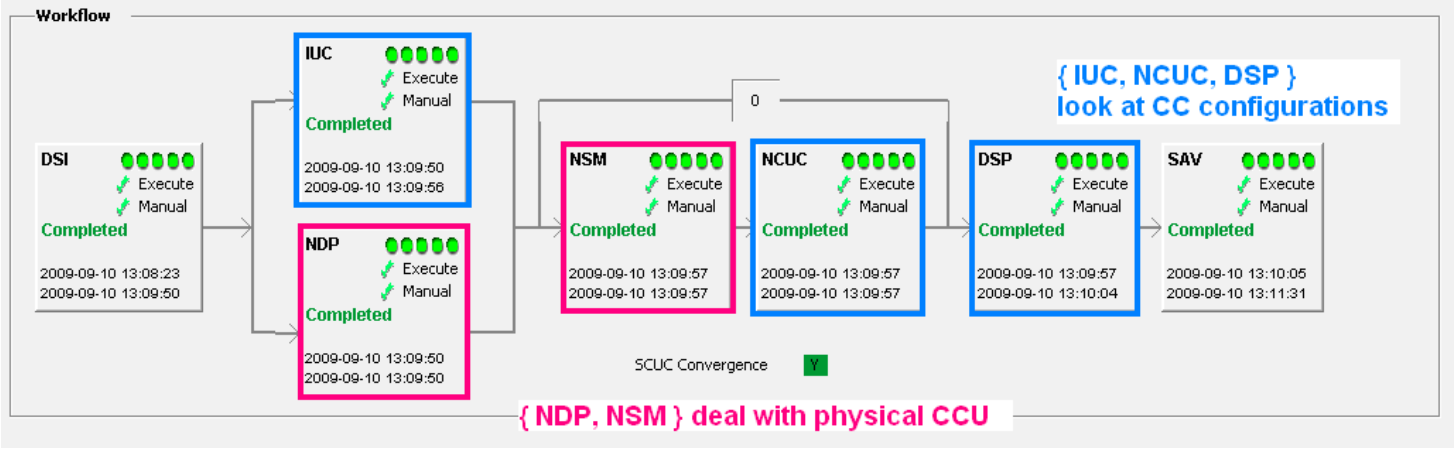
- For each time interval
  - Only one CCGR is awarded online reserve/energy
  - Either offline NSRS or Energy/online reserve is awarded not both

- CCGR committed at the end of study period shall be a shutdown capable CCGR of the CCT.

- If a CCGR is already self committed in an hour then RUC will not transition the CCT to another CCGR in the same hour.

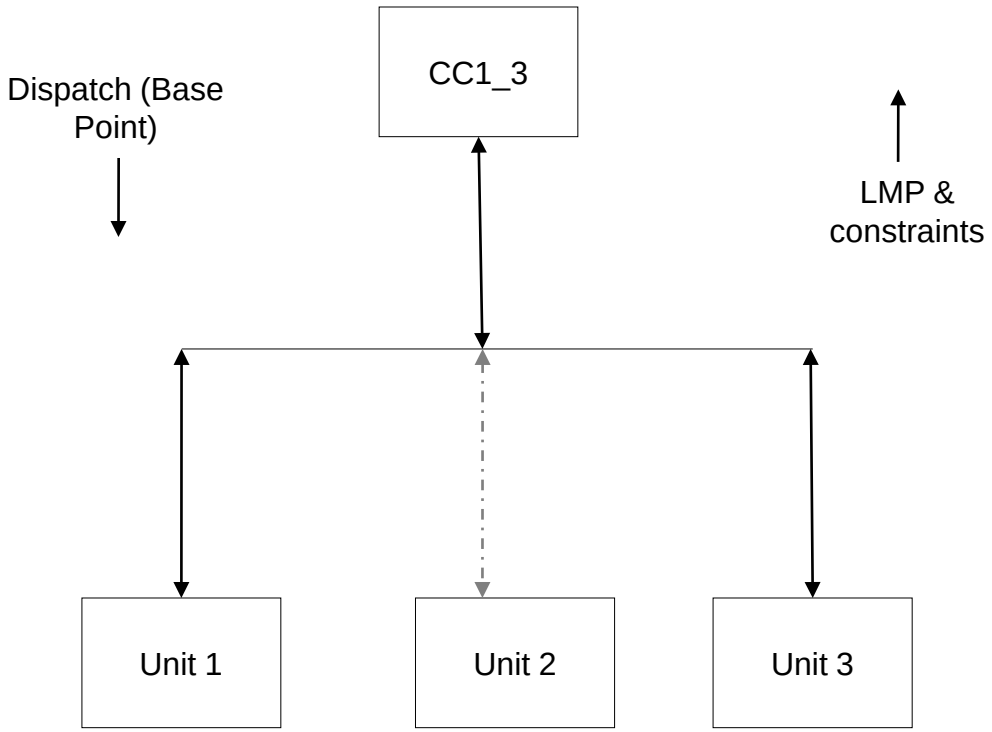
CCT Modeling in MMS

- All Network Constrained Unit Commitment (NCUC) and Economic Dispatch (SCED) modules model CCGRs at the logical Resource Node.
- All Network Security Analysis (NSM) applications model power injection at the CCT unit connectivity node(s).



CCT Modeling in MMS

MMS disaggregates dispatch from logical Resource Node to CCT physical Resource Node(s) and aggregates Shift Factors from connectivity node(s) to logical Resource Node



1) Logical Resource Node Energy Dispatch Schedule (Base Point) Disaggregation (NCUC to NSM)
   - Energy schedule for CC configuration (from NCUC) is distributed to power output of active units in the online CCGR
   - Using capacity weights (HRL) as distribution factors

$$PowOut_{CCU,i} = \frac{HRL_{CCU,i}}{\sum_{i \in CCGR} HRL_{CCU,i}} \times EnergySch_{CCGR}$$

			CC1_1	CC1_2	CC1_3	CC1_4
CC1		HRL	1X0	2X0	1X1	2X1
Unit 1	CT	100	X	X	X	X
Unit 2	CT	100	A	X	A	
Unit 3	ST	100			X	X
		300	100	200	150	300

If NCUC dispatches CC1_3 @ 80 MW

NSM will see it as injections
Unit1 @ 40MW
Unit2 @ 40 MW

2) Aggregation of Shift Factor (NSM to NCUC) [LMP and Constraints]
   - Linearized constraints are passed from NSM to NCUC to optimize energy offer. The aggregated Shift Factors are needed for this
   - In DAM & RUC, NCUC uses capacity (HRL) weighted average of Shift Factors from NSM for active physical units of the online CCGR for the CCT

$$SF_{CCGR} = \frac{\sum_{i \in CCGR} \left(HRL_{CCU,i} \times SF_{CCU,i} \right)}{\sum_{i \in CCGR} \left(HRL_{CCU,i} \right)}$$

			CC1_1	CC1_2	CC1_3	CC1_4
CC1		HRL	1X0	2X0	1X1	2X1
Unit 1	CT	100	X	X	X	X
Unit 2	CT	100	A	X	A	
Unit 3	ST	100			X	X
		300	100	200	150	300

If there is a binding constraint with the following SFs
Unit 1=0.085
Unit 2=0.077

NSM will pass a SF for CC1_3 equal to (0.085*100)+(0.077*100) / (100+100) =0.081

CCT Modeling in MMS

- In Real Time Market (SCED), aggregated SF is calculated by EMS using telemetry power output weighted average of units that are online in current operating configuration
- SCED Base Points and UDBP from LFC are for the online CCGR.
- DALMP, DASPP and RTLMP
  - logical Resource Node -> based on aggregated SF
  - Physical Resource Node -> based on physical SF
- RTSPP
  - logical Resource Node -> based on CCGR BP
  - Physical Resource Node -> based on time weighting

Resource Status Determination

Initial status based on

- COP—all CCGR
- Telemetry – Current Online CCGR
- Historic number of:
  - Online Hours
  - Offline Hours
  - Current day start-ups

EMS Current Commitment Status

Resource Name	Status
Station1_Unit1	OFF
Station1_Unit2	OFF
Station2_CC1_3	ON
Station2_CC2_5	ON
Station3_CC1_4	ON
Station4_CC1_1	OFF

EMS History Commitment Status

Resource Name	Online Hours	Offline Hours	No. Startups
Station1_Unit1	0	51	0
Station1_Unit2	0	3	2
Station2_CC1_1	0	65	0
Station2_CC1_2	0	51	0
Station2_CC1_3	51	0	0
Station2_CC1_4	0	150	0
Station2_CC2_1	0	75	0
Station2_CC2_2	0	65	0
Station2_CC2_3	0	60	0
Station2_CC2_4	0	51	0
Station2_CC2_5	45	0	0
Station2_CC2_6	0	45	0

Resource Status Determination

Missing COP before DAM/RUC study period

If COP is not available for any particular hour from the current hour to the start of the study period for any CC configuration, then the Resource Status for those hours are considered as equal to that of the *last known hour's COP* for that configuration.

Missing COP within DAM/RUC study period

If COP is not submitted for any hour in the RUC study period then *the configuration is set as unavailable* for those hours

Conflicting COP Resource Status before DAM/RUC study period

If multiple configurations for the same CC plant show as ONLINE for the same hour, then the configuration which has been *ON for the longest* is considered as ONLINE and all other ONLINE configurations are considered OFFLINE

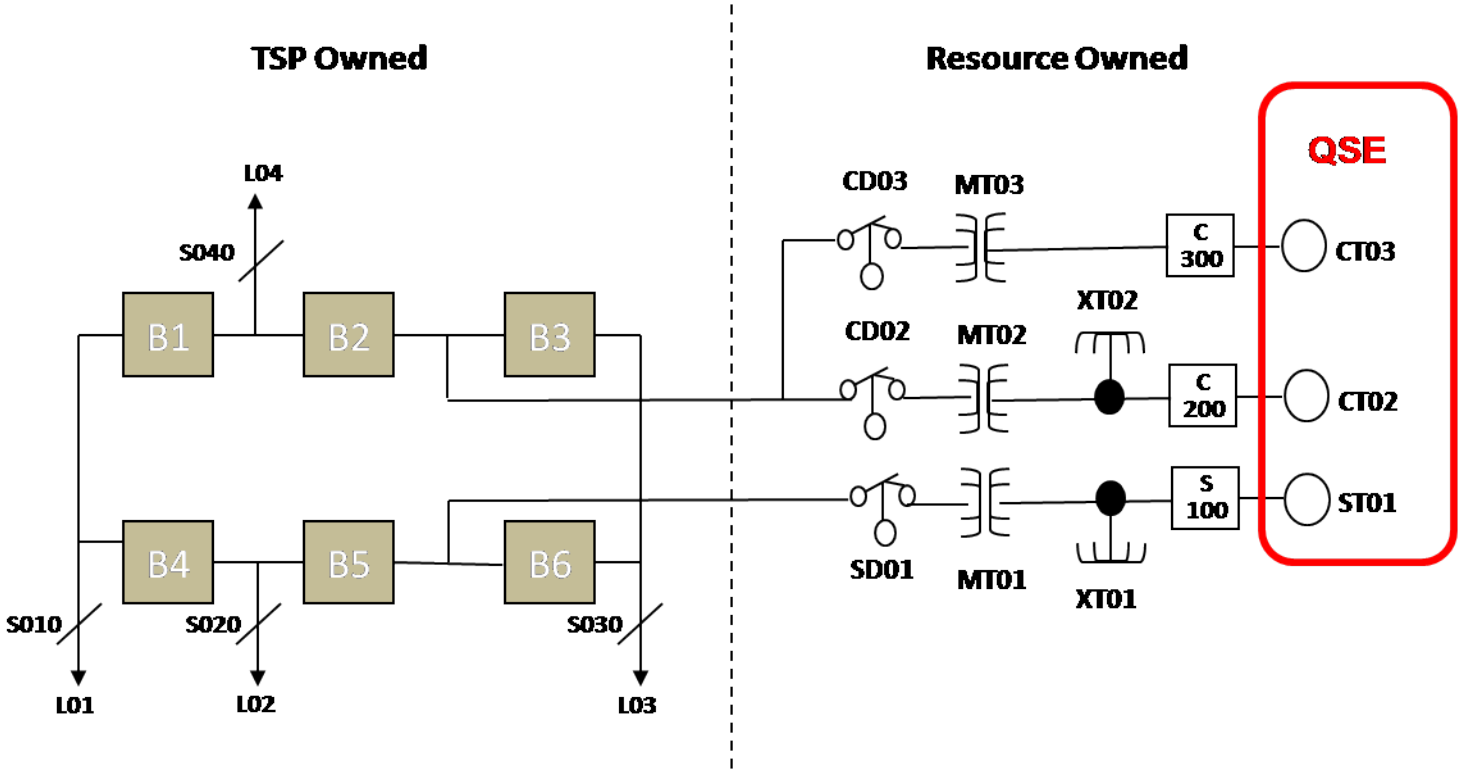
Conflicting COP Resource Status within RUC study period

If multiple configurations for the same CC plant show as ONLINE for the same hour within study period, then the ONLINE configuration with *largest HSL* is considered as ONLINE and all conflict configurations are considered OFFLINE.

The configuration whose status is changed will not get a RUC commitment due to the change.

Outage Scheduler entries are by CCT Generation Unit

If the CCGR includes a primary generation unit that is subject to an outage, then MMS DAM/RUC applications uses the alternate unit for the outaged unit in the CCGR.

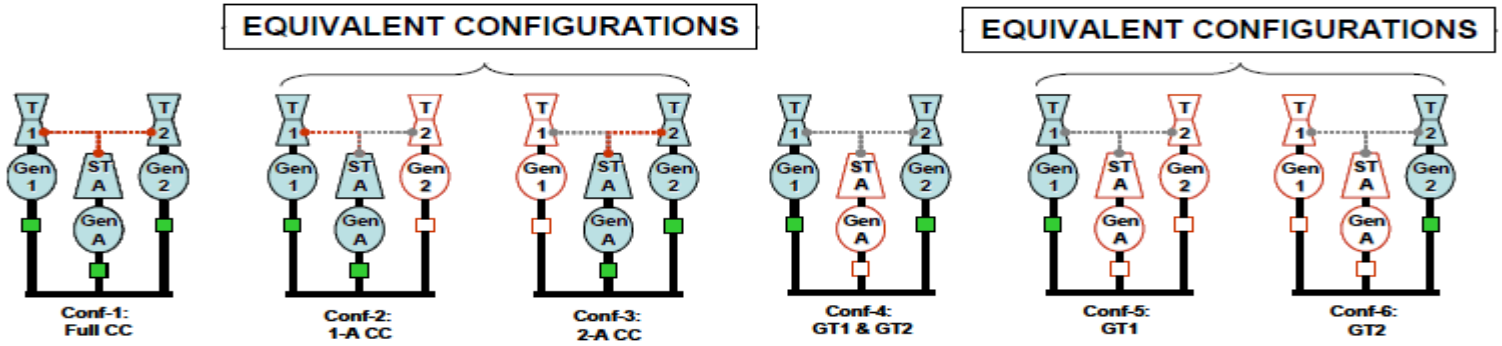


Primary & Alternate Generation Unit Selection

For an outaged primary CC Unit (CCU) with multiple alternates, DAM/RUC selects:

1) Alternate CCU with ***highest voltage*** level
2) Alternate CCU with ***highest capacity*** (per the RARF)
3) Alternate CCU that is ***first in database***, (i.e. randomly)

SCED - only dispatches the telemetered online CCGR



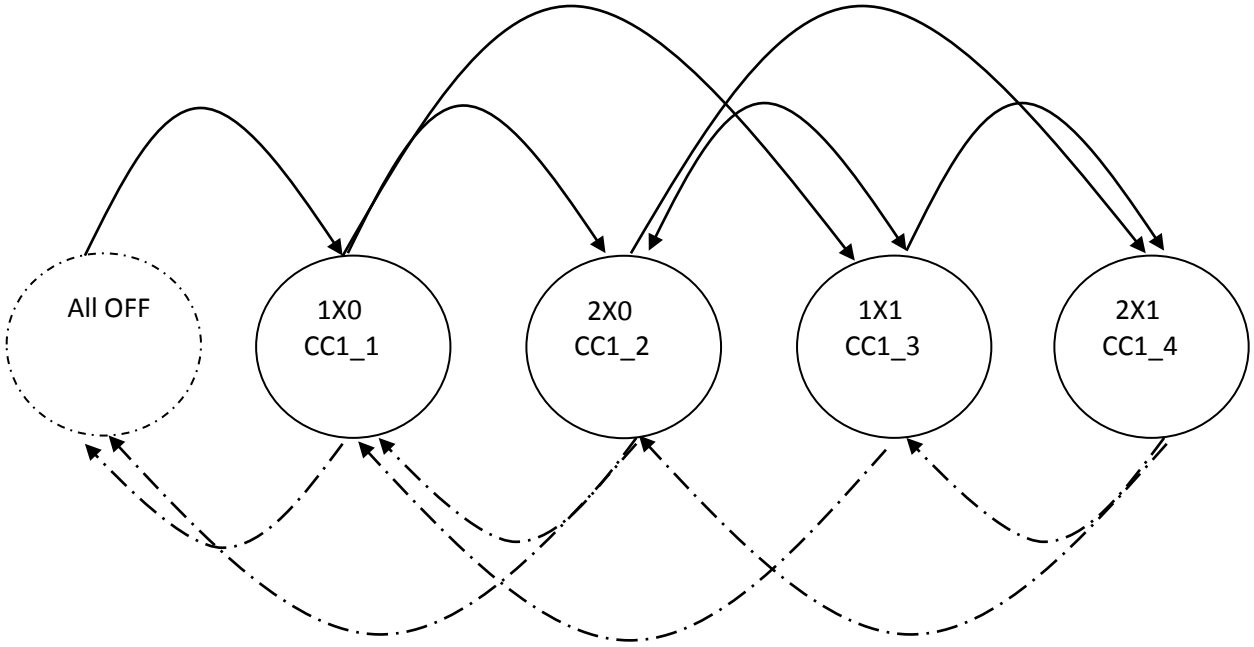
Up Transition

- Number of primary units in To CCGR >= Number of primary units in From CCGR

Down Transition

- Number of primary units in To CCGR < Number of primary units in From CCGR

Transition Matrix		To configuration				
		OFF	1	2	3	4
From configuration	OFF		↑			
	1	↓		↑	↑	
	2	↓	↓		↑	↑
	3		↓	↑		↑
	4			↓	↓	



Start Up and Transition Modeling

Transition

- Transition cost [1->2] = max(0, StartUpCost [2]– StartupCost [1])
- ***Down transition*** –> transition costs are considered as ***zero*** in MMS
- # of startups = # of up transitions for the CCGR.

S&B

- MMS will provide S&B the warmth state for each start and each up transition.
- Settlements calculates transition cost for up & down transition based on the warmth state from MMS

Start Up and Transition Modeling

Up Transition

- Considers Min On time; Min off time; Max on time; Max Startup #
- Time from “to configuration” was last off > Min off time;
- Time from “to configuration” was last off is used for the up transition warmth state

Startup

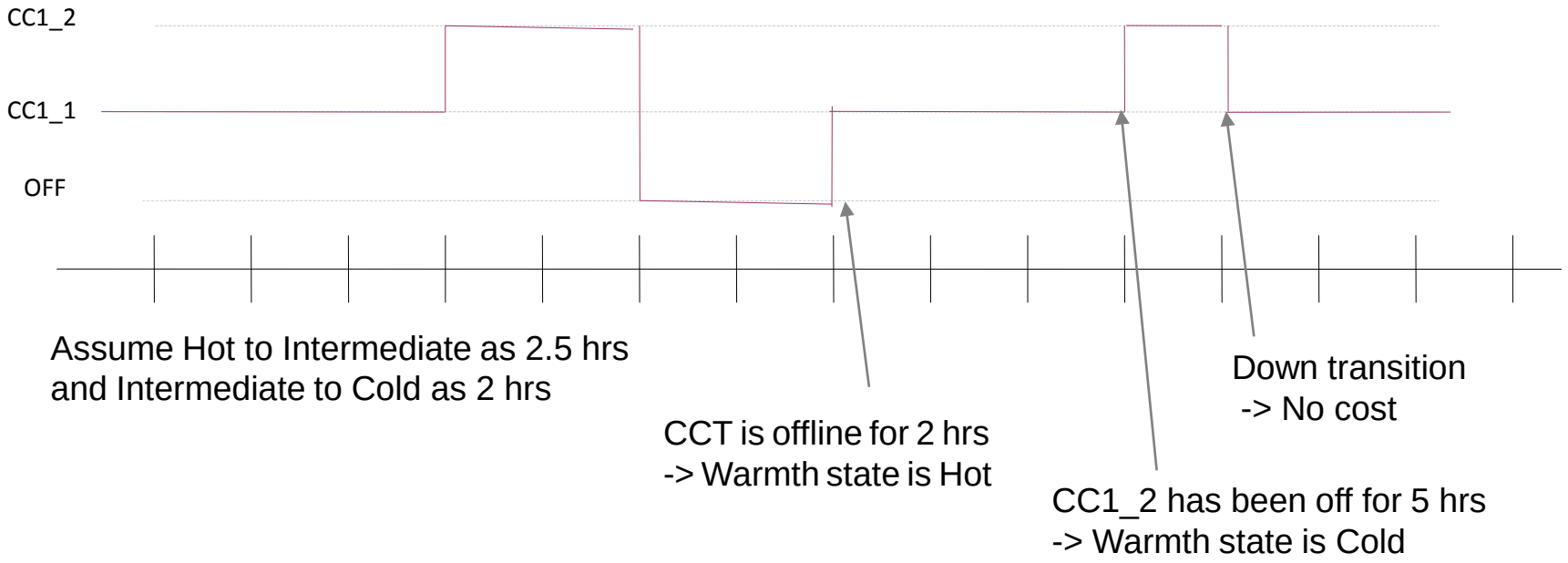
- Considers Min On time; Min off time; Max on time; Max Startup #
- Time from “plant” was last off > Min off time;
- Time from “plant” was last off is used to for the start up warmth state

Down Transition

- Considers Max on time only

Warmth state is determined for

- Startup cost -> by offline time of CCT
- Transition cost -> by offline time of To-CCGR



Summary

- 3PO & AS offer for each of the CCGRs are co-optimized and settled at the abstract logical Resource Node for the CCT
- CRR offer, DAM Energy only offer/bid, PTP Obligation bids, QSE to QSE trades can not be submitted at logical Resource Node
- Offline Non-Spin offer can be submitted only for the CCGR that are marked as startup mode. If multiple offers exist then highest HSL one is used
- Only the AS Responsibility in COP from CCGR with highest HSL will be used
- Only Online COP from CCGR with highest HSL will be used during RUC
- Either offline NSRS or Energy/online reserve is awarded and only one CCGR will be awarded for each time interval
- HRL is used to aggregate SF and disaggregate dispatch between logical and physical RN
- The LMP/SPP calculation is based on HRL weighted aggregate SF in DAM/RUC and MW weighted aggregate SF in SCED
- MMS model primary & alternate generation resource
- Transition cost [1->2] = max(0, StartUpCost [2]– StartupCost [1])
- Down transition cost is zero
- Warmth state is based on offline hrs of the CCT for Startup and in the case of a transition, it is based on offline hrs of the To-CCGR member of the transition pair

DAM SPP for a logical Resource Node

- **CCGR specific awards are settled at the CCT logical Resource Node
- **All other DAM non- Resource specific awards are settled at the specified CCT generation unit Resource Node

DAM CCT physical Resource Node LMP:

$$LMP_{CCU}^{DAM} = \lambda_{sys}^{DAM} \pm \sum_{lines} SP_{line}^{DAM} \cdot SF_{CCU}^{line}$$

DAM logical Resource Node LMP:

$$LMP_{CCT}^{DAM} = \lambda_{sys}^{DAM} \pm \sum_{lines} SP_{line}^{DAM} \cdot SF_{CCGR}^{line}$$

Note: the logical Resource Node LMP is a weighted average of CCGR generation unit Resource Node LMPs. The calculation is performed implicitly through aggregation of the SF for each of the CCGR generation units of the awarded CCGR using an HRL based weight factor. If primary is outaged then alternates HRL is used in determining the weighted average SF.

If none of the CCGR generation units are committed, the logical Resource Node aggregated SF is calculated assuming injection from all of the generation units in the CCT registration.

SCED LMP

In real-time, the operational CCGR configuration is unique and known through telemetry provided by EMS. The Shift Factors for the CCGR is provided by the EMS TCM subsystem.

$$LMP_{RN}^{SCED} = \lambda_{sys}^{SCED} \pm \sum_{lines} SP_{line}^{SCED} \cdot SF_{RN}^{line}$$

**The SCED LMP calculation for the logical Resource Node calculation is performed implicitly, using the aggregated SF provided by TCM for the operational CCGR, and is a by-product of optimized SCED base point dispatch.

The aggregated SF of the operational CCGR is the weighted average of the CCGR generation unit SFs weighted by telemetry power output of each of CCT generation units that are online.

RT SPP

**RT SPP for the CCT Logical Resource Node is calculated the same as that for all other Resource Nodes

$$RTSPP = \sum_{y} (RNWF_{y} * RTLMP_{y})$$

$$RNWF_{y} = [Max(0.001, \sum_{r} BP_{r,y}) * TLMP_{y}] / [\sum_{y} (Max(0.001, \sum_{r} BP_{r,y}) * TLMP_{y})]$$

Where the Base-Points used in the above settlement equation are the SCED Base Points issued to the CCGR.

Since SCED does not provide Base Point to the CCT generation units, the SPP at each of the generation unit Resource Nodes is the simple time-weighted average of the generation units SCED LMPs over the Settlement Interval.

Settlements & Billing Overview

Pam Shaw

Settlements Workshop Materials

- Posted http://nodal.ercot.com/training/index.html
  - Day Ahead Market (DAM)
  - Reliability Unit Commitment (RUC)
  - Real Time Market (RTM)

Future Training Classes

Combined Cycle focus - Settlements calculations

Review the impacts for Settlements calculations:

- Day Ahead Make Whole Payment
- RUC Settlements

  Make Whole Payment/Clawback Charge

  RUC Capacity Short

  RUC Decommitment Payment
- Real Time Energy Imbalance at Resource Node
- Black Start and RMR Availability
- Base Point Deviation
- Emergency Base Points

Combined Cycle focus – Day Ahead Make Whole

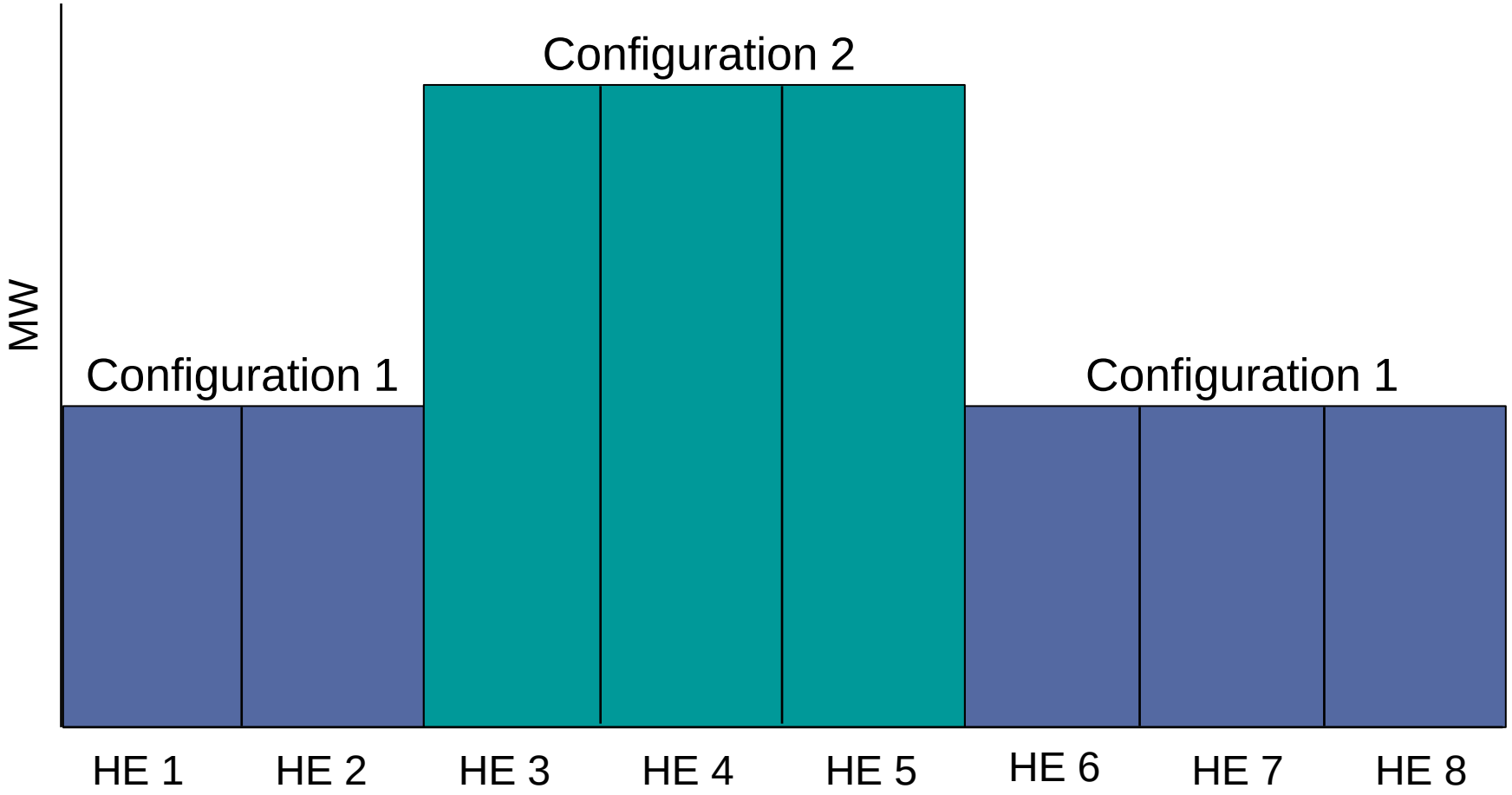
The Day Ahead Make Whole Payment compensates an eligible Generation Resource for the portion of its guaranteed operating costs that are greater than the Day Ahead energy and ancillary service revenue.

The payment for Day Ahead Make Whole for combined cycle units will be at the train level and is a result of comparing all guaranteed cost for the train to all revenue for the train.

CCGR level data is utilized within the make whole calculation. The inputs used to calculate each interval for a train will correspond to the CCGR that is DAM-Committed for that hour.

Startup eligibility will be based on Real Time telemetry for the Combined Cycle train. If the CC Train is committed in multiple configurations during the day, further compensation may be awarded during the Startup transition process.

Combined Cycle focus – DAM CC Transitions



Combined Cycle focus – Day Ahead Make Whole

		Resource Node		Resource	
Bill Determinant	Description	Logical Resource Node	Physical Resource Node	CC Train	CCGR
DAMWAMT	Day Ahead Make Whole Payment	x		x	
DAAIEC	Average Incremental Energy Cost	x			x
DAEOCQTY	Energy Offer Curve Quantity	x			x
DAEOCPR	Energy Offer Curve Price	x			x
DASUO	Start Up Offer	x			x
DAMEO	Minimum Energy Offer	x			x
DAMCOMMITFLAG	DAM Commitment	x			x
DAMSUFLAG	Start Up Eligibility	x		x	
DAMTFLAG	Transition Eligibility	x		x	
DAMWENEFLAG	Make Whole Energy Eligibility	x			x
DASPP	Settlement Point Price	x			
DASTARTTYPE	Start Type	x			x
DAMGCOST	Guarantee Cost	x			x
DAESR	Energy Revenue	x			x
DAASREV	Ancillary Services Revenue	x			x

Combined Cycle focus – RUC Make Whole or Clawback

The RUC Make Whole Payment compensates an eligible Combined Cycle train for the portion of its guaranteed operating costs that are greater than the Real Time energy, emergency, and ancillary service revenue.

The RUC Clawback Charge will evaluate if the revenue paid to the train is greater than the guarantee for the operating day and may clawback a portion of revenue based on clawback factors. Factors are determined based on if the train had a TPSO for any of its CCGRs for at least one hour of the Operating day.

The RUC make whole/clawback calculation for combined cycle units will be at the train level; however, all input data during RUC hours will be for the committed CCGR. QCLAW hour inputs will be based on the telemetered CCGR.

Combined Cycle focus – RUC Make Whole or Clawback

Startup eligibility will be based on Real Time telemetry for the Combined Cycle train. If the CC Train transitions from a Self Commitment, a DAM commitment, or a previous RUC commitment to a RUC commitment in a different CCGR during the day, further compensation may be awarded during the Startup transition process.

Settlements evaluates transition compensation based on the startup cost associated with the transition and not based on physical “upward/downward” transitions.

The CCGR telemetered by EMS is used to determine eligibility for transitions from one CCGR to another. The data is available by time stamp (hh:mm:ss format) and also available in an interval data cut (CCTS determines which CCGR is online the longest in a 15 min settlement interval).

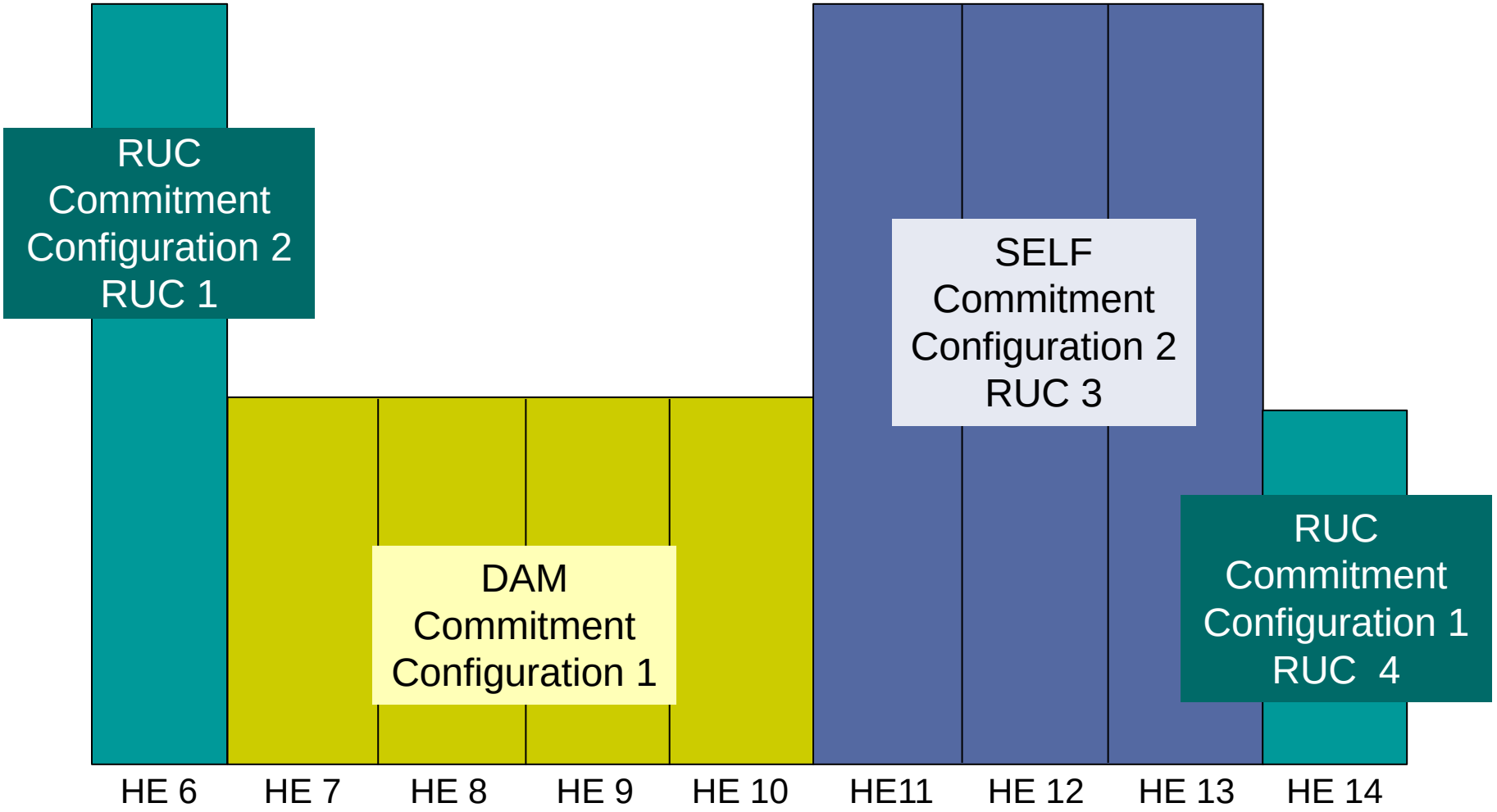
Minimum energy is compensated based on Real Time Metered Generation from the train.

RUC Make-Whole Payment Eligibility for SU Transitions

Three possible transitions. Must pass these eligibility rules:

1 DAM to RUC	• RUC is contiguous to DAM commitment • RUC not eligible for SU • RUC committed in different CCGR than DAM • Train is online and generating in the RUC committed CCGR for at least 1 minute
2 RUC to RUC	• RUC is contiguous to previous RUC • RUC not eligible for SU • RUC committed in different CCGR than prior RUC • Train is online and generating in the RUC committed CCGR for at least 1 minute
3 SELF to RUC	• RUC is contiguous to previous SELF commitment • RUC committed in different CCGR than SELF • Train is online and generating in the RUC committed CCGR for at least 1 minute

Combined Cycle focus – RUC CC Transitions



Combined Cycle focus – RUC Make Whole or Clawback

		Resource Node		Resource	
Bill Determinant	Description	Logical Resource Node	Physical Resource Node	CC Train	CCGR
RUCMWAMT	RUC Make Whole Payment	x		x	
RUCCBAMT	RUC Clawback Charge	x		x	
ADJRUC	RUC Adjustment	x		x	
DASUO	Day Ahead Start Up Offer	x			x
EOCPR	Energy Offer Curve Price	x			x
EOCQTY	Energy Offer Curve Quantity	x			x
HSL	High Sustainable Limit	x			x
LSL	Low Sustainable Limit	x			x
MEO	Minimum Energy Offer	x			x
QCLAW	QSE Clawback Intervals	x		x	
RGFTC	Resource Generic Fuel Type Category			x	
RTAIEC	Real Time Average Incremental Energy Cost	x			x
RTMG	Real Time Metered Generation	x		x	
RTSPP	Real Time Settlement Point Price	x			
RUC	RUC Commitment	x			x
RUCHR	Total RUC Committed Hours	x		x	
RUCTFLAG	RUC Start Up Transition Eligibility	x		x	
SELFCOMMITFLAG	QSE Self Committed Interval	x			x
STARTTYPE	Start Type	x			x
STATUSSNAP	Resource Status (On, Off)	x			x
SUO	Start Up Offer	x			x
VERIME	Verifiable Minimum Energy Cost	x			x
VERISU	Verifiable Startup Cost	x			x

Combined Cycle focus – RUC Capacity Short

5.7.4.1.1 Capacity Shortfall Ratio Share

(5)For Combined Cycle Generation Resources, if more than one Combined Cycle Generation Resource is shown On-Line in its COP for the same Settlement hour, then the provisions of paragraph (5)(a) of Section 3.9, Current Operating Plan (COP), apply in the determination of the On-Line Combined Cycle Generation Resource for that Settlement hour.

ERCOT Settlement Implementation:

Check the STATUSSNAPs, which designate if a CCGR is on-line (1) or off-line (0) for each RUC process. If two or more CCGRs have a value of 1 in the same hour, then Settlements will alter the CCGR(s) with the lower HSL(s) to a value of 2 = invalid. The value of the CCGR with the highest HSL will remain (1) on-line.

Combined Cycle focus – RUC Decommitment Payment

If ERCOT decommits a QSE committed Train that is not scheduled to shutdown within the Operating Day, then the train is eligible to be considered for the RUC Decommitment Payment.

The Decommitment Payment compensates the Train to start up at the end of the decommitment period while also considering the revenue the train would have made had it been online in Real Time as planned.

The SUPR, MEPR and LSL used to calculate payment for each contiguous decommitted period for a Train shall be the SUPR, MEPR and LSL that corresponds to the CCGR that is decommitted in the first hour of the contiguous decommitted period.

Combined Cycle focus – RUC Decommitment Payment

		Resource Node		Resource	
Bill Determinant	Description	Logical Resource Node	Physical Resource Node	CC Train	CCGR
RUCDCAMT	RUC Decommitment Payment	x		x	
ADJRUCD	Adjust RUC Decommitment Payment	x		x	
MEPR	Minimum Energy Price	x			x
NCDCHR	Number of Decommitted Hours	x		x	
RUCD	RUC Decommitment	x			x
RUCDFLAG	RUC Decommitment Eligibility	x		x	
RUCDSTARTTYPE	RUC Decommitment Start Type	x		x	
SUPR	Start Up Price	x			x

Combined Cycle focus – Real Time Energy Imbalance

All QSEs that have generation, load, energy trades, DAM purchases or sales, and self-schedules at any Settlement Point are assessed a charge or payment for the imbalance of Energy at the Settlement Point.

ERCOT will pay or charge a QSE for their net injection or withdrawal at a settlement point.

Due to certain restrictions regarding Settlement point activity, the activity at a Generation site that has a Combined Cycle train is assessed at both the Logical and the Physical resource nodes.

Combined Cycle focus – Real Time Energy Imbalance

		Resource Node		Resource	RTLMP	
Bill Determinant	Description	Logical Resource Node	Physical Resource Node	CC Train	Gen Site	Resource ID
RTEIAMT	Real Time Energy Imbalance Payment	x				
DAES	Day Ahead Energy Sales	x (3PO)				
GSPLITPER	Generation Unit Splitting Percentage	x		x	x	
MEBMP	Metered Energy Bus (MP)				x	x
NMRTETOTMP	Net Metered Real Time Energy Total (MP)				x	
NMSAMTTOT	Net Metering Settlement Payment				x	
RTRMPR	Real Time Locational Marginal Price at Bus				x	x
SSSK	Self Schedule at Sink	x				
SSSR	Self Schedule at Source	x				

RTEIAMT	Real Time Energy Imbalance Payment	x	
DAEP	Day Ahead Energy Purchase	x	
DAES	Day Ahead Energy Sales	x (Energy only)	
RTQQEP	Real Time QSE to QSE Purchase	x	
RTQQES	Real Time QSE to QSE Sale	x	
SSSK	Self Schedule at Sink	x	
SSSR	Self Schedule at Source	x	

Combined Cycle focus – Other

Black Start and RMR Availability:
If a Combined cycle Train is under contract for Black Start or RMR, the Availability calculation will be based on the entire CC Train. The train is considered “available” if at least one of the contracted CCGRs are “available”.

Base Point Deviation Charge:
The Base Points and telemetered generation considered for the Base Point Deviation charge are integrated over the 15 minute settlement interval for the Combined Cycle Train (AABP and TWTG).

Emergency Base Points:
The Emergency Base Points and telemetered generation considered for the Emergency Base Point calculation are integrated over the 15 minute settlement interval for the Combined Cycle Train (AEBP and RTMG).

Conclusion

Conclusion

Market Participant Follow-up Information

- Questions?
  - Email address: NodalMarketTransition@ercot.com
  - Subject line: “CC Workshop”

- Next scheduled workshop:
  - June 2, 2010
  - Houston, TX
  - Check ERCOT meeting calendar for location & details

References

MMS - Day-Ahead Market and Supplemental Ancillary Service Market Requirements Specification (B2) v3.0

MMS - Reliability Unit Commitment Requirements Specification (B2) v2.0

MMS - Overall Market Management System and Other Processes Requirements (B2) v2.0

SIG0003 Combined Cycle Plants v5.0

White Paper - Combined-Cycle Unit Modeling in the Nodal Design v3.0

EDS 2 - Release 4 - NMMS Modeling Guidelines v1.0

EDS - Resource Registration Guide v4.2

COMS - Details on Settlement of Combined Cycle White Paper v3.0

ABB2008-102482 : Treatment of fraction HOT2INT and INT2COLD parameter