A536: Real-Time Scheduling

Real-Time Commitment (RTC) and Real-Time Dispatch (RTD)

Preliminary Design Considerations

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1 INTRODUCTION

1.1 Goal Statement

Define the rules, bidding parameters, and constraints for the commitment and dispatch functions of the real-time scheduling system.

1.2 Definitions, Acronyms, and Abbreviations

Term	Description
10_{00}	10-minute units started by RTC_{00}
10_{15}	10-minute units started by RTC_{15}
10_{30}	10-minute units started by RTC_{30}
10_{45}	10-minute units started by RTC_{45}
30_{00}	30-minute units started by RTC_{00}
30_{15}	30-minute units started by RTC_{15}
30_{30}	30-minute units started by RTC_{30}
30_{45}	30-minute units started by RTC_{45}
BME	Balancing Market Evaluation
EDRP	Emergency demand response program
RTC	Real-time commitment
RTC_{00}	Real-time commitment that posts on the hour
RTC_{15}	Real-time commitment that posts at 0:15 after the hour
RTC_{30}	Real-time commitment that posts at 0:30 after the hour
RTC_{45}	Real-time commitment that posts at 0:45 after the hour
RTD	Real-time dispatch
RTD-CAM	Real-time dispatch – corrective action mode
RTS	Real-time scheduling (RTC, RTD, and RTD-CAM)
SCUC	Security constrained unit commitment
SNET	Short notice external transaction
$SNET_{00}$	Short notice external transactions scheduled by RTC_{00}
$SNET_{15}$	Short notice external transactions scheduled by RTC_{15}
$SNET_{30}$	Short notice external transactions scheduled by RTC_{30}
$SNET_{45}$	Short notice external transactions scheduled by RTC_{45}
UOL	Upper operating limit
UOL_E	Emergency upper operating limit
UOL_N	Normal upper operating limit

1.3 Background

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1.4 Business Need

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1.5 System Impact

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2 Real-Time Commitment (RTC)

As shown in Figure 1, RTC is a multi-period security constrained unit commitment and dispatch model that co-optimizes to simultaneously solve load, reserves and regulation. Each RTC run optimizes over ten quarter hour periods for a total optimization horizon of 2 ½ hours. Each RTC run receives a label in terms of our description of the model that indicates the time at which the results of the run are posted. These results apply to the 2 ½ hour period that starts 15 minutes after the RTC results post, e.g., RTC_{15} posts at time 15 and optimizes from time 30 through time 180. RTC will run every 15 minutes.

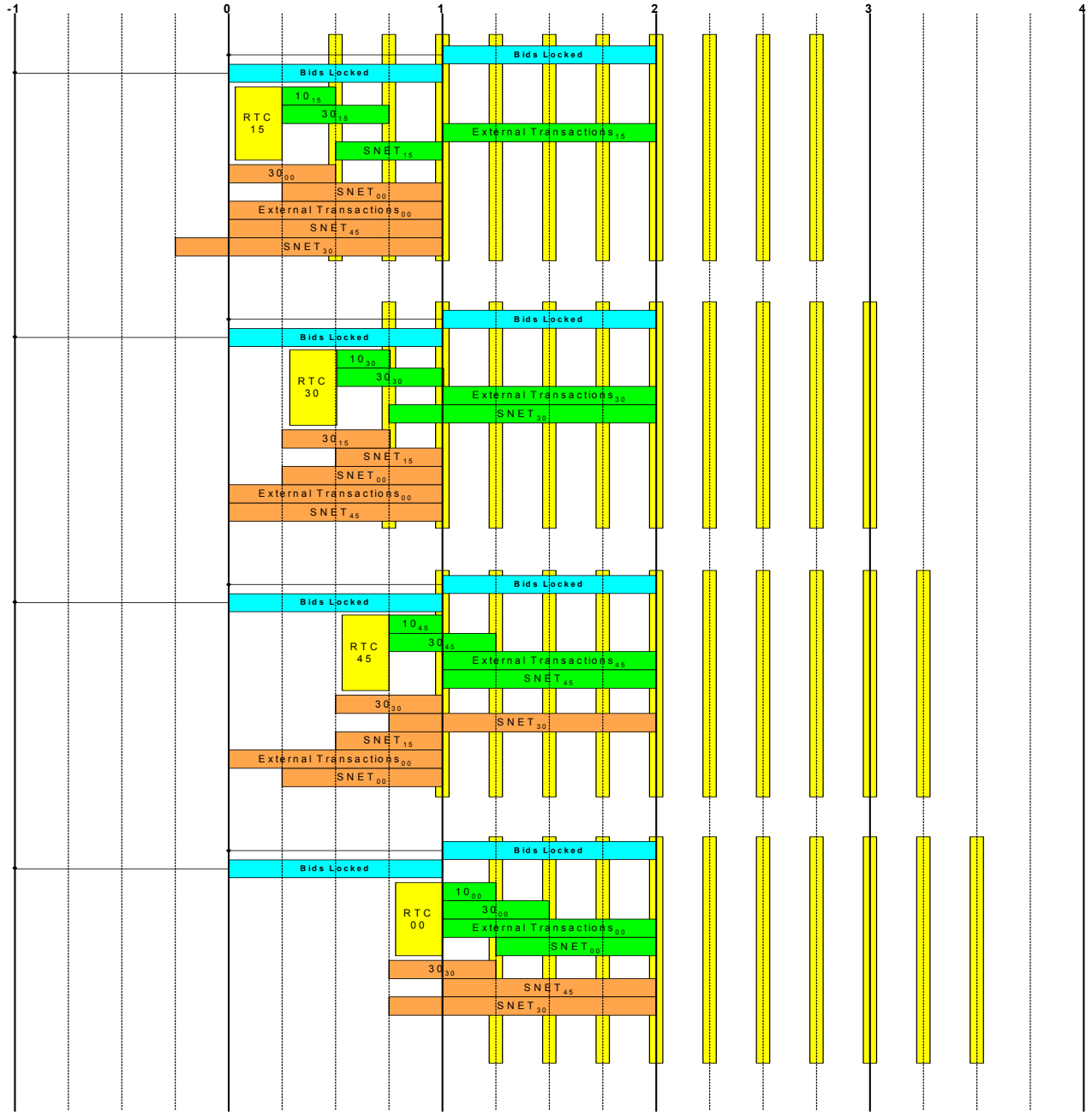

Figure 1. Real Time Commitment Process

2.1 Objective Function and Constraints

The most important element of any description of scheduling software is the objective function, the solution requirements and the constraint set. The overall objective is to minimize the total as-bid cost over the 2 ½ hour optimization timeframe. The solution requirements are:

- Commit, dispatch and schedule resources to meet forecast load plus losses
- Meet all reserve requirements by product type and location
- Meet the regulation requirement

The constraints modeled in RTC include but are not limited to:

- All transmission constraints (base case, contingency, thermal, voltage, stability)
- Generation bidding parameters (ramp rates, startup times, minimum down times, minimum generation levels, Upper Operating Limits, minimum run times)

The costs that are included in the optimization include but are not limited to:

- Generation startup costs
- Generation minimum generation costs
- Generation incremental energy costs
- Import generation costs
- Export schedule benefits
- Wheel through schedule benefits
- Dispatchable load schedule benefits
- Reserve schedule availability costs (Lost opportunity costs are implicitly captured through other costs)
- Regulation schedule availability costs (Lost opportunity costs are implicitly captured through other costs)

2.2 Generation

2.2.1 Bid Representation

Generators will be able to bid in one of three general constructs:

- Dispatchable i.e. will follow a 5 minute (or 6 second) basepoint
- Self scheduled lower limit with a dispatchable range i.e. will follow a 5 minute (or 6 second) basepoint above a market participant specified lower limit. A physical lower limit must also be bid in for emergency redispatch situations.
- Self scheduled with no dispatchable range

Each generator will be able to specify a normal upper operating limit (UOL_N) and an emergency upper operating limit (UOL_E). These limits will be recognized both day-ahead and in real-time. Dispatchers will determine if the normal or emergency ratings should be used for the day's unit commitment before running the day-ahead market model. The exact details of the rules that determine whether the day in question is normal or emergency are still to

be finalized but operations staff will make this decision before initiating the SCUC run for a day. An "emergency" day allows the SCUC to use the entire units output up to its Emergency UOL for energy or reserves. On other days reserves and energy can only be scheduled up to the Normal UOL. Operators will be allowed to call for emergency UOLs after the day-ahead market if it becomes apparent that the real time market is going to be unexpectedly tight. The criteria are yet to be defined.

Inter-temporal constraints will be modeled in RTC. The parameters that define the maximum and minimum allowable values for each of the inter-temporal constraints in SCUC and RTC may be different:

- Minimum run time – maximum value allowed will be 1 hour
- Startup time – units can specify a 15 minute or 30 minute start time
- Minimum down time – maximum value allowed will be 168 hours
- Maximum starts/stops[1]

Bids for energy and ancillary services will be locked one hour before the beginning of the hour in which that bid would apply. Bidding restrictions currently in place on BME bids for segments of the generators curve scheduled day-ahead would be reflected in similar limits for RTS.

Generators will be required at all times to either have a valid bid submitted up to its currently stated upper operating limit or to have scheduled the unit on an outage.

2.2.1.1 Energy Bid Representation

- Steam units will be bid in as they are in SCUC today with a startup cost, minimum generation cost and incremental energy bids that are blocks.
- Gas turbines may choose to submit bids with a minimum operating level plus a dispatchable range. They will be block loaded in day-ahead and RTS schedules only up to the specified minimum operating level. A gas turbine that chooses a minimum operating level equal to it maximum operating level will be treated as gas turbines are today.

2.2.1.1.1 Startup Cost Bid Representation

- Start up costs bid as they are in SCUC today.
- The Market Participants can choose between a startup cost defined by:
    - Hour of the day
    - Time dependent increasing cost function (to model warm start steam).
    - Time dependent decreasing cost function (to model gas turbine willingness to restart quickly after it has shut down).
    - Time dependent and allowed to be increasing or decreasing. Currently start-up cost must be a monotonically increasing function of down time so this option may not be possible.
- Gas turbines will have a real time startup cost that will be used by RTC.

[1] It has not yet been determined if the software or the market participants will be responsible for managing this intertemporal constraint in real time. It is and will continue to be modeled in SCUC.

- RTD does not make commitment decisions and will not use this startup cost in any scheduling or pricing decisions.

- RTD-CAM will be able to commit gas turbines and the startup cost will be built into the incremental energy cost considered by the RTD-CAM commit mode. The RTD dispatch schedules and prices will be based only on the incremental costs of the units.

2.2.1.1.2 Minimum Generation Bid Representation

- Minimum generation cost bids will be submitted in the same form as they are in SCUC today.

- The minimum generation operating level is defined by a MW level. This level may change hourly in SCUC and may change quarter-hourly in RTS.

- The minimum generation cost is defined by a total minimum generation cost in $.

2.2.1.1.3 Incremental Energy Bid Representation

- Incremental energy bids will be submitted in the same form as they are in SCUC today with some number of incremental block bids.[2] Each block is defined by a quantity

- Each block is defined by a single incremental $ bid

- Incremental energy blocks must have monotonically increasing bid prices but do not need to be below the average cost of the minimum generation block

2.2.1.2 Ancillary Service Bid Representation

Bidding constructs for ancillary services will apply in SCUC and all the RTS scheduling packages (RTC, RTD and RTD-CAM).

Bids for reserves scheduled day-ahead may not be increased between the day-ahead and real-time markets.

2.2.1.2.1 10 Minute Spinning Reserve Bid Representation

- Availability bids will be $0/MW by definition for all units capable of providing spinning reserve.

- Units that can only provide spinning reserves if they are on-dispatch or bid with a self-scheduled lower limit and a dispatchable range.

- Units do not explicitly define the quantity of reserve provided

- Reserve quantities will be defined by the units reserve ramp rate but may also be limited by the size of the dispatchable range on the unit as defined by the applicable Emergency or Normal Upper Operating Limit

2.2.1.2.2 10 Minute Non-Synchronized Reserves Bid Representation

- Availability bids will be allowed

- Reserve quantity will be defined by the applicable Emergency or Normal UOL

- A unit that has an energy bid curve must also bid reserves. If no availability bid is submitted a bid of $0 will be assumed

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[2] 12 blocks have been proposed. This number needs to be high enough to allow bidding flexibility but not so high as to affect performance if many units opt to use the full block definition.

- Units that bid must be able to synchronize and generate within 10 minutes

2.2.1.2.3 30 Minute Synchronized Reserves Bid Representation

- Availability bids will be $0 by definition for all units capable of providing spinning reserve.
- Units that can only provide spinning reserves if they are on-dispatch or bid with a self-scheduled lower limit and a dispatchable range.
- Units do not explicitly define the quantity of reserve provided
- Reserve quantities will be defined by the units reserve ramp rate but may also be limited by the size of the dispatchable range on the unit as defined by the applicable Emergency or Normal Upper Operating Limit

2.2.1.2.4 30 Minute Non-Synchronized Reserves Bid Representation

- Availability bids will be allowed
- Reserve quantity will be defined by the applicable Emergency or Normal UOL
- A unit that has an energy bid curve must also bid reserves. If no availability bid is submitted a bid of $0 will be assumed
- Units that bid must be able to synchronize and generate within 30 minutes

2.2.1.2.5 Regulation Bid Representation

- Availability bids will be allowed for regulation.
- Units will also specify a regulating capability in MW and MW/min.

2.2.1.3 Inter-temporal Constraints

The RTC engine will have the same capabilities as today's SCUC to model inter-temporal constraints. The day-ahead schedules of all units capable of being started within 30 minutes will no longer be passed through into real time as must take capacity. Market participants must manage this risk for themselves.

2.2.1.3.1 Startup Time

- Will be limited to a maximum of 30 minutes
- Units can specify a startup time of as little as 15 minutes

2.2.1.3.2 Minimum Run Time

- The maximum allowable minimum run time will be 1 hour.
- The minimum runtime can be as short as 15 minutes

2.2.1.3.3 Minimum Down Time

- The maximum allowable minimum down time will be 168 hours.

2.2.1.3.4 Maximum Number of Starts/Stops

It has not yet been determined whether this will be tracked by the market participant or the software. The difficulty in tracking it in the software is that RTC has a limited optimization horizon. It may make ill-informed decisions as it will not know that it needs the unit in four hours time. Whichever way the limit is handled, it is important that

operations knows when a unit is reaching its limit so that they know turning it off may make the unit unavailable for the remainder of the day.

2.2.2 Commitment

Unit starts and stops will be controlled by RTC in most cases. The exception is the commitments made by RTD-CAM. The RTC runs that post at 15 minutes past each hour determine the economically evaluated external transactions scheduled for the following hour, i.e., RTC_{15} determines the economically evaluated external transaction schedules for time 60 through 120.

The other 3 RTC runs in each hour must make some assumptions about all the transactions that were scheduled either as pre-scheduled, economically evaluated or SNETs. In any quarter hour period, in any RTC run that economic transaction decisions are made all external transactions will be evaluated consistent with their bids. RTC will treat all transactions as fixed injections or withdrawals in quarter hour periods where economic evaluations are not being made. This will require some form of pre-processing to ensure transaction feasibility. RTC will not select specific transactions to be cut but rather will indicate to the operator that some number of MWs of transactions need to be cut in order to maintain feasibility. The operator will then use the IS+ tools to curtail the appropriate transactions.

2.2.2.1 Startup

All units in RTC will receive binding startup notifications consistent with startup time included in their real-time bids. Units that submit a 30-minute start-up time will receive a binding startup notification from the RTC that posts its results 30 minutes before the scheduled start of the unit. Units that submit a 10 to 15-minute start-up time will receive a binding startup notification from the RTC that posts its results 15 minutes before the scheduled start of the unit.

A unit that is scheduled to start at time 60 with a 30-minute startup time will be given a binding commitment by RTC_{30}. RTC_{15} may have indicated that the unit was likely to start at time 60 but that commitment is only advisory. RTC_{45} will not re-evaluate that commitment but rather will take the commitment of that unit as a given for time 60 and for the duration of the units minimum run time.

A unit that is scheduled to start at time 60 with a 15-minute or less startup time will be given a binding commitment by RTC_{45}. RTC_{30} may have indicated that the unit was likely to start at time 60 but that commitment is only advisory.

On-dispatch units receive a real-time bid production cost-guarantee once they receive a binding commitment. If, in hindsight, the prices in RTD did not support the commitment made by RTC, the unit would receive a real-time bid production cost guarantee. Units that are self-scheduled fixed or self-scheduled with a dispatchable range receive no real-time bid production cost guarantees.

2.2.2.2 Shut Down

Unit shut down decisions are not binding until the commitment immediately before the scheduled shutdown. RTC_{15} may indicate that a unit will be shut down at time 45 but this is not binding until RTC_{30} schedules that shutdown for time 45.

2.2.3 On-Dispatch Unit Schedules

The schedules produced by RTC for on-dispatch units are a binding commitment up to the minimum generation level of the on dispatch unit. The binding commitment includes a real-time bid production cost guarantee. The dispatch from RTC above minimum generation is only advisory. RTD and RTD-CAM are responsible for the 5-minute dispatch of the on-dispatch units above their minimum generation levels.

2.2.4 Self-Scheduled With Dispatchable Range Unit Schedules

The schedules produced by RTC for self-scheduled with dispatchable range units are binding up to the self-scheduled lower operating limit. These schedules are binding in the sense that a failure to generate at a level consistent with the self-scheduled lower limit is behavior auditable by the Market Monitoring Unit. These units receive no real-time bid production cost guarantee.

The dispatch from RTC above the self-scheduled minimum generation level is only advisory. RTD and RTD-CAM are responsible for the 5-minute dispatch of these units above their self-scheduled minimum generation levels.

2.2.5 Self-schedule Fixed Unit Schedules

The schedules produced by RTC for self-scheduled fixed units are binding up to the self-scheduled lower operating limit. These schedules are binding in the sense that a failure to generate at a level consistent with the self-scheduled fixed output level is behavior auditable by the Market Monitoring Unit. These units receive no real-time bid production cost guarantee.

2.3 Demand Side Resources

2.3.1 Dispatchable Load

Load that has demonstrated that it meets all metering and deliverability requirements can bid into RTC. RTC will commit and dispatch the resource as if it were just another generator on the system. Loads that are able to respond on a shorter time frame than the 15 minute notice provided by RTC may treat the RTC schedules as advisory and wait for dispatch signals from RTD.

2.3.2 Interruptible Load

Contractual interruptible loads will be evaluated like dispatchable loads if there are prices associated with those contracts. If there are no prices associated with the interruptible loads they will be handled by the operators in real time and those decisions will be plugged into real-time scheduling processes as fixed injections as soon as the decision is made to interrupt that load.

2.3.3 Aggregators

2.3.4 EDRP

Once EDRP warnings and alerts have been sent out to all the registered loads they will be treated the same way as interruptible loads. If there are prices associated with the EDRP loads then RTC will commit and dispatch them. If the decision to actually curtail the EDRP loads this decision will be fed immediately into all the real-time scheduling processes

2.4 Transactions

There are five classes of transactions:

- Pre-scheduled before SCUC
- Economically scheduled by SCUC converted to pre-scheduled
- Pre-scheduled before RTC
- Economically scheduled by RTC

- Short notice external transactions

Within each of the classes of transactions there are three types of transactions

- Imports
- Exports
- Wheels

SCUC transactions can be bid hour-to-hour or as multi-hour block transactions. SCUC transactions are hourly but can indicate their willingness to be scheduled on a quarter hour basis. RTC transactions are hourly or can be quarter hourly to the extent that the interface over which the transaction is being scheduled supports quarter hourly transactions, schedule changes and ramps directly through an OSS type tool. Interfaces that allow quarter hourly schedule changes will permit quarter hourly defined pre-schedules in real time.

Every fourth RTC run does economic evaluations of external transactions. RTC_{15} optimizes over a timeframe from time 30 through time 180. An economic evaluation is performed for time periods 60 through 120 for which binding external schedules are generated. The external schedules for time period 30 through 60 have already been established and will be treated a fixed injections and withdrawals. External transaction schedules for time period 120 through 180 are determined based on economics but the schedules generated for this period of time are not biding until RTC_{15} of the next hour is run.

There is a fundamental question as to how quarter hour periods where economic transactions are not being evaluated should be treated. If interface capacities have not been reduced since scheduling the transactions there should be no problem. If they have been reduced however we need a mechanism to reflect those reduced schedules in the RTC solution. This will require some form of pre-processing to ensure transaction feasibility. RTC will not select specific transactions to be cut but rather will indicate to the operator that some number of MWs of transactions need to be cut in order to maintain feasibility. The operator will then use the IS+ tools to curtail the appropriate transactions.

This approach will also be applied in RTD as the same external interface infeasibilities can result from real time transmission interface reductions.

2.4.1 Transaction Bid representation

2.4.1.1 Pre-scheduled Before SCUC Transaction Bidding

Pre-scheduled before SCUC transactions are bid in to SCUC with a bid price giving the transaction the highest possible economic priority. These transactions will maintain their highest economic priority bid price whenever economic evaluations are performed.

2.4.1.2 Economically Scheduled SCUC Transaction Converted to Pre-scheduled Bidding

These transactions will be bid into the day-ahead market. Bids will be restricted to a level that ensures PSTs an economic priority. Following the receipt of a day-ahead schedule and an approved conversion of the transaction to a real-time pre-scheduled transaction the bids are passed to RTC with a price that assures it a priority over other economically scheduled. If the conversion to pre-scheduled fails then the transaction is passed to RTC with its original day-ahead bids.

2.4.1.3 Pre-scheduled Before RTC Transaction Bidding

This is a transaction without a day-ahead schedule that is approved as a real-time pre-scheduled transaction. These transactions will be passed to RTC with a bid price assuring it an economic priority over economically scheduled transactions, but less than other PSTs.

2.4.1.4 Economically Scheduled RTC Transaction Bidding

These transactions will be bid into RTC. Bids will be restricted to a level that ensures PSTs an economic priority. It is possible to allow day-ahead scheduled economic transactions an economic priority over real-time economic transactions by applying a lower priority bid limit; however no decision has yet been made.

2.4.1.5 Short Notice External Transaction Bidding

If these transactions are approved, in periods where the economic evaluation has already been performed they are passed into RTC as fixed injections. In periods where the economic evaluation has not yet occurred they are passed into RTC with bids consistent with other prescheduled before RTC transactions.

2.5 Ancillary Services

2.5.1 Demand Curve

A demand curve for 30-minute total reserves will be included in the RTD and RTC models. The reserve requirements for 10-minute spinning reserve requirements, 10-minute total reserve requirements and the locational elements of the 30-minute reserve requirements will be hard limits in the model.

2.5.2 Schedules

Reserve schedules will be determined in RTC but are not communicated to the Market Participants. They could be used to define market participant schedules if RTD and RTD-CAM failed for some reason.

2.5.3 Market Clearing Prices

No market clearing prices for ancillary services will be posted from the RTC model. The shadow prices of reserves should be captured out of the model so that reserve prices can be calculated in real time in the event that the RTD model fails. We will need the shadow prices both to test the RTC solution. They may also serve as a useful validation of the RTD results.

3 Real-Time Dispatch (RTD)

RTD is a multi-period security constrained dispatch model that co-optimizes to simultaneously solve load, reserves and regulation. RTD makes no unit commitment decisions. It simply dispatches the resources available to it on a least-as-bid cost basis. RTD will run every 5 minutes.

Each RTD run optimizes over a period of 1 hour with a number of periods in the hour of various duration, 5 minutes, 10 minutes or 15 minutes. The first period of each RTD run is always a 5-minute run. As much as possible RTD will attempt to line up with the 15-minute timeframes established in RTC.

Each RTD run receives a label in terms of our description of the model that indicates the time at which the results of the run are posted. These results apply to the 1 hour period that starts immediately the RTD results post, e.g., RTD-15 posts at time 15 and optimizes from time 15 through time 75.

Import, export and wheel through transactions are considered as fixed injections and withdrawals by RTD.

3.1 Objective Function and Constraints

The most important element of any description of scheduling software is the objective function, the solution requirements and the constraint set. The overall objective is to minimize the total as-bid cost over the 1-hour optimization timeframe. The solution requirements are:

- Meet forecast load
- Meet all reserve requirements by product type and location
- Meet the regulation requirement

The constraints modeled in RTD include but are not limited to:

- All transmission constraints (base case, contingency, thermal, voltage, stability)
- Generation bidding parameters (ramp rates, minimum generation levels, Upper Operating Limits.)

The costs that are included in the optimization include but are not limited to:

- Generation incremental energy costs
- Dispatchable load schedule benefits to the extent there a 5-minute dispatchable loads
- Reserve schedule availability costs (Lost opportunity costs are implicitly captured through other costs)
- Regulation schedule availability costs (Lost opportunity costs are implicitly captured through other costs)

There was some discussion of functionality in RTD that would allow the model to under generate or over generate in some periods in order to reduce costs in other segments of the hour being optimized. Operations were not comfortable building a model that allowed them to not meet load.

However, the multi period optimization will be allowed to ramp down cheap fast ramping capacity in preparation for a load pickup at the same time that it is ramping more expensive slow moving capacity up. This will at times allow the software to, at some price create additional ramp room to meet large load pickups. Our hope is that the 15-minute load forecasts and load target solved to in RTC and RTD will help in this regard.

An alternative that was briefly discussed was allowing the operator to control the ramping in a particular 5-minute periods in situations where they know they are going to derate an interface or turn on or off a Gilboa pump. They could use the functionality to help smooth out load bumps caused by these kinds of scenarios.

3.2 Generation

3.2.1 Bid representation

All bids passed to RTD must have first been submitted in RTC and will have passed all the RTC bid requirements.

3.2.1.1 Energy Bid Representation

RTD is a dispatch model. The incremental energy bid curves are passed to it directly from the bids submitted into RTC. No startup or minimum generation costs are required in RTD.

3.2.1.1.1 Incremental Energy Bid

- Incremental energy bids will be submitted in the same form as they are in SCUC today with some number of incremental block bids[3].

[3] 12 blocks have been proposed. This number needs to be high enough to allow bidding flexibility but not so high as to affect performance if many units opt to use the full block definition.

- Each block is defined by a quantity
- Each block is defined by a single incremental $ bid
- Incremental energy blocks must have monotonically increasing bid prices but do not need to be below the average cost of the minimum generation block

3.2.1.2 Ancillary Service Bid Representation

Ancillary service bids for RTD are passed directly from the bids submitted to RTC.

3.2.2 On-Dispatch and Self-Scheduled Flexible Units

RTD and RTD-CAM are responsible for the 5-minute dispatch of the on-dispatch units above either their minimum generation levels or their self scheduled minimum generation level. These dispatches will honor ramp rates.

There are four sets of basepoints that are relevant

- Basepoints for pricing
- Basepoints for setting other units schedules
- Basepoints communicated to the units
- Basepoints used for billing and settlement

3.2.2.1 Basepoints for Pricing

3.2.2.1.1 Dual Dispatch

3.2.2.1.2 Hybrid Dispatch

3.2.2.2 Basepoints for Schedules

3.2.2.3 Basepoints Communicated to the Units

3.2.2.4 Basepoints for Billing and Settlement

3.2.3 Self-Scheduled Fixed Units

RTD and RTD-CAM will take self-scheduled fixed level schedules as fixed injections.

3.3 Demand Side Resources

3.3.1 Dispatchable Load

Load that has demonstrated that it meets all metering and deliverability requirements to respond to a 5-minute dispatch signal may be scheduled by RTD. Loads that require longer notifications times will be scheduled by RTC.

3.3.2 Interruptible Load

Load that has demonstrated that it meets all metering and deliverability requirements to respond to a 5-minute dispatch signal may be scheduled by RTD. Loads with bids that require longer notifications times will be scheduled

by RTC. Contractual interruptible loads called by the operators will be treated as fixed injections by the RTD package and will be fed into the solution as soon as is practicable after the operators have made the decision to curtail the interruptible load.

3.3.3 Aggregators

3.3.4 EDRP

Once EDRP warnings and alerts have been sent out to all the registered loads they will be treated the same way as interruptible loads. If there are prices associated with the EDRP loads then RTC will commit and dispatch them. If the decision to actually curtail the EDRP loads this decision will be fed immediately into all the real-time scheduling processes

3.4 Transactions

A pre-processing function will ensure transaction feasibility in RTD. RTD will not be evaluating external transactions and will treat them as fixed injections and withdrawals.

If there are infeasibilities RTD will not select specific transactions to be cut but rather will indicate to the operator that some number of MWs of transactions need to be cut in order to maintain feasibility. The operator will then use the IS+ tools to curtail the appropriate transactions.

3.5 Ancillary Services

A full two-settlement system for ancillary services will be implemented for all operating reserves and regulation. Ancillary services providers selected day-ahead will be paid the applicable day-ahead regulation or locational reserve clearing prices

The key changes to the ancillary service market design will be the removal of availability bids for spinning reserves in the day-ahead and real-time markets, the implementation of a consistent reserve demand curve in both real time commitment and dispatch and locational reserve clearing prices calculated directly from the shadow prices of reserves.

3.5.1 Demand Curves

A demand curve for 30-minute total reserves will be included in the RTD and RTC models. The reserve requirements for 10 minute reserves and the locational elements of the 30 minute reserve requirements will be hard limits in the model.

3.5.2 Schedules

Schedules will be posted each five minutes out of RTD. Prices and settlements will be made on a five-minute basis. Reserve schedules will also be generated by RTD-CAM dispatches that may not correspond to well defined five minute time periods.

3.5.3 Market Clearing Prices

Market clearing prices will be set using the shadow prices directly from the RTD or RTD-CAM model, whichever is applicable to the period of time being settled. Generally this will be the RTD that is run every 5 minutes. If, however an RTD-CAM run is performed its results will apply until a subsequent RTD-CAM is run or until a valid RTD run is used to determine unit schedules and energy prices.

3.5.3.1 Locational Clearing Prices

Reserve requirements will be solved for the Control Area, East of Central East and for Long Island. There are locational requirements specified for 10-minute spinning reserve, 10-minute total reserve and 30-minute total reserve. These reserve requirements correspond to locational reserve prices for West, East of Central East excluding Long Island and Long Island.

Long Island reserve prices will be mitigated such that they never exceed the Eastern reserve price for the same level of reserve product.

Reserve prices are determined directly from the shadow prices of the reserve constraints extracted from the SCUC, RTC, RTD or RTD-CAM models. The first matrix is the shadow prices from the model. The Incremental value of the reserves is determined by adding up the shadow prices from the bottom left to the top right. The last step mitigates LI prices to not exceed Eastern prices.

Shadow Prices			
	Control Area	East	LI
Spin	0	3	1
10 Minute Total	0	1.52	0
30 Minute Total	1	0	0

Incremental Value			
	West	East excl LI	LI
Spin	1	5.52	6.52
10 Minute Total	1	2.52	2.52
30 Minute Total	1	1	1

Final Prices			
	West	East excl LI	LI
Spin	1	5.52	5.52
10 Minute Non-Synch	1	2.52	2.52
30 Minute Reserve	1	1	1

Day-ahead reserve prices are calculated using the shadow prices from SCUC. Real-time reserve prices will be calculated using shadow prices from either RTD or RTD-CAM. Prices could also be determined from RTC if a third settlement was ever implemented or if RTD and RTD-CAM both failed to operate for some period of time.

3.5.3.2 10-Minute Spinning Reserve Prices

10-Minute Spinning Reserve providers will be paid the applicable locational 10-minute spinning reserve clearing price. There will no longer be any separate lost opportunity cost payments.

3.5.3.3 10-Minute Non-Synchronous Reserve Prices

10-Minute Non-Synchronous Reserve providers will be paid the applicable locational 10-minute non-synchronous reserve clearing price. There will no longer be any separate lost opportunity cost payments.

3.5.3.4 30-Minute Reserve Prices

30-Minute Reserve providers will be paid the applicable locational 30-minute reserve clearing price.

3.5.3.5 Regulation Clearing Prices

Regulation prices in the day-ahead and real time markets will also be determined directly from the shadow prices extracted from the SCUC, RTC, RTD and RTD-CAM. There are currently no locational regulation requirements. To the extent that locational requirements are added in the future a locational pricing logic similar to that applied to reserves would be applied to regulation.

3.5.4 Second Settlement Protection for Day-Ahead Scheduled Reserve Providers

Non-synchronized reserve providers.[4]

RTD energy and reserve prices will be consistent with each other

4 SCUC Changes

SCUC changes that need to be written up

- Transactions scheduling at times other than top of the hour

5 ISSUES, POSITIONS, AND RESOLUTIONS

External control areas to provide reserves

Counting Western reserve to meet Eastern requirements

Regulation demand curve

Revision of SNETs

[4] Can these units be switched in and out on a 5-minute basis?