ERCOT Concept Paper for

Real-Time Market Improvements:

Co-optimization of Energy and Ancillary Services

&

Multi-Interval Real-Time Market

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# Executive Summary

ERCOT stakeholders are considering new initiatives to improve the efficiency of Real-Time Market operations. The effort may consist of one or both of the following components:

* Real-Time Co-optimization of Energy and Ancillary Services. Co-optimization is the process of simultaneously procuring energy and Ancillary Services (AS) from available Resources, at the lowest production cost[[1]](#footnote-1) to meet the Real-Time system demand for energy and AS. This results in the optimal allocation of all Resources’ capacity between energy and AS. The ERCOT Day-Ahead Market (DAM) currently co-optimizes in its execution. However, the current Real-Time (RT) market is unable to consider capacity reserved for AS (e.g., capacity above the Resource’s High Ancillary Services Limit, or HASL) even if the energy offer or bid for that capacity would be economical. Using Real-Time Co-optimization, the Real-Time Market clearing process would consider all available capacity to serve system demand for energy and procure AS capacity at the lowest possible cost1. Market clearing is designed to normally occur every 5 minutes. The process under consideration would be similar to the clearing process for energy and AS in the DAM. Accordingly, Real-Time Co-optimization can be thought of as “running the DAM every five minutes in Real-Time.” The objectives of Real-Time Co-optimization are to enable appropriate scarcity pricing through optimal use of a Resource’s capacity for energy and AS, and to enable market participants to adjust their energy and AS portfolios in Real-Time. A market design change, which was implemented on June 1, 2014, represents an approximation of a Real-Time Co-optimization based on the Operating Reserve Demand Curve (ORDC).

Note: The proposed Real-Time Co-optimization incorporates the same ORDC in setting up the individual AS demand curves (by disaggregating the ORDC).

* Multi-Interval Real-Time Market. The main objectives of the proposed Multi-Interval Real-Time (RT) Market are to enable additional Resources to contribute to Real-Time price formation and to expand access to the Real-Time Energy Market, thus enhancing competition and lowering overall costs to Load-serving Entities.

This enhancement would enable the Real-Time Market to, apart from considering offers and bids from the existing portfolio of Resources, to also consider offers and bids from other Resources that can be committed and/or dispatched only in blocks of MWs and/or have time-related (temporal) constraints. This is achieved by allowing the Real-Time Market to analyze, in conjunction with current system conditions (system demand for energy or Generation To Be Dispatched - GTBD) for the current five-minute interval, and forecasted system conditions (ERCOT Short Term Load Forecast or STLF) for the next consecutive future five-minute intervals, to a maximum of 30 minutes out.

This could enable increased participation in the Real-Time Market by Load Resources with the following attributes:

* + Resources with temporal constraints, including but not limited to start-up time or ramp period longer than the current 5-minute SCED, minimum or maximum run times, or return-to-service times;
	+ Resources that are “blocky” and therefore unable to deliver incremental fractions of their offers or bids, as is required of marginal units under current SCED.

In the Multi-Interval RT Market, Locational Marginal Prices (LMPs) (and AS Market Clearing Price for Capacity, or AS MCPCs if RT Co-optimization is included) would be binding for only the first (current) five-minute interval. In addition, Commitment Instructions issued by the Multi-Interval RT Market would be binding. Resources thus committed based on forecasted future conditions would be eligible for make-whole payments if actual Real-Time binding prices left them insufficiently compensated.

These initiatives, which are already in place in other Independent System Operator/Regional Transmission Organization (ISO/RTO) markets, may be considered and implemented separately or together.

ERCOT Staff has developed this concept paper as a starting point for stakeholder consideration of these Real-Time Market improvements.

# RT energy and AS Co-optimization

Co-optimization is the process of simultaneously procuring energy and Ancillary Services (AS) at the lowest production cost [[2]](#footnote-2) while meeting system demand for energy and AS. The result is optimal allocation of all Resources’ capacity between energy and AS.

In other words, the energy and AS Co-optimization clearing process ensures that, while maintaining the lowest cost for procuring the required MWs, the pricing outcomes for energy and AS — Locational Marginal Prices, or LMPs, and AS Market Clearing Prices for AS Capacity, or MCPCs), are such that, the Resources are provided the best possible total revenue outcome from the energy and AS awards.

The objectives of Real-Time Co-optimization are to enable appropriate scarcity pricing through optimal use of Resource’s capacity for energy and AS, and to enable market participants to adjust their energy and AS portfolios in Real-Time.

This concept document refers to the current set of AS products — namely, Regulation Up (Reg-Up), Fast Responding Regulation Service-Up (FRRS-Up), Regulation Down (Reg-Down), Fast Responding Regulation Service-Down (FRRS-Down), Responsive Reserve Service (RRS) and Non-Spin. The concepts presented here are equally applicable to the proposed Future AS product set — Reg-Up, Reg-Down, FRRS-Up, FRRS-Down, Fast Frequency Response Service (FFRS), Primary Frequency Responsive Service (PFRS), Contingency Reserve Service (CRS), and Supplemental Reserve Service (SRS).

Finally, RT Co-optimization as described here is equally applicable to either a single interval or a Multi-Interval RT Market.

## High Level Description of the Clearing Process and Outputs

Under Co-optimization, the RT market clearing **procures** the following, nominally once every 5 minutes (for the current 5 minutes):

1. Energy, in the form of Base Points, to meet the system demand for energy as represented by Generation To be Dispatched (GTBD); and
2. Reserve capacity sufficient to meet the AS demand. Each type of AS will have its own ‘bid-to-buy’ demand curve. Each AS demand curve is developed from a disaggregation of the Operational Reserve Demand Curve (ORDC) in use in the current RT market.

Put another way, every 5 minutes the market clearing would result in the following:

1. Base Points for energy to all Resources to meet the system demand for energy (GTBD). These Base points are valid for the next 5 minutes or until the next clearing of the RT market. This is the same as in the current RT Market.
2. LMPs at all required locations that are binding for the next 5 minutes or until the next clearing of the RT market. This is the same as in the current RT Market
3. Reg-Up and Reg-Down awards and associated Reg-Up and Reg-Down MCPCs. This capacity is procured as Regulation Reserve Service and will be utilized by the ERCOT Load Frequency Control (LFC) engine to send regulation signals every LFC cycle – 4 seconds for the next 5 minutes or until next clearing of the RT market
4. RRS awards and RRS MCPC. This procured capacity must be available to be converted into energy, if required, in the next 10 minutes (like a call option). This responsibility to deliver exists for the next 5 minutes or until the next clearing of the RT market
5. Non-Spin awards and Non-Spin MCPC. This procured capacity (Online and/or Offline) must be available to be converted into energy, if required, within the next 30 minutes following an instruction and must also be able to sustain the energy deployment for a 1 hour period (like a call option). This responsibility to deliver exists for the next 5 minutes or until the next clearing of the Real-Time market

Resources with Non-Spin awards in RT are **not** eligible for Make-Whole payments. This treatment is the same as in the current design.

In order to award an Offline Resource Non-spin, the following factors are considered

* + 1. Is it qualified for Non-Spin?
		2. Has the resource satisfied its minimum down time?
		3. Can the Resource startup in 30 minutes and reach LSL (check the warmth state and the associated cold, intermediate and hot startup times)?
		4. Does it have adequate ramping capability to meet the performance requirements associated with its award?

1. Appropriate constraints are enforced to limit energy and AS awards based on the Resources’ telemetered ramp rates. This is to ensure that the awards for energy and AS are ramp feasible.

Stakeholder discussions will be required to develop methodology to share the ramp rates between energy and AS (similar to the ramp sharing between current Security Constrained Economic Dispatch or SCED and LFC).

1. AS MW awards and associated MCPCs are published simultaneously with energy Base Points and associated LMPs — i.e. after every RT market clearing (nominally every 5 minutes). QSEs will not be required to immediately incorporate these AS awards into their control systems; i.e., there is no hand shaking between ERCOT and the QSEs representing Resources with regard to receipt and acknowledgement of AS awards. Rather, this is intrinsically done via the AS offer that can be updated at any time by the QSE.
2. Market clearing can, be re-initiated by ERCOT, prior to the normal 5-minutes, as with the current design.
3. Resources in Start Up or Shut Down mode are not considered as available for energy dispatch nor are they considered available to provide AS.
4. The key performance metric for the Resource is its ability to follow the energy Base Point. Like the current RT Market, the results of the proposed RT Market with energy and AS Co-optimization are effective immediately; i.e., the Base Points, LMPs, AS awards and AS MCPCs are binding upon RT Market clearing.

### Pricing Run Changes (modifications to NPRR 626)

A pricing run based on NPRR 626 (Reliability Deployment Price Adder) will be required to mitigate price reversals associated with the deployment of Load Resources and/or out-of-market reliability deployments that may otherwise reduce the total Real-Time price in times of scarcity. The objective of the pricing run will remain the same — that is, to determine the positive change to System Lambda when Load Resources or out-of-market reliability deployments occur. This positive change to System Lambda is added to all original energy prices (LMPs), and under RT Co-optimization the same positive change to System Lambda would be added to all the original MCPCs.

This pricing run will not require the modification of dispatch limits (High Dispatch Limit or HDL, and Low Dispatch Limit or LDL) for “in-market” Resources because in RT Co-optimization, the concept of High Ancillary Service Limit or HASL does not exist. Rather, the Resource’s entire capacity (between its Low Sustained Limit or LSL and High Sustained Limit or HSL) is considered available for allocation between energy and AS.

## Settlements

In general, the current approach described in the ERCOT Nodal Protocols for AS imbalance settlements for ORDC will be employed for the settlement of AS in Real-Time. The changes from the current approach will be that each AS type will have its own AS imbalance settlement. Each AS type will have a 15 minute MCPC that is computed as a time-weighted average of the individual RT Market (i.e., 5 minute) AS MCPCs.

### Are There any Make-Whole Payments to Resources?

There are no Make-Whole Payments to Resources that can be directly attributed to the conceptual market design changes presented here. Make-Whole provisions to Resources that exist in the current market design may still apply (e.g. Emergency Base Point Settlements).

### Is There Any Uplift Required?

No changes from current market.

Just as occurs in the current Real-Time AS Imbalance Settlement process, as implemented by NPRR 568, etc., any occurrence of uplift to load on a Load-Ratio-Share basis arises only when the Real-Time AS Imbalance Settlement process results in a net payment to Resources.

## Telemetry Changes for Generation and Controllable Load Resources

Currently, the QSE representing the Generation Resources or Controllable Load Resource sends every 2 seconds, for each Resource, their respective AS Responsibility (Reg-Up, Reg-Down, RRS, Non-Spin) and corresponding applicable AS Schedule (RRS and Non-Spin).

Under RT Co-Optimization, the telemetry for AS responsibility and schedule are not required. The Resource specific AS Offers can be updated at any point in time and will represent the willingness of the QSE representing the Resource to sell capacity for AS in the upcoming next RT Market.

The proposed RT Market considers the following Resource specific data to optimally allocate the Resource’s capacity:

1. Telemetered HSL, LSL (for Controllable Load Resource or CLR it is the Maximum Power Consumption or MPC and Low Power Consumption or LPC) , and ramp-rates, every 2 seconds
2. Energy Offer Curve or EOC that is locked down by the end of the adjustment period (for CLR, this is the Real-Time Market Energy Bid)
3. AS Offer that can be modified at any point in time

Further discussion via the stakeholder process will be needed to determine the proper timeline for updating AS Offers and EOCs. There may be a need for additional telemetry to be used in conjunction with the AS offer to provide QSEs more flexibility.

## Telemetry Changes for Load Resources with UFR

One key issue involved in integrating Load Resources armed with high-set Under Frequency Relays (UFRs) into RT Co-optimization will be the practicality and necessity of arming/disarming the UFRs based on RRS awards. If determined to be impractical or infeasible, then these Load Resources would be ineligible to actively participate in the RT Market; instead their AS responsibilities originating from DAM, Trades, etc. would not be re-cleared in the RT Market —and they would effectively become price takers in the RT Market. This requires further discussion by ERCOT staff and stakeholders.

## AS Deployment Process

* 1. Regulation Up and Regulation Down:

No material change from current process.

Change is that LFC, will get as input, after every RT market clearing (usually every 5 minutes), a new set of QSE level Reg-Up and Reg-Down Responsibilities based on the Resource specific Reg-Up and Reg-Down awards.

* 1. Responsive Reserve Service or RRS:
		1. Self-Deployment of UFR-type Load Resources due to frequency deviation from a forced outage (Unit Trips):

No change

* + 1. ERCOT release of RRS capacity to SCED:

Major change

Under RT Co-optimization, the current process of ERCOT reserving RRS capacity and releasing it under scarcity conditions would be discontinued and

 replaced with a “HASL-free” operation in which RRS is procured until the RRS supply and demand curves intersect — i.e., “RRS supply” = “RRS demand”. Under scarcity conditions, energy to be served is given priority and smaller amounts of RRS would be procured — effectively similar to the release of RRS to SCED in current market. This results in scarcity pricing through the ORDC.

The current ability for the operator to manually enter an offset to GTBD will be retained to allow ERCOT the ability to react to persistent frequency deviations.

* 1. Non-Spin:
	2. On-Line Non-Spin (including Quick Start Generation Resource with telemetered status of On-Line):

No change. Currently the online Non-Spin capacity is always available to SCED. Under RT Co-optimization, the “HASL-free” operation described above would allow this capacity to be converted to energy, if required.

* 1. Off-Line Non-Spin (truly Off-Line)

Even under a RT Co-optimization, similar mechanism as the current market design would be employed to deploy truly Offline Non-Spin. ERCOT can, depending on the analysis of current and forecasted conditions, instruct Offline Resources with Non-Spin responsibility (at that time) to come Online. These Resources have the responsibility to deliver for 1 hour after they come online in or are recalled whichever comes first.

Further ERCOT staff and stakeholder discussions will be required to revisit the current procedures for deploying truly Offline Non-Spin to mitigate local congestion when no market solution is available.

Under RT Co-optimization, consistent with current practice, Resources with Non-Spin Responsibility that are Offline and deployed for Non-Spin are **not** made whole to their Energy Offer Curve, **nor** are they made whole on their Startup Costs and Minimum Energy Costs.

## Disaggregation of the ORDC into RegUp, RRS, Non-Spin Demand Curves

Under RT Co-optimization of energy and AS, the AS requirements for each type of AS (RegUp, RegDown, RRS, Non-Spin) to be procured are modeled as a demand curve. The AS demand curves for AS serve the same purpose as the Power Balance Penalty Curve for energy.

The Operating Reserve Demand Curve (ORDC), which is based on statistical distributions (mean and standard deviation) of Online Reserves will be used to setup the AS demand curves for each AS type.

Note: If RRS from Load Resources are not part of the RT market (i.e. price takers), then the RRS demand curve will need to be modified (reduced) by the amount of price taking RRS MW from Load Resources. However, in the event of an ERCOT manual deployment of RRS from Load Resources, the RRS demand curve will be augmented by the deployed amount of RRS from Load Resources.

For Non-Spin, the demand curve continues on until the price on the ORDC is zero (0 $/MW) — which is currently around 7,000 MW of total reserve.

AS Plan MW Requirements are used to disaggregate the ORDC as shown in the figure below.

Figure : Disaggregation of the ORDC into RegUp, RRS, Non-Spin Demand Curves

ORDC for Online Reserves

RegUp Demand Curve

RRS Demand Curve

Reserves (MW)

$/MW/h

MW

Non-Spin Demand Curve

### Discussion Items:

1. For Non-Spin, should the statistical distribution of Online Reserves be used or Online+Offline Reserves or some combination? Note that the price on the Non-Spin demand curve will be lower if the statistical distribution of the Online+Offline Reserves is used.
2. How should the demand curve for Reg-Down be determined? Is it the same as the Reg-Up demand curve? I would think it should be related to the offer cap of RGSD rather than VOLL which is the way the RGSU works. The idea is that it’s the value of the service before we would no longer continue buying the capacity. Since we must buy the full capacity of RGSD that point would be the offer cap.
3. Do we need to model AS demand curves based on ORDC in the DAM? Yes. This would be far superior to the current methodology which reduces the requirement before clearing the DAM and then clearing at the maximum price offered. That is a random value and likely is not reflective of the reliability risk created. A demand curve would ensure that the price cleared is reflective of the scarcity of the service. The only risk created is that offers may currently occur in excess of the demand curve. These offers would be ignored if the insufficiency were small. For instance, the value of RRS for the last few MWs is roughly $4500/MW, so offers could exist at higher levels than this and the DAM engine decide not to fully procure the RRS service for that hour as it would deem the price of full procurement as being too high. This can be remedied however, in the selection of lower offer caps which will be discussed further in next section.
4. If we model AS demand curves in the DAM, as the DAM is voluntary, are there any issues? Resources do not have to participate since it is not mandatory to submit Resource specific Offers for energy and AS. The DAM is not necessarily voluntary for A/S procurement. All A/S obligations must either be self-provided or will be procured through the DAM or RUCed. Resources prefer the DAM to RUC. This would be especially true if a demand curve were adopted that would guarantee higher prices if scarcity were to occur.
5. If we model AS demand curves in the DAM, then what is the process of achieving required levels of AS procurement in the DAM when the DAM process does not procure enough? Is it Reliability Unit Commitment or RUC? The same process could be used as is used in the current market. DRUC. This is not a good solution, but would continue to be rarely if ever used.
6. If AS demand curves are **not** modeled in the DAM, then AS procurement is effectively given higher priority than energy — that is, in DAM, all energy demand has a price and hence can be curtailed, whereas the AS penalty is extremely high. This ensures that the AS Plan MW Requirements are procured. However, in RT, AS demand curves are modeled based on ORDC. The amount of Non-Spin procured depends on the intersection of the Non-Spin demand curve and the offer stack for Non-Spin. Hence, the procured amounts of Non-Spin can exceed or be less than the AS Plan MW Requirement for Non-Spin. If there is more Non-Spin procurement than the AS Plan, then loads are charged this amount on a Load-Ratio-Share. This is the same as the current process of AS Imbalance Settlements. So use demand curves.

For the proposed Future Ancillary Service product set, the determination of the statistical distribution parameters (mean and standard deviation) will need to convert the Hourly Reliability Unit Commitment or HRUC time snapshot of FFRS reserves and SCED snapshot of FFRS reserves into PFRS Reserve equivalents using the applicable ratio (R).

## Co-ordination of the Power Balance Penalty Curve, Maximum value of ORDC, and Value Of Lost Load (VOLL)

In scarcity conditions, the AS demand curves sets the AS MCPC, similar to how the Power Balance Penalty Curve sets LMPs in the energy market under scarcity conditions.

The design of a Real-Time energy and AS Co-optimization is such that the market clearing will ensure that serving the inelastic system demand for energy (GTBD) is given priority over reserving capacity for AS. This means that the relationship between the prices for energy (LMP) and AS (MCPC) are such that the awards (Base Points) to serve energy will be prioritized over awards for AS.

This will be achieved by setting the maximum value ($/MW/h) on the AS demand curves (one curve for each AS type) and coordinating these values with the maximum value of the Power Balance Penalty Curve for energy. AS demand curves will be based on the ORDC.

This co-ordination ensures that in the worst case scenario, the minimum excess revenue a supplier can receive from energy sales (LMP minus EOC) is greater than the maximum excess revenue the supplier could receive from the sale of AS (MCPC minus AS Offer).

Excess revenue per MWh of energy award, over and above the submitted EOC from the sale of energy, is (in $/MWh)

LMP – EOC

Excess revenue per MW of AS award, over and above the submitted AS Offer from the sale of AS, is (in $/MW/h)

MCPC – AS Offer

Thus, in a worst case scenario, a supplier’s minimum excess revenue per MWh of energy sales occurs when the Power Balance Penalty curve sets the energy price (LMP) and the supplier has submitted its EOC at System Wide Offer Cap or SWOC, as follows:

Minimum Excess Revenue per MWh of energy award =

Maximum value of Power Balance Penalty Curve minus SWOC =

VOLL+1 – SWOC

Similarly, in a worst case scenario, a supplier’s maximum excess revenue per MW/h of AS sales occurs when the AS demand curve sets the AS price (MCPC) and the supplier has submitted its AS Offer at 0 $/MW/h, as follows:

Maximum Excess Revenue per MW/h of AS award =

Maximum value of ORDC minus AS Offer of 0$/MW/h =

Maximum value of ORDC

Therefore, the design parameters should be such that the maximum excess revenue per MW/h of AS award is less than minimum excess revenue per MWh of energy award, as follows:

Maximum Value of ORDC < VOLL+1-SWOC

The figure below lists the maximum value of ORDC possible for different values of VOLL, SWOC and maximum value on the PBPC.

Figure 2: Table of various combinations to set the maximum price ($/MW/h) on the AS Demand Curve

|  |  |  |  |
| --- | --- | --- | --- |
| VOLL($/MWh) | SWOC($/MWh) | Maximum PBPC ($/MWh) | Maximum value of ORDC ($/MW/h) |
| 9000 | 9000 | 9001 | 0.99 |
| 9000 | 7000 | 9001 | 2000.99 |
| 9000 | 1000 | 9001 | 8000.99 |
| 18000 | 9000 | 18001 | 9000.99 |

Note: The top row represents current VOLL and SWOC as established in PUCT and ERCOT market rules. Values for VOLL and/or SWOC in the lower rows would require changes to PUCT and/or market rules.

The purpose of the ORDC is to appropriately price energy to reflect the current reliability conditions on the grid. Since the ORDC implementation, there is no longer the necessity to allow offer curves to rise to the value of lost load as we no longer need Resource energy offers to reflect energy scarcity conditions. Thus, the offer cap can be lowered to a level that appropriately covers conditions where a unit must recover its costs through the energy price offered. So I would propose the following levels for the SWOC and max ORDC:

 SWOC ($/MWh) = 3,000

 Max ORDC ($/MW/h) = 6,000

# Multi-Interval Real-Time Market

The main objectives of the proposed Multi-Interval Real-Time (RT) Market are to enable additional Resources to contribute to Real-Time price formation and to expand access to the Real-Time Energy Market, thus enhancing competition and lowering overall costs to Load-serving Entities.

This enhancement would enable the Real-Time Market to, apart from considering offers and bids from the existing portfolio of Resources, to also consider offers and bids from other Resources that can be committed and/or dispatched only in blocks of MWs and that may have time-related (temporal) constraints. This is achieved by allowing the Real-Time Market to analyze, in conjunction with current system conditions (GTBD) for the current five-minute interval, also the forecasted system conditions (STLF) for consecutive future five-minute intervals, up to a maximum of 30 minutes out.

This could enable increased participation in the Real-Time Market by Load Resources with the following attributes:

1. Resources with temporal constraints, including but not limited to start-up times or ramp periods longer than the current 5-minute SCED, minimum or maximum run times, or return-to-service times;
2. Resources that are “blocky” and therefore unable to deliver incremental fractions of their offers or bids, as is required of marginal units under current SCED parameters.

In the Multi-Interval RT market, Locational Marginal Prices (LMPs) and AS MCPCs (if Multi-Interval RT Market includes RT Co-optimization) would be binding for only the first (current) five-minute interval. In addition, Commitment Instructions issued by the Multi-Interval RT Market would be binding. Resources committed based on forecasted future conditions would be eligible for make-whole payments if actual Real-Time binding prices left them insufficiently compensated.

This section provides a high-level description of the concepts involved in a Multi-Interval RT Market. This description of the Multi-Interval RT Market is from the perspective of not considering RT Co-optimization. Where applicable, notes are added to inform the reader of the impacts of including RT Co-optimization.

## High Level Description of the Inputs, Clearing Process and Outputs

The Multi-Interval RT Market is cleared (normally) every 5-minutes, in which, the market clearing process considers a set of consecutive 5-minute intervals, of up to a maximum of 30 minutes, starting with the current 5-minute interval.

This market clearing process is similar to a DAM process in that multiple intervals (24 hourly intervals in the DAM and up to 6 five-minute intervals here) are simultaneously optimized. One of the major differences is the consideration of Resource Ramp Rates in the Multi-Interval RT Market clearing process. This is required to ensure that the awarded energy Base Points (and if RT Co-optimization is included, the awarded AS) are feasible.

The inputs to setup the data for the current (first) five-minute interval of a given market clearing process in the Multi-Interval RT market will be the same as the current single interval SCED — i.e., based on telemetry. To set up necessary data for the future five-minute intervals, additional information will be used, notably:

1. Short-Term Load Forecast – to setup the energy demand for the future intervals under analysis
2. eTag data – to setup the total DC-Tie export/import to be added to the total energy demand for future intervals

More discussions will be required to decide, when setting up necessary data for future 5-minute intervals, on whether to persist current telemetered data on Resources for Status, Limits (HSL, LSL), Output Schedule, etc. or to consider Current Operating Plan or COP data and wind forecast data (if available with a 5-minute granularity for Wind Resource HSLs).

More discussions will also be required on the modeling of Resources with telemetered Status of Start Up or Shut Down for future 5-minute intervals for a given instance of a RT market clearing.

The outputs of each Multi-Interval Market clearing are:

1. Binding energy Base Points and LMPs for the current (first) 5-minute interval
	1. If RT Co-optimization is included, then, Binding AS awards and MCPCs for the current (first) 5-minute interval;
2. Binding commitment instructions for Resources (e.g. Load Resource curtailment instructions) at the start of any 5-minute interval (including current 5-minute interval) in the analysis window of up to a maximum of 30 minutes and
3. Advisory or indicative Base Points and LMPs for the future 5-minute intervals
	1. If RT Co-optimization is included, then also include, advisory or indicative AS awards and MCPCs for the future 5-minute intervals

The figure below illustrates a sequence of Multi-Interval RT Market clearing.

Figure 3: Multi-Interval RT Market Overview

*8:40 8:45 8:50 8:55 9:00 9:05 9:10 9:15 9:20 9:25 9:30 9:35*

Intervals where **ONLY** Commitment Instructions are **binding** and the LMPs and MW awards (energy, AS) are **indicative**

Interval where the LMPs, MW awards (energy, AS) and Commitment Instructions are **ALL** **binding** commitment instructions

Sequence of Multi-Interval RT Markets

Analysis window of rolling 30 minutes

RT Market Execution: Depicts the start and end times of the clearing process and the length of symbol is indicative of maximum time allowed to clear market

### Execution/Run Times for Multi-Interval RT Market Clearing

The hardware and software implemented to clear the market should be such that the execution/run time is shortened as much as possible.

### Transmission Constraints

Transmission constraints to be considered are input to the Multi-Interval RT Market clearing process via the Transmission Constraint Manager or TCM as they are now. Transmission constraint data is persisted for the entire analysis time frame. Further discussion will be required to determine how to integrate known future topology changes into TCM in order for potential transmission constraints in the near future to be considered by the Multi-Interval RT Market.

### Short Term Load Forecast

The accuracy of the short term load forecast is critical for proper functioning of the Multi-Interval RT Market. It will be necessary to setup the required metrics on short term load forecasting in order to monitor and measure its performance. Forecasting system demand will never be perfect; consensus must be achieved on a definition of what is ‘good enough’.

### Wind Forecasting

The accuracy of the short term wind forecast is also important for a proper functioning of the Multi-Interval RT Market — specifically translating to the setup of the Wind Resources’ HSL in future five-minute intervals. Determining appropriate required metrics will be critical. Forecasting Wind Resource HSL will never be perfect; consensus must be achieved on a definition of what is ‘good enough’.

### Multi-Interval RT Market analysis window

This concept paper contemplates the use of an analysis window of 30 minutes divided into 6 five-minute intervals. Based on discussions with stakeholders this can be changed and is dependent on the accuracy of the Short Term load Forecast and Wind Forecast.

### Pricing Run Changes (modifications to NPRR 626)

The pricing run as described in NPRR 626 (Reliability Deployment Price Adder) will continue to be used in the proposed Multi-Interval RT Market. It will be setup to treat each five-minute interval in the analysis window separately.

The following modifications to the pricing run will be required:

1. Enabling ‘blocky MW’ committed by the Multi-Interval RT Market clearing process to participate in price formation. This treatment is similar to how Load Resources deployed for RRS are handled in the current market, with the exception that the strike price for their energy is submitted by the QSE representing the committed Resource.
2. Enabling ramp-constrained Resources to participate in price formation.

The primary objective of the pricing run will remain the same; that is, to determine the positive change to System Lambda when Load Resources, out-of-market reliability or ‘blocky” MWs, or ramp-constrained Resource deployments occur. This positive change to System Lambda is added to all original energy prices (LMPs) and the same positive change to System Lambda is added to the original ORDC price adder. (The change would also be added to original MCPCs if RT Co-optimization is included).

## Three Part Offer/Bid or Single Part Offer/Bid from a Load Resource

Further discussions will be required to determine what the components of a Three Part Offer or Bid from a Load Resource would mean; whether there is a need for validation; and whether a single part offer or bid from a Load Resource would be the preferred approach for simplicity.

The use of Offers to sell from a Load Resource will depend on the resolution of “LMP-G” discussions underway at the Demand Side Working Group (DSWG).

## Settlements

The changes to settlement that are directly attributed to the proposed Multi-interval RT Market are new potential Make-Whole payments to Resources, and potential uplift to consumers to cover the Make-Whole payments to Resources.

If RT Co-optimization is included then the Settlement section of the RT Co-optimization description in this document describes the necessary settlement changes

### What Are the Make-Whole Payments That May be Necessary For Resources?

The Multi-Interval RT Market will require two categories of Make-Whole Payments.

**Resources that are ramp-constrained and are awarded a binding Base Point that is uneconomical for them.** The impact of considering Resource Ramp Rates may, in some scenarios, lead to a Resource being awarded a binding Base Point and corresponding binding LMP for the first (current) 5-minute interval that is not consistent with its EOC. For example, when the clearing process awards a higher Base Point to a Resource with a high ramp rate and a higher EOC to catch the increased forecasted (future) demand for energy in comparison to the Base Point this Resource would have been awarded in a single interval SCED. In such cases, this Resource is eligible for Make-Whole payments for the intervals (with binding Base Point and LMP) in which the Resource is ramp-constrained.

Resources that are committed for a future interval and, after following the commitment instruction, the binding RT LMPs (and MCPCs) for that interval are uneconomical for them. A Resource could be issued and successfully follow a commitment instruction only to experiences binding RT prices (LMPs and MCPCs) that are uneconomical due to forecast errors. In such cases, this Resource would be eligible for a Make-Whole payment. The Resource that wasissued a commitment instruction would be made whole for X 5-minute intervals (where X=3,4,5,6 5-minute intervals?). The Resource’s QSE will need to factor in the maximum duration of the Make-Whole payment in its Resource Offer or Bid.

The pricing run should mitigate the magnitude of the Make-Whole payments and associated uplift to consumers.

Current market design Make-Whole provisions to Resources may still apply (e.g. Emergency Base Point Settlements).

Further discussion will be required on this topic as well as potential alternative approaches to uplift.

### Is There Any Uplift Required?

Make-Whole payments to Resources that are either ramp-constrained or Resources following commitment instructions that turn out to be uneconomical will inevitably result in market uplift. As noted earlier, the pricing run should mitigate the magnitude of the Make-Whole payments and reduce the amount of uplift required.

Alternative approaches to uplift may be considered.

1. The term Production Costs refers to the use of submitted Energy Offer Curves, AS Offers, and Energy Bid Curves (if applicable) and any associated mitigation of the Energy Offer Curves due to transmission congestion. [↑](#footnote-ref-1)
2. The term Production Costs refers to the use of submitted Energy Offer Curves, AS Offers, and Energy Bid Curves (if applicable) and any associated mitigation of the Energy Offer Curves due to transmission congestion. [↑](#footnote-ref-2)