Day-Ahead Reliability and Reactive Cost Allocation
Final Report

December 13, 2013

Contents

Executive summary

In order to examine the problem statement related to the calculation and allocation of reactive costs, the PJM Interconnection Market Implementation Committee formed the Day-Ahead Reliability and Reactive Cost Allocation (DARRCA) subgroup. The DARRCA group came up with one proposal for allocation of reactive service in real time and one proposal on how allocate reactive service when called on in the Day-Ahead Energy Market. In both cases it was generally agreed that make whole costs for reactive services called on in the Day-Ahead Energy Market and the Real-Time Energy Market should be allocated to the same areas (zones or regions) and final payers.

Allocation of the day-ahead make whole costs for units called on for reactive service

The group generally agreed with the decision to allocate the cost of reactive service called on in the Day-Ahead Energy Market to the zones that benefit. The group proposed one additional change to allocate the cost not only to real-time load, but to real-time load plus exports. However there are at least two different ways to implement this and the group could not reach consensus on how this should be implemented.

Allocation of start and no load costs for units providing reactive service in real time

The group could not come to consensus on the final package for start and no load costs for units providing reactive service in real time. One proposal emerged from the discussion, proposed by the market monitor; however in a survey to the group, preferences were mixed on each individual item.

Purpose of this report

This report will review and describe the work done by the sub-group of the Market Implementation Committee: Day-Ahead Reliability and Reactive Cost Allocation (DARRCA). The group met nine times from December 2012 through October 2013. The group was in the process of creating solution packages when it decided to combine the issues of this group into those of a larger group, the Energy Market Uplift Senior Task Force (EMUSTF).

Issue review

The problem statement and issue charge were modified a number of times over the course of the DARRCA meetings. When the meetings concluded, there were two issues being worked:

Table 1: Issue Breakdown

	Allocation of day-ahead operating reserve costs for units called on for reliability	Allocation of costs for units providing reactive service in real time
Market	The Day-Ahead Energy Market	The Real-Time Energy Market
Impacted	Charges	Charges/Credits
Tasks	Review the allocation filed with the FERC on November 30, 2012.	Consider the start and no load make whole cost allocation
How it got here	PJM made a change to commit reliability units in The Day-Ahead Energy Market on September 13, 2012. PJM filed to allocate the costs for reactive, black start and reactive interface control as it is allocated in The Real-Time Energy Market.	The PJM Independent Market Monitor believes start and no load costs for units providing reactive services should not be paid by balancing operating reserves but instead allocated like the rest of reactive service make whole costs.
Why are we looking at this	The FERC requested a stakeholder process to review allocation changes	This was presented as a problem statement, requested by the Market Monitor, and approved by PJM stakeholders.

The problem statement can be found here: Day-Ahead (DA) Reliability and Reactive Cost Allocation. [i]

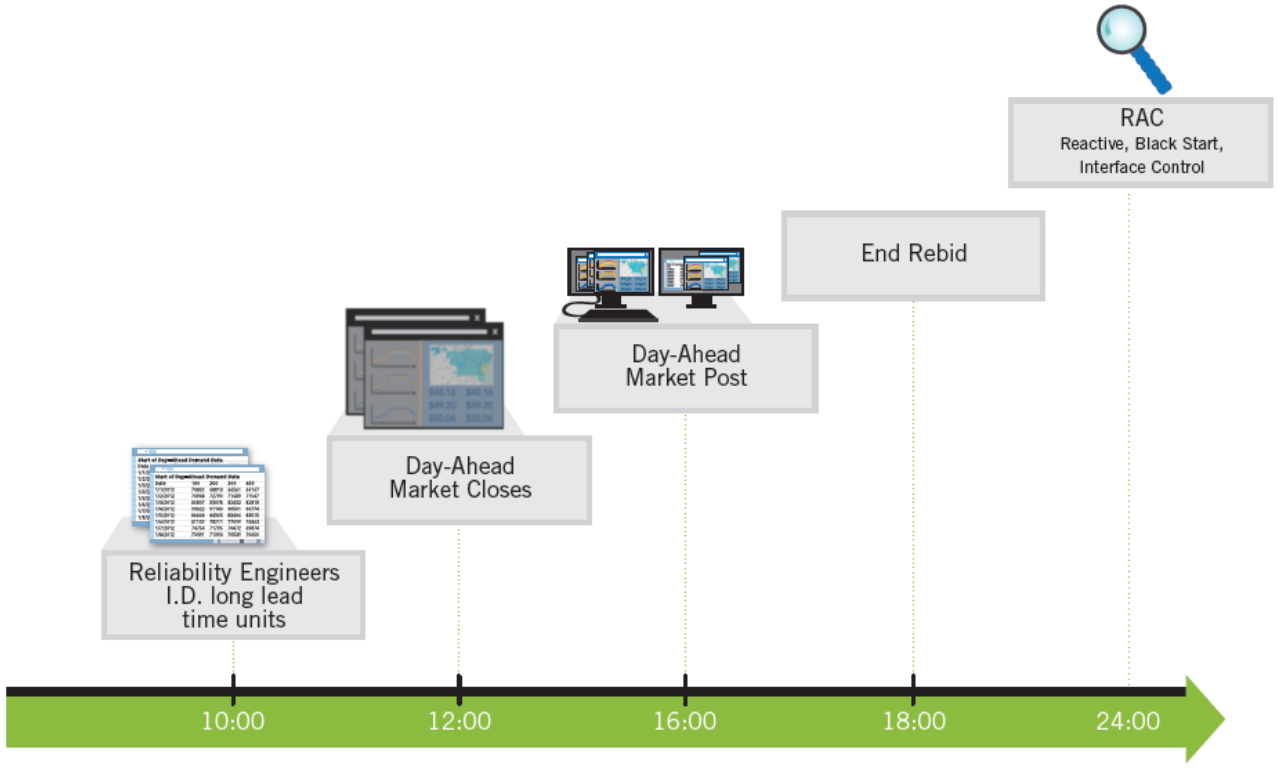
Allocation of day-ahead make whole costs for units called on for reactive service

The transmission system was originally built to deliver the coal-based energy and capacity in the west to the load in the east. With the rapid pace of fuel switching from coal to gas, PJM began to experience more voltages issues than it had in the past. PJM Planning processes started to address light load reliability analysis criteria in July 2011 through the operational efficiency review.

Prior to 2012, the clearing process of the Day-Ahead Energy Market generally followed the graphic below. At 10 a.m. the reliability engineers would pass on any necessary information into the day-ahead market operations group and participants would enter information until noon. Between noon and 4 p.m. the market would solve and then assignments would be posted. A rebid period would begin at 4 p.m. for any units that did not clear in the initial run

and would close at 6 p.m. Prior to the operating day PJM does a Reliability Assessment Commitment (RAC) run to ensure adequate units committed for reactive service and reactive interface control. This paradigm and way of running the Day-Ahead Energy Market worked well for many years.

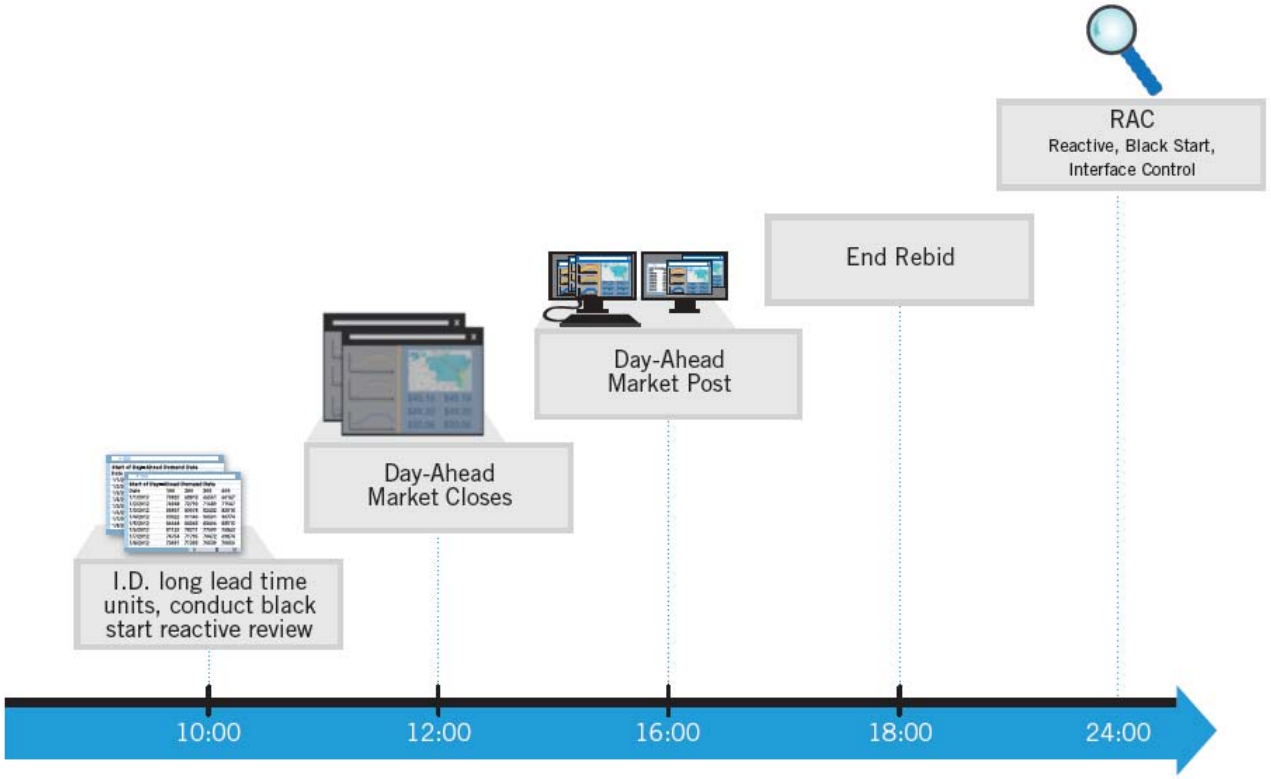
Figure 2: Day-Ahead Timeline prior to September 13, 2012



In May, 2012, PJM began to experience unusually high rates of balancing operating reserves due, in part, to low natural gas prices. These lower gas prices caused low-cost combustion turbines to be scheduled more frequently in the Day-Ahead Energy Market but not run in real time due to the need to commit certain out-of-merit steam units in the Real-Time Energy Market for reliability. Committing units for reliability may occur to resolve voltage issues and ensure adequate reactive service/interface control capability. Since these units are committed in the RAC run, they were not included in the initial run of the Day-Ahead Energy Market and caused a disconnect between the Real-Time Energy Market and the Day-Ahead Energy Market. Units scheduled in The Day-Ahead Energy Market, but not run in real time by PJM are subsequently made whole through lost opportunity cost (LOC) payments that ensure that generators following PJM dispatch instructions are not forced to operate at a loss. Due to the fact that LOC payments are a variable and unhedgable component of the cost to serve load, it is generally desirable to minimize LOC payments.

PJM has an obligation to commit resources in a least cost manner while maintaining reliability. On September 13, 2012, PJM changed how the Day-Ahead Energy Market cleared so the dispatch algorithm would include the commitment of units needed for reactive services. Previously, these units were committed during the reliability run, which occurs after the posting of the Day-Ahead Energy Market results.

Figure 3: Day-ahead timeline after September 13, 2012



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Prior to the close of the market PJM operations would estimate the units needed for reactive support and interface control so that they would be included in the Day-Ahead Market solution. This change reduced the amount of LOC payments that PJM had to pay units that it did not need in real time, but changed the way costs for reactive services being provided in real time are allocated.

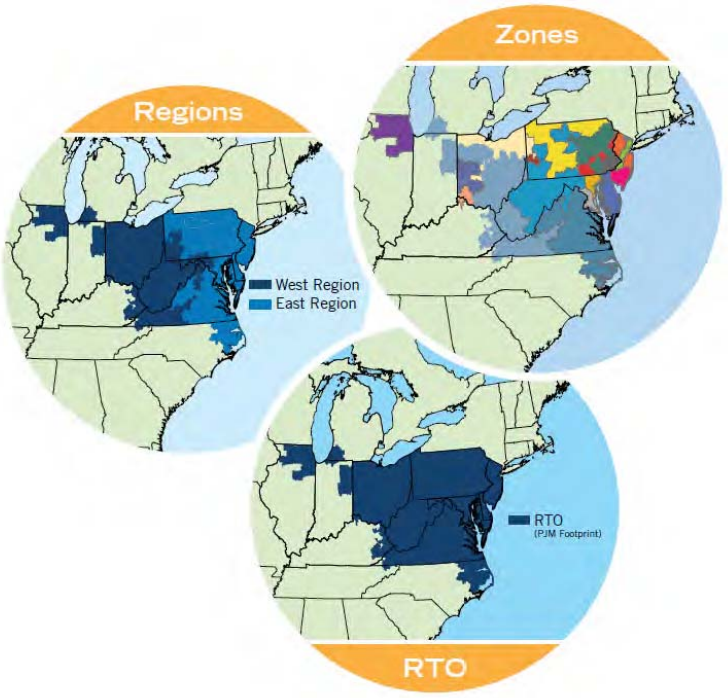
When units were being committed for reactive services after the close of the Day-Ahead Market they would be allocated to real-time load in the zones that benefitted or all zones if the reactive service was needed for transmission that is greater than 345 kV. Since PJM was now committing these units in the Day-Ahead Market, the make whole costs were allocated simply to day-ahead operating reserve costs. These costs are allocated to all load and exports in the Day-Ahead Energy Market without regard to location. This allocation methodology does not allow for a more specific allocation of make-whole costs for resources that are committed for reliability to provide specific reliability services, such as reactive service. Prior to the change, generation resources committed after the day-ahead run and are run in real time to provide reactive services are allocated to load in the zone where the reactive service was needed. Once PJM changed the time at which that unit was committed, the cost of the same unit providing the same service was now allocated to the entire RTO.

In a filing with the Federal Energy Regulatory Commission (the FERC) on November 30, 2012, PJM explained that if such a resource would not otherwise have been scheduled in the Day-Ahead Energy Market but for the expectation that it would be needed for reliability in real time, then the better approach would be that the operating reserves cost

associated with scheduling this resource in the Day-Ahead Energy Market should be allocated the same way they would have been allocated had the resource been scheduled in the Real-Time Energy Market. PJM requested to immediately implement this solution to address concerns with the allocation of operating reserve make-whole payments in the Day-Ahead Energy Market and to engage stakeholders to determine any other solutions to address this problem.

The review of this decision was the first part of the problem statement that the DARCA group was tasked to review.

Allocation of start and no load costs for units providing reactive service in real time



If a unit is called on for reactive service in real-time and LMP is not sufficient to cover the cost of the unit, the unit is credited make whole payments. Make whole credits are used to compensate the unit for following PJM dispatch instructions in real-time operations. Units providing reactive services are made whole through reactive service credits using solely their incremental offer and the real-time LMP. If the make whole credits are insufficient in covering the unit's entire incremental offer, the remainder of its offer is made whole through balancing operating reserve credits. The costs of providing reactive services are paid by real-time load in the control zone where the service was provide, while balancing operating reserve credits are paid by deviations from day-ahead or real-time load plus exports in the RTO, Eastern or Western region, depending on the allocation process. The issue brought up by Monitoring Analytics was that a portion of the costs of providing reactive services, particularly start and no load cost is being paid through balancing operating reserves and not through the reactive service allocation method. The cost of start and no load for units providing reactive is allocated deviations and real-time load plus exports as balancing operating reserve charges, instead of the real-time load of the control zone where the service was provided. The purpose of the problem statement was to review the calculation and allocation of the cost of reactive service.

Education provided

Allocation of day-ahead make whole costs for units called on for reactive service

Reasons why units might be called on in the Day-Ahead Energy Market out of merit

Units can be called on for reliability in the day ahead for (1) black start for automatic load rejection (ALR) (2) reactive interface control (3) reactive service.

For black start service, automatic load rejection is used in some areas for black start; these are units that disconnect from the grid in the event of a blackout and thus are able to help restore the grid. A certain amount of black start MW are needed in each zone, as prescribed in the transmission operator's restoration plan and units are called on in order of least cost.[ii]

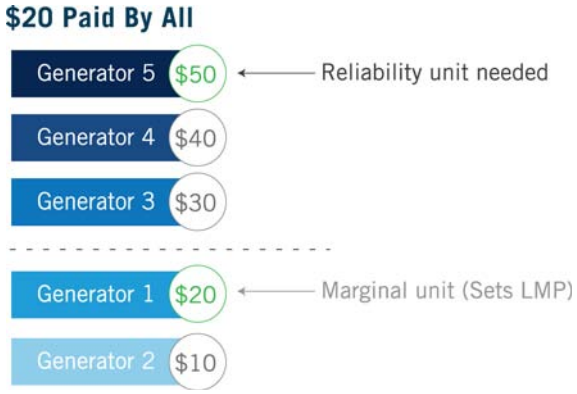
Reactive interfaces are a set of transmission lines that are listed in PJM Manual 37. Units are called on based on the reliability assessment that includes as inputs: power flow studies, transfer limit calculations, load forecast, and day-ahead committed units. Additional units may be called on in the day ahead to control flows and the units are committed in order of least cost.

Units can be committed for reactive service in the Day-Ahead Energy Market based on many different reasons including: reactive needed from the power flow study based on reliability assessment, actual high or low voltage, post contingency low voltage or voltage drop, high voltage control typically in a wide area. Reactive service is localized because VARs do not travel well, so units need to be close to the problem and are limited to a selection of units that can help. The need for reactive power can be outage related but this is not always the case. Units are always committed in least-cost order.

Why don't reliability units set LMP?

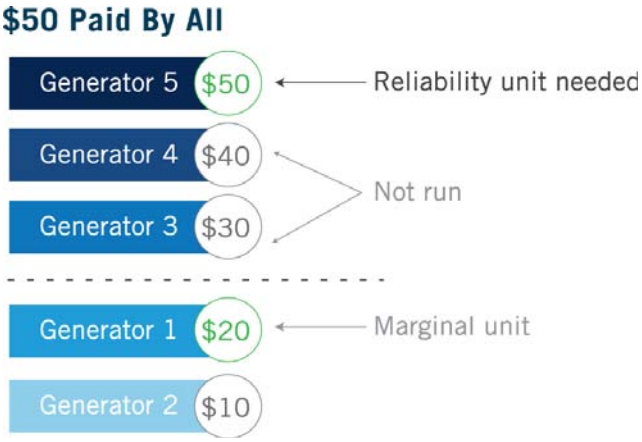
The following is a very simplistic example using only the energy portion of LMP and a system of five generators. It is for a conceptual understanding and not a technical understanding on why reliability units do not always set LMP.

Figure 2: Reliability units not setting LMP



In a very simplistic example, PJM needs a unit for reliability reasons (generator 5) but that unit is so "out of the money" it does not set LMP. Again in a very simplistic example where there are five generators, no congestion and losses, the marginal unit (generator 1) will set LMP.

Figure 3: Reliability units setting LMP



To maintain control of the system, PJM needs to send price signals that incent the behavior it desires. If LMP is set by generator 5 then generator 3 and 4 would come online and begin generating. Should this occur there would be more generation than load and the system would be unbalanced.

Allocation of start and no load costs for units providing reactive service in real time

What is the financial impact of start and no load for reactive being allocated to balancing operating reserves?

The PJM Independent Market Monitor simulated balancing operating reserve rates with and without additional credits to start and no load being allocated to balancing operating reserves. The reduction of balancing operating reserves is shown below:

		Balancing Operating Reserve Rates ($/MWh)		Impact	
Category	Region	Without Credits to Units Providing Reactive Services	Current	($/MWh)	Percentage
Reliability	RTO	0.0227	0.0245	0.0018	7.7%
	East	0.0219	0.0219	0.0000	0.0%
	West	0.1152	0.1154	0.0001	0.1%
Deviation	RTO	0.6754	0.8147	0.1394	20.6%
	East	0.3319	0.3332	0.0013	0.4%
	West	0.1239	0.1265	0.0026	2.1%

[iii]

Reactive service costs: Where are they the largest?

In the 2013 State of the Market Report, the PJM Independent Market Monitor states: "In 2012, the DPL, ATSI and PENELEC control zones received 62.5 percent of all reactive service credits. "[iv] According to the Independent Market Monitor, reactive local voltage support rates were highest in DPL ($1.952), PENELEC ($1.557) and ATSI ($0.6310). [v]

Survey results

September 2013 the DARRCA group sent out a survey to the Market Implementation Committee. Eight individuals responded representing 43 companies. The following questions were asked:

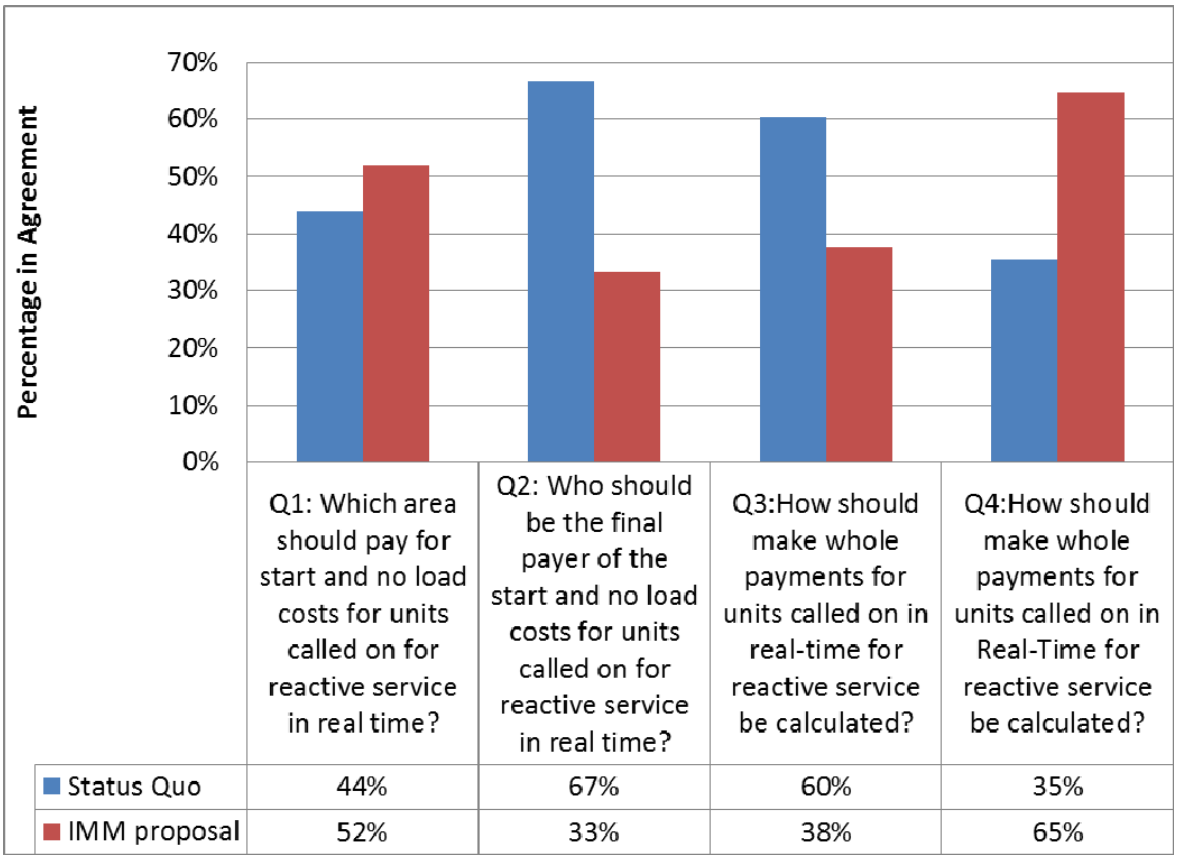
Q1: Which area should pay for start and no load costs for units called on for reactive service in real time?

Q2: Who should be the final payer of the start and no load costs for units called on for reactive service in real time?

Q3: How should make whole payments for units called on in real-time for reactive service be calculated?

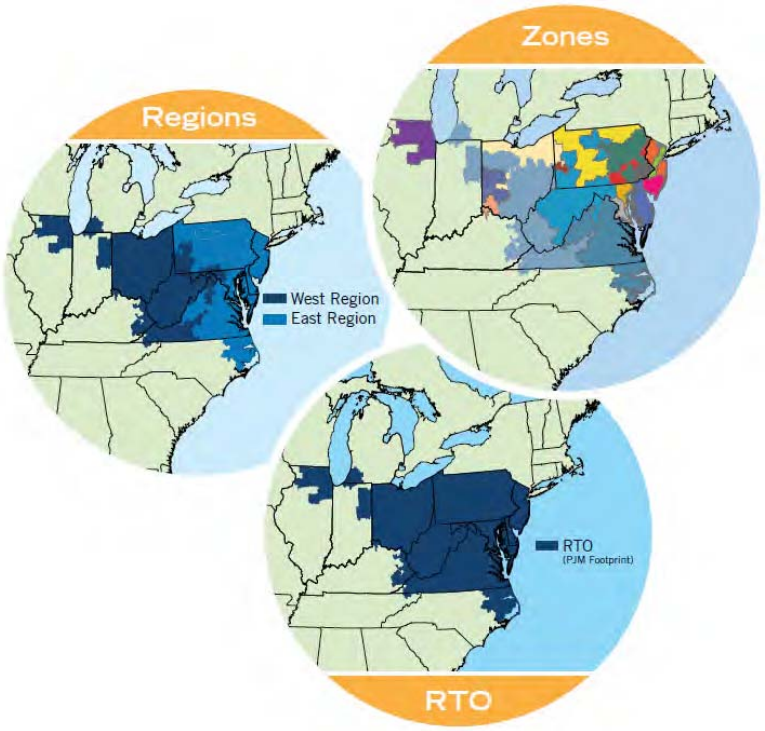
Q4: How should make whole payments for units called on in Real Time for reactive service be calculated?

Figure 4: DARRCA Survey Results



	Q1: Which area should pay for start and no load costs for units called on for reactive service in real time?	Q2: Who should be the final payer of the start and no load costs for units called on for reactive service in real time?	Q3:How should make whole payments for units called on in real-time for reactive service be calculated?	Q4:How should make whole payments for units called on in Real-Time for reactive service be calculated?
Status Quo	44%	67%	60%	35%
IMM proposal	52%	33%	38%	65%

Q1: Which area should pay for start and no load costs for units called on for reactive service and real time?



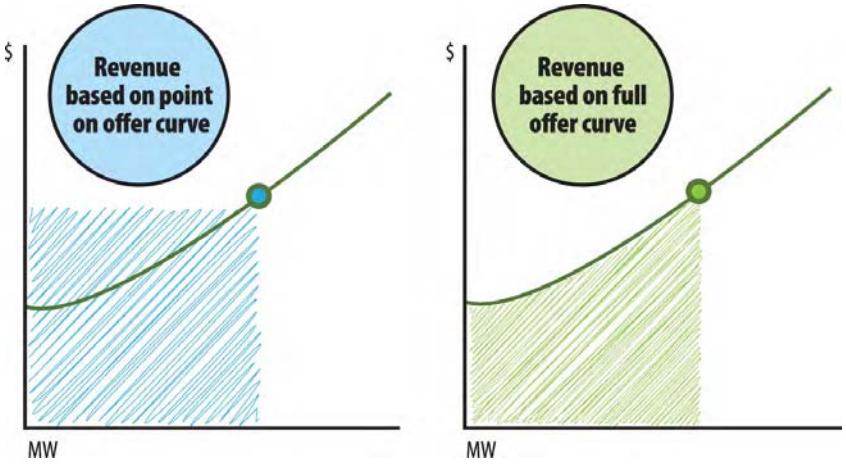
The first question posed to the group was which area should pay for start and no load costs for units called on for reactive service in real time? This question is a geography issue more than anything else. It is asking what area should be the final payer.

The status quo is that start and no load for reactive units called on in real time are allocated through the balancing operating reserve cost allocation methodology. This means that the payers of these costs are regional or entire PJM footprint and not allocated to zones that benefit. 52 percent of respondents preferred the IMM proposal that reactive service should be paid by the zones that benefit. 44 percent of respondents preferred status quo of allocating to the region or entire PJM footprint.

Q2: Who should be the final payer of the start and no load costs for units called on for reactive service in real time?

The second question is not a geography question but is about who should pay for the start and no load costs. 67 percent preferred status quo which is BORCA: RT Deviations or RT Load + Exports. This is noteworthy because it does not align with the preferred answer for the previous question.

Q3: How should make whole payments for units called on in real time for reactive service be calculated?

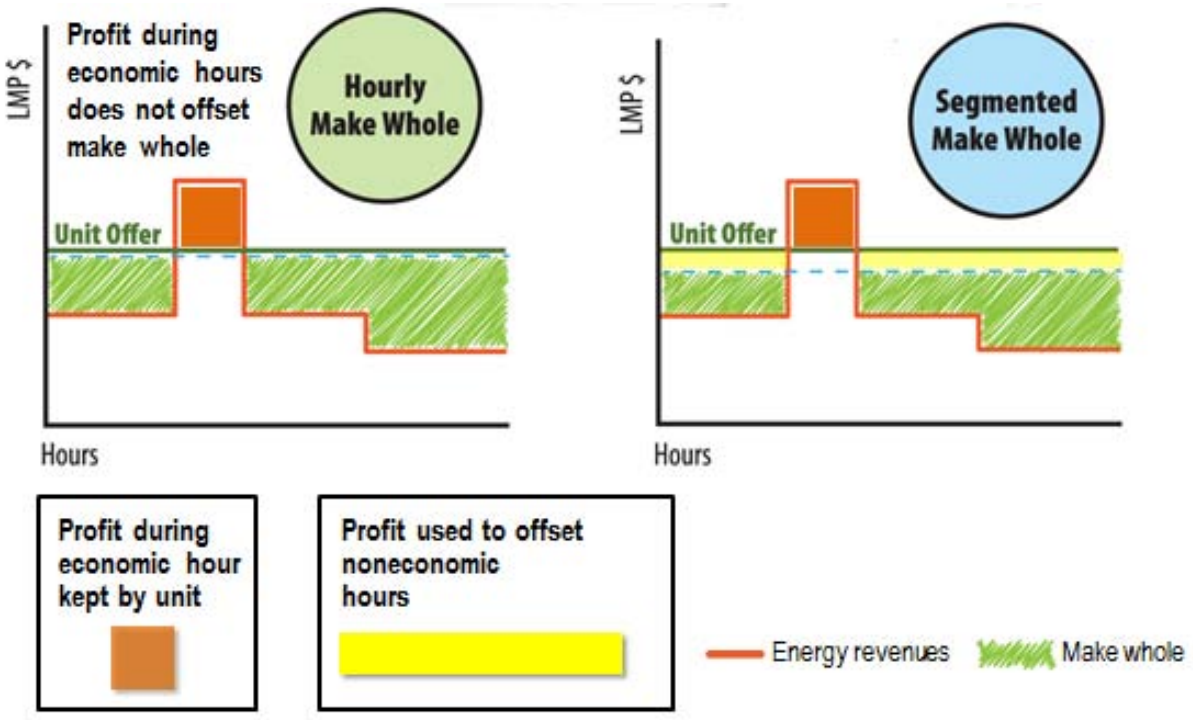


The third question was asking about when calculating reactive service should the make whole be calculated using a point on the offer curve (status quo) or using the full offer curve (IMM proposal). In calculating make whole in operating reserves, the calculation is done based on the full offer curve, however reactive

service is calculated based on a point on an offer curve. A unit will be paid more for reactive service if the make whole is based on the point on the curve than on the full offer curve. Part of the reason for this difference is that in the evolution of the make whole payments for the two services. The operating reserve make whole rules were negotiated in a large cost allocation package in 2008. Reactive service was not included in this package and was traditionally a small amount of MW because units providing the service were on for economics.

60 percent of respondents preferred a point on the offer curve, and 38 percent preferred the IMM option (also used in make whole for operating reserves). 2 percent of respondents were undecided.

Q4: How should make whole payments for units called on in real time for reactive service be calculated?



Currently reactive service make whole costs are calculated hourly (status quo) however operating reserve make whole credits are calculated on segments (IMM proposal). The differences between these two make whole philosophies is that when doing an hourly make whole, each hour is treated separately. When using segments, profits in one hour is used to offset revenue deficiency in other hours within the segment. This is shown in the figure on the right, the unit is made whole to the entire offer and is able to keep all profit made. In the segmented make whole, on the right, the make whole payments are offset by the profit in the economic hour. 35 percent of survey respondents preferred status quo which is the hourly make whole for reactive service while 65 percent felt that it should be calculated by segment as it in in balancing operating reserve payments.

Final packages

Allocation of day-ahead make whole costs for units called on for reactive service

Day-ahead reactive make whole costs, allocation of costs: region

Issue

Review the changes made with the FERC on December 1, 2012.

Status quo and Package A

Both Status Quo and package A allocate the cost for day ahead reactive make whole to the zones that benefit or to all zones if the interface that needs reactive support is 345 kV or higher.

Day-ahead reactive make whole costs, allocation of costs: final payer

Issue

Review the changes made with the FERC on December 1, 2012.

Status quo

Status quo allocates Reactive make whole from units scheduled in the day ahead to real time load.

Package A

The Market Monitor suggested that reactive costs in real time and day ahead should be allocated to real-time load and exports.

Allocation of real-time make whole costs for units called on for reactive service

Real-time start and no load costs, allocation of costs: final payer

Issue

Start/No Load costs are allocated to different payers than other make whole costs for reactive (Issue brought by PJM Independent Market Monitor)

Status Quo

Currently make whole costs to cover start and no load costs for units providing reactive service in real time are allocated through the balancing operating reserve process which means the final payer is real time deviations or real time load plus exports.

Package A

Package A option is to include start and no load cost into the reactive service bucket and allocate the start and no load cost to real time load (or real time load plus exports depending on how it is resolved in day ahead).

Real-time start and no load costs, allocation of costs: region

Issue

Start/No Load allocated to different regions than other make-whole costs for reactive (Issue brought by PJM Independent Market Monitor)

Status quo

Currently make whole costs to cover start and no load costs for units providing reactive service in real time are allocated through the balancing operating reserve process which means the regional payer is the east region, west region or RTO.

Package A

Package A option is to include start and no load cost into the reactive service bucket and allocate the start and no load cost to the zones the benefit (if interface is greater than 345 kV to the entire PJM footprint).

Real-time start and no load costs, allocation of costs: final payer

Issue

Start/No Load are allocated to different payers than other make whole costs for reactive (Issue brought by Monitoring Analytics)

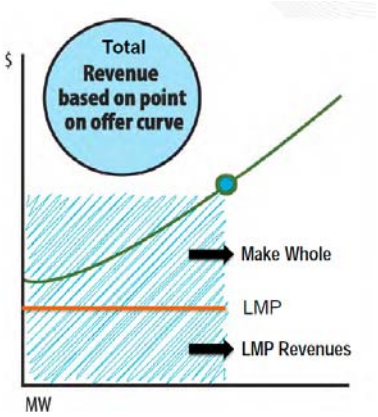
Status Quo

Currently make whole costs to cover start and no load costs for units providing reactive service in real time are allocated through the balancing operating reserve process which means the final payer is real time deviations or real time load plus exports.

Package A

Package A option is to include start and no load cost into the reactive service bucket and allocate the start and no load cost to real time load (or real time load plus exports depending on how it is resolved in day ahead).

Real-time incremental costs, make whole calculation: part of the offer curve used

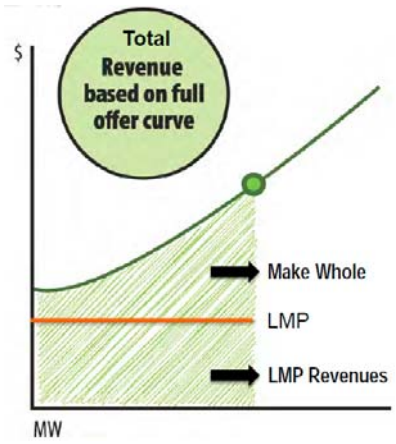


Issue

Inconsistent Interpretation of offer (Issue brought by PJM Independent Market Monitor)

Status quo

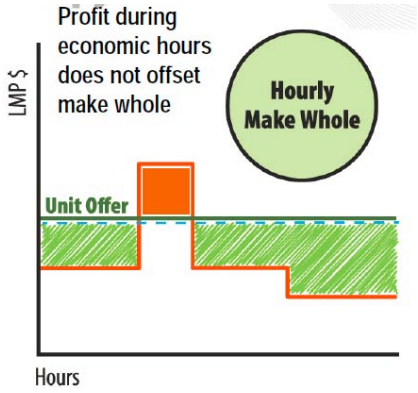
Currently in the calculation of make whole costs only incremental point on the curve is used.



Package A

Package A option is to include start and no load cost into the reactive service bucket and allocate the start and no load cost to real time load (or real time load plus exports depending on how it is resolved in day ahead).

Real-time incremental costs, make whole calculation: hours or segments

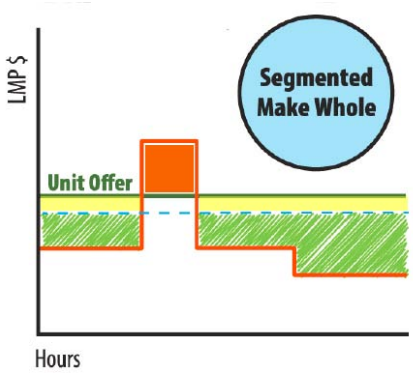


Issue

Reactive is calculated hourly, BOR is calculated in segments

Status quo

Currently make whole costs for reactive is calculated hourly. This means that every hour is considered separately and profit in one hour is not used to offset make whole in other hours.



Package A

Package A option is calculate reactive service make whole in segments like balancing operating reserves.

Conclusion

For allocation and calculation of reactive costs, the Day-Ahead Reliability and Reactive Cost Allocations (DARRCA) group came up with one proposal for allocation of reactive service in real time and one proposal on how allocate reactive service when called on in day ahead. For the allocation of both it was generally agreed that day ahead and real time should be allocated to the same areas and final payers.

Allocation of day-ahead make whole costs for units called on for reactive service

The group generally agreed with the decision to allocate the cost of reactive called on in the Day-Ahead Market to the zones that benefit. The additional change they proposed was to allocate the cost not just to real time load but to real time load plus exports, however there are at least two different ways to implement this and there was no consensus on how this should be implemented.

Allocation of start and no load costs for units providing reactive in real time

There was no consensus on the final package that came from the discussion on start and no load for units providing reactive service in real time. One clear proposal seemed to fall out of the discussion, proposed by the Independent Market Monitor; however in a survey to the group, preferences were mixed on each individual item. Further the survey did not garner many responses. This may be indicative of a lack of interest in the topic.

Appendix

The FERC material

November 30, 2012: PJM Filing

Re: PJM Interconnection, L.L.C., Docket No. ER13-481-000 Allocation of Day-Ahead Operating Reserve Charges

January 28, 2013: The FERC acceptance of PJM filing

Order Accepting Tariff Revisions

Meeting materials

October 17, 2013 DARRCA meeting (9/9)

Agenda / Minutes

Item 02A - Problem Statement Charge Charter

Item 02B - DARRCA Snake Diagram

Item 02C - Work Plan

Item 02D - Education History

Item 03A - Survey Presentation

Item 03B - Pre-survey Education

Item 03C - DARRCA DA Reactive Options

Item 03D - DARRCA Matrix

August 19, 2013 DARRCA meeting (8/9)

Agenda / Minutes

Item 02A - DARRCA Snake Diagram

Item 02B - DARRCA Work Plan

Item 03A - Education Review DARRCA

Item 04A - MA Reactive services Credits Proposal Details

Item 05A - DARRCA

Post Meeting DARRCA Matrix

Reactive service Outages

June 17, 2013 DARRCA meeting (7/9)

Agenda / Minutes

Item 02A – DARRCA Educational Chart

Item 03A - Interface Control Allocation

Item 03B - Day-Ahead Reliability Units LMP

Item 03C - Voltage Control

Item 04A - MA Reactive services Credits Proposal Examples

Item 05A – DARRCA CBIR Matrix

Reference - BORCA Flow Chart

Reference - PJM OATT Filing Acceptance

Post-meeting DARRCA Matrix

May 31, 2013 DARRCA meeting (6/9)

Agenda / Minutes

Item 01 - DARRCA Work Plan

Item 02A – Problem Statement 2 Remaining Issues

Item 02B - Problem Statement Including Commitment and Dispatch

Item 02C - MRC Chart

Item 04 - Collaborative Solution Matrix

Reference - BORCA Flow Chart

Reference - PJM OATT Filing Acceptance

Reference - Previously Approved Allocation Changes

April 5, 2013 DARRCA meeting (5/9)

Agenda / Minutes

Item 02A - DARRCA Snake Diagram

Item 02B - Allocation Work Plan

Item 03 - Day-Ahead Market Training

Item 04 - Impact of Reliability Unit Commitment in Day-Ahead Whitepaper

Item 05 - Matrix DARRCA

March 19, 2013 DARRCA meeting (4/9)

Agenda / Minutes

Day-Ahead Reliability Units LMP

DARRCA Snake Diagram

MA Reactive services Issues

Operations Presentation

February 26, 2013 DARRCA meeting (3/9)

Agenda / Minutes

Item 02A - DARRCA Incorporation PSEG Proposal

Item 02B - Allocation Work Plan Edited 12.14.2013

Item 02C - ER13-481-000

Item 05A - Impact Analysis

Item 05B - October 2012 - January 2013 Operating Reserve Summary

Item 06A - MA Reactive services Issue

Item 07A - Reliability Unit Simulation

January 25, 2013 DARRCA meeting (2/9)

Agenda / Minutes

Item 02A - Problem Statement Charge Charter

Item 02B - Allocation Work Plan Edited 12.14.2012

Item 03A - Operations Presentation

Item 04A - Settlements Presentation

Item 04B - 11.30.2012 ER13-481-000

Item 05A - Reactive services Issue

December 14, 2012 DARRCA meeting (1/9)

Agenda / Minutes

Item 02A - DA Operating Reserve Allocation Issue Charge

Item 02B - Reactive services and Operating Reserve Credits Problem Statement and Issue Charge

Item 02C - Problem Statement Charge Charter

Item 02D - Filing 11.30.2012 ER13-481-000

Item 03 – Allocation Work Plan

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[i] During the stakeholder process an additional portion of the problem statement was included for a time and then taken to a different stakeholder group. The issue dealt with modifying the problem statement to include: "(1) Perform education (i) on current Day Ahead and Real-Time Energy Market make whole payment cost allocation methods and (ii) functions and interactions of Day Ahead and Real-Time commitments. (2) Identify scenarios under which PJM would commit a resource in the Day Ahead Market uneconomically for reliability and consider alternative approaches to committing such resources in Day Ahead and potential improvements to the PJM Day Ahead commitment/dispatch model. (3) Determine the appropriate allocation of make whole payment for the aforementioned resources to the extent necessary." Link to the Problem Statement.

[ii] Black start make whole allocation was addressed in a separate stakeholder process Issue Tracking

[iii] http://www.pjm.com/~/media/committees-groups/committees/mic/20130226-day-ahead/20130226-item-06a-ma-reactive-services-issue.ashx

[iv] http://www.pjm.com/~/media/committees-groups/committees/mic/20130319-da/20130319-ma-reactive-services-issue.ashx

[v] http://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2013/2013q3-som-pjm.pdf page 16

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