Price Inconsistency Market Enhancements

Draft Final Proposal

August 31, 2012

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Acronyms

CB	Convergence bid
CRR	Congestion Revenue Rights
DAM	Day-Ahead Market
DLAP	Default Load Aggregation point
HASP	Hour Ahead Scheduling Process
HIR	Hourly Intertie Ramp
IFM	Integrated Forward Market
ISO	Independent System Operator
LMP	Locational Marginal Price
MCC	Marginal Congestion Component
POD	Point of Delivery
RTM	Real Time Market
SF	Shift Factor
SMEC	System Marginal Energy Component
TH	Trading Hub

1 Introduction

The ISO proposes to implement a series of changes to its market application functionality in both the day-ahead and real-time markets or to its post-process market settlements in order to address price inconsistencies. Both the ISO and market participants have observed that in certain instances the integrated forward market (IFM), hour ahead scheduling process (HASP) and real-time market may produce market outcomes containing price inconsistencies in awarded schedules or dispatches.

Price inconsistencies in the ISO markets can expose market participant to uneconomical awards and to uncertain risks. The underlying principle in the ISO market clearing process relies on awarding bids that are in merit; however, under some conditions, the interplay of various features may result in uneconomical awards. As described further in this paper, the ISO proposes to consider a series of changes to its market software and post processes that reduce the price inconsistencies.

2 Plan for Stakeholder Engagement

Item	Date
Post Issue Paper & Straw Proposal	June 18, 2012
Stakeholder Conference Call	June 26, 2012, 1 – 3 p.m.
Stakeholder Comments Due	July 06, 2012
Post Revised Straw Proposal	August 2, 2012
Stakeholder Meeting	August 9, 2012, 10am – 3 p.m.
Stakeholder Comments Due	August 16, 2012
Post Draft Final Proposal	August 31, 2012
Stakeholder Conference Call	September 10, 2012,
Stakeholder Comments Due	September 17, 2012
Board Meeting	November 1-2, 2012

3 Background

In a market solution, awards and prices are expected to be consistent with one another; that is, awards are supported by prices and follow the principle of economical awards. Assuming no ramping constraints or commitment constraints, for supply, a schedule is expected to be awarded only if the clearing price is equal to or greater than the bid-in price; for demand, schedules are awarded only if the clearing price is equal to or lower than the bid-in price. Given the interplay of market design features in both the integrated forward market (IFM) and the hour ahead scheduling process (HASP), this expected outcome may not always be attained. In some instances HASP awards are uneconomical; that is, the clearing price on a tie does not support the award and it may happen to either import or exports on any tie. In some IFM instances and more frequently with virtual bids at trading hubs (TH) and default load aggregation points (DLAPs), price inconsistencies may result in awards that are not consistent with bid-in prices. Instances where awards are uneconomical are more frequently observed but there have been other instances where economical bids are not awarded. The ISO is implementing solutions through market enhancements to overcome price inconsistencies within the scope of its current tariff authority and these items are described in this document for the sake of completeness.

4 Price inconsistencies

The cause of price inconsistencies is not unique and, therefore, several modifications need to be implemented to address the issue. The ISO proposes to implement a series of software changes or a post-process change in order to minimize the instances of price inconsistencies observed in the ISO markets. This section discusses the main causes for price inconsistencies in the ISO markets.

4.1 Scheduling Run vs. Pricing Run

The implementation of the energy market at the California ISO requires the use of two market runs: A scheduling run and a pricing run. Each run produces awards (dispatches) and prices. Currently, the binding awards are taken from the scheduling run while the binding prices are taken from the pricing run. In principle and under normal conditions, the outcomes between the scheduling and pricing runs are expected to be reasonably consistent to one another. Since the inception of the MRTU, it was always recognized that in some instances economical bids alone would not attained a feasible solution and the last resort would be the use of uneconomical adjustments. Depending on the market conditions the uneconomical adjustments could be for self schedules based on the scheduling priorities as defined with the various penalty prices or the relaxation of certain constraints[1].

[1] Issue paper on Issue Paper Parameter Tuning for Uneconomic Adjustments
in the MRTU Market Optimizations, May 6, 2008, http://www.caiso.com/1fbf/1fbfe3a2498e0.pdf

The scheduling run produces schedules and prices that are consistent with each other; that is, awards are supported by prices and follow the principle of economical awards. In the scheduling run the optimization engine to clear the market will try to achieve a solution using economical bids as much as possible but it will utilize uneconomical adjustment (cut of self schedules or relaxation of constraints) as a last resource to be able to attain a solution. The prices from the scheduling run, however, may not reflect the actual economical signal as this run uses penalty prices as a mechanism to enforce self schedules and constraint relaxation priorities when there is a need for such uneconomical adjustments. The modeling of priorities for self schedules and constraint relaxation in the scheduling run is done by means of the parameters named penalty prices[2] and are set to high values so that they are outside the range of acceptable economical bids and all effective economical bids are used before using cutting self schedules or relaxing constraints. The penalty prices are applied to the slack variables used to model the curtailment of self schedules and constraint relaxations and appended into the objective function of the formulation of the cost minimization problem. The optimization problem in the scheduling run will minimize the overall cost considering the bid cost of all resources as well as the cost associated with the use of the slack variables and their corresponding penalty prices. When uneconomical adjustments or constraint relaxations occur in the scheduling run, some prices will be determined by the penalty prices due to resources being dispatched in the penalty region or constraints being relaxed. Dispatches based on these prices are reflective of the conditions of the system, indicating the need to redispatch resources in the most efficient way to resolve system constraints, such as power balance or transmission constraints.

In the pricing run, the higher penalty prices are no longer used, and self schedules as well as constraint relaxations are modeled with lower prices that are coordinated with the bid price cap and floor such that resulting prices from the pricing run can reflect economic signals and be used for settlement purposes. In the pricing run, the information of the uneconomical adjustments and constraint relaxation is retained because after solving the scheduling run the amounts of the curtailments and relaxations are known. These instances are modeled in the pricing run with slack variables with a small range beyond the solution of the scheduling run in order to have the room in the optimization of the pricing run to find a solution. Similar to the scheduling run, the slack variables will be modeled with penalty prices. However the penalty prices used in the pricing run will be, that are coordinated with the bid price cap and floor based on the bid floor and caps in order to attain economical prices that can be used for settlement purposes. The pricing run will minimize the overall cost of the bid-in resources as well as the cost associated with the slack variables and their associated penalty prices. Furthermore, the dispatches from the scheduling run are preserved to the extent

[2] In the optimization literature the penalty prices are the means to penalize certain components of the formulation, such as constraints, so that these components are less attractive for the search of the optimal solution.

possible. Unit commitment status from the scheduling run are locked and preserved in the pricing run and they are not re-optimized in the pricing run; the optimal schedules of resources and constraint relaxations are bounded in the pricing run from curtailing or relaxing more than the optimal solution of the scheduling run plus epsilon if they were dispatched in the penalty region.[3] Optimal schedules from the scheduling run that are not dispatched into the penalty region and constraints that are not relaxed are not bounded beyond the submitted economic range or the original limits.

For an illustration, let us consider an example with a two-node, one tie line system as illustrated in Figure 1

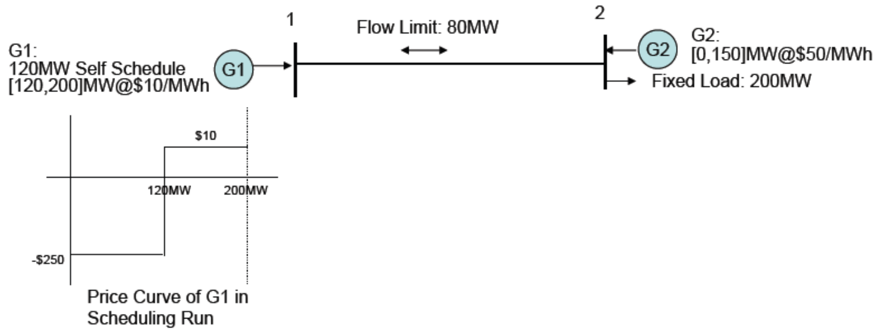

Figure 1: Scheduling run set-up

The transmission line limit between the two nodes is 80 MW (assume there are no losses). G1 has a self-schedule for 120 MW and an economical bid between 120 MW and 200 MW for $10/MWh. G2 has only an economical bid from 0 MW to 150 MW for $50/MWh. There is a fixed load at node 2 for 200 MW. In the scheduling run, G1's self-schedule is protected with a penalty price of, say, $250. With this penalty price, the self-schedule for 120 MW is beyond the economical range of all the other energy bids.

If one assumes there is no transmission limit, G1 would fully supply the 200 MW load as it is the cheapest resource. However, with the transmission constraint, only 80 MW can be used from G1, even if it is the cheapest resource and has a self-schedule for 120 MW. The self-schedule conflicts with the enforcement of the transmission constraint and needs to be curtailed to attain a feasible solution. Thus,

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[3] The full list of penalty prices used in the scheduling and pricing runs for the various self schedules and constraint relaxations is available in the business practice manual for Market Operations on the public ISO website. The stakeholder initiative for parameter tuning of uneconomic adjustments where the scheduling and pricing run are explained in more detail, together with the discussion of the parameter tuning, is also available on the ISO public website under the section of stakeholder processes. Details about the optimization formulation of the ISO market is publicly available at http://www.caiso.com/Documents/TechnicalBulletin-MarketOptimizationDetails.pdf

G1's self-schedule is curtailed to 80 MW and G2 provides the extra 120 MW to meet the load of 200 MW. Since G1's self-schedule is curtailed, the penalty price sets the prices at node 1 for -$250/MWh and with G2 setting the price at node 2 for $50/MWh, the resulting shadow price for the transmission constraint is $300/MWh as illustrated in Figure 2.

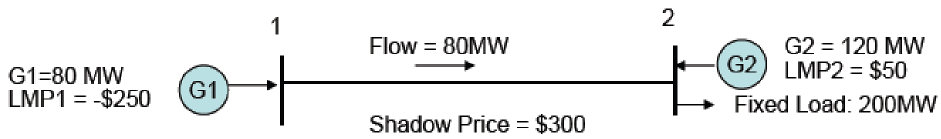

Figure 2: Scheduling run solution

The penalty price used to enforce the priorities of the self-schedule in this case sets the price. In order to find a clean price, the pricing run is set up accordingly as shown in the next figure.

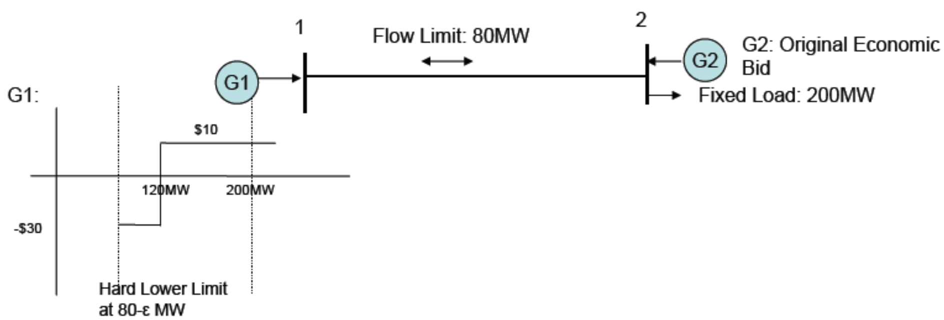

Figure 3: Pricing run set-up

The optimal dispatch from the scheduling run for G1 is bounded by below in the pricing run so that this schedule is no further curtailed in the pricing run. There is a small tolerance (epsilon) used in the limit for G1 to ensure the pricing run is able to find a feasible solution. Also, the penalty price of -$250 is replaced with the bid floor of -$30.

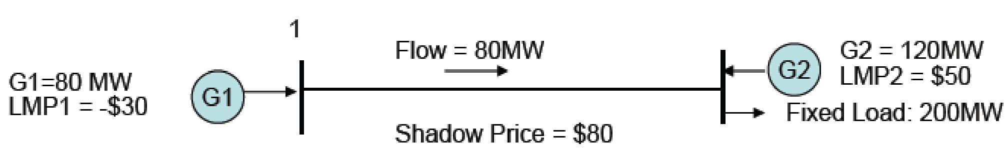

Figure 4: Pricing run solution

With this setup, the optimal dispatch from the pricing run is the same as those from the scheduling run; however, the prices are now set by the bid floor. At node 1, G1 sets the prices at the bid floor, while G2 sets the price at $50/MWh, resulting in a shadow price for the transmission constraint of $80/MWh.

Price inconsistencies arise when the prices obtained in the pricing run differ from the scheduling-run prices to the point where the optimal schedules from the scheduling run are no longer economical. Since awards from the scheduling run and prices from the pricing run are used for settlements, market participants are sometimes subject to uneconomical awards. Mismatches between the scheduling run and pricing run may be due to the interplay of: 1) the hourly inter-tie ramp, 2) wheeling bids, 3) level of bids with respect to penalty prices and bid floor, 4) overgeneration and congestion conditions that cannot be resolved strictly with economic bids. The ISO has indicated that these outcomes may be observed given the existing market features.[4]

Although there are different root causes resulting in this type of inconsistency between the scheduling and pricing runs, the mechanics driving the solution fit into the same logic. In the case of overgeneration conditions, the scheduling run will use the penalty prices as the means to prioritize what schedules are cut first to resolve the overgeneration and then in the pricing run such MW schedules are protected to not be cut further by limiting schedules to not go below the MW schedules from the scheduling run (however, the schedules from the scheduling run are not bounded by above in the pricing run). Furthermore, in the pricing run instead of using the penalty prices used in the scheduling run, lower penalty prices of -$30 are used and there are no further priorities enforced. Since now all the bids that were modeled with penalty prices lower than -$30 are equally attractive to clear the market and based on overall market conditions, the solution from the pricing run may be at a different dispatch solution. In the scheduling run, the prices were driven by non-economical bids but in the pricing run the prices are driven by economical bids and the much lower penalty price of the pricing run. This can create a mismatch of prices between the scheduling and pricing runs, and may potentially result in a mismatch of MW schedules between runs. In the end, the use of the MW schedules from the scheduling run and the prices from the pricing run leads to the price inconsistency.

For instances where the inconsistency is driven by managing congestion that cannot be resolved with economical bids, the mechanics is fairly similar. If there is congestion that requires the relaxation of a transmission constraint, in the scheduling run such constraint is going to be managed with a penalty price of $5000, based on that price the market will find the least-cost solution; however, when it comes to the pricing run, all penalty prices are adjusted, including the penalty prices of the transmission

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[4] For instance, on February 9, 2011 the ISO temporarily de-activated the Hourly Intertie Ramp (HIR) feature effective in the HASP to allow for review of some recent results where prices in the scheduling run differed from the pricing run. The conclusion is that the differences between prices in the scheduling run and the pricing run were due to over-supply conditions or congestion which resulted in the need to curtail self-schedules using uneconomic adjustment parameters.

constraint, and all these (lower) penalty prices may lead to a different solution, leading to different prices in the pricing run.

A similar outcome may be observed due to the interplay of economical bids with prices lower than the bid floor. According to the ISO Tariff[5] the bid floor is a soft floor in that bids below the bid floor may be submitted and are still included in the determination of the market solution. Based on historical data, bids below the bid floor have been consistently submitted in the market. During 2012, in the real-time market an average of 24 resources –both internal resources and system resources– have submitted bids below the -$30 bid floor in a given month, with 57 different resources submitting bids below the -$30 floor throughout 2012. Bids below the bid floor also existed in the day-ahead market, but to a much less extent, with five different resources bidding prices lower than the bid floor in 27 days throughout 2012. The existing of a soft bid floor by definition of the soft-bid floor creates the opportunity for price and bid award inconsistency for at the least the resource that submitted the bid below the bid floor. Such bids may also create price inconsistencies for other resources elsewhere in the system. Based on analysis of the cases for price inconsistencies in the month of June, it was found that about 14% of the cases with price inconsistencies were due to bids below the bid floor. To eliminate this inconsistency, should the ISO consider eliminating the soft bid floor or should ISO maintain the concept of soft bid floor and accept the resultant potential for price dispatch inconsistency that arise.

Lastly, the hourly intertie ramping also needs to be considered for consistency between prices and schedules. Prior to the HIR feature, the MW schedules of hourly interties cleared in the HASP assumed the schedule change happens instantaneously at the top of each hour and did not considered the energy through the ramp even though in reality intertie schedules will ramp symmetrically across the hour boundary. With the HIR feature, the energy produced during the inter-tie ramping is considered and reflected in the MW schedules of the HASP run as shown in the following figure

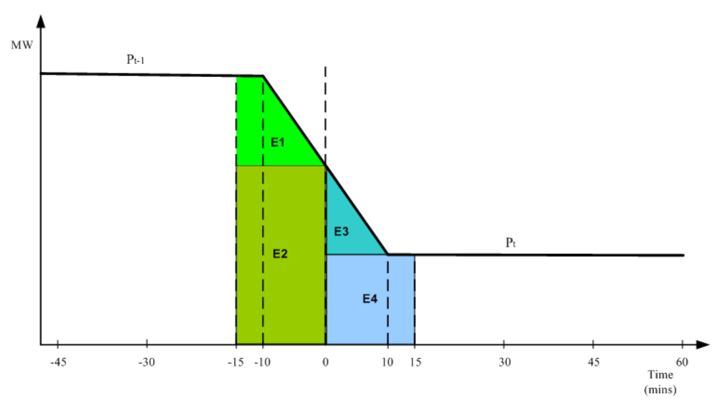


Figure 5: Hourly inter-tie ramping profile

[5] Section 39.6.1.4

From the above figure, the energy delivered through the ramp can be characterized as follows:

$$E1 = 5(p_{t-1} - p_t)$$

$$E2 = 7.5(p_{t-1} + p_t)$$

$$E3 = 2.5(p_{t-1} - p_t)$$

$$E4 = 15\,p_t$$

And the schedules in intervals 3 and 4 of the HASP run that would account for the energy delivered in the ramp period can be determined as follows:

$$p'_{t-1} = \frac{E1 + E2}{15} = \frac{5}{6}p_{t-1} + \frac{1}{6}p_t$$

$$p'_t = \frac{E3 + E4}{15} = \frac{1}{6}p_{t-1} + \frac{5}{6}p_t$$

This relationship is also reflected in a linkage of the prices of the last interval of previous hour with the price of the first interval of the HASP hour and, therefore, the prices of inter-tie awards will reflect adjustments to be consistent with cleared MW schedules as follows:

$$Adjusted\ \mathrm{Pr}ice_{\mathrm{int}=4} = \frac{1}{6}\mathrm{Pr}ice_{\mathrm{int}=3} + \frac{5}{6}\mathrm{Pr}ice_{\mathrm{int}=4}$$

Including the linkage of the last interval price of the previous hour into the hourly intertie pricing helps improve consistency between intertie settlement prices and intertie awards from HASP. To the extent there is an uneconomical solution in the scheduling run affecting the last interval of the previous hour, the interplay of this price with the hourly intertie price may result in inconsistency between the intertie awards from the HASP scheduling run and the prices from the HASP pricing run.

4.2 Point of Delivery (POD) vs. Nodal Constraints

When a convergence bid is submitted at a point of delivery (POD) location, the market clearing process evaluates such a bid at the physical location that is associated to the POD. Thus, the bid is cleared at the physical location using the clearing price of the physical location, but the bid is still financially settled at the price of the POD location which reflects the point at which energy enters the ISO controlled grid. Price differentials between the physical and the financial location may exist due to losses between the two locations. With the POD design itself, there may be an inconsistency that in some instances may materialize in uneconomical awards. The mapping of PNodes on gen-ties to POD APNodes is to account for losses on non ISO controlled grid between the physical resource and the point of delivery to the ISO grid. The point of delivery also reflects the effective location a metered entity is measured at. Therefore if a resource has a long gen tie, the revenue meter delivery is corrected to reflect the delivery at the point of delivery to the ISO controlled grid. As a result, ISO dispatches must also reflect the MW delivered to the same point of delivery. In addition, the ISO's power flow analysis is performed at the grid level.

One of the main challenges with the introduction of convergence bids in the Integrated Forward Market was to consistently achieve alternating current (AC) power flow solution. With convergence bids awarded at certain locations, represented as injections that the system may not be able to support, there is the potential for AC power flow divergence. For this reason, the ISO implemented a function called Nodal Constraints to limit the injections of convergence bids at certain locations - CAISO tariff section 30. Nodal constraints are formed from a set of individual locations. When a nodal constraint binds, its shadow price is propagated only to its constituent nodes.

Price inconsistencies may arise in the IFM due to the interplay of the POD definition and the creation of nodal constraints. For a convergence bid put in at a POD location, the bid is mapped and cleared at the physical location, but it is settled at the financial location. A nodal constraint created in the IFM may result in price separation between the physical and financial locations associated to the convergence bid. The nodal constraint may include, among other nodes, the financial location at which the convergence bid was submitted; however, the nodal constraint may not include the physical node at which the convergence bid was actually cleared. So when the nodal constraint is binding, the nodes internal to the nodal constraint will effectively reflect the congestion created by the nodal constraint; whereas any other node outside this nodal constraint will not have any contribution to that congestion. Hence, the physical and the financial locations may see two different congestion prices. Since the physical location is used to clear the award, the virtual is cleared without taking into account the congestion created by the nodal constraint, while the financial location has the congestion from the nodal constraint. Thus, when the bid is cleared based on the price at the physical location, and it's settled based on the price at the financial location, it may result in an uneconomical award.

4.3 APNode *vs.* ANode

This type of price inconsistency usually affects physical and convergence bids at DLAPs and convergence bids at trading hubs (TH) in the IFM.

For DLAPs, an APNode price is determined based on the weighted average price of all constituent Pricing Nodes (PNodes) weighted by the quantity of load in each PNode. As a result of this, an APNode price may be affected by any redispatch adjustments the software makes to resources at individual PNodes that are effective in relieving congestion. Schedules for an aggregated DLAP resource (ANode) bid into the day-ahead market are determined based on the effectiveness of adjustments of the aggregated resource in relationship to the congested constraint. Thus, based on the effectiveness and congestion, the aggregate resource may not be used to relieve congestion if its shift factor is under the defined threshold used to identify which resources may be used to relieve congestion. In contrast, some constituent Pnodes may be adjusted to relieve congestion on the same constraint. This will result in the Anode price reflecting no adjustment for congestion relief while the APNode price reflects adjustment done at some constituent Pnodes, creating a price inconsistency. This is graphically represented in Figure 6. Since the Anode price is actually used to clear the schedules, while the APNode is used for settlements this price inconsistency may result in awards out of merit, similar to those observed for convergence bids. Furthermore, when there are disconnected Pnodes, replacement-node prices will be used in the calculation of the APNode prices.

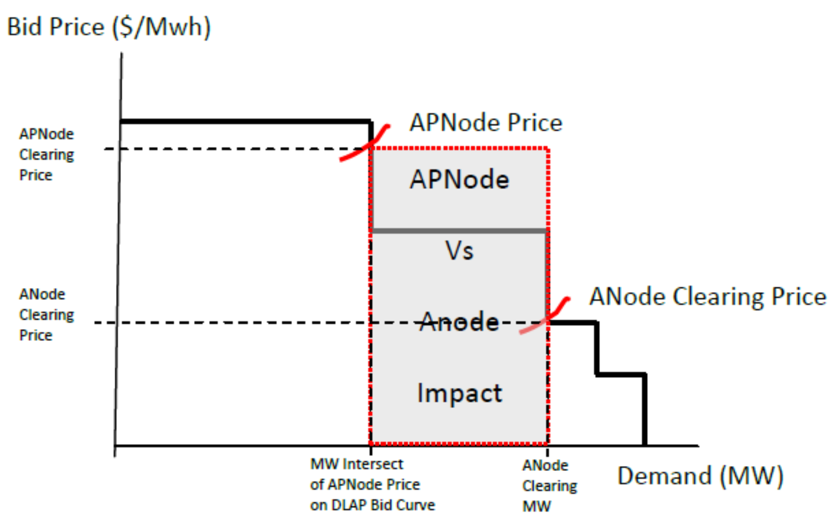


Figure 6: Illustration of APNode and Anode difference Impact

For trading hubs, prior to the Convergence Bidding, Existing Zone (EZ) Generation Trading Hub were only used as pricing indexes and not considered as a bid in optimization solution. Convergence Bidding provides the opportunity to bid at the Existing Zone Trading Hub level. Trading Hub prices are part of a settlement service for bi-lateral transactions that occur outside the ISO Markets. A Trading

Hub price does not result directly from the Market optimization. Specifically, Trading Hub prices are simply weighted prices calculated ex post from Locational Marginal Prices (LMPs) for the settlement of Inter-SC Trades (ISTs) at the Trading Hub location. The weights applied to the constituent nodal LMPs in each Existing Zone Generation Trading Hub are determined annually and separately for each season and on-peak and off-peak period based on the ratio of the prior year's total output of Energy at that PNode to the total Generation output in that Existing Zone, for the corresponding season and on-peak or off-peak period. These are the same weights as those used in the release and in the settlement of Congestion Revenue Rights (CRR). Due to differences in the definition of APNode for EZ Gen trading hub price and how the convergence bid at a trading hub (ANode) is distributed to physical locations, consistency between the Trading Hub Price and cleared bid level of a convergence bid at the Trading Hub cannot be guaranteed.

As reflected in Section 27 of the ISO tariff, the ISO market software includes a minimum shift factor or "effectiveness" threshold setting which excludes resources below the threshold with respect to any given constraint from being used to provide congestion relief on that constraint. The 2% level was chosen to allow the optimization to have reasonable means to dispatch resources to manage transmission constraints, while minimizing large adjustments to resources that are minimally effective in managing constraints. Lowering the threshold may reduce the inconsistency between APNode and Anode prices, but it may also affect the performance of the software engine as more aggregate resources may be considered in the management of binding constraints. Also, lowering the threshold may have implications of moving resources that are not very effective to relieve congestion. The ISO has been publishing the APNode vs. Anode price differential on its website at http://www.caiso.com/Documents/APNode%20and%20ANode%20data

A report on the evaluation of using a 2% threshold is also available at http://www.caiso.com/Documents/MinimumEffectivenessThresholdReport.pdf

4.4 Outages

During the run of the DAM, the IFM includes outages that are known by the time the market closes. Convergence bids submitted for the DAM are validated in SIBR and bids are accepted as long as they meet certain criteria, such as credit limit and submission of bids at valid locations. However, SIBR does not validate bids against active outages for the corresponding trading date. This means that participants can indeed submit bids for locations that are on an outage, but there is no visibility of this by the bid submission time. The only means for participants to know whether a location is disconnected or not prior to submitting a bid is to model the outages posted on the CAISO website on the most current CRR model, but this effort may not give a definite picture of disconnected locations.

In the DAM clearing process, convergence bids submitted at disconnected locations will not be considered at all in the market clearing process and will result in a 0 MW award, regardless of its bid-in price. As a part of the disconnected-node functionality, a price from a replacement node will be used for such disconnected nodes. However, it may happen that the price associated to the disconnected node at which convergence bids were submitted is such that the convergence bid appear to be in economical merit. Since the bid was accepted for a disconnected location that now has an associated price from a replacement node, this may create the expectation with market participants that their bid was not awarded economically as they see 0 MW awards even though the associated price should support some awards.

5 Financial Impact of Price Inconsistencies

This section introduces the historical impact of price inconsistencies associated with HASP awards and difference between APNode and ANode. The costs for the inconsistency due to the interaction of POD and nodal constraints is not presented as it is rather an infrequent occurrence; also, the cost associated with convergence bids not awarded at disconnected nodes is not presented since this is not a material cost to the market.

Figure 7 illustrates the monthly cost of uneconomical awards for HASP awards broken out by imports and exports. The dollar value associated with this metric quantifies the amount by which the payments to participants were uneconomical; this is calculated as (clearing price less bid-in price) times the HASP MW award, keeping the sign convention accordingly for imports and export. This metric is based on the original market results and do not reflect any price corrections done for HASP markets.

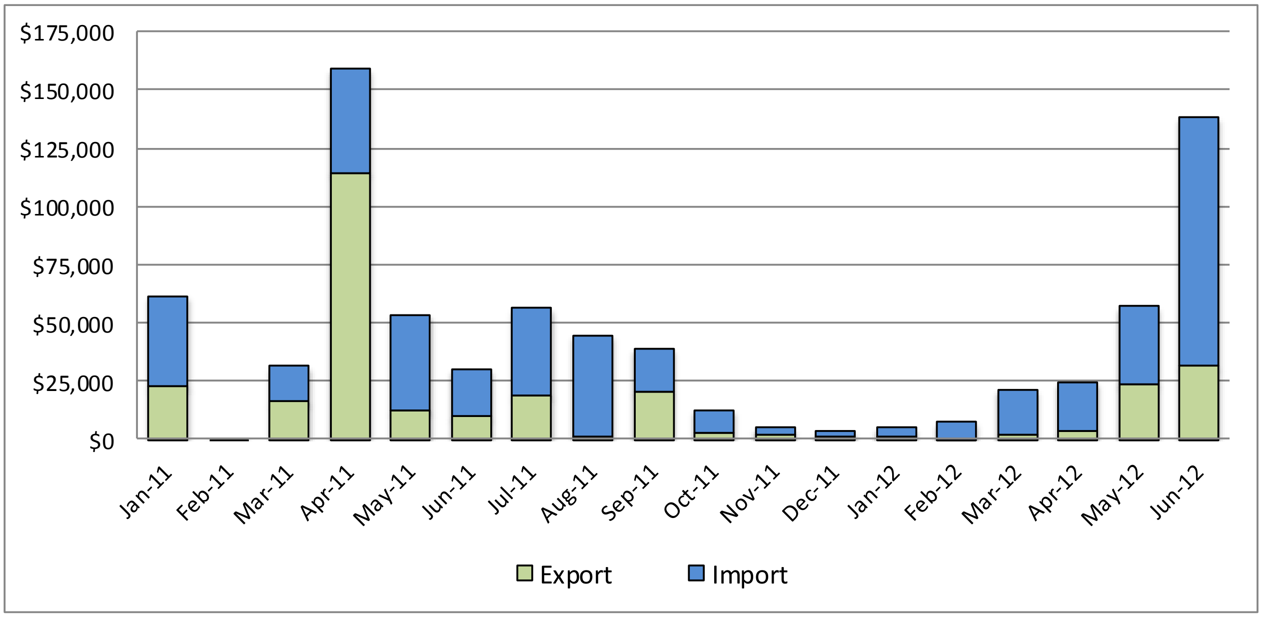


Figure 7: Cost of uneconomical awards in HASP

Figure 8 and Figure 9 show the cost of the price differential between the APNode and Anode for DLAPs and THs, respectively. The cost is calculated as (cleared schedules at the aggregate node times (APNode price less Anode price), and is broken out by each direction: positive when the APNode price is higher than the Anode price, and negative otherwise. Thus, positive values indicate load was charged more than the bid cleared would warrant and when the cost is negative load may have expected to clear for more energy. The cost is aggregated for all three DLAPs in Figure 8 and is aggregated for all three THs in the Figure 9. For DLAPs, the cost is also separated by physical bids and convergence bids, while for THs there is only a pocket for convergence bids. The period covered in this metric is from the activation of convergence bids, February, 2011, up to June 2012.

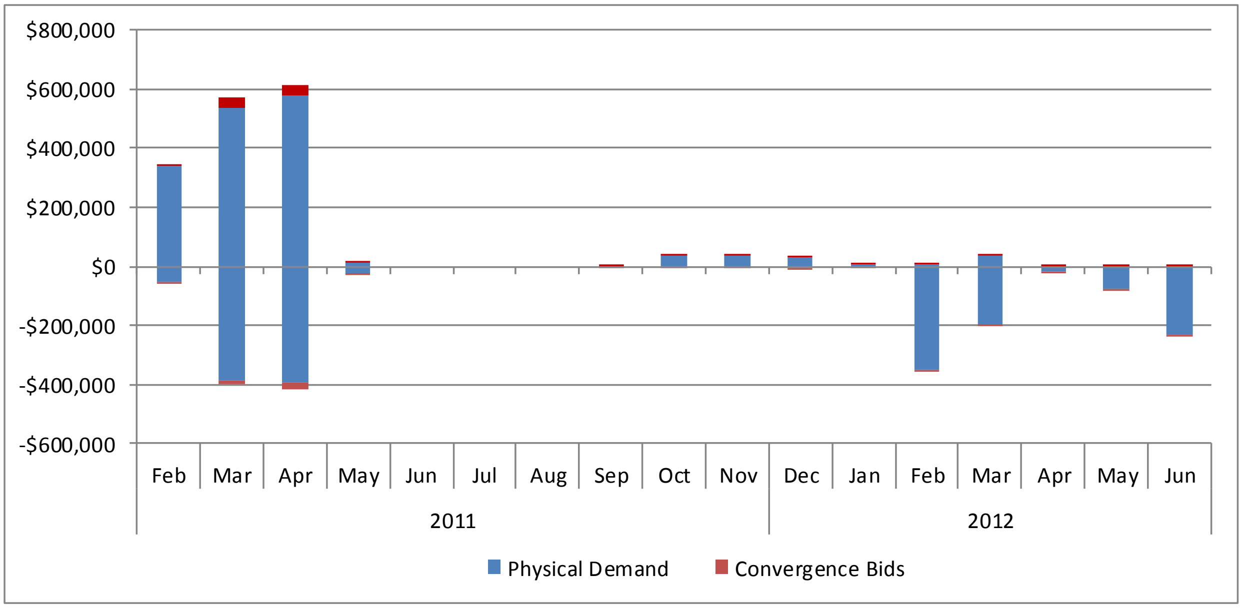


Figure 8: Cost of APNode vs. Anode Price difference for DLAPs

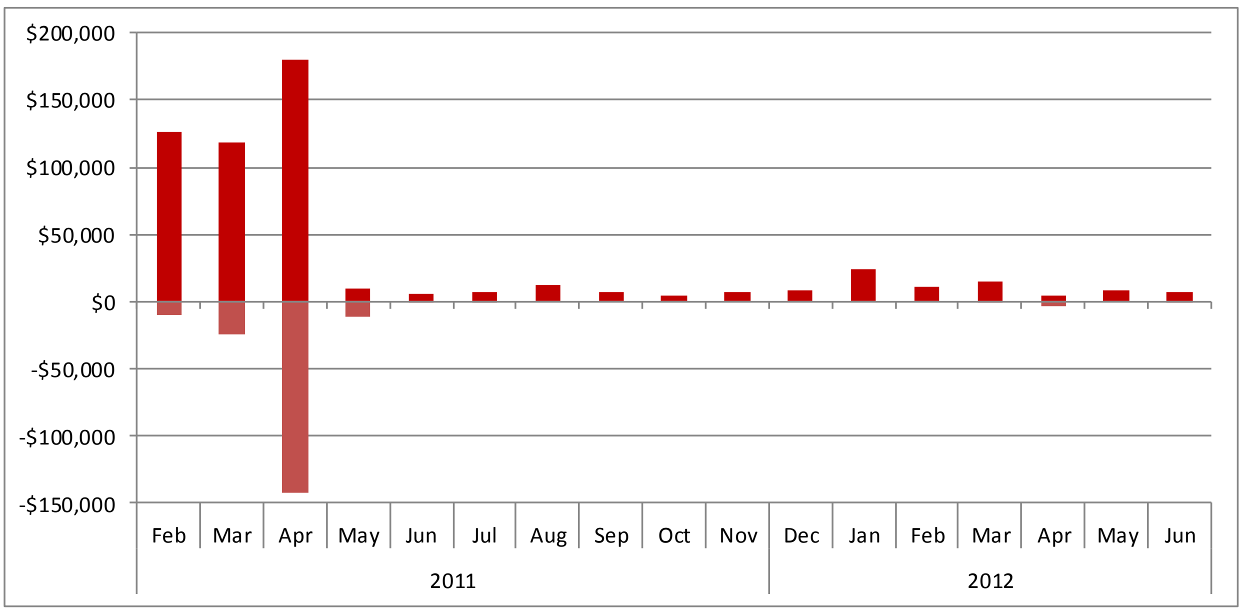


Figure 9: Cost of APNode vs. Anode Price difference for THs

6 Solutions to Address Price Inconsistencies

The ISO outlines below two high level options for resolving the pricing inconsistency currently observed in the markets. The ISO is recommending Option A which allows for a targeted approach of each root cause of price inconsistencies.

6.1 Option A- Targeted Enhancements.

Given the different nature of reasons for price inconsistencies, the ISO is proposing to address each item specifically, as described further in the following subsections. Within the scope of the stakeholder initiative, at this stage the ISO is discussing only the policy-related issues. Once a final proposal is defined, the ISO will move towards the implementation stage, where the enhancements are prioritized based on internal timelines and costs estimates.

6.1.1 Scheduling vs. Pricing Run.

In order to address inconsistencies between scheduling and pricing runs, as described in Section 4.1, the ISO proposes to use both MW awards and prices from the pricing run, instead of the current approach of using MW awards from the scheduling run and prices from the pricing run. The current paradigm of having a scheduling run followed by a pricing run will still be in place, and there will be no changes to the runs set-up. Priorities for self schedules and constraints relaxation and their associated penalty prices will remain unaltered and will continued to be used in the scheduling run. The information from the scheduling run will continue to be used in the pricing run as it currently is. The proposal will not require changes to the mathematical modeling, set-up or market engine. The proposal will rather require, once a solution has been found, a change to the post-process task of transferring market results to downstream systems in order to use MW awards of the pricing run. Since both MW awards and prices are from the pricing run and calculated optimally by the market, they are consistent to each other and this will minimize the inconsistencies created with the use of MW awards from the scheduling run. This approach will resolve most of the instances of price inconsistencies on ties awards in the HASP run. By the time of the development of this initiative, there was one instance of numerical degeneracy identified by the ISO for which the use of the pricing run results would not eliminate the price inconsistency. This scenario has been addressed by the ISO and its software vendor.

Furthermore, through the analysis of price inconsistencies, the ISO identified cases where bids below the -$30 floor were creating price inconsistencies. Since the bid floor is a soft floor, such bids are still accepted. As a part of this effort, the ISO is also proposing to make the bid floor a hard floor, and is proposing to make this change effective concurrently with the change of the bid floor from -$30 to -

\$150[6]. Having a hard bid floor will eliminate the corresponding inconsistencies between the scheduling and pricing runs when the dispatches associated with such bids are changed between runs.

For illustration purposes on the interplay between the scheduling and pricing run and the outcome with the proposed solution, let us consider the following example. Although the interplay of the scheduling run and pricing run is system wise, the focus of the illustration is on the dynamics of the HASP awards being awarded uneconomically. Let us consider an export bid for an inter-tie with two segments as shown in following figure:

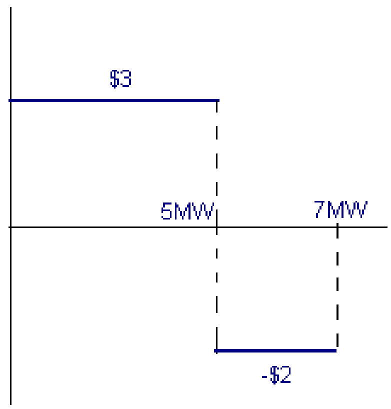


Figure 10: Illustration of an Export bid

This bid indicates the willingness to export up to 7 MW if the market clearing price is -\$2 or lower. For any clearing price between -\$2 and \$3, the optimal award would be 5 MW, while the optimal award would be 0 MW if the market clearing price is higher than \$3.

This numerical illustration captures the interplay between the scheduling and pricing runs, regardless if the inconsistency is driven by overgeneration, congestion or bids below the bid floor. The following table shows the HASP results for this specific bid. The HASP run contains seven intervals, with intervals four through seven constituting the HASP hour. Only inter-ties are settled in HASP; however, all resources including the internal resources are dispatched optimally in this run throughout the seven market intervals. For the illustration purposes, consider that conditions were such that the HASP outcome is driven by an overgeneration condition, which required uneconomically cutting self schedules. In the scheduling run the cut of self schedules does not necessary take place on the specific tie where an award is uneconomical; cut of self schedules may take place anywhere else in the system based on overall economics. However, the cut of self schedules will result in system-wise prices in the

[6] The change for the bid floor from -\$30 to -\$150 was covered in the stakeholder process for Renewable Integration: Market and Product Review. Phase I. The material of this process is available on the CAISO web site. The draft final proposal is available at: http://www.caiso.com/Documents/DraftFinalProposal-RenewableIntegrationMarket-ProductReviewPhase1.pdf

scheduling run that reflect such cuts. This will also be reflected on prices for inter-ties, and inter-tie bids will be cleared based on such prices. For this illustration, the average HASP price across the four intervals for HASP is -$7.5, and based on the bid structure described above, the optimal award for the bid is 7 MW.

Table 1: Summary of market clearing results for an export bid

Time Interval	Bid Name	I_E	Award Sch_run	Award Prc_run	LMP Sch_run	LMP Prc_run
1/1/2099 7:15	BID_GREAT	E	5	5	$25.00	$25.00
1/1/2099 7:30	BID_GREAT	E	5	5	$25.00	$25.00
1/1/2099 7:45	BID_GREAT	E	5	5	($250.00)	($35.00)
1/1/2099 8:00	BID_GREAT	E	7	5	($50.00)	$2.00
1/1/2099 8:15	BID_GREAT	E	7	5	$10.00	$1.00
1/1/2099 8:30	BID_GREAT	E	7	5	$5.00	$0.50
1/1/2099 8:45	BID_GREAT	E	7	5	$5.00	$1.00
		Hourly average HASP price			($7.50)	$1.10

In the pricing run, penalty prices associated to self schedules are set to the bid floor of -$30 (or $1000 for exports). Those schedules that were uneconomically cut in the scheduling run are now bounded in the pricing run. In contrast, economical bids are not bounded and they may indeed be redispatched in the pricing run if the prices from the pricing run support that. In the pricing run, the market clearing prices will be defined based on overall economics and since the penalty prices that determined the prices in the scheduling run are no longer in place, the prices in the pricing run will reflect such conditions. With different set of prices, there may be a different dispatch of resources. Both the set of resources being re-dispatched and the extent of the MW redispatches (with respect to the dispatches from the scheduling run) are driven by the overall economics of the pricing run. Since the prices in the pricing run will be different than those achieved in the scheduling run with uneconomical curtailments, it is expected that the optimal schedules will also change with the overall power balance most likely setting at different value (the total MW value cleared in the scheduling run may be different than the total MW cleared in the pricing run as a result of the difference in prices between runs). From the perspective of each run, the MW awards are optimal and consistent with the resulting prices. Also, the MW schedules are feasible in both runs since all constraints are enforced in both runs.

For this example, the pricing run results in an average HASP price of $1.1, which is different than that of the scheduling run. The price of-$7.5 in the scheduling run fully supports an economical award of 7 MW, while the price of $1.10 in the pricing run supports only an economical award of 5 MW.

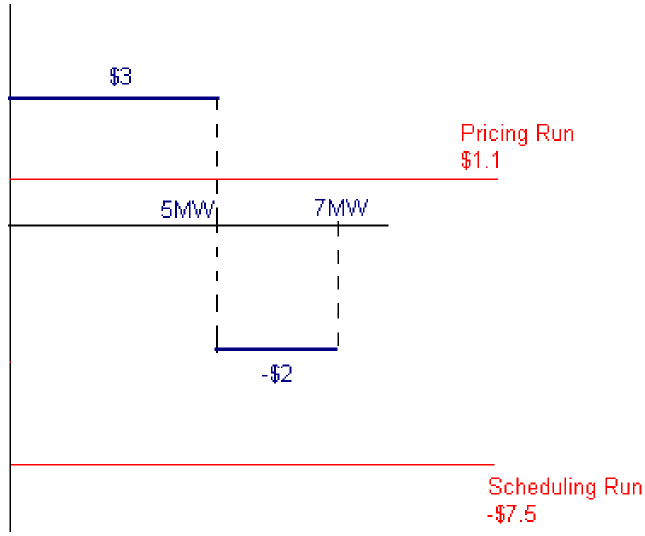


Figure 11: Economical awards for an export based on Scheduling and Pricing runs

With the current approach, the MW schedule of 7 MW from the scheduling run and the price of $1.1 from the pricing run are financially binding and used for settlements, and this setup leads to uneconomical awards (the 7 MW award is no longer supported with the HASP price of $1.1). With the proposed approach, both the MW schedule (5 MW) and price ($1.1) will be financially binding and used for settlements.

6.1.2 POD vs. Nodal Constraints

In order to address the scenario of price inconsistency due to interplay of POD and Nodal constraints, as described in Section 4.2, the ISO is currently pursuing a software enhancement so that the physical location of resources are included in the nodal constraint in case the financial location associated to those resources is also part of the nodal constraint. This will avoid price separations between physical and financial locations of PODs. Notice that with the POD design itself, there will always be an inconsistency that in some instances may materialize in uneconomical awards.

Figure 12 provides an example of how some APNodes are designed that can result in an inconsistent market award when nodal constraint is triggered pursuant to ISO tariff section 30.10.

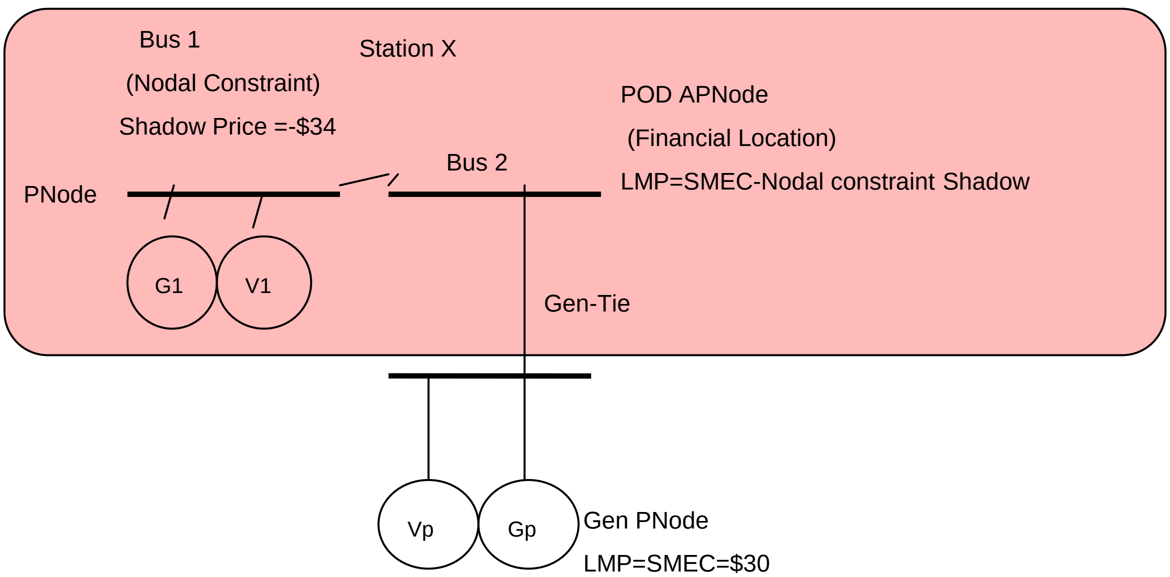


Figure 12: Illustration of the POD dispatch and financial location LMP inconsistency

The scenario in Figure 12 can result in inconsistency between physical or virtual bid price at a resource location (Gen PNode) and its POD financial location (APNode) when there is a nodal constraint a PNode at station X bus 1. In this scenario station X consists of a multi-segment bus. However when the market model is generalized to bus-branch model, bus 1 and bus 2 effectively becomes one continuous node when the switch separating two busses at the station at the same voltage level is closed. The result is that when the nodal constraint is enforced on Bus 1 due because the ISO market is not generating an AC solution and the location is identified as a problematic location, the nodal constraint is enforced to the combination bus 1 and bus 2 such that bus 1 and bus 2 prices reflect the nodal congestion shadow price.

Figure 13 illustrates the ISO's proposed solution that would treat the virtual bid Vp at the Gp location as included in the Vp and Gp nodal constraint that is being enforced at Station X. This solution ensures dispatch consistency between Vp and Gp dispatch and effect of nodal constraint shadow price.

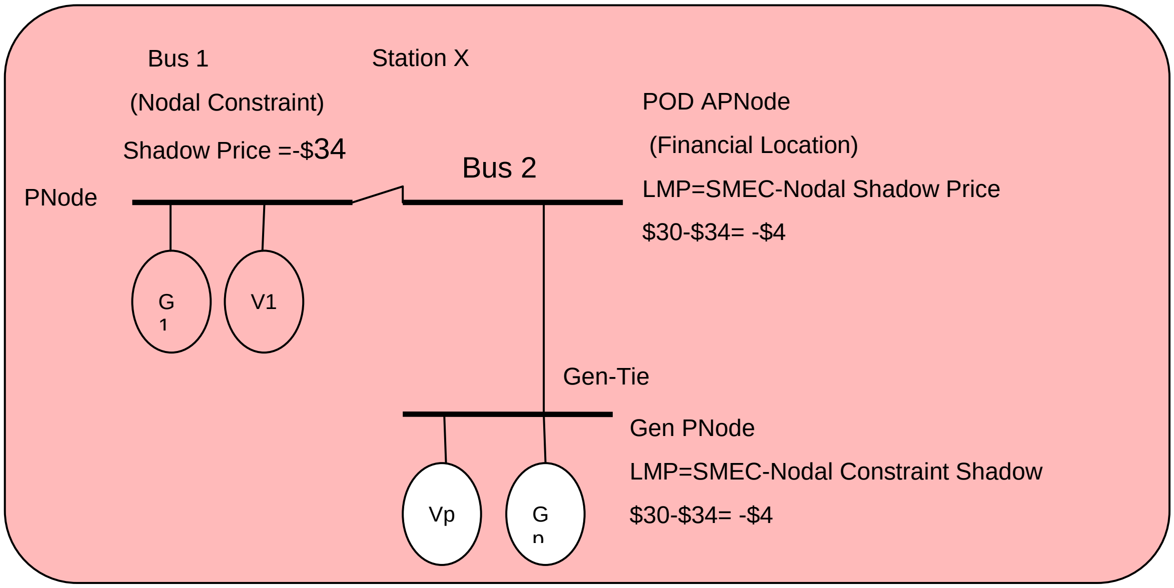


Figure 13: Solution to POD dispatch and Financial Location LMP

6.1.3 APNode vs. ANode

The ISO proposes to use Anode prices only for settlement of DLAPS and Trading Hubs in the IFM instead of APNode prices in order to minimize price inconsistencies arising from the use of APNode prices as described in Section 4.3. This approach does not require changes to the current mathematical model, the market settings or the market optimization engine, but it will require a change to the post-process task, after the solution is found, to use Anode prices for downstream applications, such as settlements and OASIS. The following example is used to illustrate the proposed enhancement.

Let us consider a demand bid for the aggregate DLAP XY_APND with two segments as shown in Figure 14

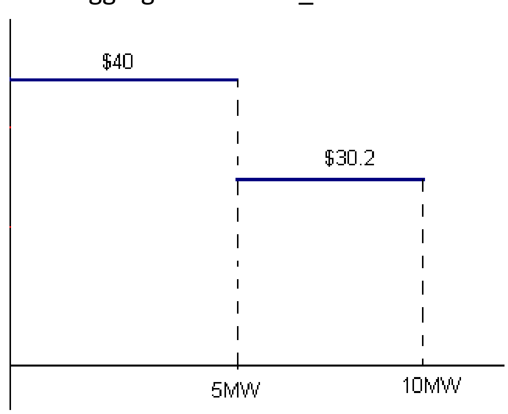


Figure 14: Demand curve at an aggregate node

The aggregate node XY_APND has five constituent nodes, and each of its nodes has a given weighting factor as shown in Table 2.

Table 2: Children nodes of an aggregate node

Node	Weighting Factor	Shift Factor
A	40%	0%
B	30%	0%
C	13%	20%
D	13%	-35%
E	4%	5%

For illustration purposes let us consider that the market outcome is such that the marginal energy component is $30/MWh, there are no losses and that there is one transmission constraint with a shadow price of -$20/MWh. Let us also assume some give shift factors for the children nodes making up the aggregate node are as listed in the above table.

The bid at the aggregate node as a whole is evaluated within the market clearing process based on its effectiveness to relieve congestion. The bid effectiveness is calculated as the weighted shift factor using both the weighing factors and the shift factors of each constituent node as shown in Table 3.

Table 3: Weighted shift factors for children nodes

Node	Weighting Factor	Shift Factor	Weighted Shift Factor
A	40%	0%	0.00%
B	30%	0%	0.00%
C	13%	20%	2.60%
D	13%	-35%	-4.55%
E	4%	5%	0.20%
		Aggregated SF	-1.75%

Given the specific location of the constraint, the children nodes of the aggregate bid may observe different effectiveness to relieve congestion on the given constraint as reflected by the shift factors. Since the bid for the aggregate node is evaluated as a whole, the weighted shift factor of such bid is calculated as the weighted sum of the effectiveness of its children. In this example the weighted shift factor is -1.75% which indicates that if this bid is incrementally dispatched, each MW will relieve congestion by 0.0175 MW on the binding transmission constraint.

As explained in previous sections, there is currently an effectiveness threshold of 2%. This threshold ensures that only resources with effectiveness greater than 2% are used to manage congestion. With a shift factor of -1.75%, the bid for the aggregate node will not be used to manage congestion and, consequently, it will not observe the congestion impact, resulting in a marginal congestion component of $0/MWh. With no losses, the clearing LMP of this aggregate bid is simply the MEC of $30/MWh. This is the Anode price. Based on its bid, the optimal dispatch for this bid is 10 MW. With the current solution, the award of 10 MW is effectively the binding award the participant will receive for this bid in the DAM market.

In regards to the binding price, however, the APNode is used. The APNode price is a post-process value calculated once the market solution is available. The price of each children node is calculated optimally within the market clearing process, and the price of each node will reflect the effectiveness to manage congestion according to its shift factor. The marginal congestion component of each children node is calculated as the shift factor times the shadow price of the constraint. Then using the weighting factors, a weighted LMP is calculated, which in turn are used to compute the APNode price as the weighted average of the individual node prices; this is summarized in the following table:

Table 4: APNode price for a bid at an aggregate node

Node	Weighting Factor	MEC	MCC	LMP	Weighted LMP
A	40%	$30	$0	$30.0	$12.0
B	30%	$30	$0	$30.0	$9.0
C	13%	$30	($4)	$26.0	$3.4
D	13%	$30	$7	$37.0	$4.8
E	4%	$30	($1)	$29.0	$1.2
				APNode	$30.4

The APNode price in this instance happens to be different from the ANode price due to the difference in accounting for the effectiveness to relieve congestion. This APNode, however, is the binding price to settle the DAM award. With respect to the demand bid in Figure 15, it is observed that the APNode price does not support the award of 10 MW that was cleared using the Anode price.

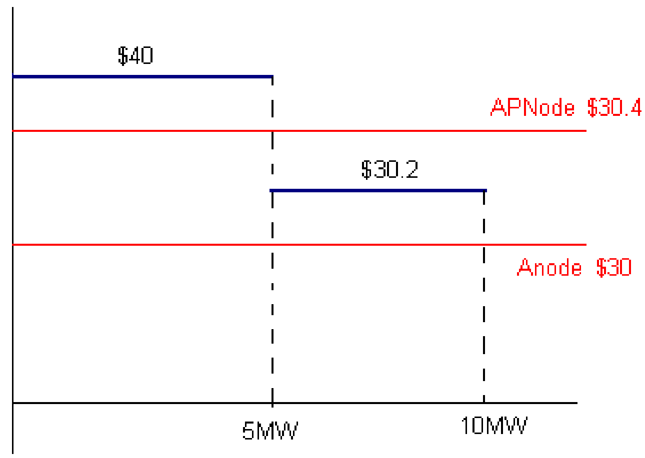


Figure 15: Economical award based on APNode and ANode prices

Based on the APNode price, only 5 MW are economical. With the current approach, the DAM awards are 10 MW at $30.4, rendering the schedule inconsistent with the price. With the proposed approach, the entire mechanics of the clearing process and the construction of the APNode price after the fact would remain unaltered. However, the binding price used to settle the 10 MW will be $30. Notice that the $30 is the original price used to clear optimally the aggregate bid, and using the Anode price instead of the APNode price will ensure the award and price used in settlements are consistent to each other. This can be attained by changing a post-process task to ensure that the Anode is sent to downstream applications instead of sending the APNode price.

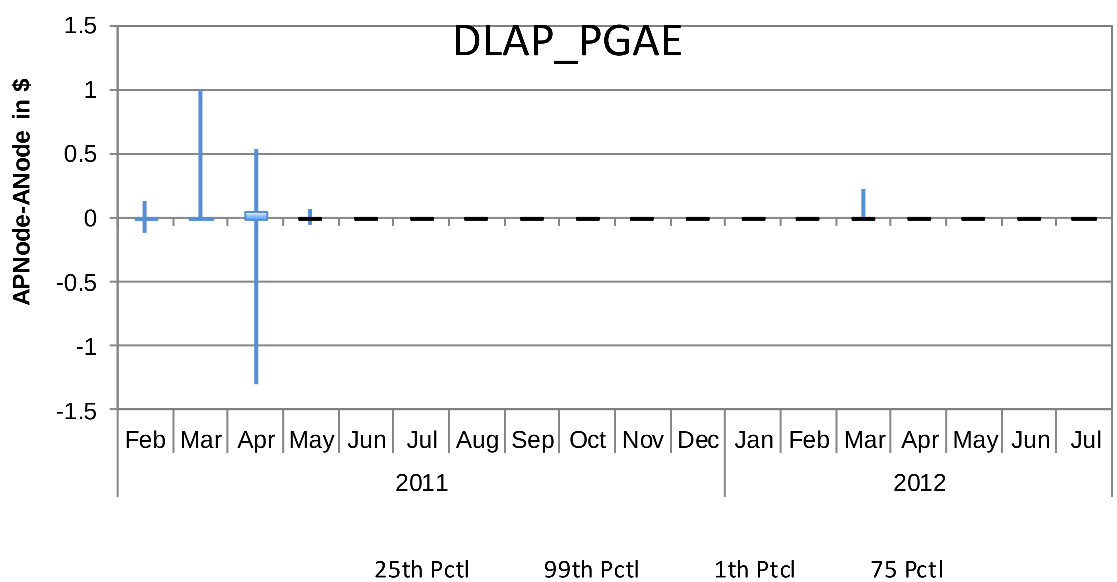
There are two considerations for this approach. First, Anode prices for aggregate resources, such as DLAPs and THs, are available only in the DAM because bids for such nodes are permitted in this market. Currently, there are no Anode prices for aggregate resources in the real-time market because these prices are not generated in RTM as there are no RTM bids for such aggregate nodes. The ISO is currently exploring the technical feasibility to generate an equivalent Anode price for the real-time market. With the current approach, there is an inconsistency in using APNode prices to settle an award cleared based on the Anode price. Both DAM and RTM use APNode prices. The ISO is proposing to use the Anode prices for both DLAPs and THs contingent upon the ISO ability to generate an Anode price for the real-time market. With no Anode price currently available in the real-time market, there are concerns of introducing another type of inconsistency across markets. DAM prices for DLAPs and THs are also used to settle congestion revenue rights (CRRs), with the proposed change of using Anode prices for DLAPs and THs, the settlements for congestion revenue rights will also used such Anode prices.

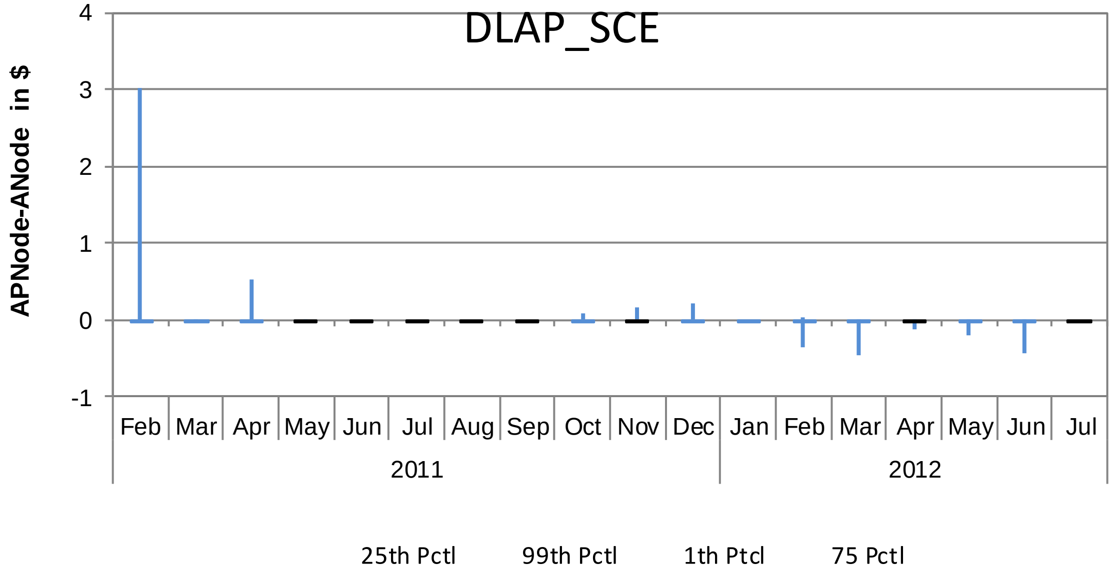
The historical trends of price differentials between the APNodes and the Anodes for the DLAPs and THs are presented in the following plots and tables in order to give a reference point for the implication of doing the proposed change. This covers the period from February 2011 when convergence bids were anabled in the market up to July 16th, 2012. The days where there was a price correction were not included as the final binding prices may have been different than the prices of the original solution. The difference is calculated as the APNode price less the ANode price, so that a positive difference indicates the APNode price is higher. The mean and standard deviations for each aggregate node for the entire period are shown in the following table:

Table 4: Statistics of Price difference between APNode and Anodes

Metric	DLAP_PGAE	DLAP_SCE	DLAP_SDGE	TH_NP15	TH_SP15	TH_ZP26
Mean	0.002791	-0.00266	0.000918	0.002372	0.019066	0.12054
Std Dev	0.30153	0.16829	0.0272	0.66162	0.12641	0.29769
Variance	0.09092	0.02832	0.0007401	0.43774	0.01598	0.08862
Range	29.53061	12.34517	1.6284	59.79703	7.06295	19.61293

The following charts show the monthly distribution of prices for each aggregate node. The upper and lower end of the vertical lines stand for the 99th and 1st percentile, while the upper and lower side of the box stand for the 75th and 25th percentile. Therefore, the box covers for the mid 50 percent of the sample while the ends of the vertical lines cover for the price sample falling between 1 and 99 percent of the distribution.




DLAP_SCE
APNode-ANode in $
4
3
2
1
0
-1
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
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Jan
Feb
Mar
Apr
May
Jun
Jul
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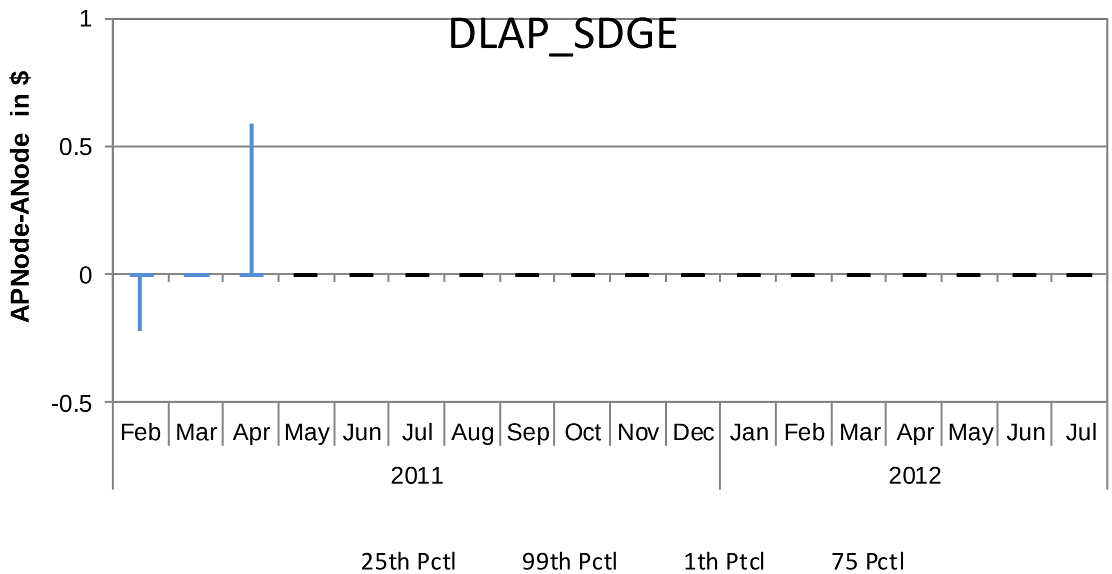
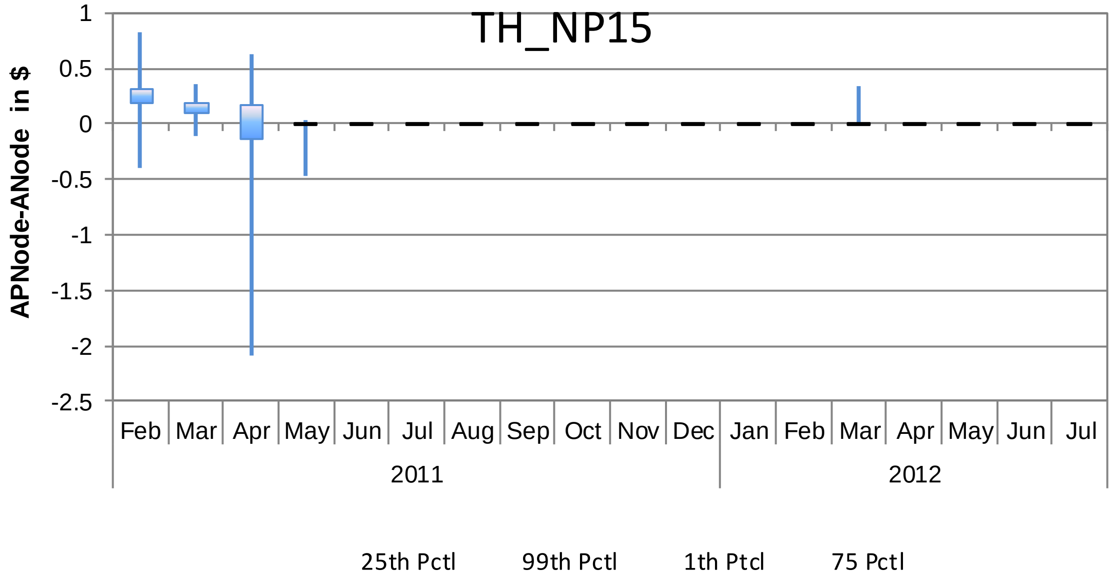
2012
25th Pctl
99th Pctl
1th Ptcl
75 Pctl


DLAP_SDGE
APNode-ANode in $
1
0.5
0
-0.5
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
2011
2012
25th Pctl
99th Pctl
1th Ptcl
75 Pctl



TH_NP15
APNode-ANode in $
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
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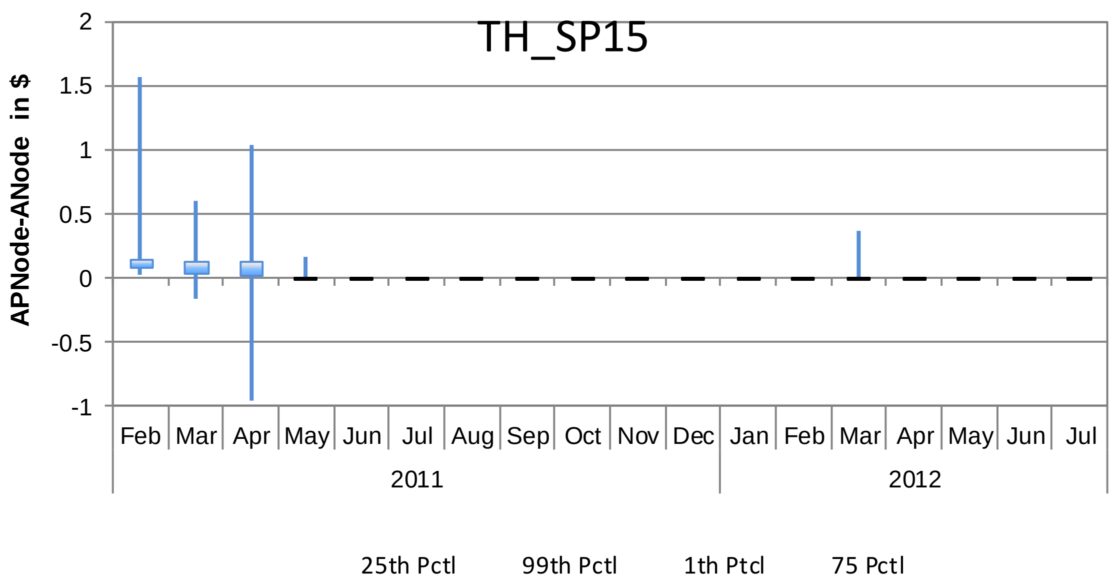
99th Pctl
1th Ptcl
75 Pctl



TH_SP15
APNode-ANode in $
2
1.5
1
0.5
0
-0.5
-1
Feb
Mar
Apr
May
Jun
Jul
Aug
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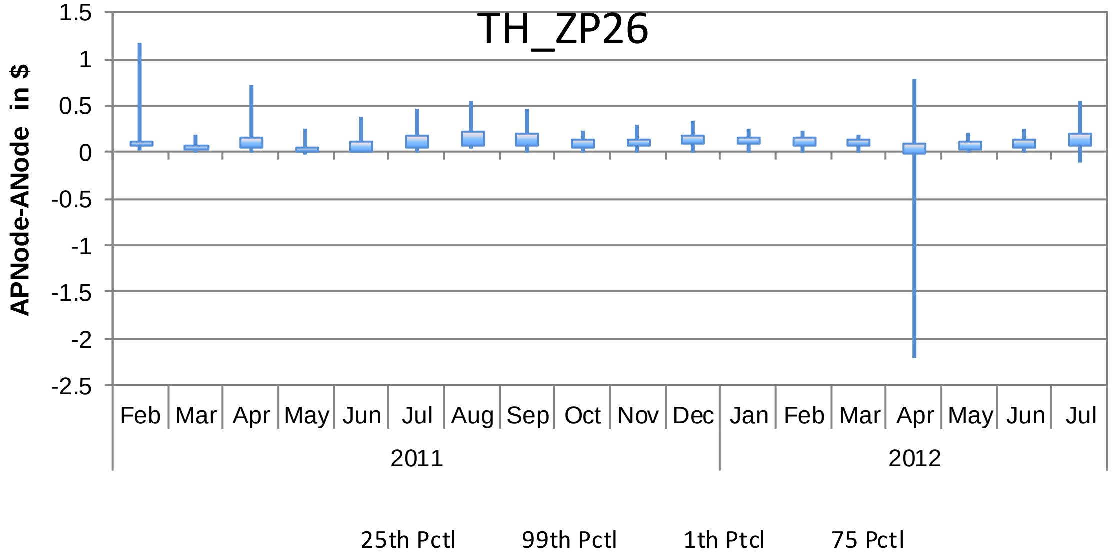
1th Ptcl
75 Pctl



6.1.4 Disconnected Nodes

In order to address the limitation of convergence bids at disconnected nodes, as described in Section 4.4, the ISO originally proposed to provide the list of disconnected nodes applicable to the corresponding DAM run by 6pm one day prior to the DAM run. It is important to highlight that the purpose of having available the list of disconnected nodes is for bidding in the DAM which by its nature is a looking ahead market. For this reason, this list is not meaningful to be generated in real time as requested by a stakeholder. A list of disconnected nodes generated in real-time would not, in general, capture the set of disconnected nodes that would occur for a near future time.

It is worth to mention that the lack of this information results in a convergence bids being place at disconnected nodes, and this may create the expectation that a bid should be cleared in some instances. This, however, does not create a material loss for the participant. As one stakeholder pointed out, placing a bid at a disconnected node does not restrict the participant from bidding at any other valid locations and, thus, it is not a loss of opportunity. The only instance where this may not hold is if the participant reaches its credit limit for convergence bids. Making available the disconnected nodes, will not change the end result of not awarding the bid, it will only allow the participant to know in advance the location is disconnected.

After consideration of feedback from stakeholders, a comparison among other ISO practices and the concerns about potential exploitive opportunities raised during the evaluation of this proposal, the ISO is not pursuing the posting of disconnected nodes in this final proposal in order to further consider the merits, opportunities and incentives that this information provides. While the ISO had proposed to publish the disconnected nodes by 6pm a day before the day-ahead market, some parties were concerned that the timing proposed of any publication of disconnected nodes could create unintended consequences and suggest the publication of disconnected nodes be performed coincident with the 5 a.m. outage report. While this draft final proposal will not incorporate a disconnected node publication, the ISO is committed to continuing to work with stakeholders to explore the appropriate level and timing of transparency regarding disconnected nodes the ISO can consider incorporating into its business practices in the future.

6.2 Option B- Bid Cost Guarantee

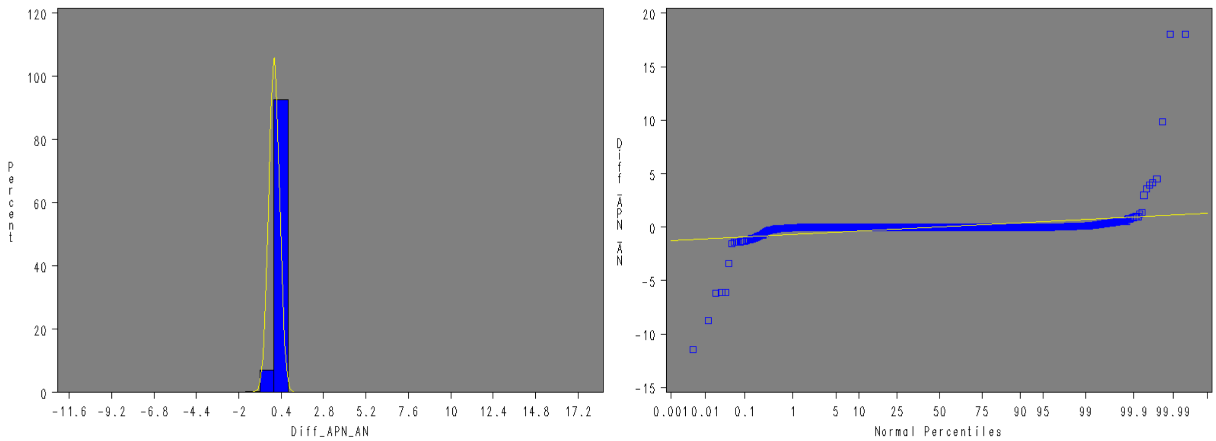
In the original straw proposal the ISO considered a bid-cost guarantee as an alternative to the targeted enhancements. Through further evaluation of this option as well as feedback from stakeholders, the ISO is focusing only on the targeted enhancement. A bid-cost guarantee addresses the problematic outcome rather than the root cause. As indicated by some stakeholders, the bid-cost guarantee concept is for covering actual costs, such as generation costs, which in the case of convergence bids there is no costs associated to, and in the end it would place the burden on measured demand. This approach does not improve market efficiency. The ISO is not pursuing a bid-cost guarantee in the interim as this approach would not be significantly different to the effort and time required for the permanent approach. Either a permanent or interim approach would require stakeholder process to agree upon the specifics of the bid-cost guarantee and then would need an implementation and testing stages. This would result in the same effort required to implement the targeted enhancements. Furthermore, attempting to implement an interim bid cost recovery approach could actually delay the implementation of the recommended approach.

7 Next Steps

The ISO will discuss the Draft Final Proposal with stakeholders during a conference call on September 10, 2012. The ISO is seeking comments on the draft final proposal to resolve price inconsistencies. Stakeholders should submit written comments by September 17, 2012 to gbalderete@caiso.com

8 Appendix A

As a reference of the discussion of APNode vs. ANode, this appendix contains the statistical charts for the price differential between APNode and Anode.



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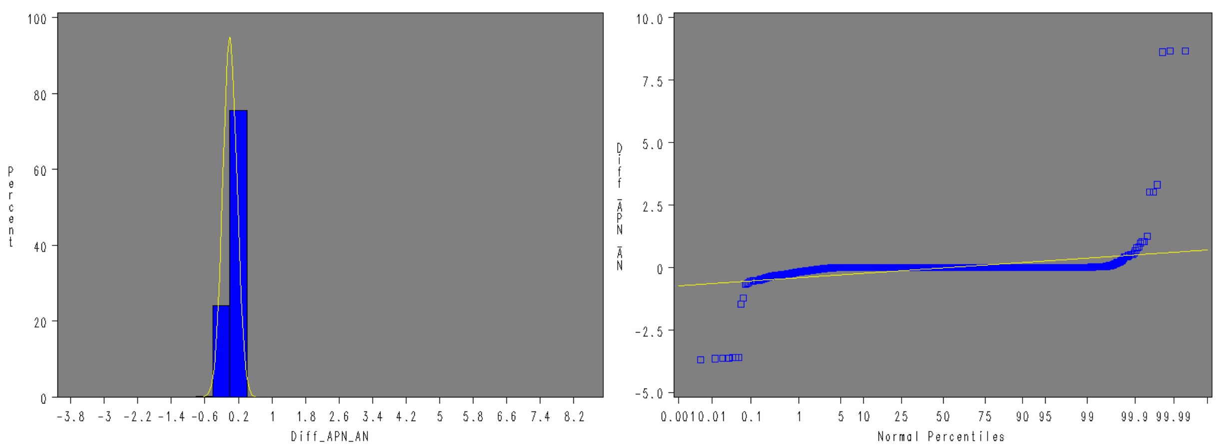
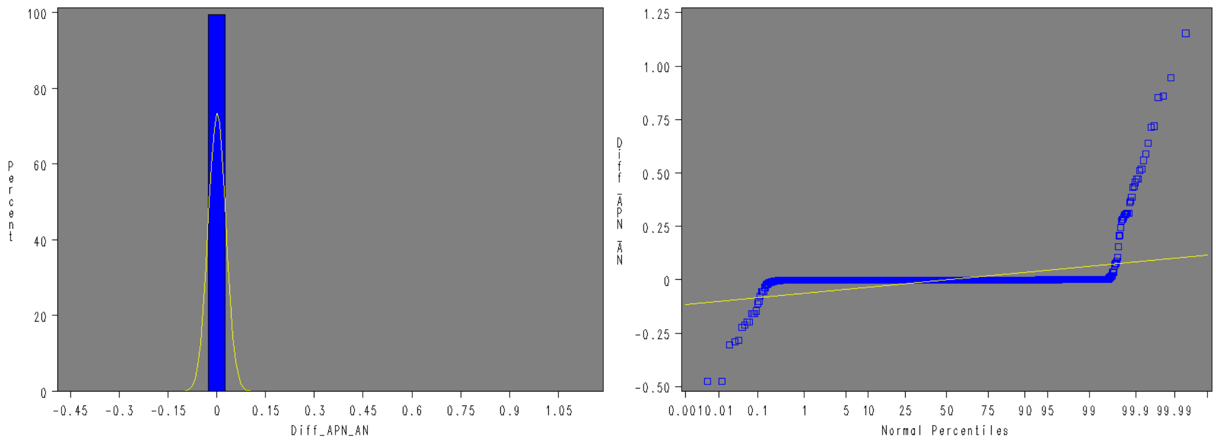
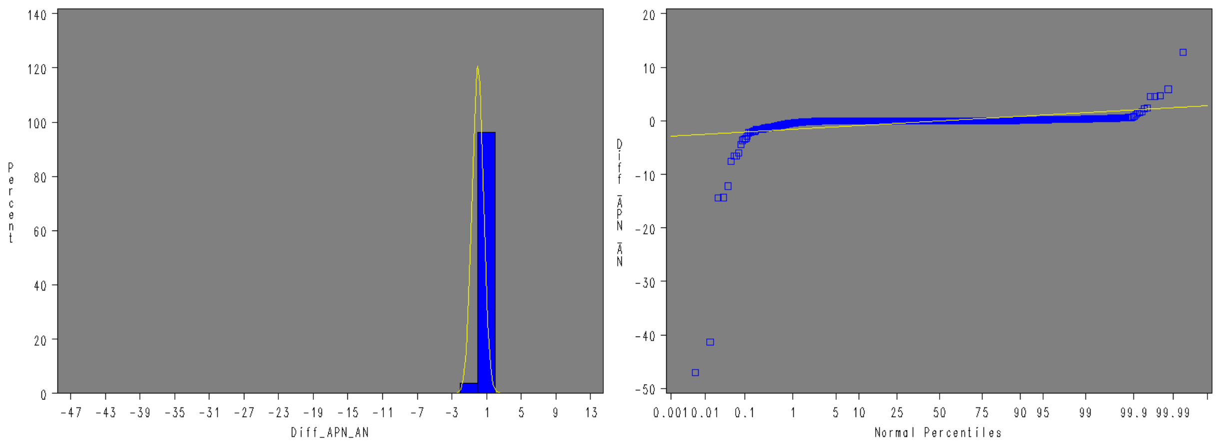


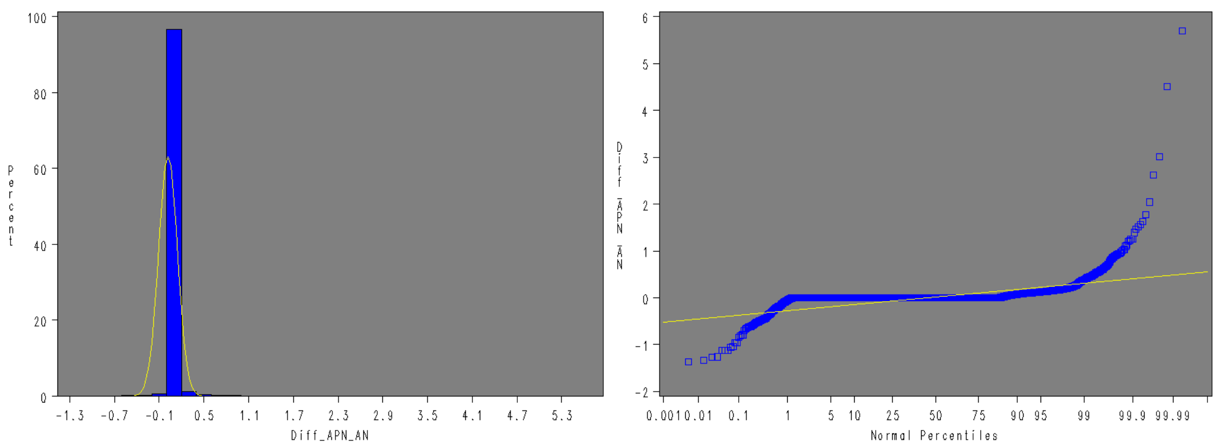
DLAP_SCE



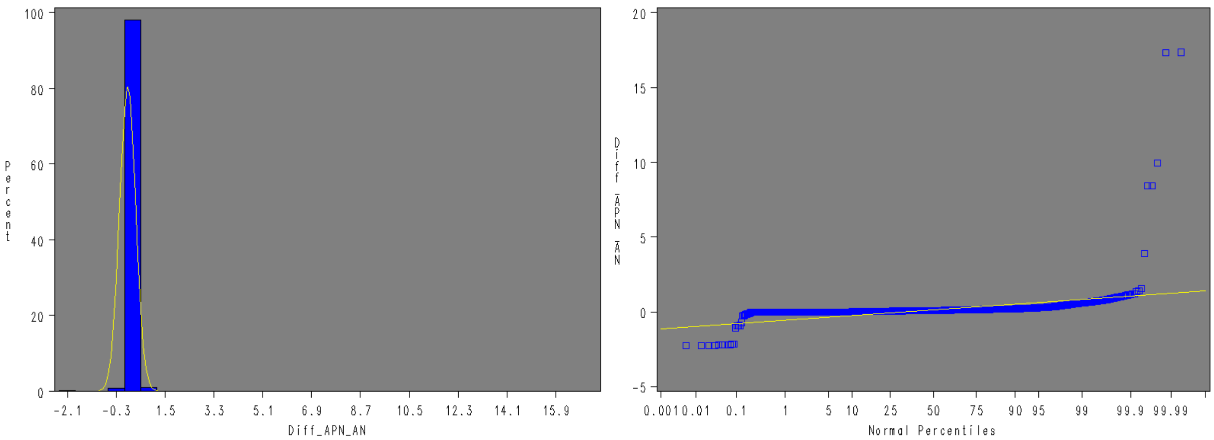
DLAP_SDGE



TH_NP15



TH_SP15



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20
0
Percent
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-0.3
1.5
3.3
5.1
6.9
8.7
10.5
12.3
14.1
15.9
Diff_APN_AN
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10
5
0
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Diff_APN_AN
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0.01
0.1
1
5
10
25
50
75
90
95
99
99.9
99.99
Normal Percentiles

TH_ZP26