**Opinion on**

**Implementation of the Full Network Model**

by

**James Bushnell, Member**
**Scott M. Harvey, Member**
**Benjamin F. Hobbs, Chair**
**Shmuel S. Oren, Member**

**Members of the Market Surveillance Committee of the California ISO**

Adopted January 30, 2014

## Executive Summary

The Market Surveillance Committee (MSC) of the California Independent System Operator (ISO) has been asked to provide an opinion on the California ISO's proposal for implementation of a Full Network Model for selected external balancing authority areas.[1]

In the body of this opinion we provide a detailed discussion of two issues:

- The use of the expanded full network model to improve the representation of loopflows in the California ISO day-ahead market; and
- The determination of schedules and prices for interchange transactions with adjacent balancing authority areas using this expanded full network model while continuing to model interchange as sourced on the tie lines connecting the California ISO with adjacent balancing authority areas.

We conclude that testing and implementation of a full network model is an important, indeed, essential first step on the road towards better regional integration and more accurate system modelling. These modelling improvements are necessary in order to achieve the goals of the Energy Imbalance Market as well as to comply with obligations stemming from the September 8, 2011 blackouts. We expect that a successful implementation will help to reduce the cost of meeting load in real-time as well as the energy market imbalance charges currently borne by California load. We stress, however, that creating and testing the full network model is likely to be a difficult and complex task. Other ISOs have similarly attempted or are currently attempting to represent flows outside their areas, and have experienced serious challenges in improving the accuracy of their estimates.

[1] California ISO, Full Network Model Expansion, Draft Final Proposal, December 30, 2013, www.caiso.com/Documents//DraftFinalProposal-FullNetworkModelExpansion.pdf

We therefore fully support the steps proposed in in this initiative, with the recognition that the CAISO must remain flexible in the specifics of its implementation. At this time it is impossible to fully predict what the results of each step of the process will be. However, given the experiences of other ISOs, it is reasonable to expect that the CAISO will be successful in developing an improved modeling of loopflows but that the results of the initial efforts will need to be carefully monitored and followed by further adjustments.

Given the uncertainties, it is critical that the CAISO have in place a plan for testing, adaptation, and calibration of the modeling. There also needs to be broadly accepted metrics and standards for defining what constitutes improvement in the representation of loopflows. The Draft Final Proposal contains a well thought out process for adjustments and a reasonable set of metrics. The CAISO has recently posted an addendum that more fully describes their planned approach to developing and testing the Full Network Model prior to implementation.[2] We therefore believe it is time to take the first steps toward better integration, as the later steps cannot be possible without the first.

Besides expressing strong support for the proposal in this opinion, we also discuss five sets of stakeholder concerns, and conclude that none of them are a sufficient reason for delaying or significantly revising the plan for developing and testing the full network model. We also identify a number of reasons why predictions of loopflows by the full network model may not be completely accurate, one important reason being the continued representation of interchanges with some balancing areas as injections or withdrawals at interties. However, these possible sources of inaccuracy can only be assessed and corrected for if development and testing of the full network model proceeds now.

## 1. Introduction

The Market Surveillance Committee (MSC) of the California Independent System Operator (CAISO) has been asked to provide an opinion on the ISO's proposal for implementation of a full network model (FNM) of selected external balancing authority areas.[3] The full network model would allow explicit modeling of loopflows on the California ISO transmission system from generation and load located outside the CAISO balancing authority area, potentially enabling the CAISO to decrease the cost of meeting load as well as to reduce real-time congestion rent shortfalls. In addition, the proposed implementation of at least some elements of the full network model is a necessary step for the implementation of the Energy Imbalance Market (EIM) with PacifiCorp in October 2014.

These issues have been discussed in MSC meetings in Folsom on September 6 and November 15 2013, and January 16, 2014. In addition, MSC members have participated in stakeholder calls

[2] See California ISO, Full Network Model Expansion, Draft Final Proposal Addendum: Pre-Implementation Analysis, January 23, 2014, www.caiso.com/Documents/Addendum-DraftFinalProposal-FullNetworkModelExpansion.pdf .

[3] California ISO, Full Network Model Expansion, Dec. 30, 2013, *op. cit.*.

discussing the Full Network Model on June 18, September 18, November 4, December 5, 2013, and January 7, 2014.

.

The remainder of this opinion is organized as follows. Section 2 reviews the most recent CAISO proposal. We then discuss two of its features in detail in Sections 3 and 4, including stakeholder concerns that have been expressed about those features.

## 2. The CAISO Proposal

The CAISO full network model proposal has four main elements:

1. Extend the network topology represented in the CAISO's models to include the transmission systems of all directly interconnected balancing authority areas, the balancing authority areas involved in the September 8, 2011 blackout, EIM participants, and the transmission networks of some additional balancing authority areas needed to model the flows on the transmission systems of the EIM entities and the September 8 systems, specifically BPA, Idaho Power and Salt River Project;[4]

2. Represent all net interchange among the modeled balancing authority areas;

3. Represent internal generation and load on the systems of the September 8 entities, the EIM entities and BPA, Idaho power and Salt River Project; and

4. Utilize the extended network topology and representation of net interchange, generation and load to better model load and generation on other balancing authority systems that create loopflows on the CAISO transmission system. These steps thereby enable the CAISO to take account of predictable loopflows on the CAISO transmission system in clearing the ISO's day-ahead market.

Note that the CAISO would continue to model and price interchanges with external balancing authority areas that do not either join the EIM or enter into an interchange scheduling agreement with the CAISO as if the power was sourced or sunk at points on the tie lines with the CAISO. However, the expanded network model would be used to calculate the flow impacts of those interchange transactions in order to determine the congestion component of locational marginal prices, and with this improved representation of interchange flows, the California ISO would enforce physical transmission limits on tie lines.[5]

[4] It is our understanding that the network topology included in the full network model will include almost all of the WECC transmission system, the main exceptions being the transmission systems in Alberta, British Columbia and Montana.

[5] For instance, such an interchange would be modeled as an injection at the relevant tie line bus. Using the FNM to represent the resulting flow impacts would likely result in much (perhaps most) of the flow coming into the CAISO directly over that tie line, but because of Kirchhoff's laws, a significant portion would flow through non-CAISO lines in the WECC network and then ultimately into the CAISO over other tie lines. This implies that compared to the present CAISO network representation (radial interties), less physical flow would be modeled as coming in directly over the scheduled tie line.

The first element of the full network model is reliability driven and includes improved network modeling not only of the systems directly involved in the September 2011 blackout but also of other systems that the CAISO needs to include in the model in order to accurately represent flows impacting the systems involved in the blackout.

This first element is also essential to implementing the EIM with PacifiCorp and includes improved network modeling of the PacifiCorp balancing authority areas and of other transmission systems that the CAISO needs to include in the model in order to accurately represent flows on the PacifiCorp system and calculate the impact of changes in PacifiCorp-CAISO interchange on other transmission systems. In addition to enabling EIM implementation with PacifiCorp, and providing better modeling of the September 8 entities, the extended network topology will help the CAISO to better model the impact of external generation and load on the California transmission system, thereby improving reliability.

We do not address this first element in detail in this opinion but note that the extension of the CAISO network model to encompass a broad region outside the CAISO transmission system is consistent with the scope of the network models used by the eastern ISOs. Indeed, even the old New York power pool network model that was used in its real-time dispatch program extended far outside New York, with the reference bus for this model located at Browns Ferry, Tennessee.

In the next section, we discuss five sets of stakeholder concerns that have been raised about the other three elements of the proposal, which address the modeling of loopflows and interchange. In the fourth section we discuss the potential consequences of the design for modeling of interchange transactions of parties not joining EIM or entering into an interchange scheduling agreement.

## 3. Stakeholder Concerns with Extending the Network Model to Other Balancing Authority Networks in Order to Improve Loopflow Estimates

The second, third and fourth elements of the full network model initiative are intended to better represent the impact of loopflows on the California ISO system and allow better scheduling in the ISO's day-ahead (IFM) and real-time (RTPD) markets. This improved modeling of loopflows will benefit CAISO and EIM rate payers by reducing congestion rent shortfalls, reducing the production cost of meeting load, and improving reliability by enabling the CAISO to take these loopflow impacts into account in forward unit commitment and interchange scheduling decisions.

The CAISO believes that a material portion of congestion rent shortfalls (real-time congestion offset costs) are due to day-ahead schedules that turn out to be infeasible in real-time (unless accommodated by counterflow through out-of-merit redispatch of generation within the CAISO). These infeasibilities occur because of loopflows that reduce the transfer capability available to

the CAISO for use in meeting ISO load.[6] By better modeling these loopflows in the day-ahead market, the CAISO will reduce real-time congestion rent shortfalls. Day-ahead market schedules will be better aligned with the transfer capability actually available for use in real-time. However, the modeling of loopflows in the day-ahead market will not preclude the CAISO from dispatching generation to fully utilize the transmission system in real-time if loopflows are lower than projected in a particular period. This modeling refinement will also reduce the production cost of meeting CAISO load by better aligning the day-ahead unit commitment with the transfer capability likely to be available in real-time, enabling load to be met at lower cost through improved unit commitment and a more cost-effective scheduling of net interchange. Finally, by improving the representation of next day operating conditions external to the CAISO transmission system and their impacts on the CAISO system, the modeling of loopflows will also contribute to improved reliability for CAISO transmission customers.

Another benefit of better loopflow modeling in the day-ahead market will be reductions in real time congestion rent shortfalls. Those shortfalls have declined substantially in 2013 relative to 2012, which the Department of Market Monitoring attributes in part to "efforts to address systematic modeling differences between day-ahead and real-time including better alignment of day-ahead and real-time transmission limits."[7] Better projections of loopflows from the full network model will be another step in the process of improved modeling by the CAISO that has materially reduced congestion rent shortfalls in 2013 relative to 2012.[8]

The California ISO plans to use a number of sources of data to model the base flows used to project expected loopflows. These data will include information provided by the September 8 entities, information provided by the balancing authority areas participating in the EIM, information available from WECC, voluntary agreements with individual balancing authority

[6] See, for example, California ISO, Department of Market Monitoring, Q3 2013 Report on Market Issues and Performance, November 14, 2013, pp. 31-32; Q2 2013 Report on Market Issues and Performance, August 21, 2012, p. 22; and the 2012 Annual Report on Market Issues & Performance, pp. 92-96.

[7] See California ISO, Department of Market Monitoring, Q3 2013 Report on Market Issues and Performance, November 14, 2013, p. 31-32.

[8] It needs to be recognized in discussing these changes that the costs associated with real-time congestion rent shortfalls due to real-time loopflows are not fundamentally different from the costs that loopflows impose on a traditional vertically integrated utility. The congestion rent shortfalls due to loopflows are the difference between the projected cost of meeting load absent the loopflows (day-ahead market prices calculated without taking account of the loopflows) and the actual real-time cost of meeting load when transfer capability is reduced by loopflows.

A vertically integrated utility similarly has to meet its load at the higher real-time cost, rather than the lower cost that would have been possible absent the loopflows. The loopflows raise the cost of meeting load for both the California ISO's transmission customers and the traditional vertically integrated utility. The real potential for cost reductions is in making day-ahead commitments that recognize that the loopflows will be present in real-time. This can involve changes such as 1) avoiding the commitment of generation, that while low cost at full output, will be unable to be dispatched above minimum load in real-time because of loopflows; 2) by committing generation that, absent loopflows, would be higher cost but is lower cost than relying on quick start units to meet load when real-time loopflows reduce transfer capability; and 3) by not purchasing imports day-ahead that would be uneconomic to flow in real-time because of the high cost of the redispatch required to accommodate them.

areas, as well as recent operating experience, including flows observed in real-time during recent operating days.[9]

It is unknown at present to what extent the real-time loopflows impacting the CAISO transmission system are actually due to external balancing authority area dispatch and interchange transactions. The observed "loopflows" are simply the difference between the flows calculated by the CAISO model and those actually observed on the California transmission system. These loopflows could result from external balancing authority area dispatch and interchange transactions, but also could be caused by inaccurate modeling of the flow impact of the CAISO's interchange with external balancing authority areas due to the lack of a full network model. The discrepancies could even result from inaccurate modeling of the flow impacts of the CAISO's own generation dispatch because the external network is only partially modeled. Since the California day-ahead market and real-time dispatch do not utilize a full network model that includes external transmission systems, it has been impossible for the CAISO to even analyze the cause of the observed "loopflows," whether it is due to CAISO's internal generation and load, interchange with adjacent transmission systems, or generation and load on external systems.

Some stakeholders have expressed concerns about the modeling of loopflows in the day-ahead market using the Full Network Model initiative. We discuss five of these concerns below. First, some stakeholders worry that by taking account of these loopflows in the day-ahead market the CAISO will be foregoing its ability to manage these loop flows using WECC curtailment practices or that the CAISO will in some way be attempting to single-handedly "mitigate" or "accommodate" WECC-wide loopflow impacts. Second, some are concerned that the CAISO would need to calibrate its full network model to better account for predictable loopflows and thereby reduce congestion rent shortfalls relative to the current practice of ignoring potential loopflows in clearing the day-ahead market. In particular, a number of stakeholders have expressed a concern that absent an adequate calibration process, the CAISO would implement modeling changes that reduce, rather than improve, the accuracy of the day-ahead market in terms of projecting real-time conditions and could thereby cause day-ahead and real-time prices to diverge further. Third, one stakeholder has argued that modeling both contract path scheduling limits and physical pre- and post-contingency transmission constraints on tie-lines will be unduly conservative and thereby restrict imports unnecessarily. Fourth, some stakeholders appear to have expressed a view that the CAISO should choose what loopflows to model in the day-ahead market depending on whether modeling particular loopflows are projected to reduce or raise day-ahead market prices paid or received by particular market participants. Fifth, there has been discussion of whether the enforcement of physical transmission constraints on tie lines in the day-ahead market would undermine incentives for cost-reducing transmission investment relative to the current market design.

We discuss each of these stakeholder concerns in the following subsections.

[9] Full Network Model Expansion, Draft Final Proposal, December 30, 2013, pp. 16-18.

### 3.1 Concerns about Management of Loop Flow Impacts

We understand the concern expressed by market participants over whether the CAISO might choose to voluntarily forgo use of the transmission system paid for by CAISO transmission customers in order to accommodate use of the CAISO transmission system by external balancing authority areas. However, we do not believe that this proposal would result in the CAISO foregoing the use of any truly available capacity. The modeling of flows associated with other balancing authority area transactions in the day-ahead market will not reduce the CAISO's ability to utilize WECC curtailment rules in real-time to the extent that such rules are applicable. The improved modeling of loopflows in the California day-ahead market does not change how the CAISO will dispatch the system in real-time. Rather, the proposal addresses the assumptions that the CAISO will make in determining financial schedules in the *day-ahead market* and in committing generation. The CAISO will dispatch generation to meet load at least cost in real-time irrespective of any loopflows modeled in the day-ahead market. The real-time dispatch will have to account for actual real-time loopflows but will be able to utilize any applicable WECC curtailment rules to reduce real-time loopflows and reduce the amount of real-time redispatch required.

Hence the issue is not whether the CAISO should make use of WECC curtailment rules in real-time but whether the CAISO should, in the day-ahead market, better represent the loopflows that it *cannot* curtail in real-time. Under the current system, the CAISO determines financially binding schedules in the day-ahead market without considering the expected level of the real-time loopflows that it will not be able to curtail in real-time. Disregarding those loopflows means that day-ahead market schedules may be infeasible in real-time, which can require the CAISO to resort to costly redispatch in real-time to manage flows on transmission constraints internal to the CAISO in order to accommodate day-ahead market schedules.

In addition, as the CAISO has discussed in multiple straw proposals, WECC rules do not provide the CAISO with the ability to curtail real-time loopflows on most elements of the its transmission system, even if the CAISO was able to identify the specific transactions causing those loopflows.[10] The exceptions are loopflows on the California Oregon Intertie (COI). The CAISO agrees that WECC procedures do not require them to accommodate all loopflows on COI and the CAISO proposes to take account of its ability to curtail loopflows on COI in real-time in modeling loopflows in the day-ahead market.[11]

Hence, while we agree that the CAISO should not incur costs in order to manage loopflows that it can curtail in real-time, this is not what we believe the CAISO proposes. On the contrary, it is our understanding that the CAISO proposes to model the loopflows that it is *not* able to curtail in real-time, either because it lacks a mechanism to curtail them or because of difficulties in identifying the source of the loopflows. Even in eastern markets where transmission loading

[10] See Full Network Model Expansion, Second Revised Straw Proposal, October 30, 2013 pp. 14-15; Full Network Model Expansion, Third Revised Straw Proposal, December 5, 2013, p. 20; Full Network Model Expansion, Draft Final Proposal, December 30, 2013, pp. 20-23.

[11] Full Network Model Expansion, Draft Final Proposal, December 30, 2013, pp. 21-22.

relief (TLR) procedures provide the ISOs with a general mechanism for curtailing loopflows, the ISOs model the loopflows that cannot be curtailed and must be accommodated in real-time.[12]

### 3.2 Concerns about Day-Ahead Calibration and Impact on Day-Ahead/Real-Time Price Convergence

Some stakeholders have asked that the California ISO not move forward with implementation of the loopflow modeling elements of the full network model design unless the new model in fact, and not just in theory, performs better than the current design in predicting real-time flows. We agree with stakeholders that the CAISO needs to be sure that it is implementing a model that predicts loopflows better than the current design. We believe that this is the intent and goal of the CAISO full network model proposal. There is nothing in the full network model proposal that requires that the CAISO incorporate inaccurate loopflow projections in the day-ahead market. The proposal is for the CAISO to have the capability to model loopflows in the day-ahead market in those circumstances in which is it able to predict those loopflows with reasonable accuracy. Furthermore, the proposal is to reserve for the CAISO the discretion to use the best information available to it in order to model loopflows. If the information provided by some balancing authority areas does not enhance the CAISO's ability to accurately predict real-time loopflows, there is no obligation for the CAISO to use that information.

The CAISO has explicitly reserved the option to modify or not use base schedule data that it does not believe are sufficiently accurate and we support this element of the proposal.[13] The CAISO has also stated that it will not use any model of real-time loopflows in the day-ahead market that it does not believe will provide a sufficiently accurate representation of what will happen in real-time.[14] Hence, the Full Network Model design envisions that the CAISO will actively monitor the performance of the design to ensure that it is achieving its intended goal of improving loopflow forecasts, and we agree that it is important that the CAISO actively carry out this objective.

Once the extended topology of the Full Network Model is developed, the CAISO can begin using the data it has assembled to assess its ability of using that data in predicting real-time loopflows on binding constraints. In implementing this design, the CAISO needs to begin calculating the impact of its real-time market flows on frequently binding CAISO transmission

---

[12] See Footnote 16, *infra*, regarding Midwest ISO efforts to model loopflows in its day-ahead market.

[13] See Full Network Model Expansion, Draft Final Proposal, December 30, 2013, p. 16 ("The ISO will use the best available data and can use its own analysis to develop or modify base schedules if and when necessary"), p. 17 ("the ISO will rely on its own analysis and validation, for example, to true up or estimate missing information"), and p. 18 ("While the ISO intends to leverage the data made available by the Reliability Coordinator, we will also reserve the right to create, modify, or select amongst different data sources as appropriate").

[14] See *ibid.*, p. 18: "the ISO will be tracking the difference between scheduled and actual flows to understand whether or not the base schedules are effective. Based on these results, the ISO can calibrate the net scheduled interchange. In a more extreme approach, all of the base schedule (demand, generation, and net scheduled interchange) can be set to zero."

constraints prior to the implementation of the EIM and use of the full network model in operations. Such benchmarking will enable the CAISO to calculate the observed real-time loopflows (the difference between actual flows and market flows), and assess the extent to which it is able to predict these flows using the information available to the CAISO at the time it clears its day-ahead market. It is our understanding that the CAISO does not intend to model loopflows in the day-ahead market if it is unable to develop reasonably accurate predictions of their level.

The critical decision that needs to be made now is to move forward with development of the FNM and associated software, because the analysis of base schedules and loopflows along with the calibration of the model cannot be undertaken until the CAISO has developed, at least, an initial version of the network model and software.[15] Hence the CAISO needs to make an initial decision to move forward with the network model implementation in order to be able to carry out benchmarking analyses and evaluate alternative methods to model loopflows on the full network model.

The proposed approach of the CAISO for estimating loopflows and modeling them in the day-ahead market would not be unique to the CAISO. It is also used by those Eastern ISOs who are extensively impacted by loopflows, such as MISO and PJM. The MISO had very large real-time congestion rent shortfalls during its initial year of operation (2005) which it substantially reduced during 2006 and 2007. It has continued to reduce congestion rent shortfalls in subsequent years through improved modeling of loopflows.[16]

The CAISO has committed to pre-implementation analysis and benchmarking to provide assurance to stakeholders that the model will be able to achieve its intended goals before the

[15] See *ibid.*, p. 38 regarding the need to develop the full network model and software capabilities in order to carryout benchmarking analysis.

[16] See Potomac Economics, 2006 State of the Market Report the Midwest ISO, July 2007, which noted that "(b)ased on our review of the results in 2006, we conclude that the sizable reduction in congestion costs collected in the real-time market was due to improvements in the assumed loopflows that the Midwest ISO use in operating the day-ahead market" (p. 64). Similarly, see Potomac Economics, 2007 State of the Market Report for the Midwest ISO, p. 69, which refers to the success of the Midwest ISO in incorporating "reasonably accurate loopflow assumptions in the day-ahead model." In Potomac Economics, 2008 State of the Market Report for the Midwest ISO, pp. 67-68, it is noted that "(b)alancing congestion costs have declined since 2006 due to improvements made in the day-ahead modeling of loopflow and a general decrease in congestion in 2008." The Potomac Economics 2009 State of the Market Report for the Midwest ISO, pp. 75-77 states that "the lower costs in recent years are due to improvements made in the day-ahead modeling of loopflows and an overall decrease in congestion." Meanwhile, Potomac Economics 2010 State of the Market Report for the MISO Electricity Markets, June 2011, pp. 77-79 said that "(r)eal-time congestion costs were minimal, which is expected when modeling of the transmission system is consistent between the day-ahead and real-time markets." Further, Potomac Economics' 2011 State of the Market Report for the MISO Electricity Markets, June 2012 reported that "(r)eal-time congestion costs in 2011 … were a small share of total congestion costs collected by the MISO. These costs generally occur when the transmission capability available in the real-time market is less than was assumed. In 2011, real-time congestion costs were negative (*i.e.*, a real-time surplus) for the the first time" (p. 41), In 2012, real-time congestion rent shortfalls swung back to a small positive value, see Potomac Economics, 2012 State of the Market Report for the MISO Electricity Markets, June 2013, p. 47.

FNM is implemented.[17] We support this approach. The CAISO cannot provide this assessment unless it moves forward with this initiative. After the Full Network Model is implemented, the CAISO has committed to providing ongoing metrics to enable market participants to evaluate performance.[18] Stakeholders should be able to monitor the overall accuracy of the California's ISO's loopflow projections through occasional after-the-fact reports, perhaps by the Department of Market Monitoring. These reports could report aggregate results without disclosing the specific methods that the CAISO uses to predict the real-time loopflows on an individual constraint. The Department of Market Monitoring could choose the criteria it applies to evaluating CAISO performance, but some obvious approaches would be to calculate the frequency and magnitudes of over- and under-projections of loopflows, and to evaluate the cost of those errors using day-ahead market and real-time constraint shadow prices.

Similarly, while it is important that the CAISO test the accuracy of its loopflow projections and use these tests to adjust its modeling methods so as to improve the accuracy of its projections, the goal of developing more accurate loopflow projections will not be served by requiring the CAISO to specify in advance all of the methods it might use to adjust its models to better calibrate projected loopflows with actual loopflows. The CAISO needs to have the flexibility to develop appropriate adjustments as it evaluates the quality of its projections and gains an understanding of the sources of errors in its projections. CAISO stakeholders need to hold the CAISO accountable for the accuracy of its projections but allow it flexibility in the methods it uses to develop those projections.

We must recognize that loopflows, relative to predictions, will vary from day to day just as real-time load varies from day to day. Forecasts are rarely perfect. Some market participants have predicted that it will be harder to accurately project loopflows in the WECC than in the eastern interconnection, for example due to difficulties in predicting hydro operations. It is possible that this will turn out to be the case. But the issue is not whether the CAISO's loopflow projections will always be perfect but whether they will be more accurate, on average, than no forecast at all. The analysis of virtual bids in Department of Market Monitoring annual and quarterly reports suggests that market participants are able to submit bids targeting constraints that will bind more tightly in real-time than day-ahead because of loopflows. If market participants are able to predict these impacts better than the current day-ahead market model, then these loopflows must be predictable to some degree.[19]

[17] See Full Network Model Expansion, Draft Final Proposal, December 30, 2013, Section 11, pp. 38-39.

[18] *Ibid*., p. 39.

[19] See California ISO, Department of Market Monitoring, 2012 Annual Report on Market Issues and Performance, p. 97: "DMM estimates that about $70 million out of $95 million of real-time congestion revenues paid to virtual positions in 2012 resulted from excess day-ahead power flow on constraints whose power flow limits were reduced between the day-ahead and real-time markets." If virtual bidders can predict these deratings well enough to submit these bids, the California ISO should be able to predict them. The reduction in real-time congestion rent shortfalls during 2013 suggests that these loopflows can be predicted and reflected in the day-ahead market, and the FNM will provide another incremental improvement in the modeling of loopflows that impact transmission constraints on the CAISO grid.

Vertically integrated utilities elsewhere in the WECC do not have binding day-ahead market financial schedules. As a result, the way they take account of predictable loopflows is less visible than modeling assumptions in the CAISO's day-ahead market. However, it is reasonable to assume that other WECC utilities impacted by predictable real-time loopflows schedule their imports while accounting for the liklihood that those transactions would have to be cut in real-time (or require costly out-of-merit dispatch to accommodate in real-time) due to loopflows. Hence, we do not believe that the steps the CAISO proposes to take to account for the impact of predictable loopflows is fundamentally different from what other WECC system operators and utilities do to protect their ratepayers from the financial and reliability consequences of such loopflows.

There is no reason to require that the CAISO act as a helpless victim that enters into financially binding day-ahead market schedules that it, and market participants, know will have to be settled at a loss in real-time. Furthermore, the CAISO should not be required to accommodate interchange transactions with costly out-of-merit redispatch because the day-ahead market schedules do not reflect the impact of predictable loopflows. As we just noted, the predictability of these flows is shown by the fact that virtual bidders have been able to submit paired virtual demand/supply bids that generate significant profits because of differences between day-ahead and real-time prices that are believed to be due to real-time constraint deratings associated with real-time loopflows.[20]

It should be kept in mind that the use of the full network model will have several offsetting effects. All of these effects will tend to reduce production costs but only one of these effects will tend to reduce congestion rent shortfalls. First, use of a broader network model of external balancing areas and the modeling of their dispatch and external transactions may predict additional loopflows that will use up transmission capacity on the CAISO transmission system. Second, however, the use of the full network model may also at times involve modeling counterflows on the CAISO transmission system than will reflect predictable counterflows that will increase transfer capability, allowing greater use of transmission to be scheduled in the day-ahead market. Third, use of the network model will also cause the dispatch of CAISO schedules in the day-ahead market to partly flow over external paths, as it will in real-time, thereby reducing the calculated market flows on some internal CAISO lines. Hence, the combined effects are not uniformly towards increased congestion on all lines in the day-ahead market but likely a mixture of both increased and decreased congestion.

Overall, we agree with stakeholders that the CAISO should use the full network model and the associated base schedules to improve, not worsen, the modeling of real-time congestion in the

[20] Some stakeholder comments suggest that there is some confusion regarding the role of virtual bids in contributing to real-time congestion rent shortfalls. The source of real-time congestion rent shortfalls is not constraints that bind in the day-ahead market because of virtual bids, but rather these shortfalls are due to constraints that bind in the real-time dispatch, which does not include virtual transactions, only physical generation and load. Moreover, there can be congestion rent shortfalls regardless of whether or not a constraint binds in the day-ahead market. Real-time congestion rent shortfalls arise when the market flows scheduled in the day-ahead market exceed the market flows that can be accommodated on the constraint in real-time. This is likely to be the case if the constraint is impacted in real-time by material loopflows that were not modeled in the day-ahead market.

day-ahead market. However, this goal can only be achieved if the CAISO moves forward with developing and testing the full network model and with obtaining and evaluating the information it will use to develop base schedules for external control areas. We also agree with stakeholders that, conceivably, the information that the CAISO will receive in the day-ahead market from the WECC may turn out not to be very useful in predicting real-time loopflows. But in order to determine which data and methods are useful (or not), the CAISO needs to move forward with this initiative. The time to discuss which data and methods lead to good predictions is not now, but after the CAISO has implemented the full network model in a testing environment and has had an opportunity to evaluate its ability to predict real-time loopflows using various data and models. It is not apparent to us how the CAISO can develop good models for predicting loopflows unless it starts somewhere.

### 3.3 Concerns about Effect of Day-Ahead Enforcement of Physical Constraints on Imports

A third stakeholder concern is that enforcing physical constraints (*i.e.*, the underlying pre- or post-contingency limits) on tie lines in the day-ahead market model, in addition to enforcing scheduling limits, will artificially restrict imports. We do not agree with this concern as a general issue. It is possible that there may be some circumstances in which modeling interchange as being sourced on the tie line will cause the model to systematically overstate total physical flows (the flows associated with scheduled net interchange, loopflows and perhaps loopflows associated with California generation and load). As we explained with respect to the second concern, if the use of particular data or modeling methods does not lead to good predictions of real-time line flows, then the CAISO needs to correct the modeling approach before implementing the full network model. And indeed, as we discuss at length above, this is what the CAISO proposes to do.

If there are particular tie lines on which the CAISO finds that it cannot accurately approximate the real-time physical flows with interchange modeled as sourced on the tie lines, then it could be in some cases that the best resolution would be to not enforce the physical constraint on that particular tie line. However, this is a decision to be made when it is determined that there is a modeling problem, and furthermore, that not enforcing a physical constraint is the best way to address that modeling problem. It is not a decision that should be made without regard to whether the modeling of physical flows is accurate or even understated.

There is nothing inappropriate about taking into account both flows on physical constraints and scheduling constraints in determining day-ahead or real-time prices. The CAISO already does this, taking into account the impact of interchange flows on physical constraints on all lines other than the tie lines. The price of power on all tie lines can be impacted in the current design both by the impact of the flows on physical constraints or on the scheduling constraints. The change proposed is simply to model the physical constraints on the tie lines themselves--which are not separately enforced in the day-ahead market today. Omitting physical constraints was sensible when the tie lines were modeled as strictly radial to the CAISO network, as the flows on the tie line scheduling and physical constraint would be the same. However, with the introduction of the full network model, the physical flows and the contract path flows will no longer be the same. If, by modeling the physical constraints on tie lines in the day-ahead market, the CAISO

can better predict when a physical constraint will bind in real-time, then the CAISO ought to model that constraint, thereby accounting for the cost of the redispatch required to manage the congestion impact of interchange transactions in the day-ahead market price of those interchange transactions. The import supplier or export buyer can then decide whether or not it wants to schedule the transaction based on the day-ahead market price that reflects the actual value of the power to the CAISO system.

It is important to recognize that the interchange flows used to enforce the scheduling limit and physical constraint are not the same. The flows used to enforce scheduling limits are the contract path flows that flow entirely over the scheduled tie line. The flows used to enforce the physical constraint are the flows on the full network model. In the full network model, not all of the scheduled interchanges will flow over the tie line, and the flows on the physical constraint may also be impacted by the scheduled interchanges on other tie lines and by the dispatch of internal generation. Therefore, unlike the scheduling limit, the physical limit is not an absolute limit on the net interchange scheduled on a particular tie line. Rather, when the physical limit binds, the price of the imports scheduled on this path falls to reflect the cost of the redispatch required to accommodate those flows. Hence, enforcement of the physical constraint will generally not preclude interchanges from being scheduled up to the scheduling limits, but the cost of any required redispatch would reduce the value of those imports and would be reflected in the price paid for those imports. This is appropriate. The CAISO should not pay more for imports than their economic value, after taking account of the redispatch required to accommodate their impact on the ISO's transmission constraints. The enforcement of the physical constraint on tie line flows may therefore, at times, reduce the price paid for imports, but this would be appropriate.

To summarize, there is nothing extraordinary or inconsistent about modeling physical constraints on tie lines. PJM has modeled physical tie line constraints for many years and does not model scheduling limits. The New York ISO has long modeled both physical constraints on lines and scheduling constraints, although these scheduling constraints apply to flows on interfaces, not individual lines.

Further, modeling physical constraints in combination with loopflows will not necessarily cause the physical constraint to bind at a lower level of interchange than the scheduling limit. Because the flows on physical constraints will be calculated on the full network model, the physical flows associated with interchange schedules will not be the same as the contract path flows used to enforce scheduling limits. It is possible that implementation of the full network model will provide evidence suggesting that particular scheduling constraints are currently set too low. This, however, would be evidence of problems with the WECC process for setting scheduling limits, not of the CAISO full network model design.

It is also possible that there will be some tie lines on which the way interchange is modeled would cause interchange flows on the line to be overstated. If such a situation is identified, the CAISO will need to either make changes that correct the predicted flows or perhaps not enforce the physical constraint. However, this is an empirical situation that needs to be addressed only if and when it arises.

### 3.4 Concerns about Impact of Modeling Loopflows Upon Day-Ahead Prices

A fourth concern that has been raised with the proposed modeling of loopflows is that their accurate representation in the day-ahead market would potentially raise prices for particular power buyers and/or lower the prices for particular power sellers. We agree that there is a likelihood that implementation of the full network model and more accurate modeling of expected loopflows may, in a given hour, raise the day-ahead market prices paid (or earned) by some and lower the prices paid (or earned) by others. We believe, however, that the CAISO should *not* base its modeling decisions on how that modeling would impact the prices paid by or to particular entities. This would be fundamentally inconsistent with the role of an *independent* system operator, would contradict the fundamental objective of maximizing market efficiency, and finally, would undermine confidence in CAISO markets.

To date, the CAISO has been able to effectively manage in real-time the impact of real-time loopflows. However, continuing to ignore expected loopflows in the day-ahead market increases reliability risks and appears to be inconsistent with the goals of the post-September 8 modeling changes, and particularly with recommendation 2 of the FERC/NERC joint staff report.[21] It would also undermine the goal of improved visibility and reliability.[22] A policy of selectively including those loopflows and changes in generation shift factors in order to reduce prices in a particular region would further increase reliability risks and defeat a major goal of the 2009 CAISO Market Redesign and Technology Upgrade, namely to align forward prices and schedules with actual system conditions.

Further, predictable inconsistencies between day–ahead and real-time prices not only incent virtual bids designed to take advantage of these differences, they will also impact the bidding behavior of physical market participants in ways that not only contribute to increased congestion rent shortfalls but can raise the overall level of market prices.[23]

---

[21] See FERC staff and staff of the North American Electric Reliability Corporation, Arizona-Southern California Outages on September 8, 2011, Causes and Recommendations, April 2012, p. 116, which states: "TOPs and BAs should ensure that their next-day studies are updated to reflect next-day operating conditions external to their systems, such as generation and transmission outages and scheduled interchanges, which can significantly impact the operation of their systems. TOPs and Bas should take the necessary steps, such as executing non-disclosure agreements, to allow the free exchange of next-day operations data between operating entities. Also, RCs should review the procedures in the regions for coordinating next-day studies, ensure adequate data exchange among BAs and TOPs, and facilitate the next-day studies of BAs and TOPs.

[22] These reliability risks would be magnified if additional changes were made to discourage virtual bidders from submitting bids that cause these real-time constraints to more frequently bind in the day-ahead market. This is because virtual bids in such circumstances are contributing to maintaining real-time reliability by impacting the scheduling and commitment of additional generation within the region that will be constrained by transmission in real-time.

[23]For example, when the failure to model loopflows in the day-ahead market raises prices for imports day-ahead and decreases prices in real-time, the import supplier buys back its day-ahead schedule at a profit relative to the day-ahead market price. However, it is not necessarily making a profit unless the drop in the real-time price is larger than the sunk cost of the transaction. If the drop in the real-time price is not

Even if the CAISO was to embrace a goal of achieving specific price outcomes, it is not at all clear what that goal would be. Almost *any* change in modeling of loopflows or the impacts of the CAISO's dispatch will benefit some buyers and sellers and hurt others. What criteria should the CAISO use to decide which market participants it should seek to benefit by manipulating day-ahead market prices in the suggested manner?

Furthermore, the cost and revenues of power buyers and sellers depend not only on day-ahead market prices but also on which transactions are covered by longer-term contractual arrangements. With long-term contracts in the mix, adjusting the model of interchange to achieve specific short-term price outcomes may not even help the intended beneficiaries.

Last, to the extent that the power impacted by the modeling choices is not covered by a long-term power contract, artificially reducing the energy market revenues of generation may in the longer term simply require higher resource adequacy payments to keep needed generation in operation, while eliminating the price signal that might encourage lower cost entry at these locations. The resulting market inefficiency would increase the cost of serving load.

Overall, we do not agree that a criterion for evaluating changes in modeling should be whether they move day-ahead prices in a manner that benefits, or appears to benefit, particular market participants. The criterion should be whether the changes reduce overall production costs and converge day-ahead prices with expected real-time prices. This is our understanding of what the California ISO intends and we support that goal.

### 3.5 Congestion Pricing and Transmission Investment

A fifth topic of discussion with regard to the impact of the modeling of physical transmission constraints has been whether this change would adversely impact the efficiency of the incentives provided for expanding the transmission system for delivery of power into the CAISO. At this time we have not been able to identify any such adverse impacts.

It is perhaps possible that some transmission investments outside the CAISO system would create a contract path scheduling entitlement without increasing the physical transfer capability of the transmission system. In this circumstance, the enforcement of physical transmission constraints on interties in the day-ahead market could reduce the profitability of those transmission investments. However, this would not be an adverse impact, it would instead be an efficiency-enhancing impact. The CAISO should seek to disincent, not incent, transmission investments having such properties.

---

this large, the real-time loopflows may cause import suppliers to offer supply at higher prices in the day-ahead market all the time, to cover the increased risk of not recovering the cost of transmission. Alternatively, suppliers could wait to buy transmission until real-time but then they would not be allowed to buy back their schedule at a profit. In that case, they would respond by offering supply at higher prices to cover the risk of having of real-time loopflows requiring them to sell power at a loss outside the CAISO.

It is also possible that as a result of scale economies and lumpiness in transmission investment, the size of some transmission expansions would need to be so large that they would completely eliminate transmission congestion for a number of years, making it difficult to finance those projects on a market basis (*e.g.*, awarding of congestion revenue rights). While this is a possibility, it is a possibility that exists whether the constraints being eliminated are scheduling limit constraints or physical transmission constraints. Therefore, the potential for this outcome is not related to the implementation of the full network model or enforcement of physical transmission constraints on the ties.

Finally, it is also possible that a new transmission investment on an intertie could increase transfer capability but not enough to eliminate congestion on a transmission constraint. Hence, while the scheduling limit and physical transfer capability might both rise, the price on the intertie would remain depressed because there would still be congestion. This could be the case if the binding constraint was either a scheduling limit or a physical transmission constraint. There is nothing unique about the enforcement of physical transmission constraints on the ties in this regard. Moreover, the incentive for such transmission investments would lie in the congestion revenue rights (CRRs) awarded to the entity funding the project, which should entitle the transmission investor to the difference between the internal CAISO price and the price at the intertie in the amount of the increase in transfer capability. It is possible that there are one or more imperfections in the CAISO's allocation of CRRs in such circumstances that ought to be addressed but that is also unrelated to the implementation of the full network model, nor is it related to the enforcement of physical transmission limits on tie lines in the day-ahead market.

Overall, we have not been able to identify any adverse impact on transmission expansion incentives from any element of the full network model design.

## 4. Modeling of Interchange Transactions on Tie Lines

Over the course of the FNM stakeholder process, the CAISO has changed the way it proposes to model interchange in response to market participant concerns. The second revised straw proposal called for the CAISO to model and price interchange not scheduled within the framework of either the EIM or an interchange scheduling agreement at the northern and southern scheduling hubs. The design in the draft final proposal instead calls for the CAISO to model interchange as sourcing or sinking on the tie lines, as it does today. This methodology described in the draft final proposal will likely provide some improvement in the modeling the impact of interchange on the CAISO transmission system because it will be applied to a network model whose topology will extend outside the CAISO transmission system. Nevertheless, because of how interchange is modeled, the flows modeled by the CAISO will likely differ systematically from the actual real-time flows created by interchange transactions.

Hence, while delaying the implementation of the originally proposed changes that would model interchange transactions at trading hubs and sourcing and sinking in balancing authority areas external to the CAISO rather than at points on the tie lines has avoided the need to resolve some issues prior to the initial implementation of the full network model, this change may complicate the CAISO's effort to develop a more accurate model of loopflows. Because the CAISO will be

modeling the impact of interchange transactions more accurately than today but in a manner that may produce systematic errors in projected flows on the CAISO transmission system, the CAISO will need to distinguish differences between market and actual flows on its system that that are due to its mismodeling of interchange from differences due to the impact of other balancing authorities transactions on the CAISO transmission system.

The magnitude of the difficulties created by this approach will be known only when the CAISO begins testing the full network model and this magnitude may vary from line to line and with shifts in interchange patterns. This is an additional issue that the CAISO will have to address in calibrating the model to ensure that it provides better projections of real-time loopflows than the current system.