California Energy Imbalance Market Design

Prepared by William W. Hogan

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The California Independent System Operator has overseen an effort to expand its real-time economic dispatch to incorporate a larger part of the western electricity system. The proposed Energy Imbalance Market could bring material benefits in dealing with intermittent renewables, carbon emission restrictions, and improved efficiency of the electricity market. This is an innovation that the Federal Energy Regulatory Commission should welcome and support. The challenge is to address the design details to ensure that the overlapping parts all mesh well in pursuit of these objectives.

Introduction

The California Independent System Operator (CAISO) proposal for an Energy Imbalance Market (EIM) will have important implications for the treatment of California carbon restrictions, trading in the larger western electricity market, and related treatment of electricity resource sufficiency requirements. The EIM design is intended to extend real-time balancing features of the CAISO organized market to areas outside the current footprint, without expanding the full CAISO forward markets. This design choice has advantages, but it also raises important questions that have been and continue to be discussed with the market participants. As is well known, due to the strong interactions through the transmission network, an important challenge is to maintain internal consistency of all the moving parts of an electricity market design. This is difficult enough to achieve within a single footprint, and both California and the Federal Energy Regulatory Commission (FERC) are familiar with the problem of unintended consequences when components of the design don't quite mesh or interact in unexpected ways. The difficulties are likely to be compounded when some components of the market encompass different footprints. The comments here address critical aspects of the economic dispatch, related issues of resource sufficiency, inconsistencies in transmission rate design, and the framework for incorporating different rules for forward scheduling.

Energy Imbalance Market Dispatch

The EIM proposal describes an integrated real-time energy imbalance market that allows instructed deviations from schedules in one region to be counterbalanced by changes in dispatch in other regions covered by the EIM. (California Independent System Operator, 2014) The CAISO tariff filing describes three types of benefits that should accrue from

an integrated market: (i) economic benefits from finding the most economic resources in the combined area; (ii) improved renewable integration through diversification of intermittent resources; and (iii) increased reliability by providing additional information and transparency.

A centerpiece of the EIM proposal is to create a real-time market that incorporates a model and protocol for incorporating the California carbon restrictions in the EIM real-time economic dispatch. This is an innovation in electricity dispatch models.

> "Imports of energy into California and generation of energy within California from CO2 emitting resources, result in an obligation for the market participant to surrender compliance instruments to the California Air Resources Board (CARB) for the greenhouse gas emissions associated with the energy pursuant to the California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanism Regulation. Energy generated outside of California that is not imported into California is not subject to this obligation.
>
> The EIM will account for this through the following:
>
> - It will incorporate the cost of the greenhouse gas compliance obligation into its dispatch of generation within an EIM Entity to serve ISO load, but not consider this cost when it dispatches this generation to serve load outside the ISO.
>
> - It will include a mechanism to calculate the energy produced by each generator within an EIM Entity that serves ISO load. It will provide EIM Participating Resource Scheduling Coordinators with summary reports listing these amounts. These amounts will be the basis of their greenhouse gas regulation compliance obligation with CARB.
>
> - It will allow EIM Participating Resource Scheduling Coordinators to include the costs of their greenhouse gas regulation compliance obligation as an adder to their energy bids.
>
> Greenhouse gas compliance costs will not affect the [Locational Marginal Prices] in an EIM Entity. Rather, the market optimization will calculate the marginal cost difference between EIM generation serving load in the ISO and serving load outside of the ISO. This difference will be the marginal greenhouse gas regulation compliance cost and will be the rate the ISO will use to calculate a payment to each generator in an EIM Entity for its output that served ISO load. This payment will be funded by ISO load through the LMPs within the ISO." (California Independent System Operator, 2013a)

The detailed modeling of this design is not spelled out in the EIM tariff proposal, and the details do matter. It appears that the only modification from the original proposal (California Independent System Operator, 2013b) previously reviewed (Hogan, 2013) is in the treatment of carbon adders, as discussed below. However, this changed treatment of carbon adders seems unwarranted, and a return to the elements of the original EIM design could achieve the stated objectives.

This protocol illustrates the challenge of maintaining consistency of economic dispatch, in this case contemporaneously across regions, in the face of different requirements across regions. Generation inside or imported into California is subject to the CARB requirements but generation outside the region is not constrained by these rules. This implies that market prices can and should differ in systematic ways to reflect the different regulatory treatment. There are many ways to get this wrong. Fortunately, the original EIM dispatch design addresses this problem forthrightly and presents a solution that is both internally consistent and economically efficient.

In effect, the EIM real-time dispatch recognizes all carbon emissions within California and deems certain external generators as providing imports into California. The model proposed makes the problem of deciding on the deemed energy exports simple by incorporating and optimizing this decision in the EIM model. The basic proposal is internally consistent and would not upset either incentives at the margin or treatment of related financial transmission rights. This could be seen as “efficient resource shuffling.” (Hogan, 2013)

This EIM design addresses the CARB requirements and incorporates them in a dispatch model that is compatible with achieving the economic, integration and reliability benefits. There are some important properties of this EIM dispatch model that the FERC should recognize and embrace. First, in the usual manner, once unit commitment decisions are made, the forward schedules do not unnecessarily constrain the economic dispatch. In principle, whenever there is operational flexibility for generating units and loads, there will be an incentive for them to provide bids and offers relative to schedules to allow full redispatch of the system. With a complete set of bids and offers in the EIM, the resulting real-time dispatch and associated power flows will be independent of the schedules. The short-run efficiency of the outcome should not depend on the complicated mechanics of the forward scheduling and penalties. Hence, the forward scheduling and associated rules have more to do with ensuring and allocating the costs of resource sufficiency than with dispatch efficiency.

Second, the EIM rules allow for but do not require advance decisions about which resources are to be treated as being subject to the CARB requirements. This flexibility means that the choice of who falls under the jurisdiction of the CARB program and who

does not can be made without affecting the central operation of the EIM design. Identification of who is directly supplying California through bilateral schedules or indirectly through the EIM imbalances can be done independent of the EIM design. The proposed CAISO tariff takes the path of identifying the generation in California or deemed to flow to California, and the operators of the associated resources have a CARB obligation. Compensation through the EIM accounts for the revenues associated with the carbon credits, but the formal obligation with CARB is in the last instant assigned as the responsibility of the market participants. By contrast, an EIM dispatch and payment model could be equally well implemented with a procedure wherein the CAISO assumes and disposes of the carbon obligations for imports, and does not require market participants outside of CAISO to interact directly with CARB.

This potential neutrality with respect to CARB was most obvious in the original draft design formulation of the model for the EIM. (California Independent System Operator, 2013b) . That design had the feature that the assumed price of carbon permits was a CAISO input to the model. (p. 53) As a result, it would have been possible and expected that anyone participating in the EIM could be re-dispatched to provide imports to CAISO and have to deal directly with CARB. However, some market participants observed that they were prohibited from purchasing carbon credits. (California Independent System Operator, 2014) (p. 26). This concern could have been addressed by treating CAISO as the intermediary in the settlement of EIM carbon obligations, but this is not the path the CAISO has chosen. Rather than changing the decision on who has to purchase carbon credits for the resources within the EIM but outside California and deemed to serve California load, the February CAISO tariff proposal adopts language for a change in the initial EIM model. The new design now requires market participants, rather than the CAISO, to provide the appropriate bid adder for their implied carbon permit costs. Although there is a unique carbon permit price at any one time, the revised CAISO EIM design allows for different estimates of the carbon impact and encourages entities that do not wish to or cannot purchase carbon credits to put in sufficiently high offers that they will not be selected for this purpose. "As a practical matter, EIM Participating Resources that prefer not to be dispatched to serve demand in California but are still be [sic] available to deliver supply in the EIM Entity balancing authority area [sic] able to do so. By submitting a high greenhouse gas compliance bid adder and an economic energy bid component, these resources can achieve this objective." (California Independent System Operator, 2014) (p. 26).

The introduction of participant-determined carbon bid adders is an example of a seemingly innocuous market design feature that violates the basic tenet of consistency and economic efficiency. Absent an interpretation that there is a transparent real cost premium for dealing directly rather than indirectly with CARB, this design modification produces a distortion in the real-time dispatch which will work against the stated goals of

the EIM. In effect, the EIM tariff proposal endorses economic withholding as a device to avoid the jurisdictional entanglement for entities outside of California. That same manipulation of the carbon adder could be used to change market-clearing prices for both energy and the implicit value of carbon permits. Different bidders will make estimates about the estimates that others are making for the CARB premium, and adjust their bids accordingly in order to be included in the EIM, reflect their subjective estimate of the costs of the carbon responsibility, and maximize their payments for imbalance energy and carbon obligations. The simplicity of opportunity-cost-based bidding will be lost. The resulting implied market clearing carbon permit price will not be the same as the actual carbon permit price, except in a perfect competitive equilibrium, the total cost of the EIM dispatch will increase, and we will have created a new mode of market manipulation.

The practical impact of the design defect is an empirical matter and may not be large. But we have made mistakes like this before, where market designers have created avoidable but artificial arbitrage opportunities and hoped for the best. In such events, creative market participants have exploited these arbitrage opportunities and FERC has had to improvise after the fact.

The key here is that modifying the real-time bidding as the mechanism for participants to avoid CARB jurisdiction is an avoidable mistake. The method for incorporating emissions costs into dispatch decisions can be made independent of the method for assigning compliance directly to individual generators or indirectly through the CAISO. The formal tariff proposal does not specify the mathematical details of the EIM model, but the original design would be preferred. The full efficiency of the original design for carbon permits could be recovered. As originally proposed, the CAISO could utilize the known current market price of permits in modifying the bids. After the dispatch, the CAISO could account for the carbon permits under the CARB process. Market participants outside of CAISO would not have to interact directly with the CARB market, where the transactions with carbon permits would be settled by the CAISO.

Finally, although EIM dispatch could be independent of the advanced scheduling requirements, there is an interaction with the scheduling rules in other ways. These other dimensions could be important in achieving the goal of increased reliability. Here, the complicated mechanics of the forward scheduling and penalties can have a material impact, particularly on resource sufficiency. This topic is addressed in greater detail in a later section of this paper.

Resource Sufficiency and Reliability

The real-time dispatch model for the EIM could allow for complete operating efficiency in the real-time market and, taking the unit commitment as given, the outcome need not

depend on the forward schedules. The forward schedules, however, could have important impacts on longer term efficiency and on short term reliability. The interaction with short term reliability could operate through direct unit commitment decisions and through indirect assurances of resource sufficiency for scheduled imports.

Consideration of the resource sufficiency challenge faced in the EIM proposal highlights differences between the resource sufficiency approaches within organized markets and the practices in the legacy contract-path models for forward contracting and scheduling. The EIM, by definition of its expansion to overlap both types of electricity systems, must address the fundamentally different approaches in the two systems.

Here we separate the long-term resource adequacy problem related to investment decisions from the short-term resource sufficiency problem of ensuring that enough units are available to reliably serve real-time load. Within organized markets, the essence of the short-term resource sufficiency problem reduces to the problem of reliability unit commitment (RUC). Setting aside the treatment of imports, the system operator knows which units are committed inside the organized market to serve real-time load as anticipated by the market alone. The system operator maintains a separate forecast of likely load and operating conditions that may differ from the results of a forward market (day-ahead, hour-ahead, etc.). Using estimates of the reliability of different units, the system operator can and does commit additional RUC units to provide a margin of safety for possible deviations of real-time load from the level of load that could be served based on forward schedules. The associated payment schemes and cost allocations can be complicated, but this is not the main focus here. The present issue is on evaluating resource sufficiency under the EIM proposal.

If the organized market under the RUC rules were isolated from any larger system, then the RUC process could be adequate to meet the resource sufficiency goals. However, when the organized market is part of a larger system, as in the case of CAISO in the west, then imports can be a material part of the economic dispatch. If the imports were guaranteed to be available during a scarcity condition, then the RUC process alone for the organized market might be adequate. If the imports are only a small part of a much larger overall system, then it might be a reasonable assumption that the scarcity conditions inside the organized market are either not highly correlated with the conditions in the rest of the system, or the rest of the system is big enough to guarantee the imports will be forthcoming. Then it would be possible to largely neglect the import reliability problem. However, material imports change the situation. Now the reliability assessment of the organized market must address the impacts of either offsetting imports that might not be available during scarcity conditions, or directly ensuring the reliability of imports.

The CAISO approach does not incorporate either approach. For example, in the case of the RUC commitment, the CAISO does not utilize any information on the underlying generation source or transmission arrangements for imports that clear its day-ahead market. The CAISO might make general assumptions regarding delivery of imports based on historical performance, although my understanding is that CAISO has not documented such a process. In essence, this treats imports as though they were like other internal generators subject to random outages that are uncorrelated and, therefore, diversifiable. This might be acceptable if imports were not material to the larger system. But this assumption must be fundamentally wrong when imports are material and scarcity conditions tend to propagate across the larger electricity system. Since imports will be the net of load and generation decisions outside the real-time market, the residual could be highly reliable under normal conditions but unreliable during scarcity conditions. In other words, the assumption of independence between scarcity conditions within the organized market and for the overall system is not satisfied and any RUC calculation that makes this independence assumption would be invalid under precisely the conditions that present the resource sufficiency problem.

The other approach of ensuring the reliability of imports has been the traditional method applied outside the organized electricity markets. Although the details are many and complicated, the essence of the approach is simple. Scheduled transfers of power would be accompanied by a chain of firm transmission rights along a contract path to an identified source. The firmness of the rights means that the transmission will be available under all expected conditions of scarcity, short of force majeure. In addition, the source Balancing Authority identifies the generation committed and takes on the responsibility to ensure that the designated generation or some workable substitute will actually provide the scheduled power in real-time.

The deficiencies of this contract-path model are well known, and these defects are among the primary reasons for creating organized markets as well as expanding the EIM. (Hogan, 1992) In the longer-run, expanding the organized market to cover the full integrated grid would be a good policy. But until that is undertaken, it is important to deal with the realities of the hybrid model that includes the external contract path approach for import forward scheduling in the organized market.

The blend adopted by the EIM proposal addresses the wrong problem. In particular, for import schedules the approach of the EIM is to focus on ensuring the reliability of the destination of the forward schedule (the load) rather than the source (the generation). The proposal applies penalties for actual performance that deviates from schedules, but applies the penalties to the uninstructed deviations of demand and not uninstructed deviations of the supply. "If an EIM balancing authority does not use the ISO's forecast, or uses the ISO forecast but does not schedule resources within 1 percent of actual

demand, then it will be subject to penalties if its actual load is 5 percent more than scheduled." (California Independent System Operator, 2014) (p. 4, see also section 29.11 d)

In response to suggestions that penalties apply to generation, the EIM proposal asserts "Some stakeholders recommended a similar structure for generation scheduling. The ISO concluded that a separate structure is not appropriate. It is irrelevant for EIM Participating Resources, which the ISO dispatches and pays according to bids, not schedules. For non-participating resources, the demand based penalties will also address generation over-scheduling because, as discussed above, the EIM Entity Scheduling Coordinator is responsible for scheduling non-participating resources as well as demand and the EIM resource plan must be balanced. If the EIM Entity Scheduling Coordinator over-schedules demand—i.e., if it schedules non-participating generation such that the sum of that generation and the low quantities of the bid ranges of EIM Participating Resources exceeds demand—the ISO will notify it of the unbalanced schedule." (p. 32).

This EIM proposal argument does not respond to the point at hand. The problem is not that balanced schedules are not submitted or that the actual load is not close to the schedule. That would be a different problem. The resource sufficiency issue is that the balanced schedule may not include reliable generation or transmission and the actual supply may fall short of load just when the generation is most needed. The only penalty for failure to deliver would be determined by the real-time EIM dispatch prices applied to the generation. This penalty would be consistent with short-term efficiency, but this would miss the purpose of the resource sufficiency test. If short-term efficiency were all that were required, there would be no need for a resource sufficiency test. The resource sufficiency requirement is by definition a statement that more is required. But the EIM proposal does not provide anything more to meet this resource sufficiency requirement.

This treatment of imports for resource sufficiency purposes is already a problem for the existing CAISO market design. Expansion to the EIM real-time dispatch beyond the footprint of the CAISO increases the resource sufficiency problem while reducing the short-term efficiency problem. Better operation of the real-time market should lower costs and facilitate reliance on the real-time dispatch for market participants that have not secured reliable imports. But this increases the incentive and ability of import schedulers to avoid the requirements and costs of ensuring reliable imports.

Expansion of the CAISO market to the entire western system would address this problem naturally through the coincident expansion of the RUC commitment analysis to cover all generators in the west. Absent this expansion, the principal tools available to the EIM would be application and enforcement of firm scheduling requirements with penalties for material deviations from the schedules that are not part of the bids and offers executed

under the EIM. This would require firm transmission rights, tracing to the generation source, and penalties for deviations for both loads and generation.

Transmission Rate Design

In addition to the resource sufficiency problems, the EIM proposal has an impact on the economic efficiency of forward schedules. Unlike the initial EIM real-time dispatch design, the forward market scheduling rules are not yet consistent across markets or consistent with the principles of non-discrimination that are a centerpiece of FERC policy and good electricity market design.

Under the current CAISO market design, transmission charges for access and use of the internal transmission system are based on access charges on load and exports as well as locational pricing with the implied congestion. There are no other wheeling charges for explicit transactions within the footprint or for implicit transactions that occur in the real-time or forward market dispatches. This consistent treatment of implicit and explicit transactions within the footprint supports efficiency and simplifies participation in the market.

The proposal for the expansion of the EIM does not maintain this same consistency over the wider footprint. "Under the Energy Imbalance Market, internal load will continue to pay the access charge. In order to avoid rate pancaking and in recognition of load's payment of transmission charges in the receiving balancing authority area, EIM Transfers will be exempt from wheeling charges that might otherwise be imposed by the participating balancing authority area from which the energy is exported." (California Independent System Operator, 2014) (p. 36) This is the same internal CAISO treatment for day-ahead and real-time dispatch that exists today. But while the EIM proposal applies this treatment to implicit transactions that operate through the real-time dispatch of the EIM footprint, it does not apply this treatment to explicit forward transmission schedules between the regions within the EIM.

The EIM proposal argues that this distinction is not discriminatory. (p. 36) But this argument is incomplete. With respect to real-time and day-ahead schedules, the argument is correct but only because it is limited to a comparison of the treatment of implicit vs explicit transactions occurring during the same time period (i.e., in real-time or in the forward market), exploiting a technical feature that would not arise with a full expansion of the organized market. In particular, the EIM proposal argues that there are no EIM real-time explicit transmission schedules between regions, hence, allowing treatment of the implicit EIM transmission transactions without wheeling charges is not discriminatory. Furthermore, there are no implicit forward transmission transactions because there is no forward organized market, hence, applying a wheeling charge to

explicit forward schedules is not discriminatory. This technical distinction may not be exist for the fifteen minute market, in which explicit forward schedules and implicit transactions both occur, so even by its own terms the CAISO proposal may in fact be discriminatory.

This bifurcation of the forward and real-time markets may serve as a technical rationalization for meeting the test of non-discrimination, but it does not address the inconsistency created between the forward and real-time markets. The transparent effect is to create a cost hurdle for explicit forward transactions that does not apply to implicit real-time actions. Other things being equal, the market participant would prefer to wait and handle the transaction through bids and offers in the real-time rather than make an explicit schedule in the forward market that would be subject to a charge. And we have ample experience in California and elsewhere that creating artificial arbitrage opportunities between forward markets and real-time can be a recipe for trouble. It was just this kind of inconsistency that prompted the reform of CAISO markets after the crisis of 2000.

This treatment of transmission charges introduces a distortion in the aggregate market. It works in the opposite direction of the resource sufficiency policy by creating an artificial incentive not to schedule in the forward market. The distortion will have an impact on scheduling efficiency which could increase costs independent of the reliability impact. In addition, the distortion will create a barrier that will create winners and losers if there is a later consideration of expansion of the organized market into forward markets across the EIM footprint. While that market expansion is not now on the table, the FERC should be looking ahead and not make it more difficult to consider such a beneficial reform in the future.

The basic outline of a solution is to treat transmission charges for explicit forward schedules across the EIM footprint in the same way as implicit transmission schedules in real-time operate through the real-time dispatch. An export from CAISO to serve load in another EIM region entails the same use of transmission (and the same cost of service) regardless of whether it is arranged day-ahead, through an export in CAISO's real-time market, or through participation in the EIM. Fixed costs of transmission charges should be collected as access charges, and not applied as export charges within the EIM footprint. To ensure internal consistency, charges for transactions between the combined CAISO/EIM footprint and external regions should also be revisited. Otherwise, participants could shift export scheduling to the region with the lowest export charge, exploiting the fact that flows within the combined CAISO/EIM footprint incur no incremental access charge. Indeed, there is no reason to limit the footprint of transmission entities participating in a unified regional transmission tariff to the footprint of entities participating in the real-time EIM.

Forward Scheduling

Expansion of the CAISO real-time dispatch to the EIM makes more transparent the inconsistencies in forward scheduling rules. Within the CAISO, there are financially binding forward markets including virtual bidding. This design is intended to improve efficiency and maintain consistency with the real-time result that will be anticipated by the market. Outside the CAISO, the proposal is to adapt scheduling rules to reflect something like the traditional contract path model. For the EIM area outside the CAISO, there is no organized market with bids and offers that allows for a consistent solution that achieves the efficiency of economic dispatch within transmission constraints. The EIM design for the area outside the CAISO includes base scheduling rules that are intended to meet transmission constraints, and a series of penalties for deviations from these schedules. The discussion above addresses the resource sufficiency matter, but there remains the issue of the economic efficiency of the overall EIM proposal.

The ad hoc rules for checking and modifying base schedules present a number of potential threats to the overall EIM design. The CAISO Market Surveillance Committee (MSC) Opinion included in the EIM tariff filing contains a discussion of many such issues. (Bushnell, Harvey, Hobbs, & Oren, 2013) The thrust of the MSC analysis is that the degree and importance of the anticipated market efficiency problems are largely unknown at present, and will depend on actual conditions as the market develops. The EIM proposal for forward schedules is very likely to be an improvement over the current forward scheduling rules. Subject to the judgment that an organized forward market covering the full EIM footprint is not an immediate option, it is not clear what further useful changes would be recommended, and the MSC argues for watchful waiting.

Organized electricity markets in other regions have operated reasonably well with only an efficient real-time balancing market. In the case of PJM, for example, the successful market design began this way and only later expanded to include an organized day-ahead market. The forward scheduling and unit commitment problems were not overwhelming in PJM, but eventually the market changed to construct a forward market for determining day-ahead schedules in a manner consistent with the design of the real-time market. By contrast, the New York system anticipated greater forward scheduling requirements and began with a fully integrated day-ahead and real-time market. The experience confirms the MSC conclusion. The principles of open access and non-discrimination require the organized real-time imbalance market with bid-based security constrained economic dispatch and locational prices to achieve the efficient outcome. The benefits of an extension to an organized day-ahead or other forward markets depend on conditions.

While waiting watchfully, however, it would be wise for FERC to have a plan to guide the evolution of the market design in the event that not everything works as well as we hope. In this regard, it is important to remember the mistakes of the past, especially in

California. Problems in the EIM design are likely to arise from or be related to inconsistencies in the forward scheduling and real-time dispatching models and rules. When such inconsistencies become material, there will be a strong temptation to modify the real-time rules to make them more consistent with the day-ahead procedures. This bias comes across in the EIM proposal discussion where the assumption or implicit hope appears to be that instructed imbalances in the real-time market redispatch are likely to be small and most of the action will be in the forward base schedules. This assumption could be very wrong, and may have to be wrong in order to take full advantage of redispatch when the base schedules for intermittent resources will be only approximations of the actual generation.

The recommended design principle is to create as efficient a real-time market as possible, and then to adapt the forward scheduling rules to the requirements of real time rather than the reverse. The EIM real-time model is a significant innovation that can achieve efficiency of dispatch. The design is clever, and delicate. It would be asking for trouble to modify this real-time design much, or at all, to try and validate or protect any ad hoc forward scheduling rules. For example, California and FERC should remember when the original ISO/PX design prohibited clearing of real-time economic dispatch, and attempted to force all trading into the forward market with balanced schedules. This contributed to the California crisis, although the defects in the market were evident well before the advent of high prices. (Hogan, 2002) If there are no material problems with the workings of the forward schedule rules, that would be good. But if problems develop we should keep a clear eye on moving towards an efficient forward market design that incorporates bids and offers, utilizes virtual convergence bids, respects the actual grid and security constraints, and operates compatibly with an efficient real-time dispatch.

Conclusion

Properly designed, the real-time EIM should achieve the stated objectives of (i) economic benefits from finding the most economic resources in the combined area; (ii) improved renewable integration through diversification of intermittent resources; and (iii) increased reliability by providing additional information and transparency. Successful implementation requires, in part, (i) changing the method for treating the deemed obligations for carbon permits; (ii) addressing shortcomings in the resource sufficiency rules; and (iii) ensuring transmission rate design does not impede efficiency or distort behavior. The treatment of related features in the forward markets raises issues of consistency and effectiveness. From hard experience, we know of the importance of designing forward markets to be consistent with expectations for real time conditions. The current EIM proposal could be modified to mitigate problems with ensuring resource sufficiency and scheduling efficiency.

References

Bushnell, J., Harvey, S. M., Hobbs, B. F., & Oren, S. S. (2013). *Opinion on Initial Implementation of the Energy Imbalance Market and Related Market Design Changes* (pp. 1–32). CAISO Market Surveillance Committee. Retrieved from https://www.caiso.com/Documents/Feb28_2014_TariffAmendment_EnergyImbalanceMarket_ER14-1386-000.pdf

California Independent System Operator. (2013a). *Energy Imbalance Market: Draft Final Proposal*. Retrieved from https://www.caiso.com/Documents/EnergyImbalanceMarket-DraftFinalProposal092313.pdf

California Independent System Operator. (2013b). *Energy Imbalance Market: Revised Straw Proposal*. Retrieved from http://www.caiso.com/Documents/RevisedStrawProposal-EnergyImbalanceMarket-053013.pdf

California Independent System Operator. (2014). Tariff Amendments to Implement an Energy Imbalance Market. Retrieved from https://www.caiso.com/Documents/Feb28_2014_TariffAmendment_EnergyImbalanceMarket_ER14-1386-000.pdf

Hogan, W. W. (1992). Contract networks for electric power transmission. *Journal of Regulatory Economics*, *4*(3), 211–242. Retrieved from http://www.springerlink.com/index/wh70283126518105.pdf

Hogan, W. W. (2002). Electricity market restructuring: reforms of reforms. *Journal of Regulatory Economics*, *21*(1), 103–132. Retrieved from http://www.springerlink.com/index/M488771227KN3R02.pdf

Hogan, W. W. (2013). *CAISO Energy Imbalance Market Straw Proposal: Comments* (pp. 1–4). Cambridge, MA. Retrieved from http://www.hks.harvard.edu/fs/whogan/Hogan_CAISO_EIM_Notes_062613.pdf

[i] William W. Hogan is the Raymond Plank Professor of Global Energy Policy, John F. Kennedy School of Government, Harvard University. This paper was prepared with support from Powerex Corp. This paper draws on research for the Harvard Electricity Policy Group and for the Harvard-Japan Project on Energy and the Environment. The author is or has been a consultant on electric market reform and transmission issues for Allegheny Electric Global Market, American Electric Power, American National Power, Aquila, Atlantic Wind Connection, Australian Gas Light Company, Avista Corporation, Avista Utilities, Avista Energy, Barclays Bank PLC, Brazil Power Exchange Administrator (ASMAE), British National Grid Company, California Independent Energy Producers Association, California Independent System Operator, California Suppliers Group, Calpine Corporation, CAM Energy, Canadian Imperial Bank of Commerce, Centerpoint Energy, Central Maine Power Company, Chubu Electric Power Company, Citigroup, City Power Marketing LLC, Cobalt Capital Management LLC, Comision Reguladora De Energia (CRE, Mexico), Commonwealth Edison Company, COMPETE Coalition, Conectiv, Constellation Energy, Constellation Energy Commodities Group, Constellation Power Source, Coral Power, Credit First Suisse Boston, DC Energy, Detroit Edison Company, Deutsche Bank, Deutsche Bank Energy Trading LLC, Duquesne Light Company, Dyon LLC, Dynegy, Edison Electric Institute, Edison Mission Energy, Electricity Corporation of New Zealand, Electric Power Supply Association, El Paso Electric, Exelon, Financial Marketers Coalition, FTI Consulting, GenOn Energy, GPU Inc. (and the Supporting Companies of PJM), GPU PowerNet Pty Ltd., GDF SUEZ Energy Resources NA, Great Bay Energy LLC, GWF Energy, Independent Energy Producers Assn, ISO New England, Koch Energy Trading, Inc., JP Morgan, LECG LLC, Luz del Sur, Maine Public Advocate, Maine Public Utilities Commission, Merrill Lynch, Midwest ISO, Mirant Corporation, MIT Grid Study, Monterey Enterprises LLC, MPS Merchant Services, Inc. (f/k/a Aquila Power Corporation), JP Morgan Ventures Energy Corp., Morgan Stanley Capital Group, National Independent Energy Producers, New England Power Company, New York Independent System Operator, New York Power Pool, New York Utilities Collaborative, Niagara Mohawk Corporation, NRG Energy, Inc., Ontario Attorney General, Ontario IMO, Ontario Ministries of Energy and Infrastructure, Pepco, Pinpoint Power, PJM Office of Interconnection, PJM Power Providers (P3) Group, Powerex Corp., Powhatan Energy Fund LLC, PPL Corporation, PPL Montana LLC, PPL EnergyPlus LLC, Public Service Company of Colorado, Public Service Electric & Gas Company, Public Service New Mexico, PSEG Companies, Red Wolf Energy Trading, Reliant Energy, Rhode Island Public Utilities Commission, San Diego Gas & Electric Company, Secretaría de Energía (SENER, Mexico), Sempra Energy, SESCO LLC, Shell Energy North America (U.S.) L.P., SPP, Texas Genco, Texas Utilities Co, Tokyo Electric Power Company, Toronto Dominion Bank, Transalta, TransAlta Energy Marketing (California), TransAlta Energy Marketing (U.S.) Inc., Transcanada, TransCanada Energy LTD., TransÉnergie, Transpower of New Zealand, Tucson Electric Power, Twin Cities Power LLC, Vitol Inc., Westbrook Power, Western Power Trading Forum, Williams Energy Group, Wisconsin Electric Power Company, and XO Energy. The views presented here are not necessarily attributable to any of those mentioned, and any remaining errors are solely the responsibility of the author. (Related papers can be found on the web at www.whogan.com).