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September 21, 2012

The Honorable Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, D.C. 20426

Re: Comments of the California Independent System Operator Corporation Regarding Dynamic Net Benefits Approach Docket No. RM10-17-_____

Dear Secretary Bose:

The California Independent System Operator Corporation files these comments related to the directive in the Commission's Order No. 745¹ to submit the results of a study on the requirements for, costs of, and impacts of implementing a dynamic net benefits approach to the dispatch of demand response resources. This ISO filing is in addition to the filing of a report on the results of a study, entitled *Options for Implementing a Dynamic Net Benefits Test Based on the Billing Unit Effect*, to comply with that Commission directive, which was jointly submitted in this proceeding on September 21, 2012 by a number of Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs), including the ISO, as members of the ISO/RTO Council (Joint ISO/RTO Study Filing).²

¹ *Demand Response Compensation in Organized Wholesale Energy Markets*, Order No. 745, FERC Stats. & Regs. ¶ 31,322 (Order No. 745), *order on reh'g and clarification*, Order No. 745-A, 137 FERC ¶ 61,215 (2011) (Order No. 745-A), *order on reh'g*, Order No. 745-B, 138 FERC ¶ 61,148 (2012).

² The instant comments are being submitted by the ISO alone. They do not necessarily reflect the views of the other members of the ISO/RTO Council that submitted the Joint ISO/RTO Study Filing.

I. Background

In Order No. 745, the Commission found that, “[g]iven the potential of software enhancements to determine the amount of cost-effective demand response resources purchased in the day-ahead and real-time energy markets, we believe that it would be useful for the Commission to know more about the feasibility of and requirements for implementing improvements to the existing dispatch algorithms.”³ The Commission directed each ISO and RTO to “undertake a study, either individually or collectively, examining the requirements for, costs of, and impacts of implementing a dynamic net benefits approach to the dispatch of demand resources that takes into account the billing unit effect in the economic dispatch in both the day-ahead and real-time energy markets.”⁴

The Commission directed each ISO and RTO to file the results of the required study by September 21, 2012.⁵ The Commission explained that the results filing “is for informational purposes only and will neither be noticed nor require Commission action.”⁶

In Order No. 745-A, the Commission found that the directive to file the results of the study was not meant to imply that the Commission had already determined that implementing a dynamic net benefits approach would be feasible. In this regard, the Commission rejected an argument made on rehearing that, “in requiring compliance filings for the study of a dynamic process, the Commission did not consider or resolve whether the [dynamic net benefits] test is feasible for implementation or whether the cost and burden on RTOs and ISOs of complying with this aspect of [Order No. 745] is reasonable.”⁷ The Commission explained that “[f]urther exploration of these issues is precisely the reason [Order No. 745] required a study rather than imposing this condition at this time. . . . The Commission can assess the feasibility of implementing a dynamic process in RTOs and ISOs after it receives the studies.”⁸

³ Order No. 745 at P 84.

⁴ *Id.*

⁵ *Id.* at PP 7, 84.

⁶ *Id.* at P 7 n.9.

⁷ Order No. 745-A at P 128.

⁸ *Id.* (citation omitted).

II. ISO Comments

The Joint ISO/RTO Study Filing that the ISO is submitting on this date with other members of the ISO/RTO Council in this proceeding satisfies the directive in Order No. 745 to submit the results of a study on the feasibility of implementing a dynamic net benefits approach to the dispatch of demand response resources. In addition, the ISO separately provides these comments regarding the feasibility of the ISO implementing a dynamic net benefits approach.

The Joint ISO/RTO Study Filing evaluates four general approaches that could potentially be taken by an ISO or RTO to implement a dynamic net benefits approach. The basic conclusion of the report on the joint ISO/RTO study is that the implementation of a dynamic net benefit test in the dispatch would likely have adverse impacts on the solution time of the real-time dispatch software and day-ahead market software for all ISOs and RTOs. Simplifications in other elements of the economic commitment and dispatch software platforms could address these adverse impacts, but likely would result in less efficient solutions and higher prices for power consumers. Further, the known software formulations utilized by, and available to, ISOs and RTOs today would necessarily require such a net benefit test to be implemented in a very restricted manner that would have the potential to routinely produce anomalous market outcomes and still may not adequately represent the objectives of the dynamic net benefits test.⁹

Moreover, as discussed in the attached Declaration of Dr. Khaled Abdul-Rahman, Director, Power Systems Technology Development for the ISO, it would be impracticable for the ISO to implement a dynamic net benefits approach pursuant to any of those four approaches for at least the next few years and possibly longer. Dr. Abdul-Rahman also identifies significant adverse consequences that could result from the ISO implementing a dynamic net benefits test.

The first two potential approaches set forth in the Joint ISO/RTO Study Filing are:

- Attempt to develop a solution to the unit commitment and dispatch problem that applies a net benefits test based on the billing unit effect, utilizing known mathematical dual optimization techniques and equilibrium constraints; and

⁹ Joint ISO/RTO Study Filing at i-iii.

- Attempt to develop new solution concepts that might permit a faster and better unit commitment and dispatch solutions to applying a net benefits test based on the billing unit effect.¹⁰

As Dr. Abdul-Rahman explains in his declaration, adoption of a dynamic net benefits approach under either of those potential approaches would require the ISO to make fundamental changes in the security constrained unit commitment and dispatch optimization systems used by the ISO from the current formulation based on bid cost minimization solved with a Mixed Integer Linear Program algorithm to a formulation based on the minimization of costs to wholesale consumers (*i.e.*, load).¹¹

One way to change to a formulation based on load cost minimization would be through the use of self-referential Mixed Integer Non-Linear Program algorithms, which are still under research. The type of problem presented by the formulation of those algorithms is well known in mathematics to be very difficult to solve and to have a long solution time, which poses especially significant difficulties for developing algorithms to be applied on a large scale and in a timely manner to the ISO's day-ahead and real-time markets.¹² Although the mathematical formulation for making such changes in the ISO's systems is theoretically possible, the ISO is unaware of a technological solution that exists today. There is no reason to believe that it is practically possible for the ISO to incorporate a dynamic net benefits approach as part of the ISO's optimization for at least the next few years, and even at the end of that time, it may still not be possible.¹³

The other two potential approaches set forth in the Joint ISO/RTO Study Filing are:

- Apply an ad hoc approach to apply a net benefits test based on the billing unit effect utilizing existing software solution methods that would allow an evaluation of the billing unit effect based on making all demand response bids available for dispatch versus no demand response bids available for dispatch; and

¹⁰ *Id.* at i-iii, 9-10, 19.

¹¹ Declaration of Dr. Abdul-Rahman at 3-5.

¹² *Id.* at 5-6. Such algorithms are self-referential because they will, by necessity, refer to the same locational marginal prices that the optimization program is designed to produce.

¹³ Declaration of Dr. Abdul-Rahman at 5-8.

- Apply an ad hoc approach to apply a net benefits test based on the billing unit effect utilizing existing software solution methods that would allow an evaluation of the billing unit effect from making groupings of demand response bids available for dispatch.¹⁴

Dr. Abdul-Rahman explains in his declaration that both of these potential approaches are likely to result in significant adverse consequences. As discussed in the Joint ISO/RTO Study Filing, the first of these ad hoc approaches could have undesirable consequences when applied to the day-ahead market optimization and the real-time dispatch by increasing the time required to compute a software solution and tending to raise the cost of meeting load, which adversely impacts reliability and causes the ISO to incur costs to solve additional dispatch cases in parallel. These issues would make it extremely problematic for the ISO to implement the first ad hoc approach.¹⁵

The second ad hoc approach could potentially be applied solely to the ISO's day-ahead or real-time dispatch on an uncongested transmission system. However, that approach likely would be unworkable when applied to a congested transmission system or the ISO's day-ahead unit commitment, unless combined either with fundamental changes in the structure of the ISO's dispatch software or the development of self-referential Mixed Integer Non-Linear Program algorithms as discussed above. Thus, the second ad hoc approach might only be possible in the unrealistic case of an uncongested transmission system, unless significant and fundamental changes could be made to the ISO's dispatch software or algorithms.¹⁶

The ISO respectfully requests that the Commission take into consideration the significant concerns raised in the Joint ISO/RTO Study Filing and the instant filing prior to taking any further action on a potential dynamic net benefits approach.

¹⁴ Joint ISO/RTO Study Filing at i-iii, 10-20.

¹⁵ Declaration of Dr. Abdul-Rahman at 9-10.

¹⁶ *Id.* at 10-11.

III. Communications

Communications regarding this filing should be addressed to the following individuals, whose names should be placed on the official service list established by the Secretary with respect to this submittal:

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IV. Conclusion

For the reasons discussed above, the Commission should accept these comments filed by the ISO in addition to the results of a study submitted by members of the ISO/RTO Council in this proceeding to comply with Order No. 745. Please contact the undersigned with any questions.

Respectfully submitted,

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**UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION**

**Demand Response Compensation in) Docket No. RM10-17-____
Organized Wholesale Energy Markets)**

**DECLARATION OF KHALED ABDUL-RAHMAN ON BEHALF OF THE CALIFORNIA
INDEPENDENT SYSTEM OPERATOR CORPORATION**

I. Introduction

Q. Please state your name and business address.

A. My name is Khaled Abdul-Rahman. My business address is 250 Outcropping
Way, Folsom, California 95630.

Q. By whom and in what capacity are you employed?

A. I am employed as Director, Power Systems Technology Development for the
California Independent System Operator Corporation (ISO).

Q. Please describe your professional and educational background.

A. I received my Ph.D. in Power Systems in 1993 from the Illinois Institute of
Technology (IIT), Chicago, IL. Since then, I have worked in the electric power
system industry in the U.S. focusing primarily on large scale optimization
software development, and deployment to production systems. My career
includes working for different Energy Management System, electricity market,
and information technology software vendors, and various consulting companies.
Between March 2006 and July 2009 I was employed as the Independent

Principal Consultant for Electricity Markets at Siemens Transmission & Distribution, where my responsibilities included supporting Energy Market Management software areas and deploying into production the Security Constrained Unit Commitment and Security Constrained Economic Dispatch software used in the new ISO market. In July 2009 I began work as the Principal for Power Systems Technology Architecture and Development for the ISO, and in July 2010 I became the Director of the Power Systems Technology Development group at the ISO. My current responsibilities include design, implementation, testing, deployment, and analyzing results of all market applications for the ISO's day-ahead and real-time markets. I have worked on many projects requiring deep optimization knowledge and full understanding of market design rules.

Q. What is the purpose of your declaration in this proceeding?

A. In my declaration I will explain that it would be impracticable for the ISO to implement a dynamic net benefits approach pursuant to any of the four general approaches set forth in the joint filing of members of the ISO/RTO Council, including the ISO, to comply with Order No. 745 (Joint ISO/RTO Study Filing) for at least the next few years and possibly longer. Implementing either of the first two possible approaches described in the Joint ISO/RTO Study Filing would require the ISO to make fundamental changes in the security constrained unit commitment and dispatch optimization systems used by the ISO from the current formulation based on bid cost minimization solved with a Mixed Integer Linear Program (MIP) algorithm to minimization of costs to wholesale consumers.

Further, for the reasons explained the Joint ISO/RTO Study Filing, the other two possible approaches considered in that study are likely to result in significant adverse consequences.

II. Problems with Implementing a Dynamic Net Benefits Approach

Q. What are the first two potential approaches set forth in the Joint ISO/RTO Study Filing for implementing a dynamic net benefits approach?

A. The first two potential approaches set forth in the Joint ISO/RTO Study Filing are:

- Attempt to develop a solution to the unit commitment and dispatch problem that applies a net benefits test based on the billing unit effect, utilizing known mathematical dual optimization techniques and equilibrium constraints; and
- Attempt to develop new solution concepts that might permit a faster and better unit commitment and dispatch solutions to applying a net benefits test based on the billing unit effect.

Q. Would implementing a dynamic net benefits approach under either of these two potential approaches require the use of a different resource optimization paradigm than the ISO currently employs?

A. Yes. A fundamental component of the ISO's nodal locational marginal price (LMP) market design is that it conducts unit dispatch with the goal of minimizing bid costs. The objective function of the ISO's simultaneous co-optimization of energy and ancillary services is to maximize the social welfare (*i.e.*, the sum of the supply surplus and consumer surplus shown in Figure 1, below) through bid

cost minimization. This is totally consistent with optimization software packages utilized by other independent system operators (ISOs) and regional transmission organizations (RTOs) in the U.S.

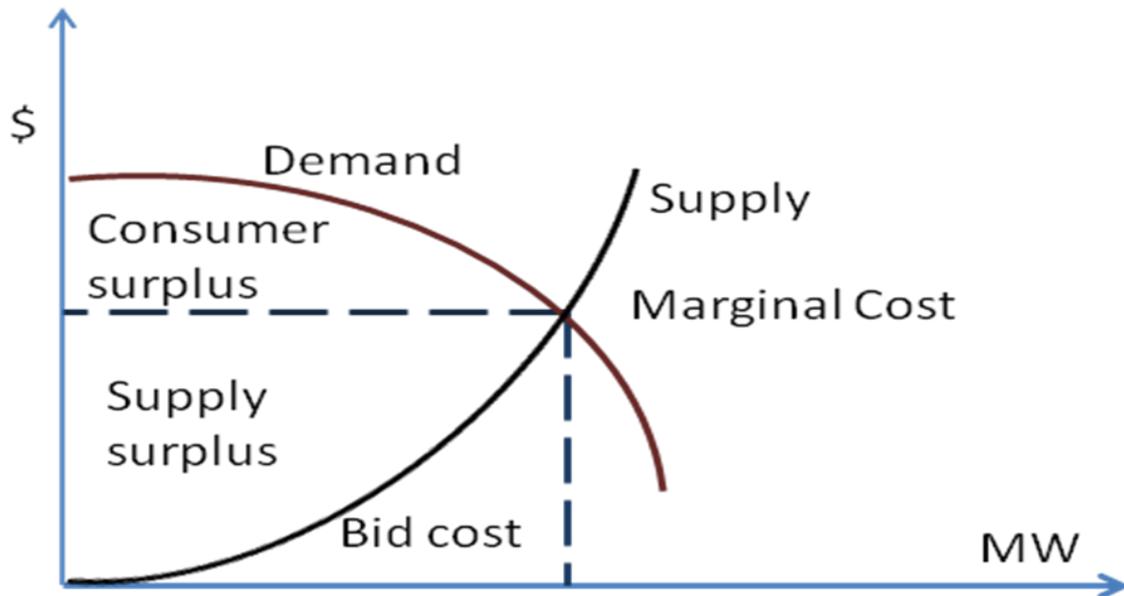


Figure 1 – Maximization of social welfare

The current bid cost minimization problem is mathematically formulated as a Mixed Integer Linear Program for the security constrained unit commitment component and a Linear Program formulation for security constrained economic dispatch and calculation of the LMPs. The ISO's market software uses the CPLEX optimization software package as a robust commercial solver to solve these optimization problems. The solver determines the commitment status of resources and then determines the MW dispatch of the different online resources. The LMPs are determined from the Lagrange multipliers of the Linear Program problem after the solution is calculated. An important mathematical

characteristic of the current bid cost minimization formulation is the capability to separate the commitment and MW dispatch problem from the LMP calculation, *i.e.*, LMPs are not part of the mathematical formulation of the current bid cost minimization problem. In other words, the LMPs are calculated at the end of the solution for settlement purposes as a byproduct of the optimization solution.

In contrast, Order No. 745 states that the goal of the net benefits test set forth in Order No. 745 is to minimize costs to load (*i.e.*, customers). Therefore, this would also be the goal of a dynamic net benefits approach. Consequently, by implementing a dynamic net benefits approach, the ISO would have to change from its existing bid-cost minimization paradigm to a load-cost minimization paradigm for at least some resources.

Q. Could a dynamic net benefits approach be incorporated into the ISO's optimization under either of the first two potential approaches set forth in the Joint ISO/RTO Study Filing?

A. A dynamic net benefits approach could *theoretically* be incorporated into the ISO's optimization as a new non-linear constraint under the current bid cost minimization objective function, or the current bid cost minimization objective function could be replaced with a load cost minimization. Both of these mathematical formulations are theoretically possible, and both would have a net benefit term that has a cross-product term of the LMPs and the bid MW dispatch variables either as a constraint or in the objective function. In a net benefit

formulation, the LMPs are not byproducts of the optimization problem as they are in the current approach. The LMPs would now be part of the optimization formulation.

The resultant formulation is known as a self-referential Mixed Integer Non-Linear Program problem. This type of problem formulation is well-known in mathematics to be extremely difficult to solve and to have long solution times due to its non-convexity, non-linearity, and discreteness, and also due to the less-developed mathematical techniques required to handle such mathematical programs with difficult equilibrium constraints. This is a major concern for the ISO since it poses practical limitations for the implementation of the Commission's net benefits test approach in its logical end-state. Some attempts to solve similar problems for small-size systems and a limited number of constraints have demonstrated the difficulty of reaching an optimal solution, as well as long execution times with lots of heuristics involved that render these approaches impractical for the ISO's day-ahead and real-time markets.

It is perhaps relevant to mention here that there was an attempt by one of the other ISOs, as part of its due diligence to comply with Order No. 745, to develop an iterative technique to incorporate the dynamic net benefits test as an additional linear constraint to solve a simple form of energy-only, single-interval real-time dispatch (not commitment or multi-interval formulation) problem. The linear constraint limits the upper MW of the demand response to lower values

each time the result of the dispatch problem fails the net benefits test. But even for the simple case of energy-only, single interval, no congestion, and no integer variables involved, the technique requires multiple market solution passes to converge to the final solution. And even with this simple form of problem formulation, the complexity and solution inefficiency increases when considering transmission congestion. When the dispatch of the demand response in a particular zone relieves congestion, lowering the limit on the demand response resource to satisfy the net benefits test will reduce the ability of the demand response to reduce congestion and thereby decrease the efficiency of the overall dispatch, which ultimately will increase costs for customers. It is also not clear how to define the net benefits test with the existence and co-optimization of energy and other market products such as ancillary services.

Accordingly, although the theoretical mathematical formulation is possible, I do not believe that the technological solution exists or even that it is practically possible for the ISO to incorporate a dynamic net benefits approach as part of the ISO's optimization in the foreseeable future.

Q. Please explain further why you believe that it is impracticable for the ISO to incorporate a dynamic net benefits approach into the optimization.

A. From a system implementation perspective, implementing a dynamic net benefits approach would mean that the ISO would need to solve the original optimization problem to determine the consumer cost without demand response. This cost is

used as a reference in the formulation of the optimization problem with demand response and in the net benefit formulation. Assuming that there is a practical solution algorithm to solve this problem – and the ISO is not aware of the existence of such an algorithm – the solution would be an iterative process of solving the problem without demand response and then with demand response and the net benefits test. It should be noted that the ISO is not aware of the existence of any commercial solution that can solve a large-scale optimization problem of the size needed to administer the ISO markets under the net benefits formulation in a robust and stable manner suitable for the day-ahead and real-time markets. From a market design and optimality verification perspective, the net benefits formulation produces LMPs that are not well-defined since the market clearing principle is not well stated, unlike the case with the ISO's current bid cost minimization. For example, it is unknown whether a demand response bid, presumably a supply bid, should be cleared when the LMP is higher than its bid price. Also, it is unclear under a given bid set and under the new objective of net benefits what the long-term impact on the market would be. It is also unclear if application of the net benefits test to the energy only market could necessarily be expanded to ancillary services markets that are co-optimized with energy in the ISO's markets.

In addition, such a change in the objective and formulation – even if it could be implemented – may undermine the current market signals provided by market clearing prices because the LMPs would no longer reflect the bid costs of the

marginal resource dispatched. Under the proposed net benefits formulation, one can argue that lost opportunity cost may occur for certain un-cleared demand response resources. In other words, there could be situations where demand response resources are not cleared even though their LMPs are higher than their bid prices. Such a situation is not possible for unconstrained physical generators.

Q. Besides the two potential approaches you discussed earlier, what are the other two potential approaches to implementing a dynamic net benefits approach that are set forth in the Joint ISO/RTO Study Filing?

A. The other two potential approaches considered in the joint ISO/RTO study are:

- Apply an ad hoc approach to apply a net benefits test based on the billing unit effect utilizing existing software solution methods that would allow an evaluation of the billing unit effect based on making all demand response bids available for dispatch versus no demand response bids available for dispatch; and
- Apply an ad hoc approach to apply a net benefits test based on the billing unit effect utilizing existing software solution methods that would allow an evaluation of the billing unit effect from making groupings of demand response bids available for dispatch.

Q. Would it be workable for the ISO to implement the first of these two ad hoc approaches?

A. No. As discussed in the Joint ISO/RTO Study Filing, the first of these ad hoc approaches could have undesirable consequences when applied to the day-ahead market optimization and the real-time dispatch, and would increase the time required to compute a software solution, thus tending to raise the cost of meeting load, adversely impact reliability, and cause the ISO to incur costs to solve additional dispatch cases in parallel. These issues with the first ad hoc approach would make it very problematic for the ISO to implement such an approach. This is because the implementation would involve repeated solutions, *i.e.*, with and without demand response resources, for the same ISO market optimization problem which, in the case of the ISO market, is a mixed integer, security constrained, and multi-interval simultaneous optimization problem not only in the day-ahead market but also in the real-time and dispatch market due to the forbidden zones and dynamic ramp rates and the look-ahead characteristics of the ISO market. Additional market power mitigation passes will also be needed for each of the market runs with and without demand response, which makes this approach not only problematic, but also impractical.

Q. Would it be workable for the ISO to implement the second of the two ad hoc approaches?

A. It would not. The second ad hoc approach could perhaps be theoretically applied solely to the ISO's day-ahead or real-time dispatch on an uncongested transmission system. However, that approach would be unworkable when applied to a congested transmission system or the ISO's day-ahead unit

commitment, unless combined either with fundamental changes in the structure of the ISO's dispatch software or the development of self-referential Mixed Integer Non-Linear Program algorithms as I discussed earlier. Thus, the second ad hoc approach might only be possible to apply in the narrow situation of an uncongested transmission system, unless significant and fundamental changes could be made to the ISO's dispatch software or algorithms. Practically, this approach suffers from the same drawbacks as the first ad hoc approach that I discussed earlier, since it requires similar repeated runs of the market with and without demand response resources even if they are grouped. In fact, the second ad hoc approach is even less attractive because it only works for uncongested transmission cases.

Q. Does this conclude your declaration?

A. Yes.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct to the best of my knowledge.

Executed on September 21, 2012.

/s/ Khaled Abdul-Rahman
Khaled Abdul-Rahman