CAISO Energy Imbalance Market Straw Proposal: Comments

William W. Hogan[i]

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Introduction

The California Independent System Operator (CAISO)-Pacificorp Energy Imbalance Market (EIM) Straw Proposal (CAISO, 2013) includes a description of a model and protocol for incorporating the California Air Resources Board (CARB) carbon restrictions in the EIM economic dispatch. This is an innovation in electricity dispatch models. The purpose of the present note is to characterize some of the model features and associated pricing implications.

Dispatch Framework

The basic model includes two zones for CARB carbon restrictions, described here as I and II. Zone I corresponds to the in California generators covered by CARB. Zone II corresponds to those outside of CARB jurisdiction but inside the Energy Imbalance Market operated by the CAISO.

In zone I there is an implicit assumption that generators must obtain emission credits to match their carbon output. The generators in Zone I face a market price for these permits, and this cost of permits is assumed to be included in their energy offers. There is no explicit representation of emissions in zone I and no assumptions regarding the location at which the power generated in Zone I is consumed.

The treatment of generators in zone II is different. Generators participating in the EIM and located in this zone will provide data on their respective emission rates to the CAISO. There is an assumed market price of permits that is used by the CAISO in its proposed EIM economic dispatch. The offers that generators make in the imbalance market do not include the emission cost as part of their energy offer. The emission cost is accounted for separately by the CAISO. In addition to the generation (g) and load (d) in zone II, there is a set of variables that are the deemed exports (E) from generators in zone II to load in zone I (if any). The deemed exports are calculated by generator, but are not differentiated by destination within Zone I. The individual export costs are for the emission factor (e) for each generator priced at the assumed market price of permits ($C_E\left(E_{II}\right) = P_E e_{II}^t E_{II}$). The individual exports must be less than the generation for the corresponding generator. The total exports from zone II must be equal to the net transfers (-y) from zone II to zone I, or zero if there are no positive transfers.

The straw proposal lays out the basics of the model. The following slight generalization is equivalent but allows for more complicated transmission constraints for energy while retaining the two zones for the asymmetric treatment of emissions. The sign conventions are selected so that the normal values of the dual variables would be non-negative.

$$\underset{d_I, d_{II}, g_I, g_{II}, E_{II} \geq 0; y_I, y_{II}}{Max} \; B_I(d_I) + B_{II}(d_{II}) - C_I(g_I) - C_{II}(g_{II}) - C_E(E_{II})$$

$d_I - g_I = y_I$	Net Loads	ρ_I
$d_{II} - g_{II} = y_{II}$		ρ_{II}
$i^t y_I + i^t y_{II} = 0$	Load Balance	λ
$H_I y_I + H_{II} y_{II} \leq b$	Transmission Limits	μ
$E_{II} \leq g_{II}$	Export Limits	θ
$-i^t y_{II} \leq i^t E_{II}$	Export Requirement	η.

To analyze the price impacts set up the Lagrangian:

$$\underset{d_I, d_{II}, g_I, g_{II}, E_{II} \geq 0; y_I, y_{II}}{Max} \quad \begin{aligned} L = {} & B_I(d_I) + B_{II}(d_{II}) - C_I(g_I) - C_{II}(g_{II}) - C_E(E_{II}) \\ & + \rho_I(y_I - d_I + g_I) + \rho_{II}(y_{II} - d_{II} + g_{II}) - \lambda\left(i^t y_I + i^t y_{II}\right) \\ & + \mu^t\left(b - H_I y_I - H_{II} y_{II}\right) + \theta^t(g_{II} - E_{II}) + \eta\left(i^t E_{II} + i^t y_{II}\right). \end{aligned}$$

For an interior solution the prices must satisfy:

$\rho_I = \nabla B_I(d_I)$.

$\rho_{II} = \nabla B_{II}(d_{II})$.

$\rho_I = \lambda i + H_I^t \mu$.

$\rho_{II} = \lambda i + H_{II}^t \mu - \eta$.

$\rho_I = \nabla C_I(g_I)$.

$\rho_{II} = \nabla C_{II}(g_{II}) - \theta$.

$\theta = \eta i - \nabla C_E(E_{II})$.

$\rho_{II} = \nabla C_{II}(g_{II}) - \eta i + \nabla C_E(E_{II})$. In other words, $\rho_{II} + \eta i = \nabla C_{II}(g_{II}) + \nabla C_E(E_{II})$.

The locational prices ρ_I, ρ_{II} reflect the asymmetry in the CARB implementation as proposed for the CAISO EIM. From the perspective of load and generation within zone I, the LMP prices satisfy the usual relationship, and equal both the marginal benefit of load and the marginal cost of generation at each location.

The situation is different in zone II. Everything looks the same for load in zone II, where the LMP equals the marginal benefit of meeting load. But for the generators in zone II, the energy prices can differ from their marginal energy costs to incorporate the effect of the marginal cost of emissions exports. Hence, the

energy price paid to generators is their marginal cost less the system marginal cost of emissions (η) plus the generator's marginal cost of emissions ($\nabla C_E\left(E_{II}\right)$). In other words, the locational energy price plus the system marginal opportunity value of carbon associated with exports equals the marginal generation cost plus the marginal carbon costs for exports for each generator.

The straw man protocol recognizes that the energy prices will produce two types of "transmission" rents. The first is the usual congestion rent, which should flow to transmission owners and holders of Financial Transmission Rights (FTRs) as in the standard model. The second rent is an emission rent which will equal $\eta i^t E_{II}$. The proposal is that this revenue should be returned to the zone II generators in proportion to their individual exports (ηE_{II}). The net effect is that the energy plus export reimbursement payments would guarantee that the net operating profits of the zone II generator would be (abusing the notation to mean at each location in II):

$$\rho_{II} q_{II} + \eta E_{II} - C_{II}\left(g_{II}\right) - C_E\left(E_{II}\right) = \left(\nabla C_{II}\left(g_{II}\right) - \eta i + \nabla C_E\left(E_{II}\right)\right) q_{II} + \eta E_{II} - C_{II}\left(g_{II}\right) - C_E\left(E_{II}\right) \geq 0.$$

The inequality guaranteeing non-negative operating profits assumes the cost functions are convex. And at the marginal the zone II generator is indifferent between both incremental generation and incremental export.

The straw proposal includes three numerical examples to illustrate these dispatch and pricing outcomes. (Spreadsheet dc21eim.xls contains an implementation which reproduces these results).

Summary

The basic proposal is internally consistent and would not upset either incentives at the margin or treatment of related FTRs. It would mean that bilateral schedules from zone II to zone I would have to identify their emissions rate in order to be compensated for the charges in the energy market as well as purchasing the emission permits.

In effect, the straw proposal makes the problem of deciding on the deemed energy exports simple by incorporating and optimizing this decision in the EIM model. This could be seen as efficient resource shuffling.

References

CAISO. (2013). Energy Imbalance Market: Revised Straw Proposal. Retrieved from http://www.caiso.com/Documents/RevisedStrawProposal-EnergyImbalanceMarket-053013.pdf

[i] William W. Hogan is the Raymond Plank Professor of Global Energy Policy, John F. Kennedy School of Government, Harvard University. 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 Provider (P3) Group, Powerex Corp., 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, Sempra Energy, SESCO LLC, Shell Energy North America (U.S.) L.P., SPP, Texas Genco, Texas Utilities Co, Twin Cities Power LLC, 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, 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).