A Closer Look at Demand Bids in CAISO Energy Market

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***Abstract*—One year of demand bids in the California energy market are analyzed and observations are reported on type, size, shape, and other characteristics of the bids. The implications of these observations, the underlying causes, and the potentials to improve demand bids by exploiting load flexibility are discussed.**

***Keywords*: California independent system operator, demand bids, day-ahead and real-time energy markets, demand response.**

I. Background

Generators and loads participate in the California Independent System Operator (CAISO) energy market by submitting supply and demand bids, respectively. Each bid is either a self-schedule bid (SB) or an economic bid (EB) [1]. Generators and loads who self-schedule are deemed to be price taker. Accordingly, they only indicate the amount of energy in MWh that they are willing to sell or buy at each market time slot. Some of the SBs also represent the existing bilateral contracts between market participants, see the CAISO document on *Inter-SC Trades* for more details [1]. In contrast, generators and loads who submit EBs are deemed to be price maker. Their bids include price components in $/MWh. While generators can submit EBs to both day-ahead market (DAM) and real-time market (RTM), loads may submit EBs only to DAM, as the RTM on the demand side is based on load prediction and load metering [1]. Some prior studies on understanding the CAISO energy market and its characteristics include [2]–[4].

II. Basic Observations

In this section, the demand bids in the CAISO day-ahead energy market in 2014 are analyzed, based on the data that is available to public at the CAISO Open Access Same-time Information System [5]. In total, $365 \times 24 = 8{,}760$ hours of bids are considered. On average, for each hour, CAISO receives demand bids from 118 load entities[1], out of which 10 loads submit EBs while all other loads solely submit SBs. In terms of the MWh size of the demand bids, only 10% are EBs. In comparison, there are 769 generators that submit bids to the CAISO day-ahead energy market, out of which 371 generators submit EBs. On average, 68% of the total MWh generation bids are EBs. Table I shows a summary of the submitted and cleared bids in the CAISO DAM. The yearly peak hour occurred at 5:00 PM on September 15, 2014 and the yearly off-peak hour occurred at 4:00 AM on March 2, 2014. It is worth adding that besides generator and load bids, CAISO receives import and export bids at its inter-ties. For example, at the peak hour in Table I, the total cleared import and export bids were 8,243 MWh and 1,644 MWh, respectively. However, such out-of-state bids are not the focus in this letter paper.

TABLE I
Summary of Energy Bids in CAISO DAM During 2014

Market Parameter (MWh)	On-Peak Hour	Off-Peak Hour	Hourly Average
Submitted Demand Bids - SB	40,477	16,172	24,262
Submitted Demand Bids - EB	4,615	1,592	2,460
Cleared Demand Bids - Total	43,182	17,748	26,081
Submitted Supply Bids - SB	15,320	7,910	10,812
Submitted Supply Bids - EB	22,702	22,316	22,368
Cleared Supply Bids - Total	38,618	13,420	19,715

In the CAISO market, each EB is a step-wise curve with up to 10 segments. On the generation side, 49% of the EBs had two or more segments. However, on the demand side, out of the 10 loads that submitted EBs, only the two largest utilities in California, i.e., Southern California Edison (SCE) and Pacific Gas and Electric (PG&E)[2], submitted bids with two or more segments. Their EBs had five and six segments in each hour, respectively. The third largest utility in California, i.e., San Diego Gas and Electric (SDG&E) did not submit EBs[3].

Fig. 1 shows the DAM demand bids at on January 31, 2014 from 6:00 PM to 7:00 PM and on August 30, 2014 from 3:00 PM to 4:00 PM. In both cases, there are four components that form the aggregate demand curve: the bids from the three major utilities and the total bids from the rest of the loads that are collectively called Others[4]. Since SDG&E only submits SBs, its curves are straight lines. As for Others, their combined bids are also practically straight lines, because other than about 6 MW EB in Fig. 1(a) and 2 MW EB in Fig. 1(b) that are at price level $100, pointed at by arrows, the rest of the demand bids by Others are SBs. It is observed that, within the typical $30 to $120 price range in the CAISO DAM, the segments in the aggregate demand bid curve almost exclusively come from the EBs that are submitted by SCE and PG&E. Note that, although the load levels are very different in Figs. 1(a) and (b), the *shapes* of bids are similar in these two figures.

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[1]There are 29 load entities which have at least 100 MW annual peak load.

[2]In the CAISO OASIS database for public bids, each market participant is represented by a resource identification (ID) number. However, based on the size of the bids during seasonal peak hours, one can easily identify the bids that belong to the three major utilities, namely SCE, PG&E, and SDG&E.

[3]Note that, the focus in this paper is on demand bids to the CAISO energy market, not to the CAISO ancillary service or other CAISO markets.

[4]Some of these loads are located in the service territories of the three major utilities, but they participate in the market independently with different IDs.

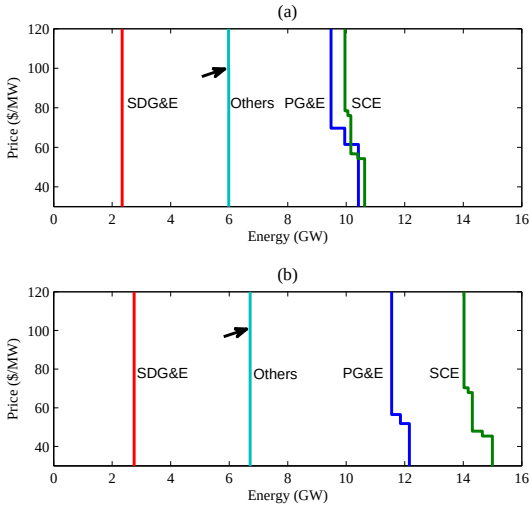

Fig. 1. Two examples for breaking down the total CAISO demand bids across the three major utilities in California: (a) winter day, (b) summer day.

III. Further Analysis and Recommendations

A. Implications

From the observations in Section II, the demand curve in the CAISO day-ahead energy market is, for the most part, a straight line. As a result, the amount of energy that is purchased by loads at each hour in this market does not, for the most part, depend on the cleared market price at that hour. As for the few segments that exist in the aggregate demand curve due to the EBs from SCE and PG&E, while they *do* affect the amount of energy that is purchased from the DAM as a function of the DAM cleared market prices, they do *not* affect the *total* energy that is purchased across the DAM and RTM *combined*. This is due to the fact that the difference between the actual load and the cleared load in the DAM are cleared in the RTM, keeping the *total* demand in the CAISO energy market independent from the cleared market prices. Therefore, *the total demand in the CAISO two-settlement energy market is currently highly inelastic.* Such low elasticity of the demand bids has at least two consequences that are undesirable for efficient operation of the CAISO energy markets: *it may cause price spikes in the DAM and RTM; and it may also facilitate the exercise of market power by generation companies* [6].

B. Underlying Causes

There are at least three reasons for the current demand inelasticity in the CAISO energy market. First, any major and unexpected change in demand due to changes in prices, i.e., any price-elastic load behavior, can have adverse impact on the accuracy of *load forecasting* that is done by CAISO. Since load forecasting plays a central role in CAISO for operating the market and dispatching generation [1], any major deviation of the load from CAISO's forecasted level, due to any reason including price-elasticity, can in turn potentially jeopardize power system reliability or cause unintended price spike.

Second, the primary objective for a load entity when participating in the DAM is to hedge against uncertainty. Specifically, submitting a demand EB is not really about practicing load elasticity and capping the load when the price is high; instead, the intention is often to perform risk management by *diversifying* purchase across DAM and RTM. In this sense, the current role of demand EBs is similar to that of another financial tool in CAISO, called convergence bid[5] (CB), a.k.a., virtual bid (VB). Convergence bidding is a mechanism whereby market participants can make financial purchases (or sales) of energy in the DAM, with the explicit requirement to sell (or buy) back that energy in the RTM. CBs pressure DAM and RTM prices to move closer together [2]. Interestingly, while SDG&E does not submit EBs, see Section II, it does submit CBs [7].

Third, there is currently very limited load flexibility available to load entities in California. On one hand, due to various economic and social reasons, the energy usage of many consumers is historically inelastic [6]. On other other hand, the existing load elasticity potential, see Section III.C, has not been utilized yet. For example, the current registered capacity of proxy demand response (PDR) resources is only 37 MW[6].

C. Potentials to Improve Demand Bids

Addressing the three obstacles in Section III-B can potentially help in enhancing demand bids and increasing load flexibility in the CAISO energy market. First, there is a need to develop new load forecasting methods that incorporate the impact of price-elasticity in demand; see [8]. Load forecasting may also benefit from new demand bidding structures that are designed to accommodate flexible loads; see [9].

Second, we may develop new demand bidding strategies that not only diversify purchase across DAM and RTM, but also exploit various load flexibility potentials to create price-elasticity in demand curves; see [10], [11]. Note that, medium and large consumers are already allowed to directly bid in the CAISO energy markets, where the bids can be as low as 100 kW in total and 10KW in each economic bid segment [1].

Finally, there is a need to make more flexible loads available through enhanced demand response (DR) programs. Some of the current DR programs in CAISO include PDR, reliability demand response resource (RDRR), participating load (PL), and aggregated participating load (APL) [3]. Most of these programs, except for PDR, are mainly designed for ancillary service market participation. However, linking these and other DR programs to energy markets could provide load entities with the *means needed* to practice price-elasticity. Of course, some load types, such as air conditioners, are minute-scale flexible loads that are best utilized in ancillary service markets. However, there are also load types, such as charging electric vehicles, water pumping and water treatment, batch processing in data centers, industrial equipment in process control, and some home appliances such as washing machine, dryer, and dish-washer, that are hour-scale flexible loads and appropriate for energy market, as long as they are properly aggregated.

[5]For instance, the total submitted demand CB, the total submitted supply CB, the total cleared demand CB, and the total cleared supply CB at the peak-hour in Table I are 9,987, 7,302, 5,055, and 4,022, all in MWh.

[6]This number was provided to the authors by CAISO on March 12, 2015.

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