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RESEARCH review

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Resource Adequacy and Capacity Markets: Are They Worth It?

The state of California appears to be poised for yet another major shift in its approach to regulating the electricity industry. These changes have sprung from the reaction to the electricity crisis of 2000-2001. The remuneration of electricity generation will be transformed from one in which revenues are based upon market-based prices for the provision of energy and ancillary *(or stand-by)* services to one in which a significant share of generation revenues will be earned for providing "capacity." Before the restructuring of the industry in 1998, generation had traditionally been built by regulated utilities, which were remunerated according to cost-based regulation principles.

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The rejection of a system focused on market-based payment for energy and related services, sometimes referred to as an "energy-only" framework, is predicated upon a belief that structural failures in the electricity industry make the energy-only model untenable. For example, a recent white paper from the California Public Utilities Commission cites the lack of price-responsive demand and the inability of operators to interrupt customers of specific retail providers as necessitating the development of a capacity-based framework.

These structural problems raise concerns about the market power of generation firms and the ability of retailers to free ride on the capacity investments of others. But are the structural failures cited in justifying capacity payments or other capacity-based requirements real, and if so, are they self imposed? Why is it that policy makers in many U.S. markets have felt that these factors, which are shared by all electricity markets, make capacity instruments necessary, while many markets outside the U.S. have adopted the energy-only approach? Last, if these structural factors are real market failures, are resource adequacy and capacity markets the most effective, and cost-effective, means for addressing them?

Recent work by James Bushnell and others shed some light on these questions. In his recent paper, "Electricity Resource Adequacy: Matching Policies and Goals" *(CSEM WP-146)*, Bushnell takes a hard look at the six different reasons often cited for adoption of resource adequacy standards and capacity markets and asks whether RA policies really address the underlying problems and provide the best solution. In "Vertical Arrangements, Market Structure, and Competition: An Analysis of Restructured U.S. Electricity Markets *(CSEM WP-126)*, Bushnell and his co-authors Erin Mansur and Celeste Saravia examine the question of why some markets are much more competitive than others, given that they all suffer from a lack of price-responsive demand.

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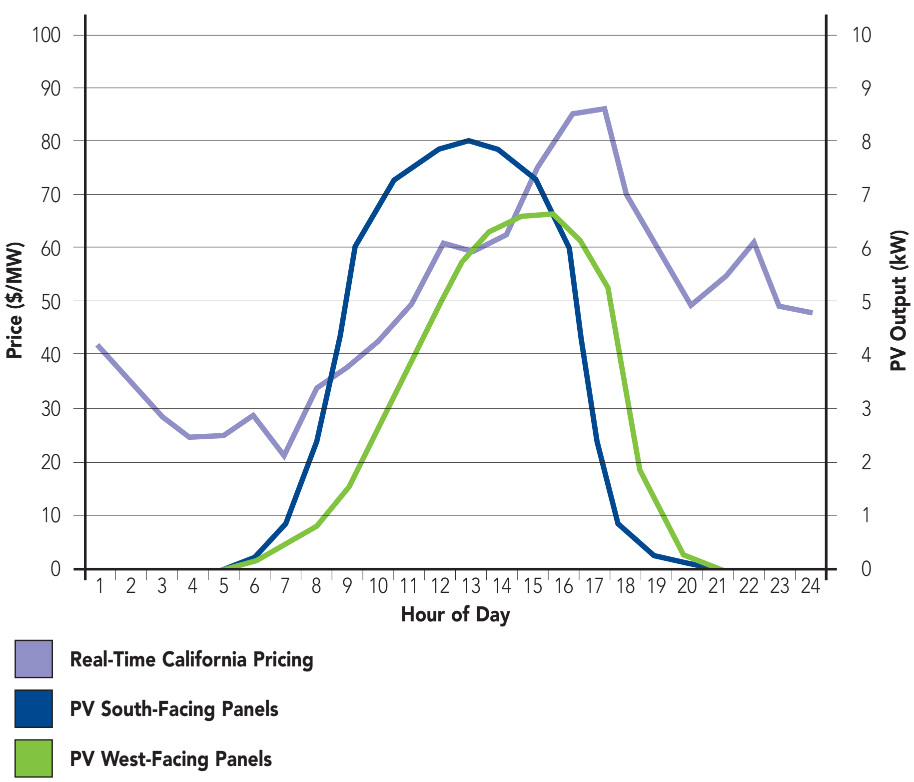
Power When the Sun Shines: Is it Worth More?

As fossil fuel prices rise and concerns over greenhouse gases and global climate change increase, greater focus turns to alternative technologies for producing electricity. Among the technologies that may help to address these concerns is solar photovoltaic cells *(PVs)*, which capture solar radiation and convert it into electrical energy. Such cells are generally built into large flat panels located at the site of the end user and thus are a form of distributed generation.

Solar PV panels, such as those that were targeted by California's proposed "million solar homes" initiative, generate electricity only during daylight hours and generate more electricity when the sun is shining more intensely in the middle of the day. As a result, in summer-peaking electricity systems, such as California and most of the U.S., power from PVs is produced disproportionately at times when the demand for, and market price of, electricity is high *(figure 1)*. Supporters of PVs argue that this makes comparisons of the value of PV power to the average price of power from competing sources misleading.

Yet, because solar panels are located at the end user's site, the financial benefit of owning them comes from reducing metered consumption and for residential customers that metered consumption is usually billed at a flat rate that represents the average price of power. In "Valuing the Time-Varying Electricity Production of Solar Photovoltaic Cells" *(CSEM Working paper #142)*, Severin Borenstein estimates how much a flat-rate tariff undervalues solar PV due to its failure to account for the fact that solar PV produces power disproportionately at high-value times.

FIGURE 1:
HOURLY AVERAGE REAL-TIME PRICE AND SOLAR PV PRODUCTION FOR JULY WEEKDAYS IN SAN FRANCISCO



Borenstein uses simulated solar PV production data for panels located in Los Angeles, San Francisco and Sacramento to determine the time-varying production pattern for panels in different locations. He puts the production data together with wholesale price data to determine how much the PV power is worth if it is valued at a wholesale price that changes every hour and compares that to the value based on an annual average price of power.

Borenstein argues that wholesale prices in California since 2001 have exhibited unusually low volatility due to the over-capacity that followed the electricity crisis. So, using those wholesale prices for the analysis may tend to under predict the price variability in the future, and understate the bias created by valuing PVs using average wholesale prices. Thus, in addition to using the actual wholesale prices, Borenstein also calculates the value of PV power values using simulated wholesale prices from a model he presented in CSEM working paper #133 *(which was published in The Energy Journal earlier this year)*. That model produces peaking prices that are sufficient over the 1999-2003 study period to cover the amortized fixed capacity costs of peaker generation units.

Using the simulated wholesale prices to value PV production, Borenstein finds that solar PV power priced at hourly-varying prices is worth 29%-48% more, depending on the location, than if it is valued at a flat-rate tariff that reflects only the long-term average price of power. He finds that the undervaluation is substantially smaller, 8%-14%, if the analysis is done using the actual wholesale prices during the sample period, but argues that these estimates are less informative.

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RESOURCE ADEQUACY AND CAPACITY MARKETS: ARE THEY WORTH IT?

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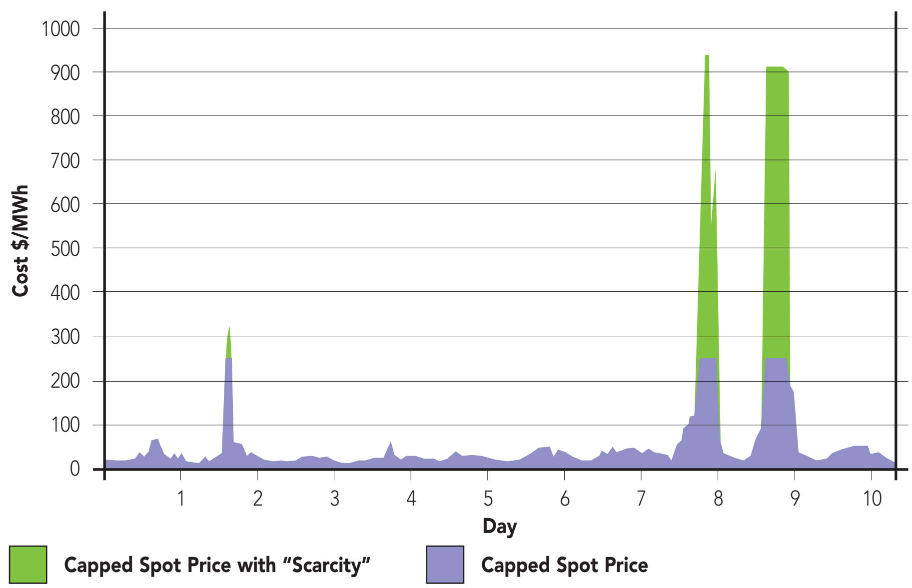
One of the primary reasons cited as a need for RA policies is the need to ensure sufficient revenues for generators to invest in capacity. It is asserted that insufficient revenues, caused by low energy price caps, have prevented generators from recovering their long-run average costs, thereby discouraging investment and potentially leading to a capacity shortfall. Assuming a competitive market, figure 1 illustrates the potentially foregone revenues when a $250/MWh energy price cap is implemented. The most straightforward solution would be to increase the energy price cap and let the price level adjust as capacity needs fluctuate. However, concerns about market power and other political ramifications have limited discussions about increasing the energy price cap. Instead, policy makers favor instituting capacity payments made to generators through a newly created capacity market or similar capacity obligation.

FIGURE 1: CAPPED AND UNCAPPED SPOT PRICES



Does the lack of price-responsive demand necessitate a low price-cap and other strong regulations to mitigate market power? Here the experience in markets outside of California is informative. In CSEM WP-126, Bushnell, Mansur, and Saravia find that three factors, the concentration of generation ownership, the price-responsiveness of imports into a market, and the extent of long-term contract commitments, largely determine the competitiveness of a market. In the first two attributes, firm size and import elasticity, California held the advantage over eastern markets. The elasticity, or price responsiveness, of imports and small-firm production in California has been much greater than that experienced in eastern electricity markets. This structural advantage was not enough to offset the lack of long-term contracts in the California market, however, as California experienced far more severe market power problems.

Another goal in setting resource adequacy policies is to prevent competing retailers from "free riding" on the resources of other retailers. Bushnell argues that the underlying problem is a failure to develop workable rules for customer migration. At issue are retailers who do not procure sufficient supplies to serve their customers. The retailer may pay a penalty for doing so, but its customers will not bear any financial consequence. Hence, customers can theoretically sign up for a cheap "fly-by-night" retailer and when that retailer goes out of business, simply go back to their incumbent provider. This potential cycle of churning customers would result in higher costs for the incumbent's other customers, even if the incumbent had procured sufficient resources. Sound policies for managing the migration of retail customers between competitive and regulated retailers would ensure that individual retailers and their customers bear the financial consequences of any shortfall for which they are responsible and would largely eliminate any incentive to free ride on system resources.

Encouraging long-term contracting and hedging by regulated utilities is another goal associated with the need for a resource adequacy policy. A variety of reasons are given for why regulated utilities in California have not unilaterally entered into more long-term or hedging arrangements but it has become clear that doing so is necessary to reduce price volatility. The RA approach would be to require utilities to acquire capacity in a forward market but one needs to be careful about defining what exactly is being procured. If it is capacity alone, then there is still the risk that the energy won't be available during the periods when it is most needed. Requiring contracts for energy purchases is really the key and can be done without inventing a capacity market.

The critical question is how RA policies address the overarching goal of providing reliable electricity service at the lowest possible price. The RA standards and capacity market proposal in California come with potentially very high price tags. Theory and evidence suggest that encouraging the introduction of real-time prices for end users, increasing the energy price cap, setting strict rules for customers migrating between competitive and regulated utilities, combined with incentives or even requirements for utilities to enter into long-term commitments and hedging agreements can achieve more reliable electricity service, without the added costs and unintended consequences of the more heavily-regulated RA policies and capacity market approaches.

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How Do Households Respond When Their Energy Bill Increases?

Electricity, natural gas and oil prices have risen dramatically over the past several years and have affected every household's budget. But when energy bills go up, how do households adjust and do all households adjust similarly? Do they cut back on other household expenditures, and if so, which ones? If there are severe weather conditions and consequently even higher energy bills, how do households manage the additional expense? As energy prices are expected to continue their steep increases, it's important to understand their impact on households, and low-income households in particular, and the tradeoffs that consumers make.

In their paper, "Do Households Smooth Small Consumption Shocks? Evidence from Anticipated and Unanticipated Variation in Home Energy Costs" *(CSEM WP-141)*, Julie Berry Cullen, Leora Friedberg and Catherine Wolfram focus on the expenditure changes a household makes when its home energy bill either expectedly or unexpectedly increases. Home energy costs refer to energy used in the house and exclude, most notably, gasoline expenditures.

The authors use data on home energy expenditures from the Consumer Expenditure Survey for households surveyed from the second quarter of 1990 through the first quarter of 2002. The study focused on those households that pay their energy bills directly and excluded those whose bills are paid by third parties. Of those who pay their bills directly, the median household spends about 5 percent of their budget on energy, while 25 percent of the households spend over 8 percent. With this survey data, the authors were also able to distinguish low-income, low-asset and low-income elderly households. Low-income and low-asset households spend a greater fraction of their budget on energy. Poor households with elderly members devote a larger fraction of their budget to energy than do poor households without an elderly member.

Cullen, et al. analyze the impact of both expected and unexpected changes in energy bills on households' spending decisions. Expected changes are those associated with additional heating needs in the winter and cooling needs in the summer and the usual seasonal change in prices. Unexpected changes result from abnormally cold or hot seasons and/or an unusual fluctuation in energy prices. They look at how these changes affect households' consumption of food, nondurables and a category identified as "strictly nondurables," which excludes apparel, medical and education but includes personal care, alcohol, tobacco and household operations. To correctly estimate the impact of an increase in energy prices on consumption of other goods, it's necessary to separate out those items that may move in tandem with energy prices. For example, as energy prices rise, households may buy more sweaters or blankets. The authors address this and other issues to create a robust estimation of the impact of energy prices on consumption of other goods.

The results for all three expense categories suggest an insignificant change in consumption in response to anticipated changes in energy expenditures. In contrast, the results suggest large negative responses to changes in unanticipated energy expenditures. For strictly nondurable expenses, the results show large and statistically significant reductions when there are unanticipated energy price increases. Households appear to cut back on non-food categories, other than apparel, medical and education, when energy bills spike.

To see how poor households responded to energy expenditure changes, the authors separately identified those households that did and did not receive any interest or dividend income, i.e., savers and non-savers. Both groups showed small and insignificant responses to anticipated changes in energy bills, however, there was a marked difference in response when the change was unanticipated. The non-saving households had a large negative response *(a more than 40 cent decrease in other expenditures for every one dollar increase in energy bills)*, while the savers showed no significant reduction in their expenditures. The non-savers appeared to be ramping down non-durable consumption when surprised by higher energy bills.

These results indicate that even households without substantial financial assets are able to manage an expected increase in energy expenses without having to reduce their consumption of other goods. However when there is an unanticipated change in energy expenses, all households, but especially those with few financial assets, adjust their consumption behavior and significantly reduce their expenses on non-food items. These findings suggest that programs aimed at helping low income families pay their energy bills during severe weather or price conditions may provide just the relief needed.

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POWER WHEN THE SUN SHINES: IS IT WORTH MORE?

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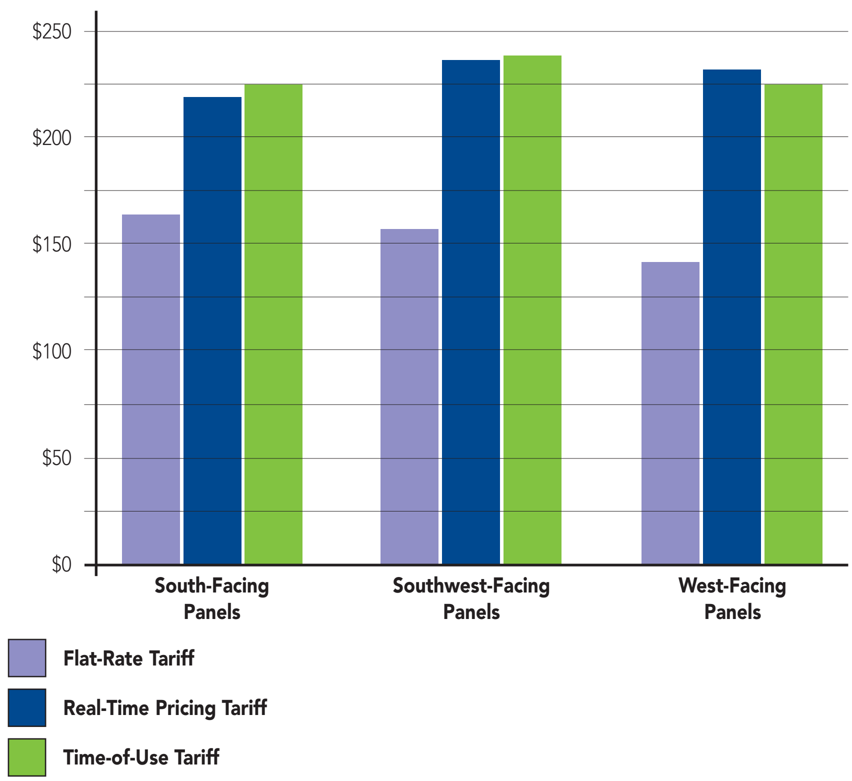
Borenstein then examines an alternative tariff that doesn't vary hourly, but does change between peak and off-peak hours. Unlike hourly-varying retail tariffs, which are practically non-existent, simple peak/off-peak "time-of-use" tariffs are in widespread use among large customers and even used by some residential customers. He finds that a simple TOU tariff, by valuing power most highly in summer afternoons and least in the middle of the night, virtually eliminates the bias against solar PVs that is created by flat-rate tariffs. An illustration of the differing valuations under flat rate, real-time pricing *(RTP)*, and time-of-use *(TOU)* tariffs is shown in figure 2.

While the study finds that the value of solar PV power is greater if wholesale electricity prices are "peaky," Borenstein points out that the current direction of restructuring in many states, including California, is quite likely to minimize wholesale price volatility. If a state institutes "resource adequacy" regulations that assure the system always has excess production capacity — and, consistent with this approach, collects revenues for capacity payments to generators through a time-invariant retail surcharge — then wholesale prices will differ little between peak and off-peak periods. With abundant excess capacity, the wholesale prices will accurately indicate that incremental power at peak times is not much more valuable than off-peak. In that case, flat-rate tariffs would cause very little bias against solar PV.

The paper points out that the time valuation of solar PV power is just one among many issues that affect its viability: savings in transmission and distribution costs, reduction in vulnerability to terrorist attack, costs due to intermittency of solar power availability, cost shifting when avoided retail tariffs cover other expenses, the continued high cost of solar PV panels and, of course, the valuation of the environmental benefits. Borenstein does not evaluate these other aspects of PV, attempting only to nail down the time-varying valuation issue.

FIGURE 2: ANNUAL VALUE OF POWER PRODUCED BY A 3kW RESIDENTIAL SOLAR PV SYSTEM IN SACRAMENTO, CALIFORNIA UNDER ALTERNATIVE RETAIL TARIFFS (Approximate unsubsidized installation cost: $24,000)



The paper also sheds some light on the most valuable directional orientation of solar panels. While PVs produce the most total electricity if they are tilted south, they produce power later in the day — when it tends to be more valuable — if they are oriented in a more westerly direction. Borenstein simulates valuations for panels facing south, south-west and west. He finds that the tradeoff between quantity and value per kilowatt-hour is significant. In all three locations, Southwest oriented panels are found to create a more valuable balance of quantity and price than the higher production of south-oriented panels or the higher average price earned by west-oriented panels *(see figure 2)*. This tradeoff, however, may become less relevant as "tracking" technology that is now hitting the solar PV market allows panels to follow the sun across the sky.

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