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Putting Demand Response to Work for California

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Introduction

In an effort to lower carbon emission, slow the pace of climate change, and level rising energy costs, California is overhauling how it makes, moves and uses electricity.

These changes include incorporating an unparalleled influx of intermittent energy resources (namely wind and solar)—both in the form of residential "distributed" self-generation and larger utility-scale—while at the same time preparing for thousands of megawatts of conventional power plants to retire.[1,2]

A growing number of customers are also seizing the opportunity to purchase and produce their own electricity through on-site generation, such as rooftop solar photovoltaics. While this explosion of customer-generated power is neutralizing electricity bills and empowering hundreds of families across the state, it also presents a challenge for grid operators grappling with how to manage this new flow of electricity onto the central electric grid.

At the same time, budding technological innovations are allowing a growing number of customers to be active participants in grid operations. Using low-cost, easy-to-program, two-way communications—such as modern programmable thermostats and mobile apps that allow for home energy management—customers can reshape their electricity consumption and align it with times when electricity is cheap, clean and plentiful on the grid.[3]

Demand response is an innovative way to reduce energy use by rewarding customers who use clean, inexpensive power when it's plentiful.

This new dance—invoking changes in demand to meet grid needs—is the next wave of "demand response" (DR), people-driven solutions that can help California adapt to the diverse changes affecting its energy landscape and realize its full clean energy potential.

Demand response is an innovative way to reduce energy use by rewarding customers who use clean, inexpensive power when it's plentiful—such as solar energy generated in the middle of the day—and less electricity when the grid is challenged by demand that is threatening to exceed available electricity. It relies on people and technology, not just power plants, to meet electricity demand. For grid operations, it's the flipside of generation, since it can reduce demand and eliminate the need for powering up more generating plants.

In this new landscape, where technological innovations and policy mandates are driving fundamental changes to the electricity grid, DR can and should play a valuable role. However, many other states and regions rely far more heavily on demand response than California.[4] For instance, New England's programs enable more than double the DR participation than in California.[5]

To unlock this valuable resource, California policy makers should:

1. **Identify** the full extent of benefits DR can offer to meet emerging grid needs;

2. **Spur** the development of high-value DR resources by ensuring that their owners and aggregators get appropriate compensation for the value they bring to the grid; and

3. **Properly account** for load-modifying DR (such as time-variant rates) in the state's long-term forecast for electricity demand, to inform decisions about what additional supply resources may be needed to meet the demand.

CHALLENGES AND OPPORTUNITIES

The new energy landscape

Because of its success in deploying clean energy, California, the nation's leader in solar installation, finds itself with "over-generation" (lots of electricity) coinciding with times when solar output is greatest (see Figures 1 and 2).[6] The duck-shaped chart shown below was created by the California Independent System Operator (CAISO) as a look into the future potential impact on their grid operations. The chart illustrates how increasing levels of intermittent resources can create new ramping patterns.[7,8] The duck chart is often said to show an impending challenge. In reality, however, it reveals a combination of past and current success in increasing renewable resources and, importantly, consumer opportunities.

The challenge for grid operators can be seen in the "neck" of the duck chart (labeled "increased ramp" in Figure 1) when solar generation comes off-line (i.e., when the sun goes down) and other resources must be used to meet demand. In response, grid managers predict the need for energy resources that can be deployed quickly to meet this steep "ramp" as the sun

FIGURE 1

The California Independent System Operator (CAISO) duck curve

net load, March 31[9]

Licensed with permission from the California ISO. Any statements, conclusions, summaries or other commentaries expressed herein do not reflect the opinions or endorsement of the California ISO. Source: California ISO. Demand Response and Energy Efficiency Roadmap. December, 2013. http://www.caiso.com/documents/dr-eeroadmap.pdf

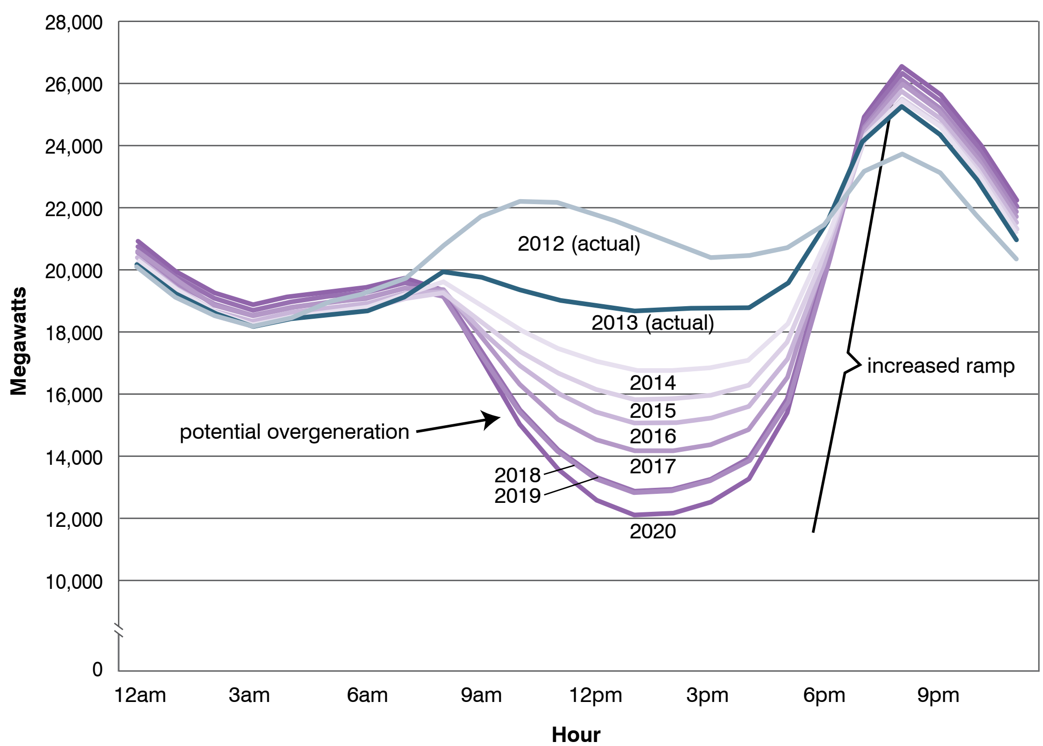
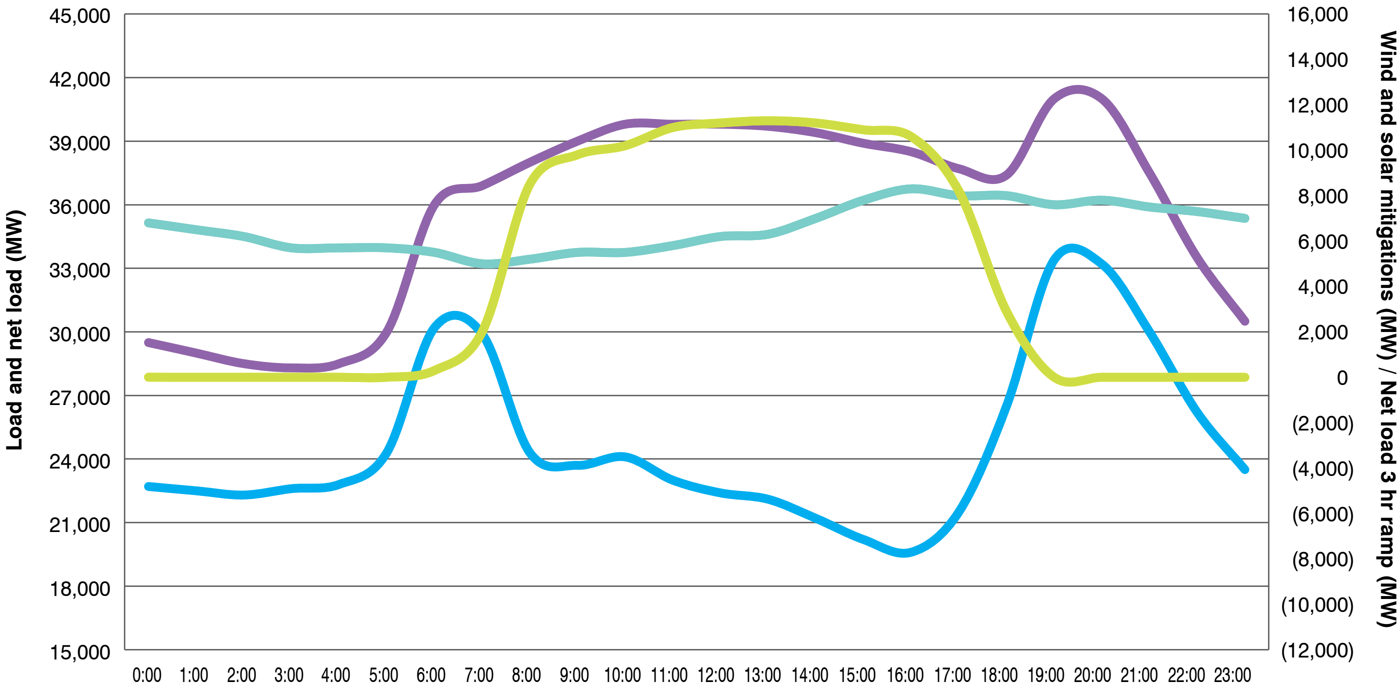


FIGURE 2

Addressing the CAISO duck curve

Load, wind, solar profiles and IG solutions (April 2020)



Source: Clean Coalition

is setting. Significantly, however, this increased ramp is predictable—the sun rises and sets on schedule. This challenge, therefore, is also an opportunity for the DR-enabled consumer to "deramp" their demand. Thus, the duck chart is what will happen if we *don't* enable consumers to play a role in managing their electricity consumption.

To understand this opportunity, context is helpful. Today's electricity customers have more information about their energy consumption, and more power to control it with energy management systems, than ever before. Smart meters, now universal throughout the state, allow consumers to better understand, monitor and act by using real-time information. Smart phones and other connective technologies, which empower customers to access this energy data anywhere at any time, are increasingly ubiquitous.

With this information and control technology, along with a DR program that enables consumer action, people can provide grid benefits by moving demand to times of day when clean, renewable electricity is abundant (i.e., the daytime "belly" of the duck). Consumers themselves will benefit. How? The chart below shows how the duck chart could be addressed, and create opportunities for customers to save money on electricity pricing.

This customer opportunity is made possible through DR. For example, a DR tariff that gives clear price signals to customers is actionable information. A low electricity price during times when solar generation is highest and a higher price when solar generation comes off-line would give customers a financial reason to use more clean electricity nestled in the "belly of the duck" (during the daytime hours when solar energy is most productive).

THE NITTY-GRITTY

How demand response can help meet California's grid needs

Like most DR programs in the country, California's programs were created to respond to emergency electricity shortages. Originally conceived as a power system resource to provide emergency response and peak load management during California's energy crisis, DR was utility-driven and "event"-based.[10] It primarily attracted large industrial, agricultural and commercial consumers. It was built on the shoulders of the one-way communications system of the time, where only the utility, but not the customer, could see and control demand. There was little broad consumer opportunity, since technological limitations (notably, the lack of smart meters), prevented wide-scale access to DR programs. Deployed before the Internet, smart grid technologies and companies like Enernoc and Comverge started aggregating DR from many customers to sell into capacity markets, but DR was rarely triggered and relatively slow in delivery. Put simply, DR historically was not intended to deliver the host of benefits that the resource is capable of today.

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With the high-tech revolution, DR's capabilities have grown dramatically. DR can now help transform our electricity system from a one-way, centralized power network where customers passively receive electricity to a two-way flow of information where people regularly contribute to system operations.

However, it's important to note that DR, beyond its unifying definition (reducing energy demand rather than increasing supply to balance supply and demand), is not a uniform product. Rather, there are many different types of DR, and different products provide different benefits. Likewise, different consumer classes can provide and benefit from different types of DR services.

Types of DR

To best describe various DR products, two distinguishing elements are helpful: 1) whether the DR is dispatchable or non-dispatchable, and 2) whether DR is triggered by the Independent Systems Operator (ISO) or the Load Serving Entity (LSE) (or utility).

Dispatchable v. non-dispatchable DR

Dispatchable DR or "event-based" DR, can respond to specific events. Imagine, for example, that a particularly hot day has created an unusually high demand for electricity. DR used to address this peak demand is dispatchable DR, since it responds to a specific event. Dispatchable DR is typically made up of contracted DR, where customers sign agreements, often with a DR aggregator, to provide energy reductions when the utility or ISO require them.

Non-dispatchable DR, or "non-event-based" DR, can reshape how and when energy is used on a daily basis. For example, imagine a time-of-use (TOU) tariff—which encourages customers to use electricity during a time of day when it is abundant and clean—where the price of energy was one cent in the middle of the day and 50 cents for a few hours around sunset. Given the opportunity to save on electricity bills, a consumer could run the washer and dryer during the middle of the day and avoid running them in the late afternoon. Although not responsive to a particular event, this type of DR would permanently and beneficially help manage our electricity grid.

ISO v. utility DR

In the case of dispatchable DR, one additional distinction is helpful—whether the DR is triggered by the ISO or the utility. Because dispatchable DR is used in response to a particular event, someone needs to determine that the event is occurring and decide whether DR can respond to it. To date, electric utilities are in charge of developing and dispatching most of the DR in California, but the California Public Utilities Commission (CPUC) is now "bifurcating" DR as either "supply-side" or "load-modifying."[11] DR dispatched directly by the ISO will be referred to as "supply-side" DR, while "load-modifying" DR will include all DR directly utilized by the utilities, including TOU rate designs. Notably, the impact of load-modifying DR must be included in the California Energy Commission's load forecast to count against the need for generation.

Table 1 illustrates these categories across the universe of possible DR in California.

Given the opportunity to save on electricity bills, a consumer could run the washer and dryer during the middle of the day and avoid running them in the late afternoon.

TABLE 1
DR categorization

	ISO TRIGGERED	UTILITY TRIGGERED
Dispatchable	Dispatchable DR Event called by ISO	Dispatchable DR called by utility
Non-dispatchable	(No such market in California)	TOU & other rates put in place by utility (in the form of price with enabling information & technologies)

Both dispatchable and non-dispatchable DR can benefit California's electricity system, customers and environment. With this background, we can now examine the benefits that DR offers.

DR benefits

The services that DR provides can generally be grouped into at least four distinct "products": 1) peak energy demand shaving, 2) flattening increasingly steep system ramps, 3) firming intermittent energy resources, and 4) relieving network congestion stress. As the energy landscape changes, these benefits will continue to grow. And as we increase skill in delivery and significant scale in aggregate (i.e. more and more people taking part in DR), DR providers (including customers, utilities and aggregators) can be rewarded for avoiding additional investments in supply-side generation, transmission and distribution resources.

Peak shaving

"Peak" energy demand occurs in the late afternoon, when people are returning home from work and turning on their air conditioners and other large appliances. We, as electricity consumers, can help solve this problem because we are "demand." Critically, the size of the system—the amount of generation and other resources—is determined by what is needed to meet the peak demand—a costly phenomenon that is well within our control.

All types of DR can deliver peak shaving, cutting demand when electricity is most costly and typically relies on the least efficient, most expensive, most polluting, last-in-line "peaker" power plants. Peak shaving can use dispatchable, event-based DR to remove the highest peaks (i.e., those that occur less than 100 hours a year) on a given day. Likewise, non-dispatchable DR can shift demand off-peak, effectively reducing peak demand permanently (which in turn translates to avoided investments in new peak generation capacity and the size of the electric grid planned to meet it).[12]

In fact, EDF's analysis shows that if half of California's Investor-Owned Utilities (IOU) customers switched to their electricity company's existing TOU rates, we could reduce peak demand by enough to save the need for about 30 "peaker" 100 megawatt power plants.[13] And because peaker power plants run so infrequently and inefficiently, this same transition to TOU rates could save electric utilities and customers nearly $500 million annually, a nearly 20% system-wide cost reduction.[14] That is significant money worth saving and pollution worth avoiding.

All types of DR can deliver peak shaving, cutting demand when electricity is most costly and typically relies on the least efficient, most expensive, most polluting, last-in-line "peaker" power plants.

Reducing the slope of system ramps

System ramp refers to an emerging challenge for grid operators in California, when electrical supply increases or decreases quickly, illustrated (see Figure 1, page 5). Specifically, the "net load"—or the amount of electricity production from variable generation resources minus the demand—is expected to skyrocket in late afternoon, coinciding with reduced availability of solar generation. This offers an opportunity for empowered and educated consumers because they can earn money for reducing their peak energy consumption during the late afternoon and shifting it to the mid-afternoon, for example, when solar energy is abundant.

Customers can participate in non-dispatchable DR, such as well-orchestrated TOU rates, to help make system ramps less steep.[15] They can increase demand when the supply of clean energy is plentiful, and decrease demand when supply is constrained or reliant on peaker plants. For example, paying less for electricity during the daytime (starting at noon and ending at 3 p.m. when over-generation is expected to occur) would increase consumption of available clean energy. Higher rates when ramp is needed (e.g., late morning hours, or sunset hours) send a market signal that supply is scarcer and more expensive.

Firming intermittent resources

Renewable resources, such as wind or solar power, have naturally variable outputs that change with the wind and sun. Conventional power plants have high start-up and shut-down costs and are not well-suited to fill in during these relatively sudden and short generation dips. Instead, a responsive and flexible power resource is needed to "firm" the intermittency and successfully integrate renewables into the grid. DR, particularly dispatchable DR, can help anticipate grid balancing challenges by reducing demand over the (usually short) duration when the sun goes behind a cloud or the wind stops blowing. Technological advances such as "automated DR," which can be triggered electronically without any manual intervention, can help to provide this fast-acting service.[16]

Relieving network congestion stress

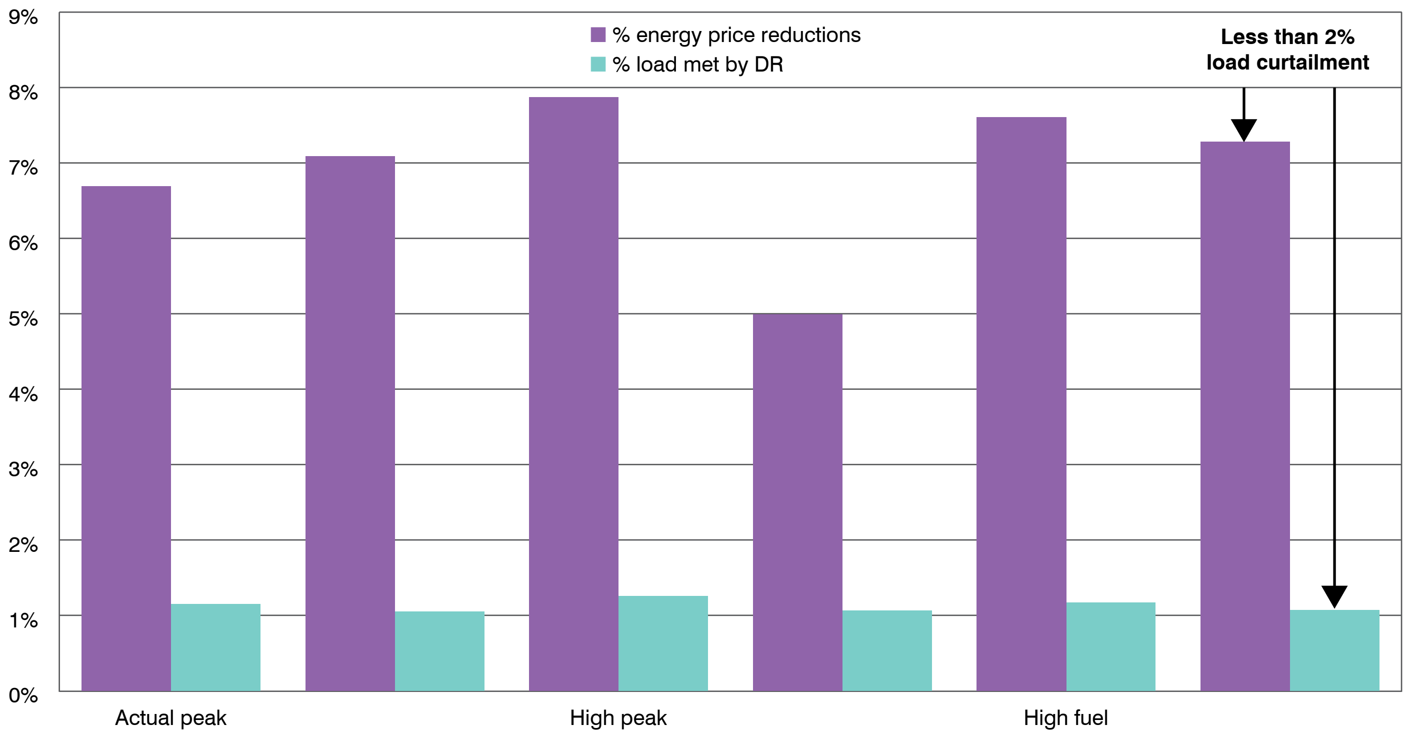
The electrical grid is not only made up of generation facilities (like power plants), it also includes transmission and distribution (T&D) wires to send electricity across the state. This ensures that the electricity generated at a power plant reaches the people that use it. But transmission and distribution have limited capacity; in areas where electricity is in high demand, T&D can become constrained. T&D constraints can be addressed, for example, by expanding T&D infrastructure, installing local distributed generation (like rooftop solar), rerouting electricity to a different transmission line (if available), or by using DR.

All types of DR (although particularly non-dispatchable DR) can help address this issue. By reducing demand and associated congestion, additional T&D lines can be avoided.[17] Relieving congestion can also lower wholesale market prices, since DR eliminates the need for more expensive power plants during periods of otherwise high demand. For example, in 2007 the Brattle Group quantifies DR market impacts for PJM, the Independent System Operator (ISO) in the Mid-Atlantic region. The results indicate that a less than 2% reduction of PJM's peak load would reduce wholesale prices by 5–8% on average (see Figure 3).[18]

FIGURE 3

Quantifying demand response benefits in PJM

Simulated load curtailment and corresponding price reduction in Mid-Atlantic states



Brattle Group. Quantifying Demand Response Benefits in PJM. PJM and MADRI, 2007.

SEIZE THE MOMENT

Three steps to get the most from DR

As discussed earlier, DR is not a uniform resource but a set of different and diverse products. These products, matched to different possible benefits, and offered by different consumers, provide the basis for the following recommendations to increase their value to the system:

1. Identify the benefits that DR provides

The first step towards efficiently integrating more DR resources into grid operations is to identify the value of the specific services a given DR program or tariff can provide, and to codify through law, regulation or regulatory decision that that value merits pursuit. As discussed above, we generally can point to four benefits associated with DR: peak shaving, reducing the slope of system ramps, firming intermittent energy resources and relieving network congestion. The list of benefits will grow and change over time, thus identification should be a predictable process as the energy landscape evolves. This identification process should also involve thoughtful matching between different types of DR programs and the benefits that each type of DR can offer.

All those involved in procuring and deploying DR—customers, aggregators and utilities—should have a reason, as well as the financial ability, to do so.

2. Motivate DR providers to deliver value to the grid

Once DR programs are matched with benefits, a second step is needed: a financial mechanism to offer DR providers an incentive to supply these valuable services to the grid. Put differently, all those involved in procuring and deploying DR—customers, aggregators and utilities—should have a reason, as well as the financial ability, to do so.

California's regulatory structure can make it difficult to provide DR.[19] In other parts of the United States, "Independent System Operators" like CAISO run "wholesale capacity markets."[20] Wholesale capacity markets provide payments to energy resources including DR to ensure that there will be enough energy supply to meet future projected demand. Unlike markets that trade wholesale energy and pay energy providers for electricity, wholesale capacity markets pay providers for this capability to provide energy as a future commitment. However, the CAISO only runs a wholesale *energy* market, not a wholesale *capacity* market, and this existing market alone does not offer full compensation for resources.[21] Instead, the CPUC has a procurement process to satisfy reliability requirements (Resource Adequacy and Long Term Procurement), leaving third-party providers to rely on bilateral utility contracts—a state-run process that is meant to approximate what a capacity market does (i.e., ensure that sufficient energy supply will exist to meet predicted future demand).[22] While this approach may provide some protection after the vacating of FERC Order 745, the result is an uneven playing field. DR providers must sign a contract with a utility to get compensation, but utilities can bid directly into CAISO's markets.[23] This dynamic hinders the natural expansion of DR resources, and could result in both an over-procurement of new fossil-fueled generation and deployment of more expensive energy resources, such as peaker power plants.[24]

Without a fully developed market for DR resources, other mechanisms must unlock DR potential in the state, such as retail tariffs that compensate customers for providing DR services. In developing these mechanisms, we recommend identifying and paying for the multiple benefits that DR can provide, with recognition of high-value locations where it could avoid more costly and polluting investments. These mechanisms can motivate DR providers to deliver those services where they are most valuable to the electricity system. In addition, longer-term DR contracts could also advance the evolution of California's DR market.[25]

In essence, then, this recommendation can be broken down into two necessary actions. First, DR should be allowed to compete on a level (or more level) playing field like other resources. Second, the compensation that those providing DR receive should be related to the benefits delivered to the system. However, each type of DR may provide different types (and amounts) of grid benefit, and not all DR can be monetized in California's wholesale energy markets (even if and when supply-side DR is allowed to be bid direction into the market, demand-side non-dispatchable DR cannot do so.)

Compounding this issue of motivation and mechanisms, different DR programs are treated differently. Some receive credit for value (such as dispatchable DR for peak demand reductions), while others do not (such as non-dispatchable DR for ramping relief). The outcome is, not surprisingly, inefficient. Rather than procuring the least cost DR first, utilities procure the DR that is (artificially) the most valuable. Ensuring that a mechanism links the identified benefits that DR can provide to compensation for the resource owner is critical to motivating DR. One way to do this with non-dispatchable DR is through retail tariff reforms.

Table 2 can be used to indicate the direction the state is currently moving towards in providing compensation and provide a basis to further integrating these ideas.

These mechanisms can motivate DR providers to deliver those services where they are most valuable to the electricity system.

TABLE 2

DR categorization

California's compensation mechanisms

	ISO TRIGGERED	UTILITY TRIGGERED
Dispatchable	Resource Adequacy (RA) credit provided, possibly through Demand Response Auction Mechanism going forward	RA credit currently provided; potentially will not be provided in the future under current CPUC settlement and proposed decisions
Non-dispatchable	No such market in California	Credit or mechanism still needed

Dispatchable, ISO triggered DR

DR that is managed and dispatched by the ISO is becoming the focus of future resource adequacy (RA) credits in California. This credit has value, which principally reflects the benefit DR provides in avoiding peak electric demand, and should be further developed to value the diverse benefits DR can provide. Appropriately valuing these services is of particular interest after the courts vacated FERC Order 745 and the clear compensation guidance that it provided.

Allowing third-party DR providers to bid independently into a market would be a major step forward. As discussed above, in California, DR programs are typically sponsored through bi-lateral contracts with utilities, rather than sold on the market.[26] This procurement mechanism limits the number of DR providers who can do business in California at any one time. The CPUC is currently contemplating a Demand Response Auction Mechanism (DRAM), which would allow more DR providers to compete, including those offering newer and faster technology platforms.

In addition to limited market payments for DR resources, additional barriers stand in the way of DR market integration. A CAISO-commissioned study identified some of these barriers:

expensive telemetry requirements (how DR is measured), an inflexible system of recording demand response registrations, and the inability to test new technologies for regulation.[27] We recommend that the CAISO prioritize and tackle these barriers, using its yearly stakeholder initiatives process as one mechanism to do so.[28]

Dispatchable, utility triggered DR

DR that is managed and dispatched by a utility, but cannot be dispatched by CAISO, currently receives RA credit (and can thus be compensated as capacity, not just energy). As California moves towards integrating more DR into the CAISO market, dispatchable, utility-triggered DR will need to be moved into CAISO markets to be sure it will receive RA credit. The DR settlement put before the CPUC suggested that RA credits would end for this type of DR by 2019, but the CPUC decision accelerated this timeline. This would reflect the movement of the state toward offering RA credit only for DR that can be dispatched by the ISO. If dispatchable, utility-triggered DR cannot receive RA credit, however, the current customers and their aggregators should still be eligible to receive compensation for the specific grid and market services they provide.

Non-dispatchable DR

Non-dispatchable DR programs primarily consist of retail rates designed to reward customers for using clean, off-peak electricity.[29] These rates can simultaneously enable the use and deployment of clean technologies for more customers. Time-variant rates are developed and managed by the utilities, which do not currently receive RA credit—or any credit—for having them. This artificially limits a utility's interest in offering tariff options to customers and may actually present them with a disincentive, since these programs reduce growing peak demand and ramping needs, and thus the utility revenue tied to building the electricity grid.

Just as customers on a TOU rate, for example, pay a lower electric bill if they change consumption use to times when electricity is less costly, utilities should see adequate value in deploying well-designed TOU and other time-variant rates. A mechanism is needed to give the utilities a reason to provide more non-dispatchable DR options to their customers. This mechanism should be based on the values that the non-dispatchable DR provides, including reducing system, customer and environmental costs from traditional generation.

More accurate forecasting could help identify, value and deliver DR.

3. Incorporating DR into forecasting

Forecasting is the process of predicting future demand and whether there is adequate supply to meet it. In California, forecasting is principally done through California Energy Commission's (CEC) Integrated Policy Report (IEPR), in collaboration with the CAISO and the CPUC. The state's demand forecast forms the basis of decisions about utility investments. More accurate forecasting could help identify, value and deliver DR. We recommend that non-dispatchable DR (including good rate design) be accurately included in the IEPR so it counts towards reducing peak demand. To do this, it is necessary to adjust how forecasting is conducted.

Currently, forecasting is done using a top-down approach at the system level, looking at the need for generation based principally on system peak. Incorporating a more bottom-up distribution level forecast would uncover additional approaches to meeting grid needs. For example, a bottom-up approach could find that particular areas on the distribution system are constrained, and that DR (as a non-transmission resource) could address this issue and provide system-level benefits such as reductions in peak demand. By taking into account contributions beyond peak demand, resources that provide multiple benefits to the grid, like DR, would become more valuable and more justly valued.

The next chapter begins

We will have to accelerate the shift to a clean energy economy with innovative, user-friendly technology that puts people in the driver's seat.

California is on the forefront of managing a cleaner and more complex grid, with a growing level of intermittent energy sources. On December 4, 2014, the CPUC took another step forward for DR when the Commissioners unanimously approved a decision crafted by departing CPUC President Michael Peevey ("Peevey DR Decision"), a significant contribution to the acceleration of clean energy deployment in California. Peevey left largely intact the settlement proposed by most parties, while underscoring a commitment to non-dispatchable DR by providing funding for expert assistance, and accelerating the timeline for incorporating dispatchable DR resources into CAISO markets.

The Peevey DR decision, and the proposed settlement that established its foundation, leaves much work to do and lays out a clear timeline for effort. One avenue that clean energy advocates will need to look to is Resource Adequacy proceedings to determine how best to reward load-modifying, non-dispatchable, yet unquestionably valuable, DR for its contributions to reliability (and ramping) capacity needs. EDF sees rewarding demand-side DR like TOU rates as important as bringing supply-side DR into a truly competitive and dynamic market.

This new paradigm presents both challenges and opportunities for grid operators, regulators, policymakers and utility customers. The diversity of DR products adds another level of complexity to the challenges of DR, but these varying products also provide a diversity of benefits. Peak shaving, reducing the slope of system ramps, firming the intermittency of renewable energy resources, and relieving congestion on the electric grid are just a few of the benefits discussed in this paper, and advances in smart grid technology have paved the way for DR to play a greater, faster and more diverse role in addressing California's emerging grid needs.

Though DR has a long history in California, it has not yet reached its full potential in providing clean, reliable electricity services.[30] To unlock DR as a grid asset, utilities, system operators and policymakers should ensure that 1) the ways in which DR can meet emerging gridneeds are identified; 2) this value is recognized and transparently monetized to motivate customers and DR providers; and 3) the benefits of nondispatchable.

DR resources are properly accounted for in forecasts and planning processes. EDF-sponsored recently-enacted Senate Bill 1414 (Wolk) to help bring about these changes. Likewise, parties to the DR settlement, including EDF, have established several working groups to support fuller use of DR.

These next chapters of the California DR story are yet to be written—more action is needed if we are going to meet the challenge of climate change. We will have to accelerate the shift to a clean energy economy with innovative, user-friendly technology that puts people in the driver's seat. DR is good for people, businesses and the environment, and will unlock a future that relies on intelligent, resilient and clean energy solutions. Let's put DR to work for California.

Notes

[1] California's State Water Resources Control Board has issued a rule that will serve to eliminate most once-through-cooled resources by the end of 2020. As a result, 12,079 MW of "flexible" generation resources (i.e., resources that can turn on and off quickly) could retire as early 2017. DR has the capability to help address these flexibility concerns in a far more environmentally benign and cost-effective way.

[2] Under its current Renewable Portfolio Standard, California is set to increase its power generation from renewable sources to one-third by 2020. Increasing this amount to 50% by 2050 is actively under discussion.

[3] At the same time, initiatives such as California's 1.3 GW energy storage mandate, the deployment of smart meters or AMI, net energy metering, and the distribution grid planning expected from 2013's Assembly Bill 327 (AB 327), provide tools to enable the state to confront and leverage this new landscape.

[4] California Public Utilities Commission. *Lessons Learned From Summer 2012 Southern California Investor Owned Utilities' Demand Response Programs.*1 May 2013.

[5] Federal Energy Regulatory Commission. *Assessment of Demand Response and Advanced Metering.*October, 2013. https://www.ferc.gov/legal/staff-reports/2013/oct-demand-response.pdf

[6] Clean Coalition. May 2013. http://www.clean-coalition.org/site/wp-content/uploads/2013/06/Renewables-Integration_Power-08_ssw-17-May-2013.pdf

[7] Ramping refers to swift increases in demand, which must be met in turn quickly with supply.

[8] Further complicating the issue, the "duck-chart" presented below is illustrative of only one day, March 31. Although the graphic is useful in this illustrative context, future, typical system needs will vary. Regardless, the result is clear: a changing system with different needs than in previous years.

[9] California ISO. *Demand Response and Energy Efficiency Roadmap.*December, 2013. http://www.caiso.com/documents/dr-eeroadmap.pdf

[10] Event-based DR is distinguished from non-event-based DR. The former is used to respond to a specific event, at a specific time, and on a specific day (for example, direct load control programs), whereas non-event-based DR typically remains in effect throughout a length of time and number of days (for example, a time of use tariff).

[11] The CPUC first introduced the concept of "bifurcating" DR into supply and load modifying resources in a September 19, 2013 Order Instituting Rulemaking, R.13-09-011, http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M077/K151/77151993.PDF. However, CAISO previously introduced the concept, with the effort designed to move more dispatchable DR into its market. See CAISO *Demand Response and Energy Efficiency Roadmap,* http://www.caiso.com/Documents/DR-EERoadmap.pdf

[12] North American Electric Reliability Corporation. *2012 Long-Term Reliability Assessment.*November, 2012. http://www.nerc.com/files/2012_ltra_final.pdf. p. 48–49.

[13] Environmental Defense Fund. Residential Rate Design Proposal. CPUC R. 12-06-013. http://www.edf.org/sites/default/files/R.12-06-013%20Residential%20Rate%20Proposal%20of%20EDF.pdf

[14] Id. at Exhibit A.

[15] *Demand Response and Energy Efficiency Roadmap.* California ISO. December 2013. http://www.caiso.com/documents/dr-eeroadmap.pdf. p. 4-7; Lazar, Jim. Teaching the "Duck" to Fly. Regulatory Assistance Project. January 2014. http://www.raponline.org/document/download/id/6977

[16] Kiliccote, S., et. al. *Integrating Renewable Resources in California and the Role of Automated Demand Response.* Lawrence Berkeley National Laboratory. November, 2010. http://drrc.lbl.gov/sites/all/files/lbnl-4189e.pdf

[17] North American Electric Reliability Corporation. *2012 Long-Term Reliability Assessment.*November, 2012. http://www.nerc.com/files/2012_ltra_final.pdf. p. 48–49

[18] The study simulated impacts of curtailing loads during the top 20 five-hour blocks in 2005 under a variety of market conditions. Even a modest load reduction in PJM during super peak hours showed substantial energy and capacity market benefits to both curtailed and non-curtailed loads. Brattle Group. Quantifying Demand Response Benefits in PJM. 2007. http://brattle.com/system/publications/pdfs/000/004/917/original/Quantifying_Demand_Response_Benefits_in_PJM_Jan_29_2007.pdf?1379343092. p. 17

[19] Given the recent court decision vacating FERC Order 745, DR as a wholesale energy and capacity product is now subject to much uncertainty. A discussion of Order 745 is beyond the scope of this paper, however, the court decision would seem to indicate that the three recommendations contained here may now be more important outside of only California's market.

[20] PJM Interconnection LLM, for example, operates a capacity market.

[21] Reid, E., et. al. *Distributed Energy Resources Integration.* Olivine, Inc. Jan, 2014. http://www.caiso.com/Documents/OlivineReport_DistributedEnergyResourceChallenges_Barriers.pdf

[22] In California, this process results in credits, currently available to all types of dispatchable DR and traditional energy resources, are known as "resource adequacy" or "RA" credits. Non-dispatchable DR lowers the overall resource adequacy requirement, but does not receive credits nor any other direct economic motivation, furthering this uneven playing field.

[23] FERC Order 745 ensured that demand response customers and their representative aggregators are paid the full value of their services based on the locational marginal price. It was vacated by the courts based on concerns about overextending FERC jurisdiction.

[24] In PJM, for comparison, DR saved consumers $11.8 billion in 2013. See Central Energy Market. Demand Response Industry and Consumer Coalition Reacts to U.S. Circuit Court Decision. September, 2014. http://centralenergymarket.com/blog/demand-response-industry-and-consumer-coalition-reacts-to-u-s-circuit-court-decision/

[25] Multi-year forward obligations, for instance, can give DR providers long-term (more than a year at a time) assurance they will be in business, enabling them to secure necessary financing and develop their product.

[26] Although CAISO has allowed direct bidding by end-users into its market via the "proxy demand response program" since 2010, complexity, regulatory challenges and a lack of clarity has stymied efforts. In 2012, only 6MW of DR was registered directly with CAISO, with none of these bids actually being dispatched. CAISO. *2012 Annual Report on Market Issues & Performance.* 2012. http://www.caiso.com/Documents/2012AnnualReport-MarketIssue-Performance.pdf. p. 30.

[27] Id. at 26-7.

[28] CAISO. *Stakeholder Initiatives Catalog Process.*http://www.caiso.com/informed/Pages/StakeholderProcesses/StakeholderInitiativesCatalogProcess.aspx

[29] No distinction between ISO and utility "trigger" is needed, as non-dispatchable DR programs are not "event-based," nor does an ISO marketplace exist in California.

[30] California Energy Commission. *Integrated Energy Policy Report 2013.* 2013. http://www.energy.ca.gov/2013publications/CEC-100-2013-001/CEC-100-2013-001-CMF.pdf

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