First Person—ISO: A Multifaceted Strategy to Integrate Solar in California

The Story in Brief

Mark Rothleder is Vice President of Market Quality and Renewable Integration at the California Independent System Operator (ISO). In this interview with *EPRI Journal*, he discusses how solar is reshaping the California grid and how California ISO is integrating it into operations.

EJ: You're the longest serving employee at California ISO. What keeps you excited about grid operations work?

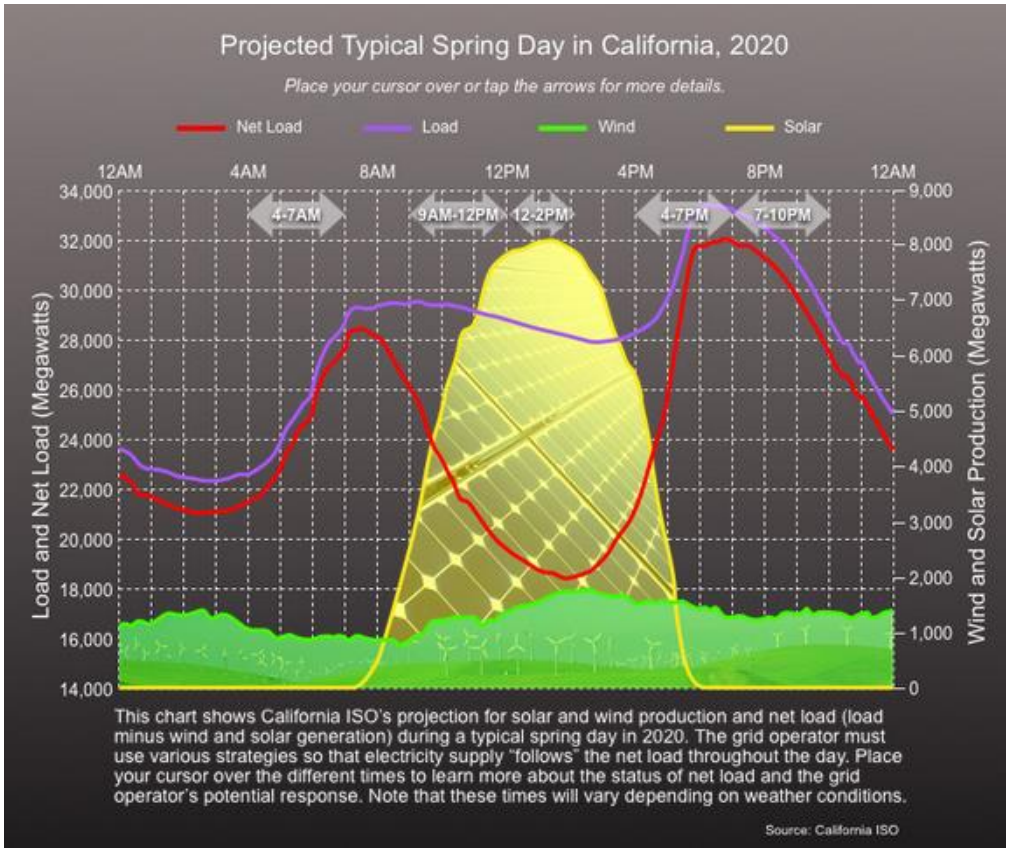

Mark Rothleder

Rothleder: I'm employee number 4, starting in 1997. It's exciting how we're changing grid operations. In 1997, it was, 'How do we deregulate and have an open market?' Now the work has expanded to, 'How do we leverage that open market to integrate renewables and reduce the impact of greenhouse gases on the environment?' Over the long term, I'm excited about the continuing transformation to a low-carbon grid—and am looking forward to the opportunity to use renewable generation to enable other sectors such as transportation and buildings to reduce their carbon footprint. There are a lot of interesting things going on and many smart people working on them, and for me California ISO is the place to be.

EJ: Describe how solar is reshaping the California grid.

Rothleder: With respect to "in-front-of-the-meter" solar connected to the transmission and distribution grids, we surpassed 7,500 megawatts of solar production during our last peak production period on March 31. For context, California ISO's installed electric generation capacity is about 72,000 megawatts. The ISO's peak load is about 50,000 megawatts. The California Energy Commission and Public Utilities Commission jointly report that about 4,100 megawatts of "behind-the-meter" solar is now installed. The transmission-connected solar has

reduced our peak loads and played an important role filling in for reduced hydropower production over the last 3 or 4 years as a result of the drought.



EJ: What operational challenges have resulted from the influx of solar?

Rothleder: This year has been a more normal hydro year, and as we start getting mountain snow runoff, we're seeing more oversupply as a result of combined solar and hydro production when there is low demand. Managing oversupply is a challenge as we reduce output of other generation resources, including natural gas and coal to the extent possible. We can't turn every other resource off because we need some of them on for the evening load ramp as the sun goes down and people come home from work and turn on appliances.

A second challenge is that we are seeing a greater load ramp in three evening hours. Three and a half years ago, that ramp was about 6,000 megawatts. Now it's approaching 11,000 megawatts, and we'll be at 13,000 megawatts in a couple more years.

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EJ: Have you experienced any grid stability problems due to solar?

Rothleder: We haven't had stability problems, although on cloudy or partly cloudy days we're getting more supply swings in the range of 1,000 to 1,500 megawatts over 10- to 15-minute periods. Those swings are expected to increase in frequency and magnitude, so we will need to have enough operational flexibility to respond quickly and effectively. We do not typically activate our operating reserves for these swings.

EJ: What is California ISO's thinking about how to address these challenges?

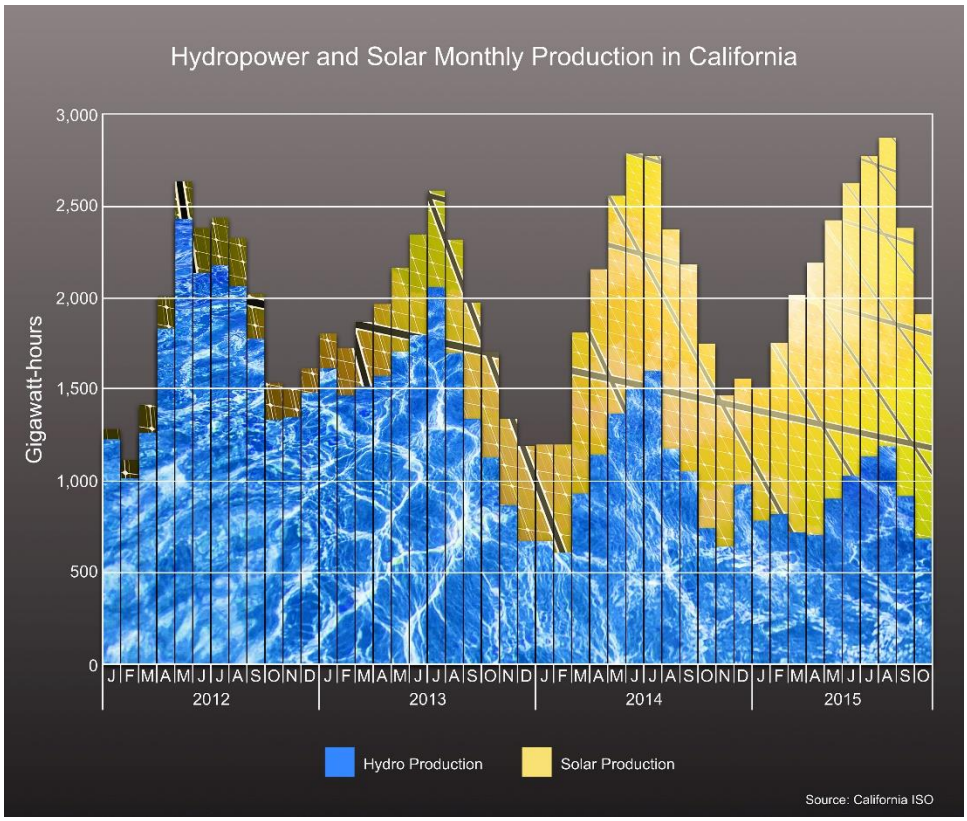
Rothleder: Our strategy is multifaceted. Energy efficiency can be helpful to bring down demand and reduce the evening ramp. Energy storage and advanced demand response are higher cost alternatives for now, but we believe as costs come down they will increasingly be part of the longer term solution to reduce solar generation curtailments. Solar and other renewable resources with smart inverters may provide grid reliability services such as frequency response, reducing the need to maintain other resources to provide such services. This does not require us to send any signals to the resources.

Aligning the retail rate structure and market design with today's grid resources is another important strategy. We need to send the right price signals, whether it's time-of-use rates or dynamic pricing. As we reach higher levels of renewables, we expect that regional coordination and diversifying the portfolio both geographically and technologically will be necessary parts of the solution.

EJ: How is California ISO forecasting solar generation right now, and what improvements are needed?

Rothleder: On the utility-connected side, a weather forecast company provides us with project-level solar forecasts. On the behind-the-meter distribution side, we work with a company that provides aggregate forecasts.

Many forecast experts track cloud movement, and that's good when there's gradual west-to-east movement across large solar fields. Where they fall short—and where research and development is needed—is thunderstorm cloud development over the fields. It's something that can happen rapidly and doesn't get adequately covered in cloud movement forecasts. Last summer, we experienced days when thunderstorm clouds developed over the solar fields in the southeast California desert, and we had some pretty big misses on our solar forecasts—off by as much as 4,000 megawatts between noon and 4:00 p.m. We're having discussions with forecast experts about developing new models to address this.



This chart of California hydro and solar production shows how solar helped to address the hydro shortfall as a result of the drought.

EJ: What are California ISO's plans with respect to operational control of solar resources?

Rothleder: For transmission-connected solar, we certainly want increased control. The newer solar projects enable the system operator to automatically dispatch the resources every five minutes, and that's been helpful. Short term, we'd like to get voltage support from solar resources, and we're involved in stakeholder efforts on the state, regional, and federal levels to develop interconnection rules to provide that capability.

Longer term, we will need active power control. When the sun rises, we get a 7,000-megawatt production ramp very quickly. If the solar doesn't have enough geographical diversity, there will come a point where the grid cannot accommodate so much, so fast—and active power controls can help manage that.

If we can get solar plants to be responsive to signals from us, we may be able to use them for frequency regulation as well. We have some demonstrations with new solar resources looking at this kind of control.

On the distribution side, we don't seek to directly control individual distributed solar resources. Instead, we're working with distributed energy resource aggregators on ways to manage these resources. Potentially, we could send signals to an aggregator requesting it to increase or decrease output.

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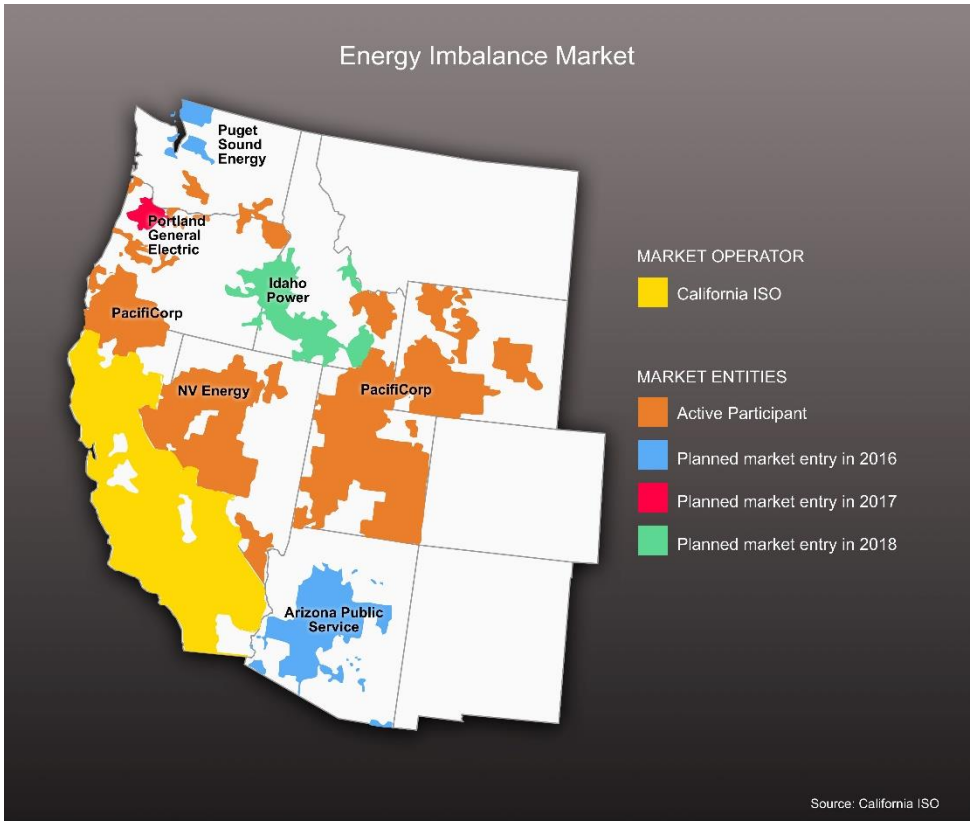
EJ: In November 2014, California ISO launched a regional coordination effort called the Energy Imbalance Market. How does the market work, and what have been the benefits and challenges?

Rothleder: The western Energy Imbalance Market is a real-time market that enables grid operators in six western states across different time zones to work together to balance last-minute energy supply and demand, which gives the participants more dispatch flexibility. For example, evening wind power in Wyoming can be used to help meet California's afternoon peak. We now have about 1,800 megawatts of economic transfer capability available in real time that was not available before. An algorithm determines the lowest cost resource to dispatch and transfer every 5 minutes and every 15 minutes to meet demand forecasts.

The market enables more efficient, cost-effective dispatches for the participants and often supports the full use of renewable energy. For example, when California has solar generation oversupply, we send the energy to our neighbors, which enables them to potentially reduce output of their non-renewable resources such as those fueled with natural gas or coal. That reduces the cost of curtailing renewable generation in California, and it saves our neighbors money because they're getting lower cost energy. Sharing flexible reserves has also reduced the participants' costs for maintaining those reserves. As of the last quarter, we're at about $64 million of benefits since the market launched.

With respect to the challenges, it's a paradigm shift for traditional balancing areas to have another market dispatch operating in parallel with their own operations. As we bring more balancing areas into the market, we will need more training on communications and information flow. For example, if an operator is ramping up a resource in response to a contingency event on the grid, he needs to inform the energy imbalance market and its automated dispatch about that action. Otherwise, the market may erroneously determine that it needs to respond to an energy shortfall.



EJ: What are the plans for the market's expansion?

Rothleder: Interest from other areas is expanding. Arizona Public Service and Puget Sound Energy are scheduled to begin participating in the Energy Imbalance Market this year. Portland General Electric will join next year, and Idaho Power announced its intent to join in 2018.

California Senate Bill 350, which passed last year, increases the state's renewables target from 33% to 50% by 2030 and authorizes the transformation of California ISO into a regional energy market—which expands upon the real-time balancing services provided by the Energy Imbalance Market to include more comprehensive services such as day-ahead grid optimization and long-term infrastructure planning. So we're working with stakeholders on a series of studies to examine how such a transformation would benefit California ratepayers, jobs, and disadvantaged communities, and how it would impact greenhouse gas emissions. Day-ahead planning would make the regional market even more efficient. If you can predict an oversupply a day in advance, the participants may not need to commit and transfer resources across markets.

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EJ: What are California ISO's needs for flexible generation capacity to help balance solar generation, and how are you pursuing them?

Rothleder: One way we're addressing the need is through our flexible ramping products. These are real-time and day-ahead energy products intended to manage generation resources so that we have enough operational flexibility, or resource options, in the right places at the right time. We use a flexible ramping algorithm that determines how much ramping capability in megawatts is needed for the next three 5-minute intervals and which resources can support that.

We're concerned about the possibility of not having enough flexible resources available as renewable generation increases and flexible resources are shut down or retired. We're quantifying how much ramping capability needs to be installed on the system to address the net load increase as a result of the reduction of solar production in the early evening. Last year, the California Public Utilities Commission put a mechanism in place for assessing flexible resource needs through its annual resource adequacy program. The commission has stated that a certain portion of our resource adequacy capacity needs to be dispatchable flexible resources. Currently, that portion is about 11,000 megawatts, but that is expected to increase.

EJ: What improvements are you working on with the flexible ramping products?

Rothleder: Currently, the ramping products enable procurement of up-ramping resources only. The next generation will have downward ramping capability to address energy oversupply. We're enhancing how we quantify ramping needs, over what period we need it, and how we allocate payments to energy resources.

EJ: California has a 1.3-gigawatt energy storage mandate. What function do you expect storage to serve in integrating solar and other renewables? What are the challenges?

Rothleder: The mandate helps to kick-start innovative storage applications. The longer term storage opportunities are in absorbing oversupply and providing frequency response.

The biggest challenge with large-scale storage is the high cost. Because grid-scale storage is such a large investment, a key question is how you share that investment among multiple entities that benefit from the projects. Small-scale battery projects don't suffer from that challenge.

EJ: What role do you expect demand response to play?

Rothleder: If you can couple demand response programs with the right price signals and time-of-use retail rates, you can potentially increase load at times when you want it—when electricity prices are low and you have an oversupply condition—and decrease load when you have too little supply or need to ramp up generation resources. I expect that such activities will be driven by large-scale industrial customers and demand response aggregators managing many smaller customers. Because demand response happens on the distribution system, it brings up the need for new coordination between distribution system operators and transmission system operators.

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EJ: How can regulatory changes help?

Rothleder: Regulatory changes can help us make better use of energy resources, which strengthens grid efficiency and reliability. These include new solar interconnection requirements and regulations that enable solar resource aggregators to participate in the energy market.

EJ: What are the most important R&D needs for solar integration?

Rothleder: Solar forecasting is one. Another is how to optimize the grid operator's control systems to make the best use of smart inverters. A third is how to use renewables for both upward and downward ramping so that they can provide reliability services such as voltage and frequency support.

EJ: What advice can you offer grid operators in other regions where solar penetration is still low but likely to grow?

Rothleder: We've been learning from their experience as well as sharing our experience using markets to integrate higher levels of renewables. Regarding advice, one is start preparing your system and your operations. Start thinking about whether you need additional flexible resources and how you will manage them to be responsive to variable solar generation. Collaborate with the renewable resource developers in your region so that they can be part of the solution.