

## Impacts of renewable energy on grid operations

*California has made great strides toward a low-carbon electric grid. However, the rapid rise in solar and wind resources coming onto the system has created a new operating paradigm, in which the system frequently has too much renewable energy, without adequate customer demand to use it. This is called “oversupply.”*

A swift rise in California’s renewable energy capacity, especially solar generation, is the main driver behind the growing occurrence of oversupply. About 2,000 MW of solar capacity has been added in each of the last three years, and all-time solar generation peaks are becoming a common occurrence.

Solar and wind resources now make up more than 60 percent of the ISO’s renewable generation. At a certain point in April 2017, the ISO had 64 percent of its electricity load served by solar and wind generation.

That’s all good news for the ISO, which has built its strategic vision around integrating renewable energy into the power grid. But it also means the state can’t use all the renewable energy it could be making.

### Managing oversupply

Currently, the ISO’s most effective tool for managing oversupply is to “curtail” renewable resources. That means plant generation is scaled back when there is insufficient demand to consume production. Curtailment is the reduction of output of a renewable resource below what it could have otherwise produced.

It is calculated by subtracting the energy that was actually produced from the amount of electricity forecasted to be generated. Unlike other renewable resources like small-conduit hydroelectric, geothermal, bio-mass and bio-gas, new solar and wind resources are able, both technologically and contractually, to respond to oversupply conditions by reducing their production output.

Curtailing renewables results in lost opportunities for clean resources to generate all of the carbon-free power that otherwise could be produced. As more renewables come onto the system, oversupply during the middle of the day, when the sun is brightest, is happening more frequently, and curtailing of solar resources is becoming a common practice. The ISO started explaining this phenomenon in 2013, with the creation of the “Duck Curve,” a graphical depiction of future loads with an increasingly renewable electricity system. [Click here](#) for more information on the Duck Curve.

### Understanding curtailments

Curtailments can occur in three ways: economic curtailment, when the market finds a home for low-priced or negative-priced energy; self-scheduled cuts, which reduce generation from self-scheduled bids; and exceptional dispatch, when the ISO orders generators to turn down output.

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Curtailment is occurring at a growing rate especially in the spring months.

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During times of oversupply, the bulk energy market first competitively selects the lowest cost power resources. Renewable resources can “bid” into the market in a way to reduce production when prices begin to fall. This is a normal and healthy market outcome. Then, self-scheduled cuts are triggered and prioritized using operational and tariff considerations.

Economic curtailments and self-scheduled cuts are considered “market-based,” because the ISO’s market optimization software automatically adjusts supply with demand.

Finally, if market-based solutions haven’t cleared the surplus of electricity that could be generated, the last resort is for the ISO to manually intervene, which is called an “exceptional dispatch.” In this scenario, ISO grid operators call on specific renewable plants to reduce output to prevent or relieve conditions that risk grid reliability. The exceptional dispatch order is considered a “manual” curtailment, because the ISO operators must manually intervene. This is not preferred, because it does not ensure the lowest cost resources are called upon to serve Californians, and in many cases, it reduces the output of renewable plants.

### **Curtailments on the rise**

In 2015, the ISO was forced to curtail more than 187,000 total megawatt-hours (MWh) of solar and wind generation. In 2016, that number rose to more than 308,000 MWh.

The overwhelming bulk of those curtailments came in the form of economic curtailments: almost 178,000 MWh in 2015, and more than 305,000 MWh in 2016.

When comparing spring months in recent years, the ISO recorded a 147-percent increase in renewable curtailment from the first quarter of 2016 to the same time frame in 2017. In the first quarter of 2017, about 3 percent of the total potential wind and solar generation was curtailed, and about 1 percent of the total potential renewable generation was curtailed. But during certain times of the year, it’s not unusual to curtail 20 to 30 percent of solar capacity. On March 11, 2017, the ISO observed solar curtailment exceeding 30 percent of the solar production for an hour.

This spring will bring an even more challenging oversupply situation. An abundant snowpack will send extra water to hydropower generators, leaving less room on the system for solar and wind energy. Snow pack in the mountains in 2017 is above normal, and we expect that in-state hydroelectric production will be more than 2016.

### **Meeting the state’s 50-percent renewable goal**

The ISO can manage oversupply conditions from operational and market standpoints, but this growing trend of curtailing renewable resources can be troubling from a policy perspective, especially as the state’s utilities transition toward fulfilling a 50-percent renewable mandate.











Curtailing renewables is counterintuitive to California’s environmental and economic goals. It reduces the output from the renewable plants in which the state has invested, and could result in overbuilding renewable plants to ensure that the state meets its 50-percent renewable mandate. Overbuilding the electric system is not financially sound.

While curtailments are currently representing only a fraction of overall load, the issue is expected to intensify in the coming years as the state strives to achieve its 50-percent renewable target. Net load is already deepening faster than was anticipated, and the afternoon-to-evening ramp is rapidly getting steeper.

## Are there solutions?

There are several promising concepts and technologies being explored to minimize oversupply and curtailment including:

 <p><b>Storage</b> – increase the effective participation by energy storage resources.</p>	 <p><b>Western EIM expansion</b> – expand the western Energy Imbalance Market.</p>
 <p><b>Demand response</b> – enhance DR initiatives to enable adjustments in consumer demand, both up and down, when warranted by grid conditions.</p>	 <p><b>Regional coordination</b> – offers more diversified set of clean energy resources through a cost effective and reliable regional market.</p>
 <p><b>Time-of-use rates</b> – implement time-of-use rates that match consumption with efficient use of clean energy supplies.</p>	 <p><b>Electric vehicles</b> – incorporate electric vehicle charging systems that are responsive to changing grid conditions.</p>
 <p><b>Minimum generation</b> – explore policies to reduce minimum operating levels for existing generators, thus making room for more renewable production.</p>	 <p><b>Flexible resources</b> – invest in modern, fast-responding resources that can follow sudden increases and decreases in demand.</p>

The ISO is working with stakeholders and state leaders to leverage these tools, and looks forward to thoughtful discussion leading to solutions to the rising trend of renewable curtailment. Without these solutions, oversupply will create barriers to the full transition to a greener, more cost-effective, efficient grid.