What is the “duck curve”?

An avian graph shows the challenges facing burgeoning solar power

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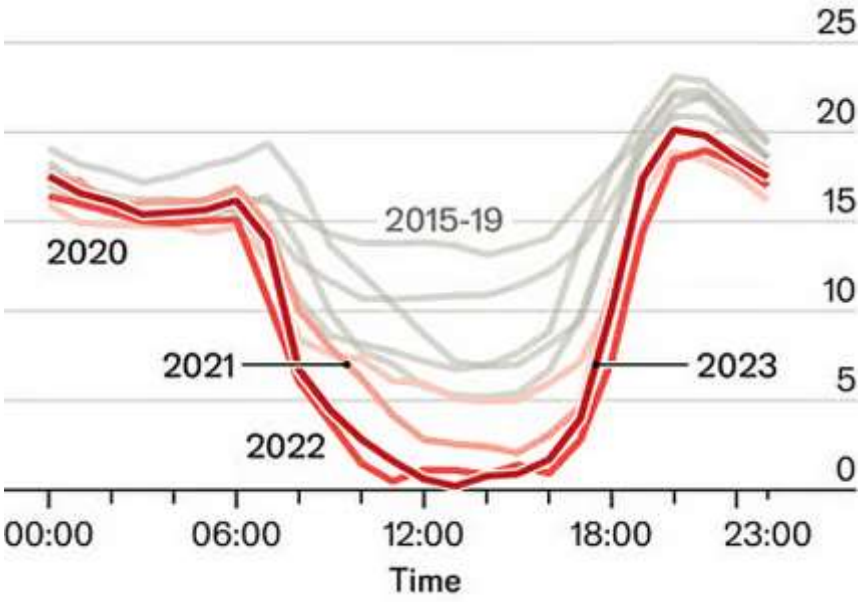
Electricity markets must match supply and demand at every moment. The electricity that consumers use must always, second-by-second, be the same as the amount produced. Demand for electricity, known as “load”, is lowest at night and highest in the early evening, as people return from work and turn on lights and appliances. Plot load, in gigawatts, against the hours of the day starting from midnight and it will look like a slanted “s”, dipping during the early hours of the morning, then rising until the early evening peak, before falling again. But solar panels are transforming energy markets—and regulators have given an avian name to one of these transformations. Why are solar panels creating a “duck curve”, and why is that a problem for electricity grids?

Solar energy is inflexible. Panels are most productive in the middle of the day, when the sun is highest; they generate very little power once it sets. That changes the calculation for the system operators who manage the electricity grid. Instead of serving the total amount of load, ensuring there is sufficient generation to meet demand, they need to concern themselves with the “net load”, or the electricity which solar power cannot provide. Plot this net load against the hours of the day and instead of a slanted “s” it looks like a duck, its belly lying low in the water during the sunniest part of the day while in the evenings its neck rises rapidly. The more solar on a grid, the faster other sources of supply must be added in the evenings to meet this peak load.

Satisfying peak load has generally meant firing up natural-gas power plants, which are far cheaper than nuclear or coal plants to run as intermittent backup. But gas plants cannot be turned up and down instantaneously. They are, essentially, huge spinning cylinders of metal, meaning there is inertia

which must be overcome. Making room on the grid for the natural-gas plants, as well as residual nuclear energy, means curtailing solar power—throwing away free low-carbon electricity in favour of more expensive and dirtier gas.

Peaking Duck
California, net electricity demand*, gigawatts.
Lowest net demand day each spring ^



* Excluding wind and solar power ^ March to May
Source: EIA

chart: The Economist

Often solar providers are paid fixed subsidies for every unit of energy they produce, so they need to be paid extra to forgo these subsidies. Oversupply can even lead to negative prices for electricity as generators bid to be paid not to produce power rather than to produce it.

There are a number of solutions to this problem. One is encouraging businesses and consumers to use electricity more flexibly; new pricing deals

may give drivers a bonus for charging their electric cars in the middle of the day, for instance. Some entrepreneurs are seeking to turn cheap solar into low-carbon liquid fuels, such as hydrogen, which could perhaps replace natural gas. Another possibility is to store the electricity for later. California, where the duck curve was first spotted (see chart), is increasingly using utility-scale batteries alongside solar. In April 2024 batteries displaced roughly half the generation that natural gas had provided during the same month the previous year. For now the duck curve is still a measure of the challenges facing grids from the rise of solar power—but it may come to be seen as a representation of the opportunities that virtually free electricity provides. ■

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