Tracking the Duck

Having installed 2.7 GW of new PV capacity in 2013, California is moving faster than any other state (and any country except China, Japan, and Germany) in bringing in solar energy to displace fossil-fuel electricity generation. However, the potential for disruption to the grid by high levels of solar generation has been illustrated by the now-infamous "Duck Curve":

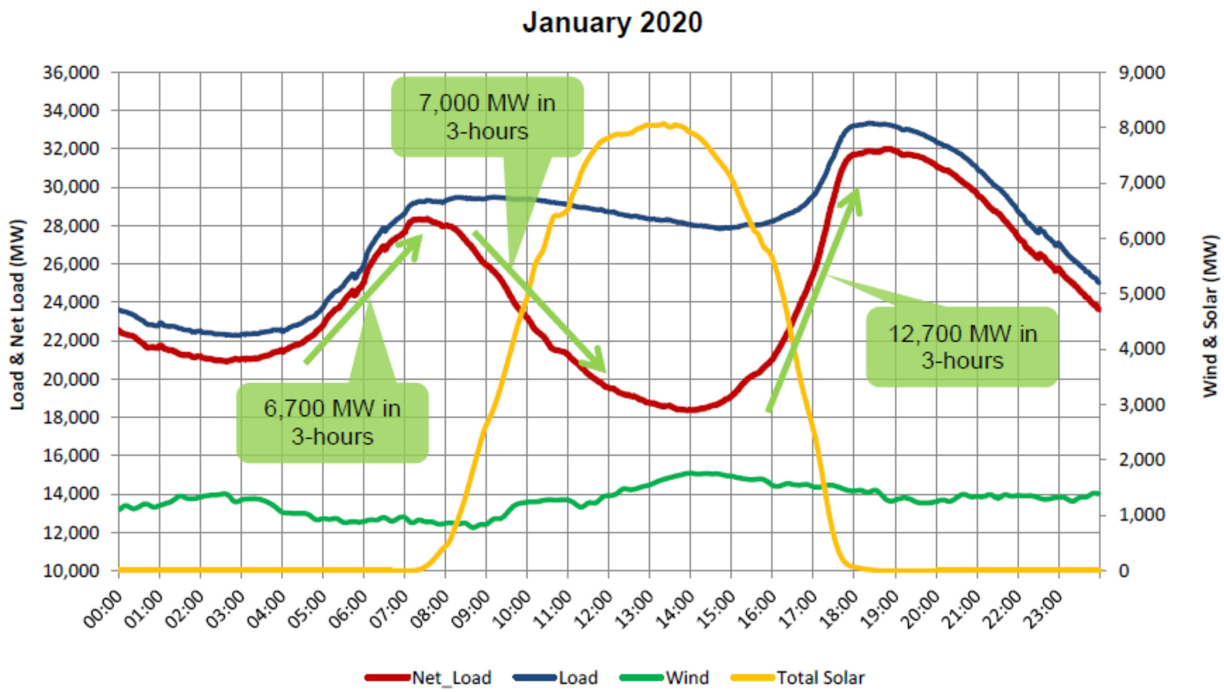

Figure 6: Load, Wind, and Solar Profiles – Base Scenario

Figure 1. "Maintaining Bulk Power System Reliability While Integrating Variable Energy Resources – CAISO Approach" (accessed at: http://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC-CAISO_VG_Assessment_Final.pdf)

The "net load" that is not covered by wind and solar resources must be met by ramping (up and down) other dispatchable power sources. Relative to the load without wind or solar, the net load profile presents an additional ramp down in the morning and a bigger, steeper ramp up before peak load in the evening. The month of January has likely been chosen because it illustrates a worst case for California: on a mild, sunny January day, midday demand (for heating and cooling) is relatively low while the solar output is high. The resulting steep "neck" of the duck by 2020 suggests that gigawatts of capacity from new, fast-ramping gas turbine generators might have to be brought online to meet the net load profile.

There are a number of reasons curves like this may be overstating the challenges to be met by 2020. Options for "Flattening the Duck" have been provided by the Clean Coalition and for "Teaching the Duck to Fly" by the Regulatory Assistance Project. For the system operators, it's also reassuring to note that this ~35% reduction in midday net load expected by solar generation in 2020 is still less than the 40% reached by Germany's grid last summer.

There is also the impact of trackers. Based on its shape, the duck curve above appears to assume that solar generation is mainly from fixed-tilt (possibly rooftop) PV (Figure 2). However, the largest solar (PV) projects in the Southwest are going in on trackers (or, for CSP, with heliostats). Bringing tracker-based solar online improves the shape of the duck. For example, PV mounted on horizontal trackers aligned along a north-south axis (such as those on the 550-MW Topaz Solar Farm) will produce less peak power in January, due to the low winter sun angle. This flattens the belly of the January duck considerably. Output from horizontal north-south trackers rises in the summer months, which will help match the higher midday summer demand from air conditioning loads.

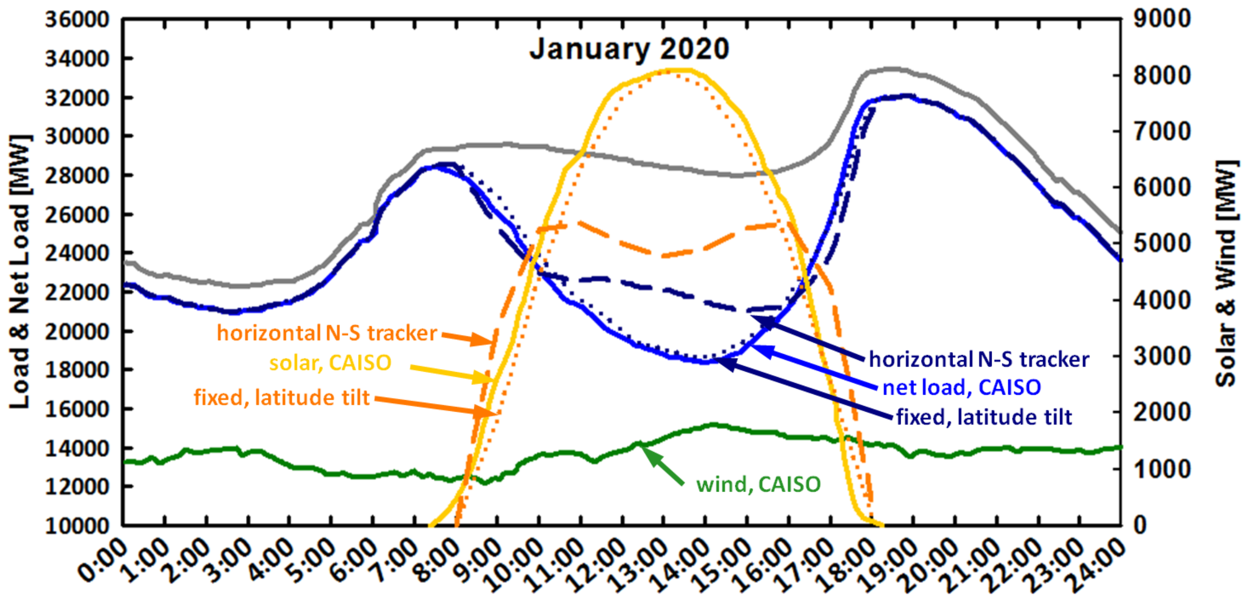

Figure 2. One example of the impact of tracking on the duck curve. Solar resource data is derived for Palmdale, CA in January.

Tracker-based solar has other ancillary benefits as well. Trackers can be "back tracked" to either reduce shading (boost output) or provide power curtailment (reduce output) for those times when over-production from PV becomes a problem (someday). PV modules on trackers can be "bladed" into high winds and tilted vertically to minimize damage from hailstorms. The combination of PV on trackers should therefore lead to some novel feedback effects on how PV modules are designed, installed, and operated. (For modules that can be tilted away from hail impacts, can cheaper front glass be used?)

The commercial PV modules of today are still designed for a residential rooftop, sized so that they can be carried by one person, up a ladder. Even large-scale ground-mount array installations therefore remain highly manual construction efforts. As tracker-based PV arrays are heavier and more expensive to install, this should incentivize development of more mechanized installation techniques. If other large-scale construction projects are a guide, this will deliver substantially lower installation costs. Meanwhile, since the PV module becomes a smaller component cost of a tracker-based array, the demand for higher energy yields (to offset higher O&M costs of trackers) should shift the cost-benefit optimum towards higher-efficiency (and mode durable) PV module designs.

A combination of government incentives and lower land costs has given ground-mount installations a dominant presence in the U.S. PV market (75% of installed capacity in 2013). The resulting opportunity for tracker-based arrays promises to change how PV is built and operated - and thereby accelerate solar's penetration of the grid.