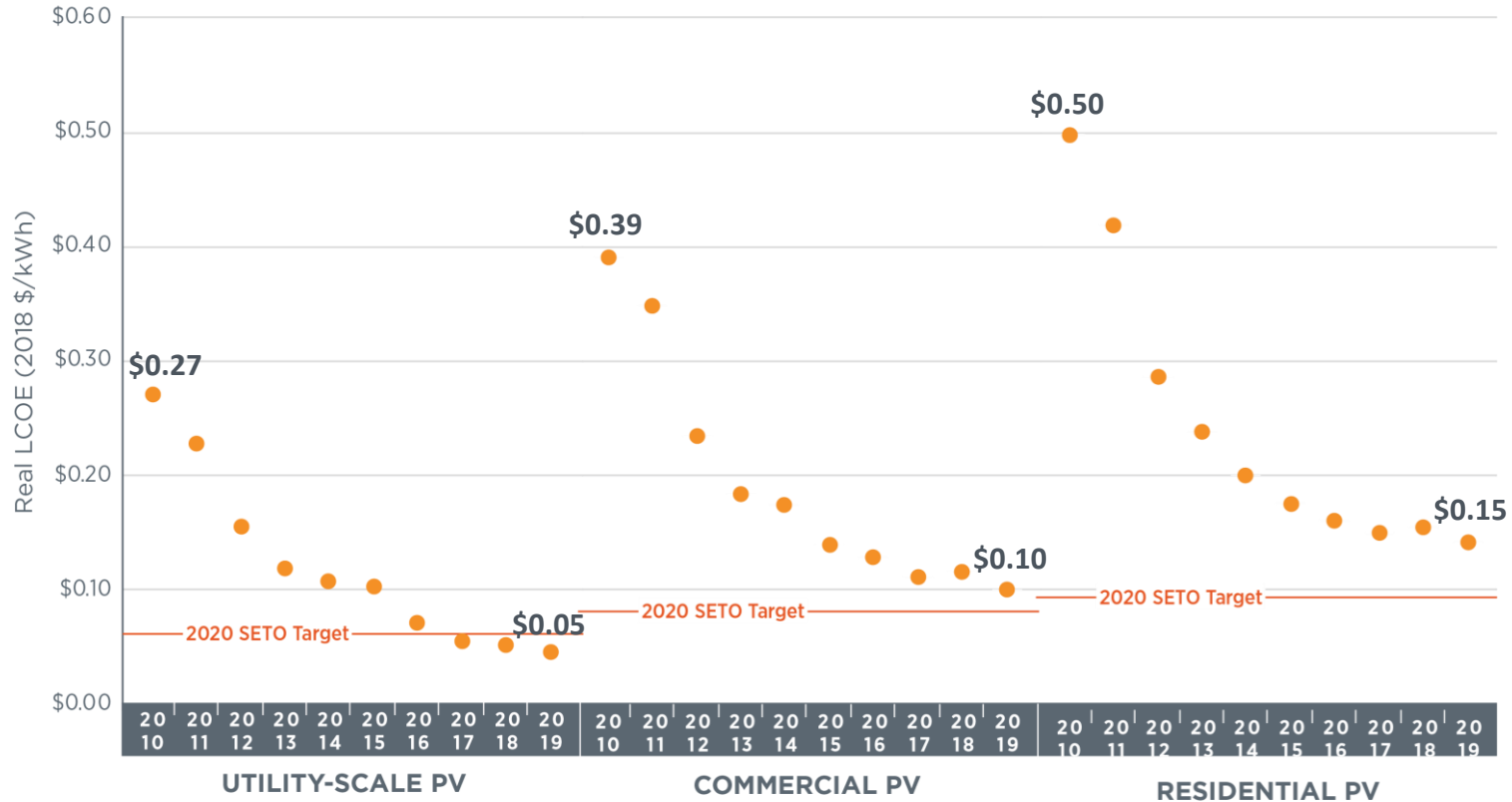


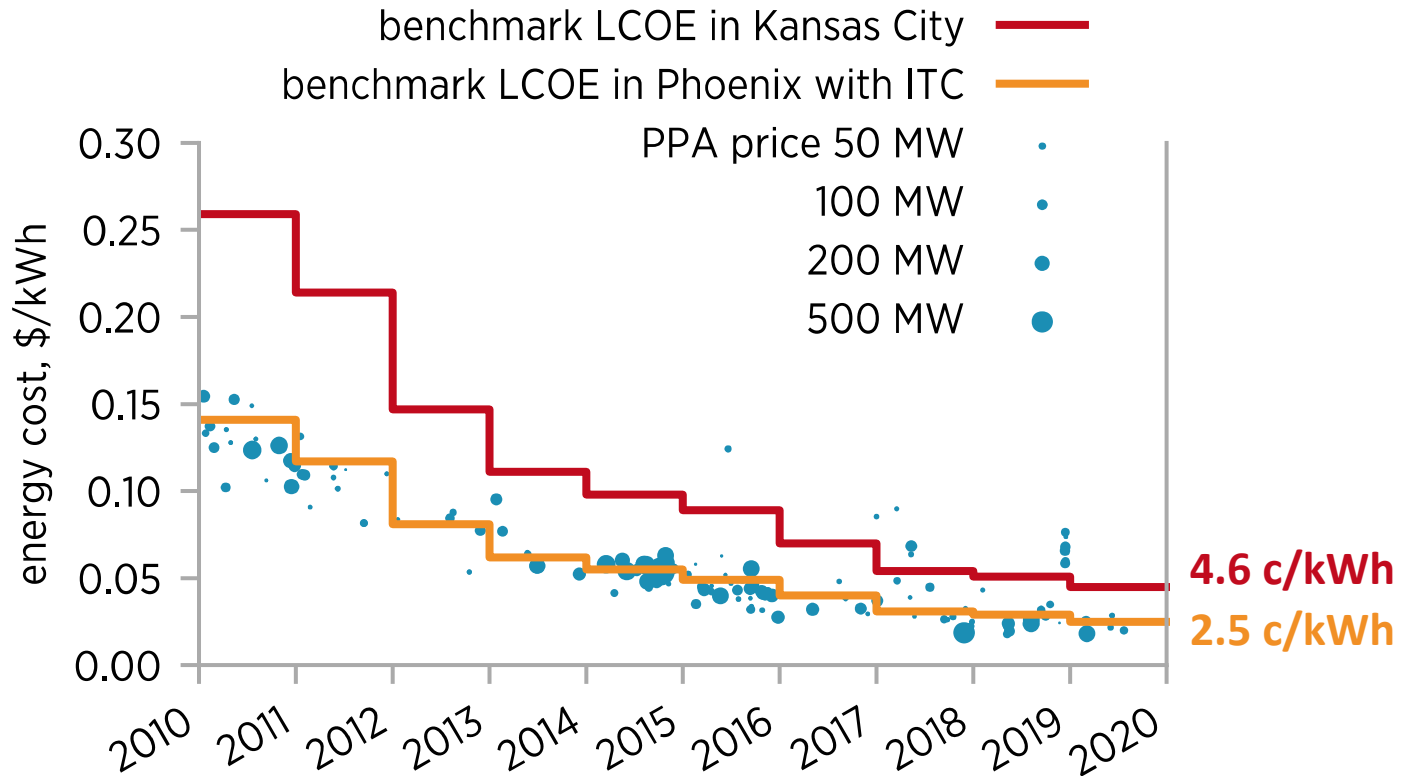
Solar Technology – Status and Prospects

Becca Jones-Albertus, Director
Solar Energy Technologies Office

Cost Declines of 70% - 80% over the Last Decade

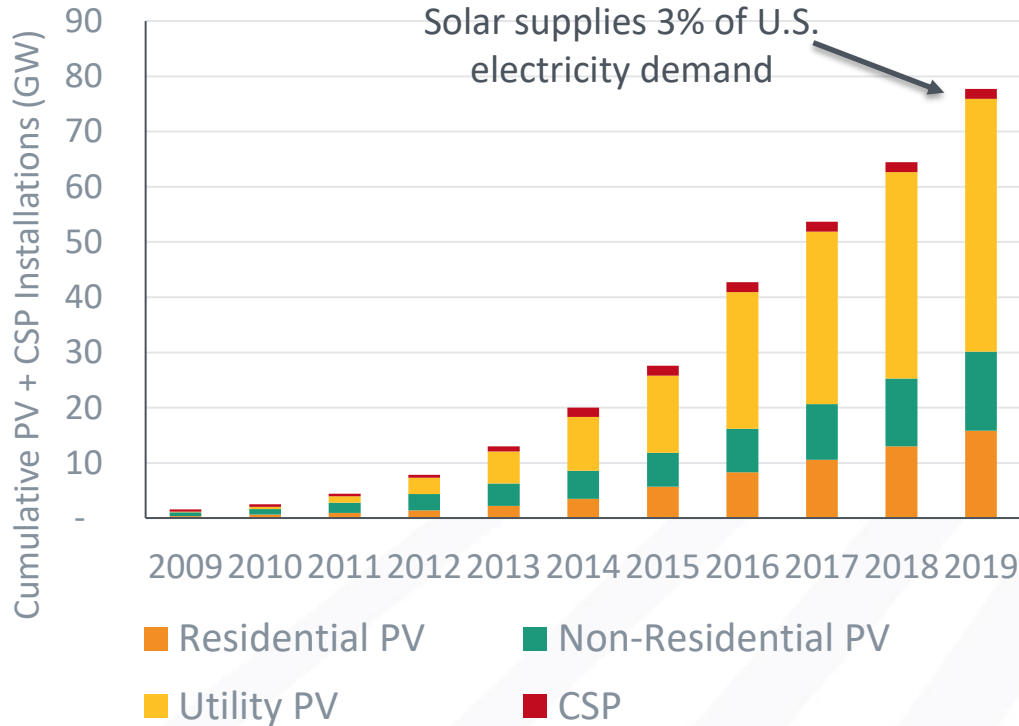


Real Costs: PPAs

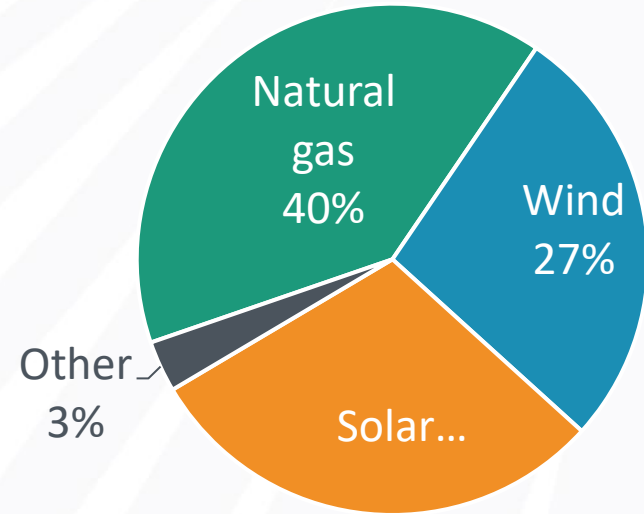


Source: NREL (Tim Silverman) and LBNL

U.S. Solar Capacity Grows 50x in 10 Years



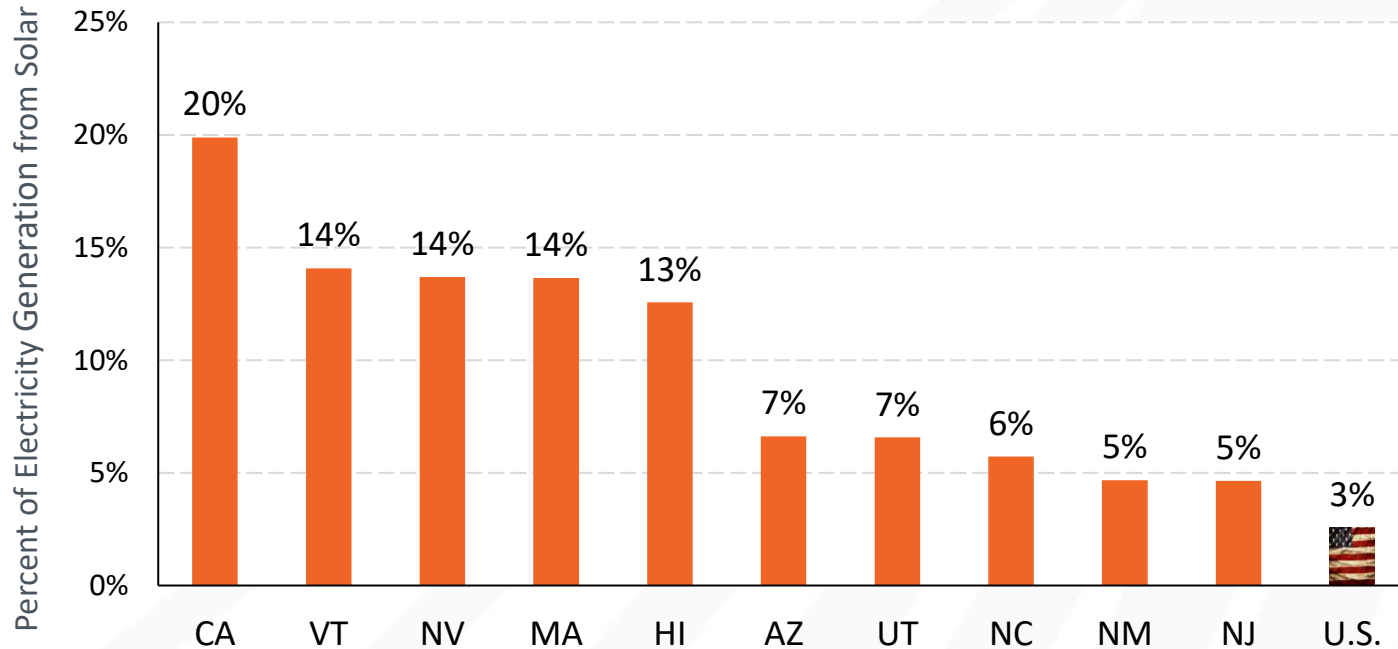
New Capacity from 2015 - 2019



There are **over 2.5 million** solar energy systems connected to the U.S. electricity grid.

Sources: Wood Mackenzie, U.S. Energy Information Administration

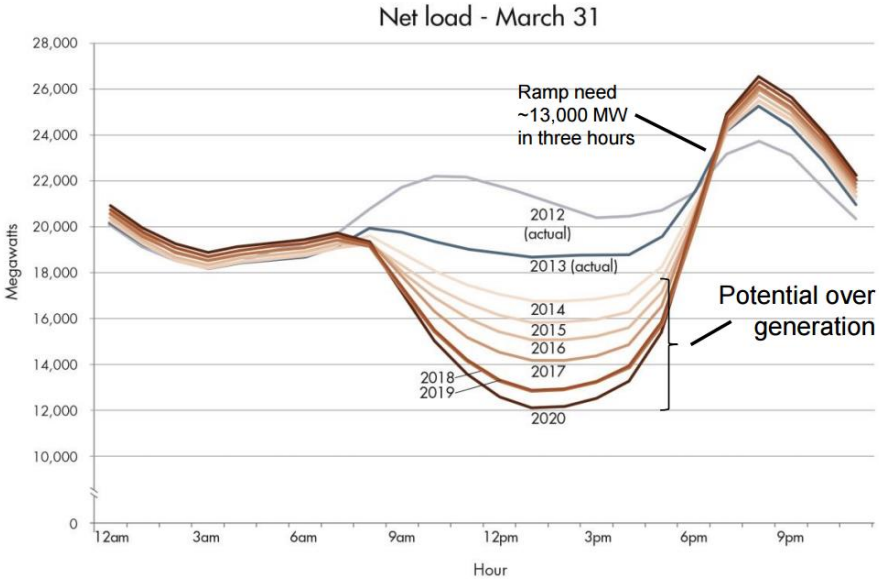
Variation in Deployment across the Country



Sources: U.S. Energy Information Administration, “Electric Power Monthly,” forms EIA-023, EIA-826, and EIA-861. U.S. Energy Information Administration, “Electricity Data Browser.” Accessed March 27, 2020. IEA, “PVPS 2019 Snapshot of Global PV Markets.”

Note: EIA monthly data for 2019 are not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore, a certain amount of solar data has not yet been reported. “Net Generation” includes DPV generation. Net generation does not take into account imports and exports to and from each state and therefore the percentage of solar consumed in each state may vary from its percentage of net generation.

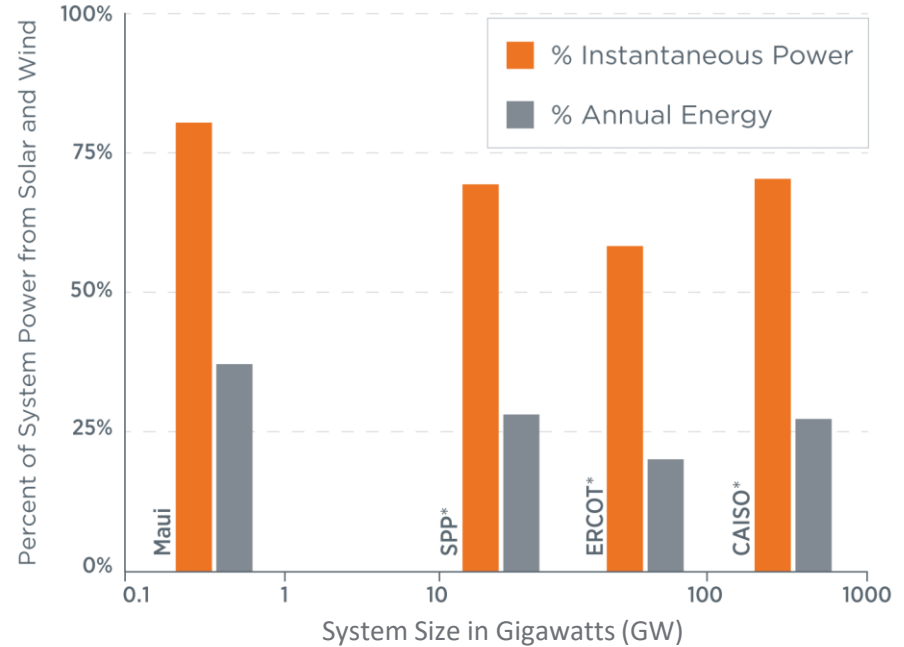
Challenges as Solar Generation Increases



California's Duck Curve

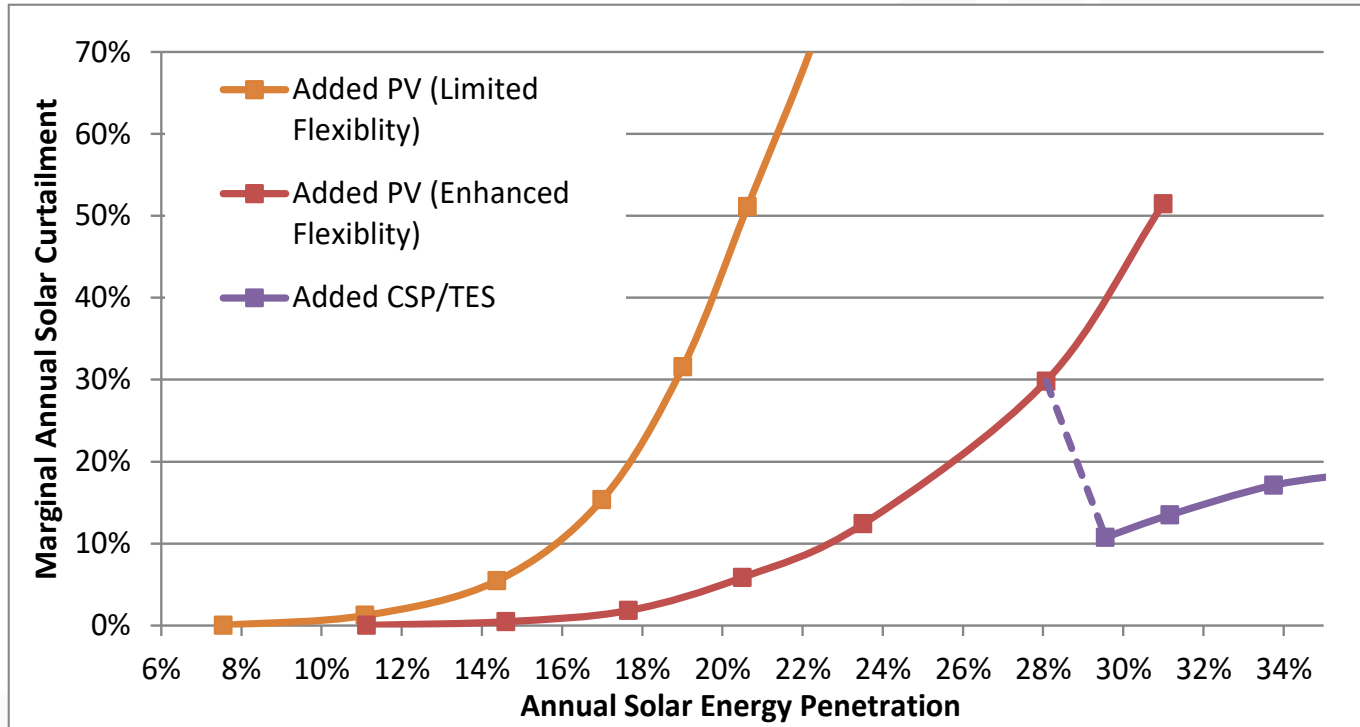
Source: California Independent System Operator

Instantaneous Power and Annual Energy from Solar and Wind by System Size



*Southwest Power Pool (SPP), Electric Reliability Council of Texas (ERCOT), California Independent System Operator (CAISO)

Grid Flexibility is Essential (Case Study: CA)



Denholm, P.; K. Clark; M. O'Connell, "On the Path to SunShot: Emerging Issues and Challenges in Integrating High Levels of Solar into the Electrical Generation and Transmission System," NREL/TP-6A20-65800, National Renewable Energy Laboratory, Golden, CO (2016).

Solar CAN Support Grid Reliability

- **Power Ramping**

- ✓ Ramp its real-power output at a specified ramp-rate
- ✓ Provide regulation up/down service

- **Voltage Control**

- ✓ Control a specified voltage schedule
- ✓ Operate at a constant power factor
- ✓ Produce a constant level of MVAR
- ✓ Provide controllable reactive support
- ✓ Provide reactive support at night

- **Frequency**

- ✓ Provide frequency response for low frequency & high frequency events
- ✓ Control the speed of frequency response
- ✓ Provide fast frequency response

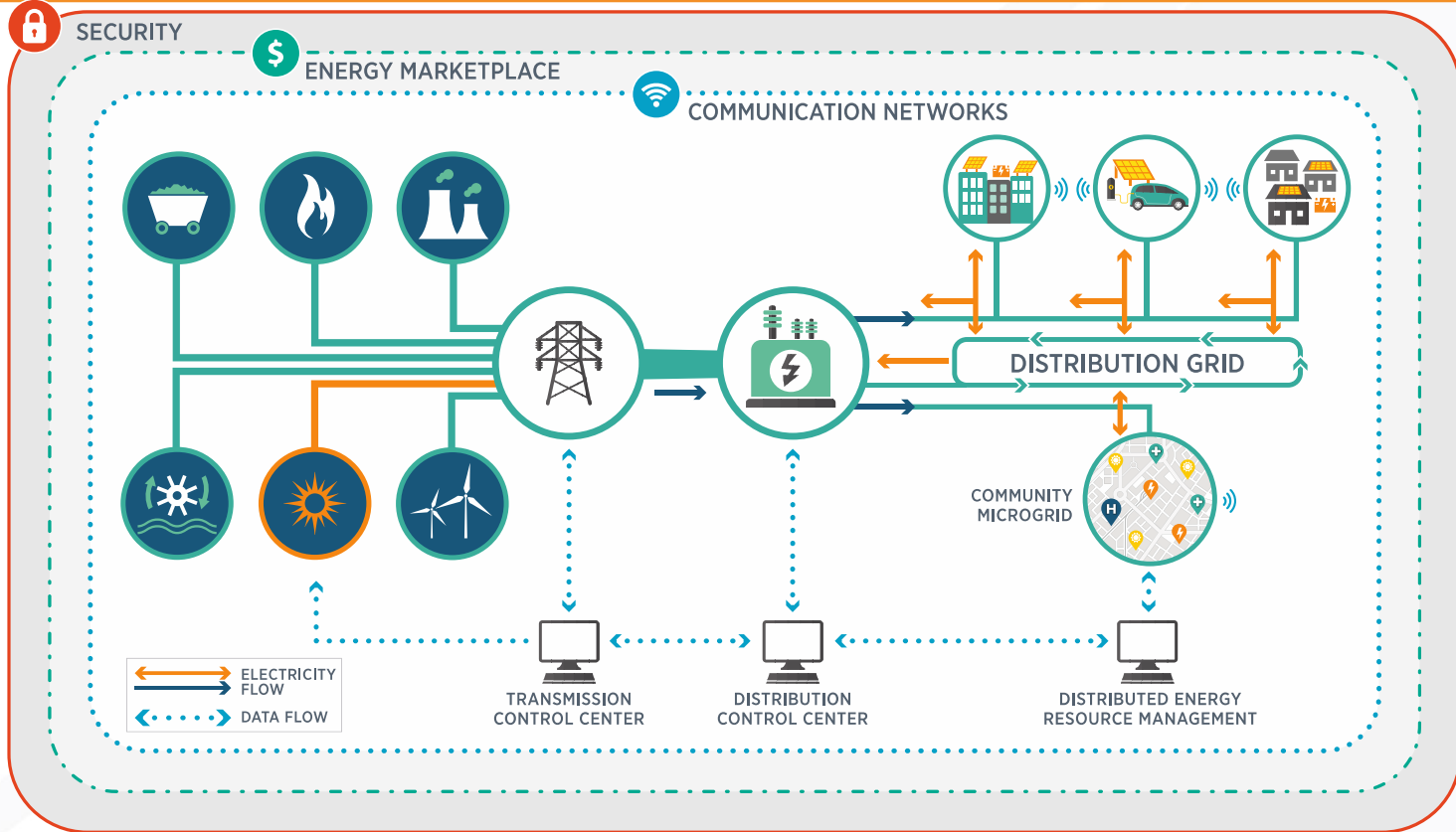
Tests successfully conducted with CAISO on 300 MW
First Solar plant

Source: Mahesh Morjaria, First Solar



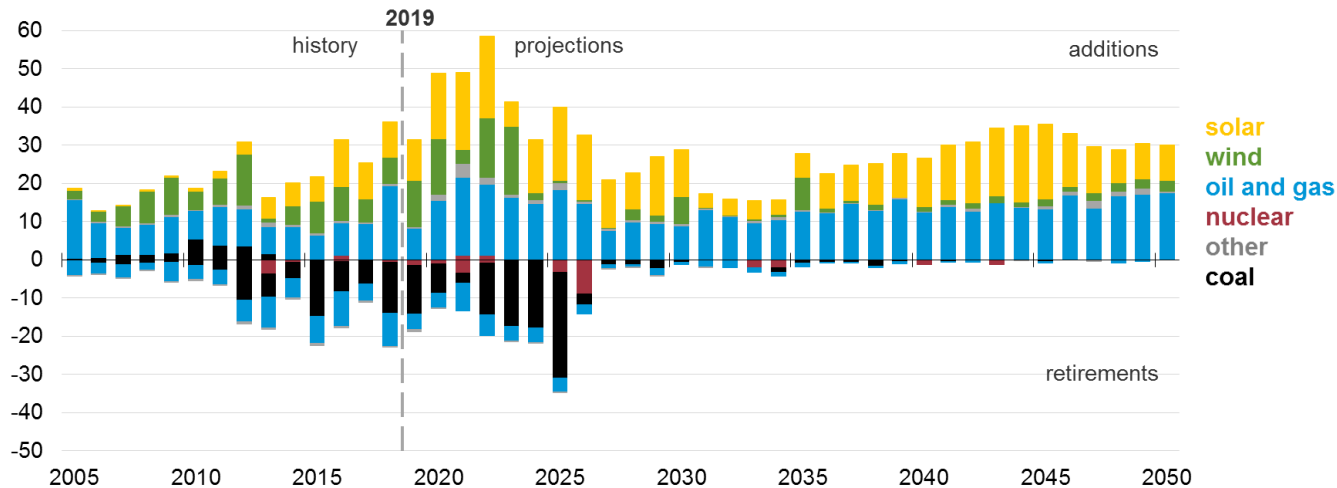
Source:
[nrel.gov/docs/fy17osti/67799.pdf](https://www.nrel.gov/docs/fy17osti/67799.pdf)

Opportunities to Enhance Resilience



This is Just the Beginning

Annual electricity generating capacity additions and retirements (Reference case)
gigawatts



- EIA projects solar will provide 17% of U.S. electricity by 2050
- Amount of storage deployment will significantly impact amount of solar deployed

Source: Energy Information Administration, 2020 Annual Energy Outlook