

Flexible Dispatch of Solar Photovoltaic (PV) Power

PV power plants have historically been set up for fixed dispatch, in power purchase agreements (PPA) for utility-scale ground-mounted projects and the regulatory schemes for residential and C&I rooftops. The entire electricity generated for the grid delivery point is dispatched or curtailed (downward dispatch), with a fixed pre-agreed payment per kWh for the total kWh generation. This business model does not utilize the full economic value of PV power.

In addition to the active power (P) output of the PV plant, reactive power (Q) for dynamic voltage support of the electric grid can easily be arranged. This capability is straightforward to set up, including the retroactive reconfiguration of inverters. It includes the ability to provide reactive power at night, known as the Q-at-night function, with the PV system acting as a Static VAr generator (SVG). Knowledgeable grid operators have been mandating such voltage support, denoted $Q(V)$, for some time now. The maximum possible Q capacity for an inverter is its total apparent power, e.g. at night, when the power plant is not providing any active power.

PV power plant functionality can be further enhanced by suitably oversizing the DC capacity of the PV array to the AC capacity of the inverter(s). Oversizing is commonly practised in PV power plants, because it improves the project financial returns (additional energy yield and hence revenue vs incremental cost of the solar panels only). This approach has widely been used in the fixed dispatch model.

Oversizing creates the option of flexible dispatch, using headroom reserves. The oversized capacity is kept in reserve as a buffer (headroom reserve) for upward dispatch. When needed, the PV output can be ramped to deliver power from the oversized, reserved capacity. PV power plants can thus compete for peak demand power supply - with the competitive effect of reducing real-time spot prices. This planning also enables the PV power plant to deliver fast frequency response (FFR) and greater primary frequency response (PFR) – enabling PV to participate in the ancillary services market. All PV power plants have built-in capability for flexible downward dispatch. Oversizing brings flexible upward dispatch into play. Active power P can be dispatched for excess grid demand, to the extent of the buffer capacity and the solar resource available at the time.

Coupled battery energy storage systems (ESS) augment the PV capability of flexible dispatch. The temporal dependency on solar resource variation is mitigated. Most PV systems are now being deployed in tandem with ESS. The PV-ESS combination is competing with conventional power plants for round-the-clock electric power supply, offering a suite of distinct advantages (e.g. precisely controlled, faster voltage and frequency responses). At an increasing number of locations worldwide, depending on the site insolation and load demand pattern, PV-ESS can offer more economical round-the-clock electricity than any other available source. Grid-forming capabilities can also be offered, e.g. black-starts, previously the exclusive domain of conventional thermal or hydroelectric power plants.

Solar electricity buyers and sellers have to agree on a financial valuation method for the additional investment of flexible dispatch (the buffer capacity, to be used on demand). This flexibility can be valued as a Call Option, using Real Options Analysis (ROA). Further detail, including an illustration of the ROA calculation, is available in our guidebook “Managing Solar Energy - Fundamental Science to Practical Systems”.