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In recent years, falling renewable costs and rising energy prices, particularly following the Ukraine invasion, have led to a rapid increase in solar PV capacity, especially in solar-rich regions like California and Spain. This growth has resulted in an oversupply of renewable energy during daylight hours, creating challenges for grid stability and market economics.

An oversupply of solar PV generation during the day, paired with none at night, creates issues for decarbonisation and market dynamics. This imbalance drives down electricity prices during the day, threatening future solar investments as revenues decline. When prices drop too low, solar cannibalisation occurs--where solar PV undermines its own profitability. Further, managing these rapid increases and decreases of solar generation creates operability challenges for system operators, and the need for markets to provide the right signals for solutions to emerge.

California"s early battery projects were expensive--Gateaway (250 MW, 4-hour duration) had a CAPEX of $1,556/kW, and other projects like Pomona and Moss Landing reached as high as $2,400/kW. However, falling lithium prices have reduced costs significantly, enabling Spain to deploy batteries at much lower costs. In 2023, Spain"s standalone battery auctions reflected a median CAPEX of EUR1,180/kW, 25% lower than Gateaway"s costs, making battery investments more attractive despite lower capacity market payments

While California has added 11.2 GW of battery storage, the system still faces challenges from solar oversupply, and solar prices remain low. Batteries have helped mitigate cannibalisation, but their impact depends on having enough storage relative to solar capacity. Moreover, many batteries rely on Ancillary Services for revenue, as these services are often more profitable than wholesale electricity markets, limiting their ability to fully absorb the solar surplus.

Spain"s increasing solar oversupply and emerging price signals suggest that the market will follow California"s lead in moving from solar-only projects to storage-integrated ones. Negative prices and zero-price hours have been recurrent in Spain since early 2024, highlighting the need for batteries to hedge against price cannibalisation.

After high solar cannibalisation, California has shifted its investment focus toward storage. Currently, 63% of projects in the permitting pipeline are standalone batteries or co-located solar-and-storage systems. Of the 162 GW of solar PV in the pipeline, 98% are co-located with batteries. In contrast, Spain has 76 GW of solar PV projects in the pipeline, but only 12 GW of batteries, with just 2.9 GW co-located with solar.

In 2024, a drop in solar prices marked Spain"s entry into a solar oversupply cycle with increasing cannibalization, similar to California"s past. Following California"s path, energy investments in Spain are expected to shift towards storage while some solar projects may not proceed or are likely to co-locate with

batteries, securing long-term profitability.

On a broader scale, one thing is also clear: the energy transition must be planned with care. Building renewables is a good thing but just building renewables can cause downfall of excess renewable investments.

When thinking about how a market with high solar penetration might evolve, CAISO provides a good peek into the future as they have already installed 11.2 GW of batteries. So, in the following paragraphs, I outline key similarities and differences between CAISO and Iberia with the aim of providing some indications of how Iberia might evolve, purely from a comparator perspective.

Both California and Spain share commonalities, including similar market sizes, high solar resources, and rapid solar PV growth.California"s average demand is 25 GW, and Spain"s is 26 GW. Since 2020, California has added 14.3 GW of solar PV (including behind-the-meter installations), and Spain has added 23 GW, including behind the meter solar. By 2024, both regions will have over 35 GW of solar PV--exceeding their average demand.

Because of this, both markets are increasingly affected by solar cannibalisation. Solar capture rates have dropped significantly--California"s fell from 73% to 61%, while Spain"s fell from 97% to 82% from 2020 to 2023. By the first half of 2024, solar capture rates dropped further to 21% in California and 55% in Spain, reflecting a growing cannibalisation issue as solar buildout continues.

During the Ukraine crisis, high gas prices masked these trends (particularly in Spain), but post-crisis, solar capture prices have plummeted to $7/MWh in California and EUR21/MWh in Spain during H1 2024, down from their peaks in 2022.

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