STORING POWER: **Market Structure Matters**

Increasing the share of renewables in the electricity generation sector requires investing in flexible resources able to counteract the volatility of renewable output. Electricity storage can play that fundamental role, as the cost of investing in these technologies has sharply declined in the past few years and is expected to decline further. However, two recent papers by David Andrés-Cerezo and Natalia Fabra, supported by Fundación Iberdrola Research Grant, identify several barriers that may impede the deployment of grid-scale storage and reduce its potential benefits. Their research calls for additional regulatory measures that provide the appropriate incentives for the deployment and efficient integration of energy storage facilities.

David Andrés-Cerezo

Electricity storage and market structure

The transition to a low carbon economy requires a massive deployment of renewable energy in the electricity sector, a process that has been taking place in the last decade and is expected to accelerate in the foreseeable future. Unfortunately, renewable technologies are intermittent: their output varies over time and can only be imperfectly forecasted. This creates a problem for electricity markets, which must balance supply and demand at every instant to guarantee the stability of the grid. **Energy storage,** by capturing electricity in periods when availability is high for use at a later period, **has a fundamental role to play in renewable-dominated electricity markets.**

This possibility has attracted considerable attention from governments and policy makers, who have made plans to open wholesale electricity markets to storage operators. In practice, most regulators are assuming that existing markets provide adequate incentives to promote investments by the necessary amount, as in general they do not consider the establishment of new markets or the implementation of a dditional policies. However, as David and Natalia point out, this optimistic view implicitly assumes that electricity markets resemble the perfectly competitive textbook version. In real-world markets, the introduction of electricity storage gives rise to externalities that may not be fully captured through the arbitrage of inter-temporal prices differences. In addition, both **storage**

and generation firms may have the ability to exercise market power, which may distort storage decisions in ways that increase total generation costs and consumer expenditures.

For these reasons, whether current market arrangements will send adequate signals for storage operation and investments will ultimately depend on the market structure. This raises several questions: Who should be able to operate storage facilities? Should the ownership of storage facilities be fragmented or concentrated in few hands? Is it better to mandate incumbent generators to invest in storage facilities, or should we ban them from having these assets? How does the profitability of storage depend on the technology mix? Two recent papers by David and Natalia aim to answer these fundamental questions, shedding light on the regulatory measures that are needed to support the adoption of storage facilities.

Theory

In the first paper, David and Natalia introduce storage in a model of wholesale market competition to understand how the market structure affects storage decisions and market outcomes. In their model, generation firms with different ability to exercise market power undertake production decisions across periods with varying demand and renewable output. Storage operators link different periods by shifting electricity from peak periods to off-peak periods. However, storage management and investment incentives differ according to the ownership structure, for which the authors consider four different cases: storage owned by a benevolent system operator, a fringe of competitive storage owners, an independent storage monopolist, and a vertically integrated firm that owns storage and generation assets. For each case, David and Natalia characterize equilibrium prices and optimal investment decisions, and then compare the different scenarios in terms of productive efficiency and total welfare.

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The problem of the social planner highlights the potential benefits of energy storage. In addition to reducing generation costs

	Social planner	Competitive storage firms	Independent storage monopolist	Vertically integrated monopolist
Operation	Marginal cost equalization	Price equalization	Marginal return equalization	Marginal cost equalization (own costs)
Prices	Equalized (within storage and realease periods)	Equalized (within storage and realease periods)	Strictly increasing with demand	Strictly increasing with demand
Marginal value of the Investment	Marginal cost savings	Marginal price differences	Marginal price differences	Marginal cost savings (in-house)
Investment	Optimal	Over-investment	Under-investment	Under-investment

and price volatility, as well as encouraging better use of available resources, electricity storage mitigates the ability of large generators to exercise market power.

The paper points out that these social gains may not be fully realized as, in the absence of new regulatory instruments or policies, the market alone does not provide adequate incentives to invest in storage capacity. Concretely, stand-alone competitive storage firms over-invest with respect to the social optimum, while investment is inefficiently low for strategic storage operators, both for stand-alone as well as for and vertically integrated firms. In the paper, the authors identify the sources behind the wedge between private and social benefits. Table 1 summarizes the key findings regarding storage decisions and market outcomes. The scenarios are ranked in terms of overall and consumers' welfare (the more to the left, the higher welfare).

In the absence of new regulatory instruments or policies, the market alone does not provide adequate incentives to invest in storage capacity

The are several take-aways from the analysis. First, market power in generation amplifies price differences above marginal costs differences between periods of high and low demand. Thus, the value of storage capacity is enhanced by the larger arbitrage profits, which incentivizes the market entry of competitive storage firms above the socially optimal benchmark. Thus, having a competitive storage segment is not sufficient to guarantee efficiency, as market power in generation distorts investment incentives. Second, strategic storage operators avoid flattening production and prices across periods in order to avoid a strong price reduction when they sell and a strong price increase when they buy. This inefficiency becomes especially notorious when the storage monopolist is integrated with a dominant firm in the production segment, as storage is merely used in-house in order to smooth own production costs. As a result of this distorted usage of storage facilities, the market generates suboptimal investments, which would need to be countered through efficient regulation, such as a remuneration mechanism as a top-up above the electricity price. Third, both consumers' and total welfare decline as more sources of market power are present in the market, which in the vertically integrated case are further compounded by the fact that it entails the lowest level of investment in storage capacity.

Simulations of the Spanish Electricity Market

To complement the theoretical analysis, David and Natalia are currently working on a follow-up paper in which they simulate the Spanish electricity market. Their goal is to provide some orders of magnitude about

the value of energy storage. Interestingly, their quantitative analysis calls attention to additional barriers that may impede the deployment of grid-scale storage and undermine its potential benefits. Among them, investing in storage capacity in the current Spanish wholesale electricity market may not be profitable for private owners.

The reason is three-fold: first, with few renewables, market prices are almost always set by the conventional technologies, whose marginal costs (and resulting) prices are fairly constant. Thus, price spreads are insufficient to make storage profitable if its revenues only come through arbitrage. Second, storage generates positive externalities, such as security of supply and carbon emissions reductions. Third, the current cost of battery storage, around 150Euro/MWh, needs to fall in the future to make storage profitable.

Despite these impediments, David and Natalia find that this low profitability is likely to be overcome in the near future, as the expected massive deployment of renewable energies in the electricity sector will increase price differences across periods, boosting the arbitrage value of storage capacity. In fact, the simulations show that this **complementarity goes both ways, as storage also makes investments in renewables more profitable because it prevents renewable curtailment in periods of high renewable production**. Overall, the quantitative exercise suggests that storage will play a key role in the electricity markets of the future, provided that: a) expected investments in renewables take place; b) investments costs in battery storage continue to fall, as they have sharply done in recent years and, c) innovative regulatory innovations are introduced aimed at mitigating market power and guaranteeing an optimal ownership structure •

Further reading

Andrés-Cerezo, D., and Fabra, N. (2020) Storing Power: Market Structure Matters, EEL 108 working paper

Andrés-Cerezo, D., and Fabra, N. (2021) On the complementarity between renewable energies and storage, EEL working paper