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Valuing Demand-side Flexibility: Toward a Supply-curve for Additional Flexible Capacity

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Extended Abstract

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Abstract Summary

As variable renewable generation expands, power systems require additional flexibility to balance supply and demand across multiple timescales. **Explicit demand response (DR)** is often presented as a key source of low-carbon flexibility, yet its market value, entry incentives, and interactions with competing flexibility technologies remain insufficiently understood. This paper evaluates the economic relevance of realistic DR resources in the French power system and examines their substitutability with utility-scale batteries.

We develop a multi-market stochastic dispatch model covering day-ahead, intraday, and reserve markets, solved using stochastic dual dynamic programming. The model includes a detailed bottom-up representation of DR operations, capturing both load shedding and load shifting under constraints on availability, event duration, recovery, minimum downtime, and number of activations. It is calibrated to the current French power mix and to a projected 2035 system with a larger share of variable renewables. We simulate the profits, system cost reductions, and modulation contributions of sixteen representative flexible loads from industrial, tertiary, and residential sectors. The framework is then extended to a co-investment model for DR and four-hour batteries.

Results show that not all DR resources are equally valuable. Flexibility from metallurgy, chemicals, paper, and residential heating emerges as promising, providing modulation contributions comparable to conventional flexible plants and requiring only moderate capacity payments to become incentive-compatible. By contrast, agri-food, water treatment, retail, and some diffuse loads appear much less attractive economically. **A central finding is that the private energy-and-reserve value of DR is far below its system value**, which supports the case for complementary capacity remuneration. We also find heterogeneous interactions with batteries: diffuse DR behaves as a substitute for batteries, whereas industrial load-shedding DR acts as a complement. Overall, the paper provides a technology-neutral framework to value demand-side flexibility and derive a supply curve for additional flexible capacity in decarbonizing power systems.

Presenting Author Biography

Olivier Massol is Professor of Economics at CentraleSupélec and researcher at the Sustainable Economy Research Group.

He is also Honorary Research Fellow at City St George's, University of London, and a member of the Scientific Council of the French energy regulator (CRE).

His research lies at the intersection of industrial organization and energy economics, with a focus on energy markets, infrastructures, and decarbonization policies.

At CentraleSupélec, he co-holds the Chair "Energy Markets and Sustainable Industries" (CEMSI), directs the Energy Transitions division of the Climate Economics Chair, and serves as Executive Director of the Gas Economics Chair.