SYSTEM VALUE AND WELFARE EFFECTS OF ELECTRIC ENERGY STORAGE TECHNOLOGIES ON POWER SYSTEMS: THE CASE OF FRANCE

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Overview

The will for limiting CO2 emissions has prompted ambitious clean energy policies in most developed countries. The electricity sector is particularly addressed by these initiatives. The adoption of renewable energy portfolio standards (RPS) or similar technology-oriented energy roadmaps is widely on the scope of policy makers. Nevertheless, the physical effects that such voluntarist targets would have over the stability of today's power systems, as well as their links with current electricity markets, use to be oversimplified when not overlooked on the energy policy debate.

Starting with a conceptual discussion around the meaning of benefits, value and profits of new flexibility technologies, this paper introduces a methodology for technology valuation and welfare quantification. The case of France under the Official Energy Transition Act of 2015 is investigated to illustrate the relevance of these issues on the energy policy debate. The Act sets the targets of attaining 27% of renewable generation by 2020 and 40% by 2030. It also imposes a nuclear moratorium by 2025, limiting nuclear participation to 50% and freezes the nuclear capacity to 2015 levels.

New emerging flexibility technologies, such as electric energy storage (EES) and demand side management (DSM), are completely disregarded on the official clean energy agendas because they are still perceived as not mature enough, very costly or are even hidden behind regulatory veils. However, technically they are able to supply multiple services to power systems at very low short-run marginal cost. The case for flexibility technologies would be of relevance on this contexts where the need for system services would likely rise and where peaking-flexible units would be displaced out of the market. A quantitative assessment of the value and the welfare effects of storage is presented on both horizons.

Methods

Analysing the power system of the future it is not only a matter of costs but of value. Therefore, the complete value of every technology should be apprehended from a whole system assessment that takes into account the full capabilities of each technology for meeting the system requirements, likewise the direct and indirect costs they involve (i.e. CO_2 emissions costs, VRE integration costs). This kind of framework put in perspective the whole interactions between system needs, supply assets and their related costs. Furthermore, the shocks introduced by the tight constraints dealing with current clean energy policies can be properly represented allowing to comprehensively assess the value that each technology add to the system.

The study is based on a comprehensive system cost optimization model that covers relevant issues of the current electricity market debate such as flexibility needs, reliability concerns and capacity adequacy requirements. The system case is represented using the DIFLEXO model, which is an investment model that co-optimizes the investment and the mothballing decisions, the economic dispatch and the frequency restoration reserve allocation, subject to technical constraints. The model has been particularly conceived to assess new flexibility technologies on a context of increasing VRE shares. The methodology proceeds by putting side-by-side the cost and capabilities of each technology in such a framework that competition and complementarities are coerced while total cost is optimized, resulting on an improved case for technologies with multiple-services capabilities. Investments decisions are endogenous and capacity is deployed whenever it prove to be optimal from a system point of view.

Results

Results obtained show that by 2020, demand-side management capabilities (DSM) are sufficient to accommodate the load variability at least cost, so, storage investments are not needed. By 2030, not only the same levels of DSM are required but 3.23 GW of storage investments are necessary. The shock of the nuclear moratorium makes room for further base and mid-load capacities supported by storage. By 2030, the system value of storage is estimated at 350 m€/year. Relevant welfare effects are found: Wind and PV increase their surplus at the expense of profit reductions of baseload conventional technologies; Surplus of peak-load technologies is not particularly affected. Consumers are significantly better-off, benefiting from a less constrained system, which induces important surplus gains. Cost-optimal storage increases overall welfare at around 670 m€/year by this horizon.

Conclusions

The study proposes clear definition of the value of new flexibility options. It also proposes a clear methodology, based on the system optimization tool DIFLEXO, to assess the complete value of bulk storage technologies. The case of France under the RPS to 2020 and 2030 are then evaluated.

Investments in storage not only create value of different categories but also creates welfare variations across different stakeholders. Therefore, new business models for the ownership and operation of storage; advanced regulatory frameworks broadening the eligibility of storage to supply multiple services; and an strategic policy instrument would be necessary to attain the cost-optimal development of storage and avoiding lock-in situations (Schmidt et al., 2015) in the mid-term. The effectiveness of energy policy instruments based on RPS targets would be enhanced if new flexibility technologies (such as storage and DSM) would also be considered when setting the directive targets.

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