Exploring the mechanics of hybrid markets in a context of deep decarbonization.

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Overview

The power sector has a key role to play through electrification and deep decarbonization to combat climate change. Nowadays the organization of the power sector in many jurisdictions is inherited from the liberalization process started in the 1980s whose key features are privatization, vertical unbundling of regulated activities from competitive segments and the reliance on private and decentralized decisions to drive both short-term operations and long-term system evolutions [Joskow 2008].

The suitability of the liberalized framework in addressing long-term issues (namely investment and retirement decisions) has always been debated and some questions remain open [Glachant, Perez 2011]. Though they remain largely overlooked, various shortcomings of the canonical liberalized model – the Energy-Only Market model – have led policymakers to introduce several ad-hoc, non-coordinated and unsatisfactory remedies [Keppler et al. 2021]. The unprecedented scale and pace of the changes implied by the decarbonization process (e.g. massive investments in low carbon technologies) exacerbate these issues and many scholars now argue that a new approach to electricity market design should be considered in the form of a hybrid market [Roques, Finon 2017; Joskow 2021; Keppler et al. 2021]. The main idea of a hybrid market is to keep competitive short-term markets for system operations and to complement them with a dedicated long-term module combining some form of planning, competitive procurement, and long-term contracts (LTC) to drive investment and retirements decisions.

The process of defining how a hybrid market should be implemented is only being initiated, however, and market designers have many dimensions and possible options to explore (e.g., centralized procurement vs. decentralized obligations, scope and type of planning, contract design,…). Finding desirable and workable designs requires an assessment of the impact of design elements, notably in terms of dynamic performances (in the pluriannual sense), considering realistic economic behaviors. This paper aims at contributing to this endeavor by analyzing one possible hybrid design option through a quantitative exercise based on optimization and dynamic simulations. The candidate market design we study notably features (1) a centralized planning exercise that determines the least-cost power mix trajectory required to decarbonize the power sector with respect to security of supply, (2) a central body that dynamically compares this trajectory with the actual system evolution and organizes technology-specific auctions to issue long-term contract-for-difference (CfD) for new capacities or phaseout compensation for existing capacities that have to be decommissioned.

Methods

Our model combines Generation Expansion Planning optimization and market simulations (System Dynamics). We further use the model developed in [Lebeau et al. 2021] with new developments aiming at complementing the core Energy-Only Market model with long-term auction modules for CfD and closure compensations, consistently with the hybrid approach.

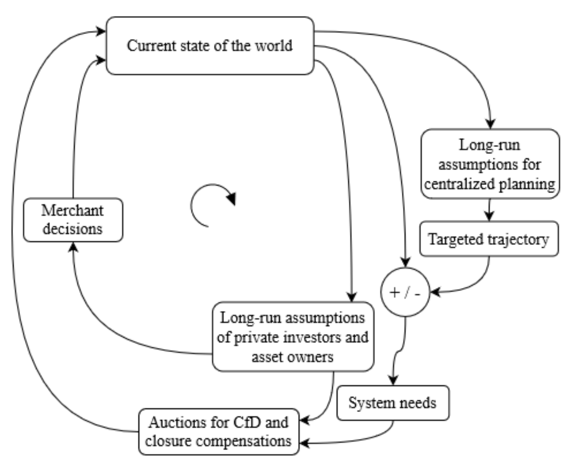

Figure 1 - overview of the long-term market simulator

Specifically, the methodology is divided in two steps. The first one consists in running a Generation Expansion Planning model that computes the least-cost portfolio evolution over several years for electricity generation and storage solutions with respect to hourly load balance and under environmental constraints (carbon emission caps). The goals of this solution is to define auctions' targeted volumes and feed the simulation model when we assume that agents perfectly anticipate the optimal evolution of the system. The second step is running a market simulation model based on the System Dynamics methodology. In this model, the state variables of the system are chronologically computed based on decision-making and operating rules governing the different components in the system, i.e., representing the behavior of various economic agents. This version of the model features a new module that embarks the system needs calculation by the central body and the introduction of competitive auctions for CfD and closure compensations.

Results

We build a stylized case study with fundamentals from California to apply the studied market design layer. Preliminary findings from simulations are threefold. First, the quantity-based long-term contracts allocation process yields capacity trajectories that are in line with policy objectives. Second, the strike price formation of a CfD is characterized depending on different attributes of the contract. In particular, we explore different configurations for the shape (e.g., baseload or generation) and duration (e.g., from a few years up to projects' lifetime) of the contract. Third, implementing this market design requires the definition of a pass-through mechanism to transfer the cost of long-term contracts to final consumers. This mechanism provides new levers for policymakers to control the price evolution for final consumers and to deal with potential stranded assets.

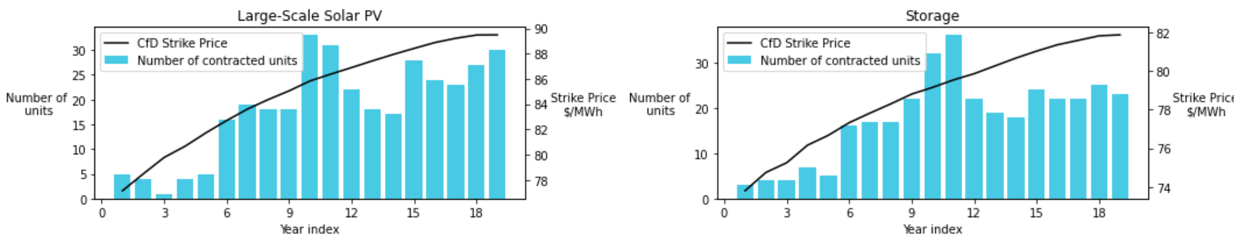

Figure 2 – CfDs' Strike Price and contracted volume for Large-Scale Solar PV (left) and Storage (right)

Conclusions

The hybrid approach to electricity market design is backed by a growing number of economists, policy makers and companies but many practical implementation features have still to be determined. This paper investigates the functioning of one possible market design falling in this category based on a modelling exercise with long-term market simulations. Working with simulations has the particular advantage of requiring a high degree of explicit assumptions, thus inviting us to question how the market design could actually materialize besides general guidelines. This paper provides insights on a hybrid market design with a particularly centralized structure, relying on a central planning and capacity-based technology-specific auctions and CfD contracts to drive the system evolution. This helps to better understand the overall functioning of this market design and several variants. Further areas of research may include implementing other hybrid market designs, improving the model reaslism and considering other case studies.

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