ON THE ROLE OF STORAGE AND DEMAND RESPONSE IN SHAPING ELECTRICITY PRICES AND SOCIAL WELFARE UNDER DIFFERENT MARKET SETTINGS.

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Overview

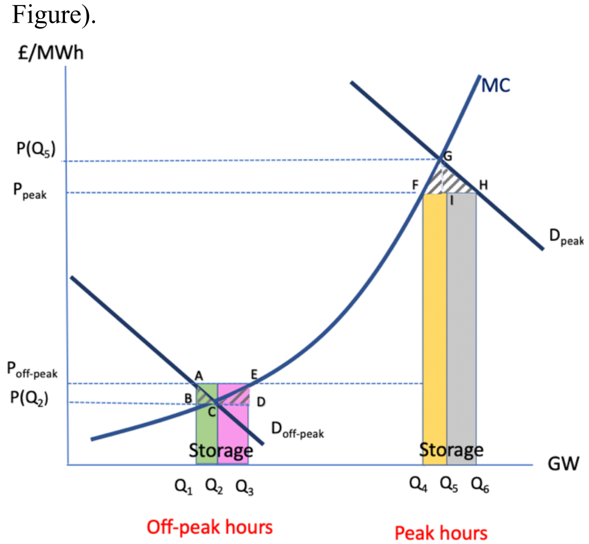
Electricity markets are currently going through various changes: rapid increase in renewable energy, significant rise in carbon prices, appearance of new market players as well as more control being given to final users via smart meters which all create new challenges as well as uncertainty for profit makers in this multi-stakeholder grid. At the same time, we observe rapidly growing energy storage possibilities with the aim of providing some flexibility as well as new profit maximisation opportunity. This means that decision making process in this changing environment has become even more complex, especially for retailers – these power grid and power sales companies need to establish new profit model taking into account buying power from electricity suppliers and selling it further to final electricity users. These electricity customers in turn, are gaining more power in controlling their usage with Real Time Pricing tariffs and demand response system and thus the popular assumption of demand being inelastic is no longer valid.

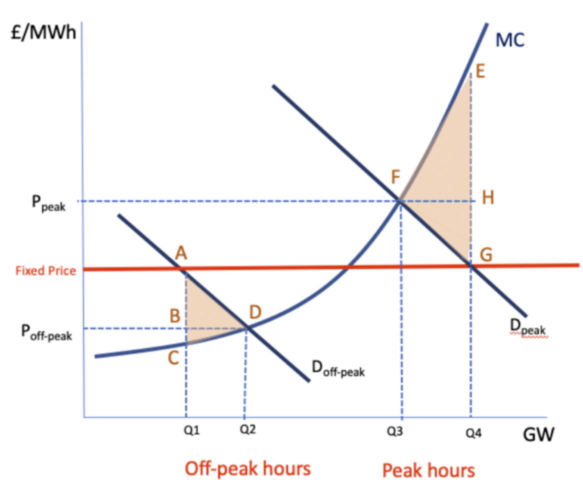
The role of this paper is to research the impact of equipping retailer with own storage facilities. We assume that retailer uses storage for profit maximisation while in some cases we allow for a social planner to be involved and maximize social welfare. Moreover, as the smart-metering and RTP tariffs are increasingly popular, we allow consumers' demand to be more elastic which is a concept not yet extensively discussed in the literature.

Apart from the intrinsic interest of understanding how price-taking retailer with storage unit changes the consumer and producer surplus, we model various different market set ups to present what-if situations including retailer having market power or increasing storage capacities. We also provide comparisons of welfare effects and measure impact on market prices given different levels of elasticities of final customers. That is contrasted with the base case scenario where there is no storage unit in the market.

Methods

The primary purpose of the empirical analysis is to measure the effect of storage in a market with more elastic demand (as shown in left Figure below) as well as to identify changes in welfare in RTP pricing tariff (right Figure).





We present dynamic optimisation model that aims at maximising social welfare (or illustrates market power) under different market settings. Firstly, we assume initial market conditions where retailer without storage covers the whole domestic demand which characterizes with low elasticity. Next, we run the model with other (increased) values of elasticities to capture the effect of customers' demand management. Once we get the results for our base case, we add storage unit and maximize retailer's profit by exploiting arbitrage – charging when the price is relatively low and discharging during peak hours. At the same time, we capture the effect of storage on prices, as with unit big enough, we can observe the impact of charging and discharging due to the difference across demand volumes. Further, we allow for market power to measure the potential loss in welfare and the role of storage in extending or limiting this effect. We check the results for each scenario with different storage volumes and capacities to measure the prospective profitability of investing in additional units. Altogether, we provide broad outlook on energy markets with storage unit across various market set-ups.

Results

Our results show couple of interesting findings including the expected mechanism of reducing market prices in peak hours (while discharging) and increasing them in off-peak hours (while charging). We do not observe though, the diminishing arbitrage potential with growing storage capacity (the profit grows together with bigger capacity), but we do see the reduction in variance of market prices. We also found out that profit of the storage is maximized in market-power set-up with inelastic demand and increasing elasticity has small but negative effect on the profit.

The analysis shows as well that increasing elasticity of final customers do not go together with the increase of consumer surplus – the biggest value is achieved in a set up with inelastic demand and retailer equipped with storage. The bigger the storage, the bigger the CS value as long as the retailer is a price-taker. In case of market power, bigger storage unit only slightly reduces the negative effects of lack of competition. Analogic situation occurs with general welfare. The average daily prices on the other hand increase by almost 30% when market-power exists and capacity of storage does not influence this value.

Conclusions

Storage can induce both private and social returns by creating profits or by impacting consumer surplus and social welfare respectively. Profit gains are possible by exploiting arbitrage in electricity price differences. The effect on welfare may occur on the wholesale level - when storage is huge and charging, it impacts the price by changing the level of demand; on the retail level it may induce relocation of consumer and producer surplus.

The goal of this paper is the measure the market effects of having retailer with storage unit in the energy market combined with more and more elastic final customers. Our main findings show that storage has strong positive effect on welfare but only in a competitive environment. In a market-power scenario, the storage significantly contributes to welfare losses and thus the role of authorities is to make sure that deployment of storage units moves along with competition. The negative effect of increased elasticity is another point that policy makers should focus on.