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Valuing flexibility in demand-side response: A real options approach

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Abstract

The investment interests in the electricity industry are transmitted through various mechanisms to other economic activities. This paper considers methods for esteeming the adaptability of demand-side response (DSR) in its capacity to react to future uncertainties. The capacity to evaluate this adaptability is particularly critical for vitality frameworks speculations given their extensive and irreversible capital expenses. The primary result of this exploration is a broad survey of current real options (RO) strategies that elucidate the suppositions and use of RO for basic leadership in engineering applications. The second result is the structure of a probabilistic RO framework and operational model for DSR that evaluates its advantages as a vitality benefit for supporting diverse market price risks. The third result of this work is the improvement of a total, general and viable apparatus for making long haul multi-arranged speculation choices in future power organizes under numerous vulnerabilities.

Keywords: Electricity, investment, uncertainty, real options analysis, demand-side response

1-Introduction

One of the important elements in investing or not investing in an industry is the cost of financing capital for both the purpose of depreciation and industrial development. Investors are more likely to appreciate the opportunity cost of the funds used for investing. One of the most important factors affecting this opportunity cost is the rate of return on investment in other sectors of the economy. In other words, investing in industry takes place when the expected benefits from investing in that industry are at least equal to the returns of other activities. The question now is what will increase the funds for investing in the electric power industry? To answer this question, first, changes in the supply of electricity and then on demand side have been analysed. On the supply side, suppose these funds are available to all power industry enterprises. Increasing financial resources for investing in the electricity industry seems to reduce the cost of financing in this industry. Since the cost of financing is one of the elements of the cost of production, it expects to reduce the cost of electricity by reducing the cost of financing in the electricity industry. On-demand, one of the factors affecting the level of demand for electricity is its price. In this way, reducing the price of electricity in a flexible price environment, household demand and production activity will increase for electricity, and thus the level of activity in the electricity sector will increase.

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In this paper, the specific spotlight will be put on the measurement of the adaptability esteem that DSR speaks to as an adjusting device and as a substitute for system resource ventures. The explanation behind this is extended in low carbon vitality frameworks must manage arranging assent hazard, advancing control, long growth and conveyance periods, and innovative unpredictability, while including a huge number of partners with conceivably clashing interests.

2- Capital budgeting techniques and real options theory: A literature review

Extensive studies have been conducted in recent years about the structure of the energy market that a summary of the most important of these studies is presented in table 1. Garcia and Arblis have conducted simulations for the Columbia Electricity Market in an article entitled "Market Power Analysis for the Columbia Electricity Market" (Garcia and Arbelaez, 2002). They have used a dynamic Cournot model to show the potential impacts of mergers in the nation's electricity wholesale market. These simulations have shown that the price level after the merger would be on average 24% more than before. The study also shows that by adding a large number of predicted contracts to the model, not only will prices not increase but will even decrease in some cases.

Table 1. General study categories

Proposed space	paper	differences
Cournot	Garcia and Arbelz (2002)	
Supply mapping with uniform payment and uncertainty	Anderson and Philpott (2002), Niu (2005), Sioshansi and Oren (2007), Holmberg (2008)	In Anderson & Philpott's paper, there is a price ceiling, and in the New York article, and the Oren and Shevsance paper, the bilateral agreements are included. In Holmberg's paper, the multiplicity and uniqueness condition of the equilibrium is analysed
Supply mapping with offer payment and uncertainty	Federico & Rehman (2003), Holmberg (2009)	Federico and Rahman, Full and Monopoly Competition, and Holmberg's Paper Consider Symmetrical Competitive Mode

In the very same route as practicing an option in the fund, real-life framework choices are liable to the adaptability of undertaking ventures just if this merit undertaking and exploiting positive economic situations while restricting danger on the drawback. Real options (RO) hypothesis, in light of the hypothesis of money related choice evaluating, is an investment tool that has been proposed in Myers (1977) to explicitly manage speculation arranging under vulnerability, however choices depend on the vulnerabilities in an undertaking's future money streams (or potentially some other significant factors) as opposed to in the stock's costs. Early research in RO valuation was to a great extent dependent on the monetary alternative evaluating models of limited contrast strategies and different techniques managing partial differential equations (PDEs), which increased gigantic prevalence following the examination of Black, Scholes, and Merton for estimating budgetary choices (Black and Scholes, 1973), (Merton, 1973a) and (Merton , 1973b). Cox and Ross thusly stretched out the investigation to think about option stochastic procedures, specifically hop forms, and built up a way to deal with the choice valuation issue that associated it straightforwardly to the structure of the basic stochastic process (Cox and Ross, 1976). In table 2, we demonstrate the summary of major methods proposed by researchers in real options valuation techniques.

Table 2. Some important researches about real options valuation techniques

Method	Some important researches
Analytical methods	- quantify the value of shutting down production (McDonald and Siegel, 1985) - analysed the effect of deferring production on the option value (McDonald and Siegel, 1986) - option to temporarily shut down and restart operations was also researched by Brennan and Schwartz (Brennan and Schwartz, 1985) - a conceptual discussion on the competitive aspect of options (Kester, 1984) - Stulz presented analytical formulae for pricing European-type options on the minimum and maximum of two risky assets (Kester, 1982) - The option to abandon a project early was valued by Majd and Pindyck (1987) - RO was then extended to the valuation of petroleum development investments (Chorn and Shokhor, 2006), (Dias, 2004), (Paddock et al., 1988) and (Siegel et al., 1987) and natural resource planning (Brennan and Schwartz, 1985), (Evatt et al., 2010), (Felder, 1996) and (Slade, 2001). - Partial-differential equations (PDEs) were also assessing the flexibility of power generation and thermal power plants (de Moraes Marreco and Carpio, 2006), (Deng et al., 2001), (Deng et al., 2003), (Fleten and Näsäkkälä, 2010) and (Näsäkkälä and Fleten, 2005). - More recently, extensions to PDEs were used to quantify the value in renewable research and development (R&D) projects (Davis and B. Owens, 2003) and (Santos et al., 2014), in postponing investments in renewable power plants (Fleten et al., 2007) and (Munoz et al., 2009), as well as in the operational flexibility of DSR (Sezgen et al., 2007) and (Skinner and Ward, 2009).
Lattices	- Cox and Ross showed that the value of the European call option could be calculated in discrete time by discounting the expected value of the option from the date of expiry at the risk-free rate of interest (Cox and Ross, 1976). - Hybrid models combining simulation and lattices were also proposed by Alstad and Foss in (2003) and by Tseng and Barz in (2002) to value generation assets
Monte Carlo methods	- Monte Carlo methods were first applied to option pricing in Boyle researches (Boyle, 1977). - Tilley first applied simulation techniques to pricing American-type options, using a bundling technique and a backward induction algorithm (Tilley, 1999). - Datar-Mathews model presents a practical approach to project valuation where the focus is put on building an RO model that uses the same framework and transparency as a standard NPV approach (Mathews et al., 2007).

2-1- Demand-side response as a real option

A model for diminishing acquirement costs for a vitality retailer utilizing DSR is proposed in (Feuerriegel and Neumann, 2014), implying impressive money related advantages. Be that as it may, the examination neglects to consider the physical compensation impact of loads, along these lines prompting a potential to overestimate of the advantages. In fact, intruding on loads does not really prompt a general vitality decrease (Agnetis et al., 2011) since the utilization, when the heap is walked out on, might be much higher than without shortening (for example because of misfortunes). This bears suggestions in the market, as this additional vitality restitution should be obtained someplace. However, numerous DSR thinks about (e.g., (Conejo et al., 2010) and (Zhu et al.,2012) will in general overlook stack recuperation.

2-2- Summary of past research

Subsequent to looking into the past research in the field of capital planning and RO connected to vitality frameworks, various research territories require tending to. These are summarized as follows:

- Valuation tools dependent on the deterministic investigation are not satisfactory for venture arranging given the expansive number of vulnerabilities influencing the basic leadership process.
- Previously published research in RO overlooks the suspicions of the monetary models from which they are inferred and neglects to consider the physical attributes of energy projects.

- A complete engineering RO framework ought to have the capacity to measure the four sorts of adaptability featured over that give more prominent incentive to an undertaking, in particular:
  - The value in having the adaptability to hold up until probably some vulnerability is settled before making a venture. Adaptability value from deferring speculation.
  - The value in having the adaptability over the venture lifetime to effectively modify choices dependent on future conditions. Adaptability esteem from exploiting upsides while limiting misfortunes on the drawback.
  - The value in having the adaptability to settle on choices over various phases of the undertaking lifecycle, not just toward the beginning or end of the venture. Adaptability esteem from early exercise.
  - The value in the capacity to adjust to differing conditions by changing the framework plan of the undertaking or venture (Nembhard and Aktan, 2009), (de Neufville, 2002), (Fricke and Schulz, 2005), (Hassan and de Neufville, 2006) and (Martinez-Cesena and Mutale, 2012). Adaptability from task plan. This fourth sort of adaptability is the thing that genuinely isolates RO from monetary ones out of a building setting since the element is essentially not found in financial options.
- There has been almost no examination in evaluating the adaptability estimation of DSR and on surveying beneficial business cases for DSR either at an operational or arranging level.

3- Modelling Supply and Demand for Capital in Activities

In this section, the capital market of the power industry will be introduced in greater detail. The allocation of capital between different sectors depends on several factors. In general, the amount of capital allocated to an activity depends on factors such as the accumulation of total capital, the return on capital in that activity, and the return on capital in other sectors. In order to illustrate this pattern of capital allocation in the economy, a fixed conversion function or CET is used. The functional form of this template in the form of a complementary compound problem (MCP) is:

$$SK[r-(\sum_{s}\theta_s PK_s^{1-\phi})^{\frac{1}{1-\phi}}]=0; SK\geq 0; r\geq(\sum_{s}\theta_s PK_s^{1-\phi})^{\frac{1}{1-\phi}} \quad (1)$$

Where *SK* is the aggregate capital of the economy, *r* is the expected return on investment of investors, PK_s is the return on capital in sector *s* and, finally, φ is the degree of capital turnover between sectors. In this way, the supply of capital in each sector is determined according to the following relationship:

$$S_{k,s}=\theta_s SK.[PK_s/(\sum_{i}\theta_i PK_i^{1-\phi})^{\frac{1}{1-\phi}}]^{\phi} \quad (2)$$

In which $S_{k,s}$ is the stock supply shows in activity *s*. In other words, the supply of capital in sector *s* has a direct relationship with the stock of total capital economy *sk* and the rate of return on capital in that sector, but with a return on capital in other sectors, PK_i has an inverse relationship. It is assumed that new investment in the electricity industry, regardless of returns and externally, will be determined, thus the relation (2) for the electricity industry *el* is:

$$S_{k,el}=KG_{el}+\theta_{el} SK.[PK_{el}/(\sum_{i}\theta_i PK_i^{1-\phi})^{\frac{1}{1-\phi}}]^{\phi} \quad (3)$$

The *KG* component in this statement represents new and exogenous investment in the electricity industry. On the other hand, the demand function of capital in each sector is determined on the basis of the production function. In the present study, we assume a fixed substitution function. If the behaviour of the production of any economic activity is defined in the form of a complementary problem, we will have:

$$AL_s[(\sum_i \omega_{i,s} p_{i,s}^{1-\tau_s})^{\frac{1}{1-\tau_s}} - (\omega_{KLM,s} P_{KLM,s}^{1-\gamma} + \omega_{E,s} P_{E,s}^{1-\gamma})^{\frac{1}{1-\gamma}}] = 0 \tag{4}$$

Where *AL* is the activity level index of the sector *s*, $p_{i,s}$, the price index of the product sector *s*, $P_{KLM,s}$, the combined index of the mediation-labor-capital-price index and the $P_{E,s}$, of the energy price index, which is determined externally. The share of product *i* in the total production of activity, $\omega_{KLM,s}$ the non-energy share in the cost of production, $\omega_{E,s}$ the share of energy in the cost of production, τ the elongation of the conversion between the various products of an industry and γ the substitution of energy and non-energy, which are externally introduced into the model. In other words, production costs are shown based on the *CES* combination of energy (*E*) and other inputs (*KLM*). Also, revenue from production is based on a *CET* mix of products manufactured by an activity. Moreover:

$$P_{KLM,s} = \{\omega_{f,s} P_{KL,s}^{1-\rho} + \omega_{m,s} P_{M,s}^{1-\rho}\}^{\frac{1}{1-\rho}}$$

$$P_{KL,s} = \{\omega_{k,s} PK_s^{1-\rho} + \omega_{l,s} P_l^{1-\lambda_s}\}^{\frac{1}{1-\lambda_s}}$$

$$P_{M,s} = (\sum_m \theta_{m,s} p_m^{1-\beta_s})^{\frac{1}{1-\beta_s}} \tag{5}$$

$$P_{E,s} = \{\omega_{ff,s} P_{FF}^{1-\upsilon} + \omega_{el,s} p_{el}^{1-\upsilon}\}^{\frac{1}{1-\upsilon}}$$

3-1- Model description

The value of market demand is shown with ε `that is not definite, but the probability of occurrence of each value is shown with a probability density function. The total supply of the total of all firms is equal to ε^*. For manufacturer *i*, the supply mapping equation is shown with $s_i(p)$ that *p* representing the price. The reverse of this supply mapping is shown with $p_i(s_i)$. And also $s_{-i}(p)$ and $s(p)$ respectively to represent the total supply mapping in the market. Each firm uses the supply mapping of the rival supply and the total supply mapping in the market. Each firm maximizes the expected profit by presenting the optimal supply mapping $E(\pi_i)$. If $\varepsilon \le \varepsilon^*$ is a market demand, then $\varepsilon - s_{-i}(p(\varepsilon))$ is the amount of demand for the accepted product of firm *i*. The proposed benefit of a single supply unit is the $(p_i(s_i) - C'(s_i))ds_i$ amount. Therefore, the firm's profit is calculated for the amount of demand realized in the market by the total profit of each unit until it reaches the accepted value of firm *i*. Given the very small units of production, the sum is converted to the following integral:

$$\pi_i(\varepsilon) = \int_0^{\varepsilon - s_{-i}(p(\varepsilon))} [p_i(s_i) - C'(s_i)]ds_i \qquad if \ \varepsilon \le \varepsilon^* \tag{6}$$

Now, given that the firm intends to offer the supply function in such a way as to maximize its expected profit, the first-order condition of maximizing the profit is obtained as follows:

$$\frac{\partial \varphi_i}{\partial p_i} = 1 - F[s_{-i}(p_i(s_i)) + s_i]$$

$$- s'_{-i}(p_i(s_i) - C'(s_i)) f[s_{-i}(p_i(s_i)) + s_i] = 0 \qquad \forall s_i \in [0, \frac{\varepsilon^*}{N}] \tag{7}$$

In the end, the following relation is obtained as a unique answer:

$$p(\varepsilon) = \frac{N[1 - F(\bar{\varepsilon})]^{\frac{N-1}{N}} \bar{p} + \int_{\varepsilon}^{\bar{\varepsilon}} (N-1) C'(u/N) f(u) [1 - F(u)]^{\frac{N-1}{N}} du}{N[1 - F(\varepsilon)]^{\frac{N-1}{N}}} \tag{8}$$

The activity choice and benefit π_c, are henceforth founded on whether the income R_c from moving the vitality that has been asked for from each DSR client c is more prominent than both the expense of contracting client c with strike value X_c and a constant availability fee C^c_{fee} and the cost $C^c_{payback}$ paid for any load recovery, $\forall t \in \{\theta_1, ..., \theta_{\tau_{\alpha,c}}\}$, $\forall s \in \{\varphi_1, ..., \varphi_{\rho_{\alpha,c}}\}$, $0 < t < s$.

$$\pi_c = R_c - C^c_{contract} - C^c_{fee} - C^c_{payback}$$
$$= -(\sum_{t=\theta_1}^{\theta_{\tau_{\alpha,c}}} (\Delta^-_{t,c}.S(t)) - \sum_{t=\theta_1}^{\theta_{\tau_{\alpha,c}}} (\Delta^-_{t,c}.X_c) + C^c_{fee}) - \sum_{s=\varphi_1}^{\varphi_{\rho_{\alpha,c}}} (\Delta^+_{t,c}.\max(S(c) - X_c, 0)) \tag{9}$$

The decision to exercise the DSR contract depends on heuristic principles and is taken just when a benefit is normally allowed that the day-ahead costs are estimated and estimated against an actual realization of day-ahead costs. The benefit augmentation target of the aggregator's normal benefit π_c got from every client is calculated with relation (10)

$$\pi_c = \max_{\phi \in \{0,1\}} E_t[\gamma(f(S(t)))]$$
$$= \max_{\phi \in \{0,1\}} [\sum_{i=1}^{N} e^{-r(t_i - t)} \phi_i .(-\sum_{t=\theta_1}^{\theta_{\tau_{\alpha,c}}} \Delta^-_{t,\alpha,c}.\max(S(t_i) - X_c, 0) - C^c_{fee} - \sum_{s=\varphi_1}^{\varphi_{\rho_{\alpha,c}}} \Delta^+_{t,\alpha,c}.\max(S(s_i) - X_c, 0)] \tag{10}$$

The total expected profit π overall customers C is then:

$$\pi = \sum_{c=1}^{C} \pi_c \tag{11}$$

3-2- RO contracts for arbitrage (day-ahead market)

In general, electricity demand is a function of the price of electricity, the level of activity of sectors, the price of fossil fuels, the price of other goods and household income. In a competitive environment, the equilibrium price and the equilibrium value are determined externally and based on supply and demand forces. The behaviour of the electricity market in the form of the MCP problem and based on the cost function of the CES layer can be written as follows:

$$P_{el}[AL_{el}\bar{S}_{el}-\sum_s D_{el,s}-\sum_h D_{el,h}]=0, \qquad P_{el}\geq 0, AL_{el}\bar{S}_{el}\geq \sum_s D_{el,s}+\sum_h D_{el,h}$$

$$D_{el,s}=\omega_{E,s}\omega_{el,s}AL_s\bar{D}_{el,s}\left(\frac{(\omega_{KLM,s}P_{KLM,s}^{1-\gamma}+\omega_{E,s}P_{E,s}^{1-\gamma})^{\frac{1}{1-\gamma}}}{P_E}\right)^{\gamma}\left(\frac{P_E}{P_{el}}\right)^{\upsilon} \tag{12}$$

$$D_{el,h}=\omega_{E,h}\omega_{el,h}WL_h\bar{D}_{el,h}\left(\frac{(\omega_{M,h}P_{M,h}^{1-\gamma}+\omega_{E,h}P_{E,h}^{1-\gamma})^{\frac{1}{1-\gamma}}}{P_E}\right)^{\gamma}\left(\frac{P_E}{P_{el}}\right)^{\upsilon}$$

Where D represents the demand, $\bar{D}$ is the demand in the base year and $\bar{S}$ is the base supply year. WL also shows the level of well-being and income of households and the AL is the level of activity. We define indicator h for households, s for activities and el for electricity. As can be seen, electricity demand has an inverse relationship with electricity prices and has a direct relation to the level of production and household income. In the day-ahead market, future costs and loads for the following day can be forecasted (Schachter and Mancarella, 2014) with the goal that an aggregator can estimate ahead of time how much load will be accessible and how much benefit π can be made by abridging and moving loads from peak periods, when power costs are high, to off-crest periods, when costs are low.

3-2-1- Price scenario model

The valve arrangement is demonstrated dependent on the current UK advertise costs, taken from the Elexon gateway of UK market index price and volume in 2010 (Debia, et al., 2019). An auto-backward moving normal (ARMA) process with regular slacks was picked (Lagarto et al., 2012). The approach used to recreate the value forms is described below:

1. The deterministic part is characterized by a total of sine models to imitate day by day peaks and troughs in the day.
2. The mean estimation of the genuine costs is determined and the residuals, is the contrast between the real costs and the reenacted costs, are evaluated.
3. Using the autocorrelation function (ACF) and partial autocorrelation function (PACF), the sequential relationship in the information is recognized, since value information ordinarily exhibits solid occasional connection since above (underneath) normal costs typically pursue above (beneath) normal costs.
4. Critical slacks from the ACF and PACF are distinguished and the request of the stochastic segment is resolved.
5. The stochastic value segment is relapsed utilizing the network of critical slacks decided in step
6. This makes an AR display with regular slacks whereby the sequential relationship in the residuals is evacuated, enabling the residuals to be demonstrated as free irregular draws from a suitable distribution.
7. The appropriate distribution is dictated by plotting the cumulative distribution function of the valuable information and its fit is thought about against various likely appropriations, as in figure 2. Here, a Pareto Tail distribution appears to give the best fit since the value information introduces extremely fat tails at each finish of the dispersion, caused by price spikes.

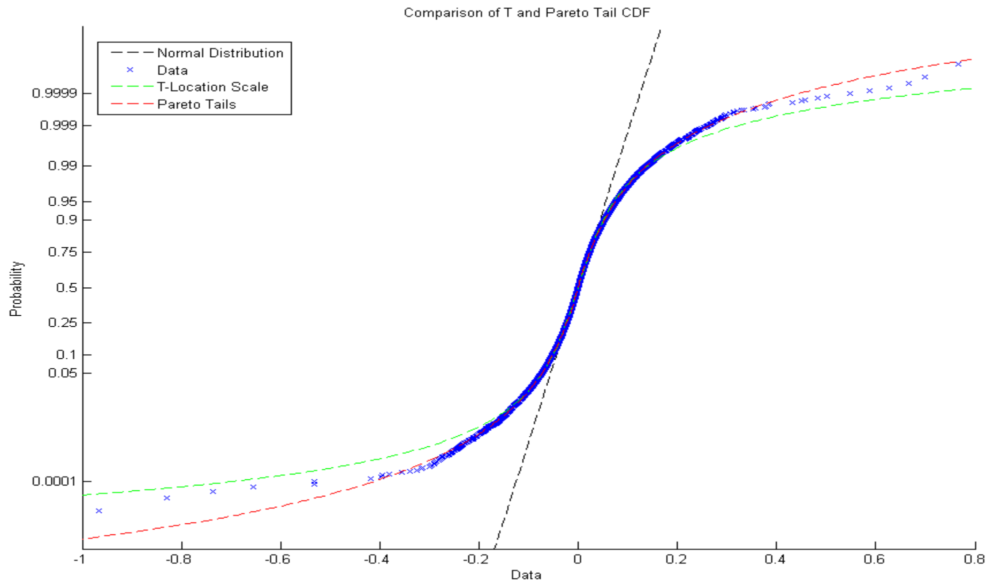

Fig 1. Comparison of T-Location scale and Pareto tail cumulative distribution function of price data

8. The ARMA(p,q) model would now be able to be composed as in equation (13) with parameters *p* and *q* with seasonal lags.

$$A_p y_t = c + M_q \varepsilon_t \tag{13}$$

Equation (13) is made out of an auto regressive lag parameter with request *p*, A_p, a moving normal slack parameter with request *q*, M_q, a consistent *c* and a mistake term ε_t. The mistake term is in this way displayed as an arrangement of irregular factors (repetitive sound), which are thought to be free and indistinguishably disseminated tests drawn from the Pareto distribution with mean α and standard deviation σ.

9. The price model would then be able to be simulated to make 10,000 new stochastic price paths utilizing the real mean value, the sinusoidal model (deterministic part), the relapse parameters, the slack vector and the residuals drawn from the likelihood circulation (stochastic segment).

The aggregator would then be able to compute the limited adjustments $P^k(t_i) = e^{-r(t_i - t)}(S^k(t_i) - X_c)$, rank them in dropping request, and total the first ϕ_{min} result with every one of the settlements up until ϕ_{max}. Based on forecasted prices, the aggregator just activities the agreements that may prompt a positive benefit, thus the normal benefit π_C is either positive or restricted to the accessibility expense as in (14).

$$\pi_C = \max[\gamma(f(S(t_i))), C^c_{fee}] \tag{14}$$

Here, an RO approach is basically taken by ensuring a benefit and evading misfortunes since DSR is enacted just on occasion when the normal estimation of load decrease surpasses the normal expense of load recuperation. To create arbitrary load profiles, the normal of 250 load profiles from four distinctive house types (flats, detached, semi-detached and terraced houses) containing electric heat pump (EHP) loads, produced utilizing the instrument, are found the middle value of over each house type, giving the particular after assorted variety stack profiles exemplified in figure 2.

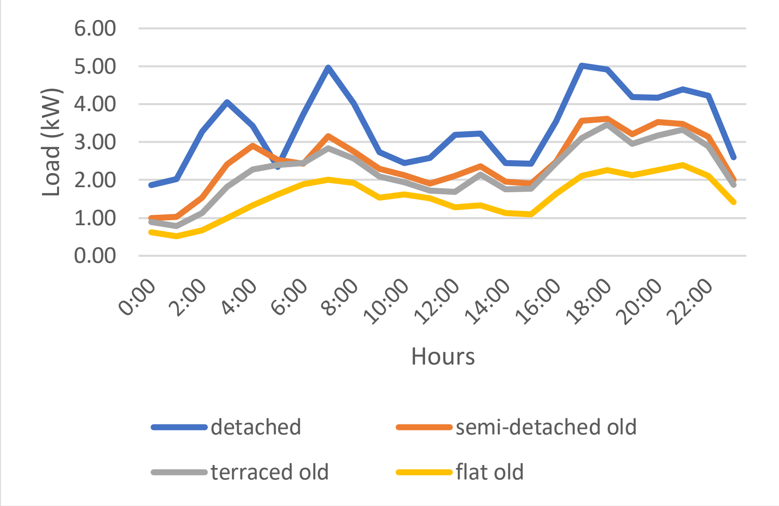

Fig 2. Example of after diversity load profiles for different house types equipped with electric heat pumps, on a typical winter day

A case of three simulated load profiles for a semi-detached house has appeared in figure 3. Each simulated load profile is accepted to speak to one day-ahead load figure, which the aggregator uses to compute the normal measure of adaptable load accessible to move back onto the market. The choice of regardless of whether to practice the individual DSR contract is along these lines dependent on the normal measure of adaptable load accessible, the normal day-ahead cost and the DSR contract cost. The real benefit created from the DSR conspire is then determined dependent on the genuine measure of load accessible and real power spot cost.

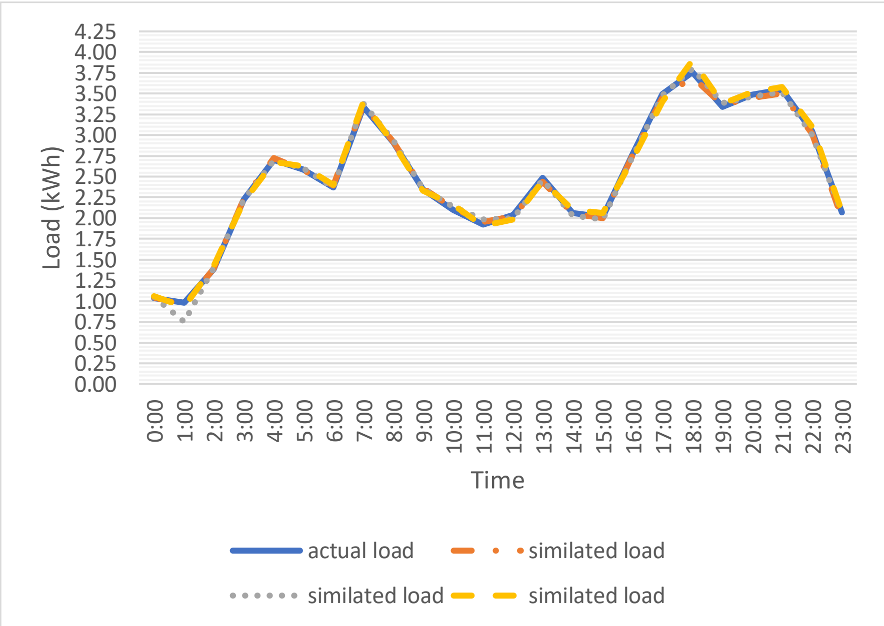

Fig 3. Simulated after diversity load profiles for a semi-detached house on a typical winter day

3-3- Numerical applications

Five cases are studied, outlined in table 3: a base situation where the heaps in the DSR portfolio are killed for one half-hour time frame and played Judas on in the following half-hour time frame with no heap recuperation; Case 1 has a 100% load recuperation in the half-hour time frame following diminishing; Case 2 has a half load recuperation in the following time frame following abridgment; Case 3 has a 70% load recuperation in the primary time frame following load decrease and a 30% load recuperation in the second time frame. Case 4 has a 30% load recuperation in the principal half-hour time span and a 20% load recuperation in the second half-hour time frame. Benefit affectability to changing economic situations is likewise evaluated, before dissecting a long haul DM speculation show.

Table 3. Characteristics of DSR load recovery for each case studied

Customer	**Total recovery (%)**	**Recovery in 1st half-hour (%)**	**Recovery in 2nd half-hour (%)**
Base case	0	0	0
Case 1	100	100	0
Case 2	50	50	0
Case 3	100	70	30
Case 4	50	30	20

4- Results

For the day-ahead market, the ideal choice to practice a DSR contract is made dependent on the greatest benefit accomplished in the day, accepting that figures at day-ahead costs are run and load profiles are known. Outward and inherent qualities are analysed at each day and age and the choice to practice the DSR contract is taken. The agreement is practiced just if the benefit coming about because of load decrease and later recuperation is sure. Consequences of benefits π are appeared as a case plot in figure 5 and compare to a dispersion work worked from 10,000 value re-enactments. A dark jewel marker assigns the normal benefits or misfortune for each case, a line in each container demonstrates the middle, and T-bars beneath or more each crate speak to the 95% and 5% Value at Risk ($VaR_{95\%}$, $VaR_{5\%}$), which means a 95% likelihood that benefits will be above $VaR_{95\%}$ and a 5% likelihood that benefits will be above $VaR_{5\%}$. Of course, the base case has the biggest potential benefit, as no heap is purchased afterload decrease. The most minimal benefits happen in Case 1 where 100% of the heap is recuperated in the principal time frame after the decrease. Here, recouping the heap more than a couple of periods have next to no effect to the benefits given that costs in back to back hours are near one another.

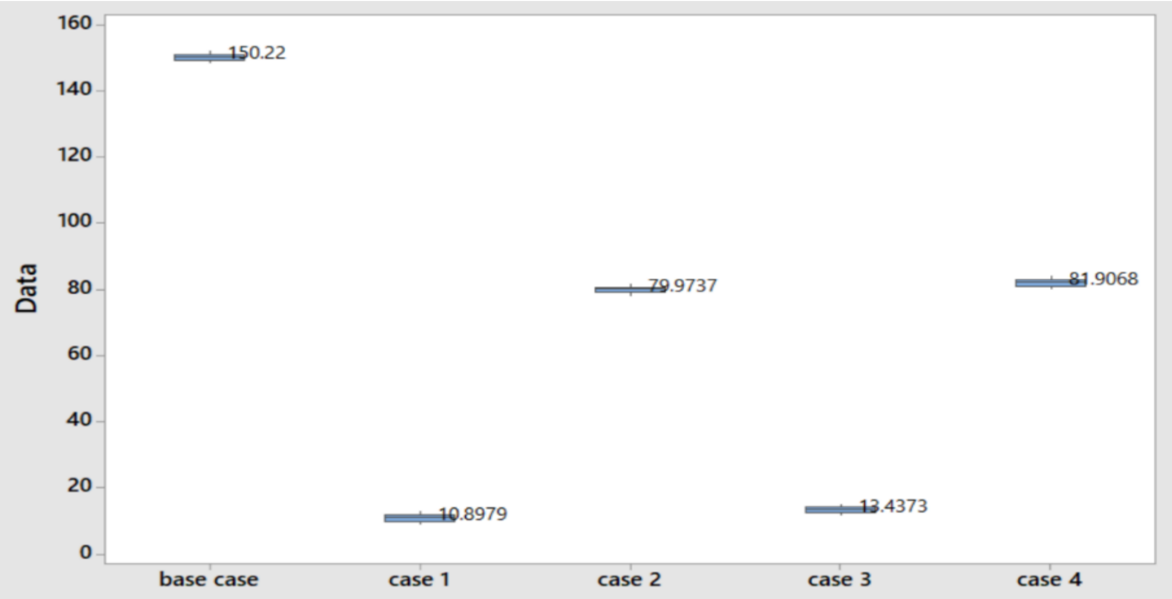

Fig 4. Box plot of daily profits (£/day) from DSR, day-ahead market

5- Discussion and conclusions

In competitive and free market conditions, the most important effect is increasing investment in the electricity industry, reducing the cost of electricity and the cost of goods. The results show that with increased investment in the electricity industry, in a competitive environment, the price level will be reduced in almost all activities. In the meantime, oil products, metals, and non-metallic minerals are the most affected. But in terms of the stability of energy prices, the price mechanism does not work.

Under these conditions, almost all activities will face a slight increase in the price index, which is mainly due to increased demand for the entire economy.

A model for surveying the estimation of DSR contracts for an aggregator in both the day-ahead and adjusting markets subject to various market value advancements, including higher instability and the presentation of value spikes was exhibited. Besides, within the sight of obscure and exceedingly unpredictable constant costs, the aggregator can utilize DSR to abstain from paying for expansive lopsided characteristics and decrease its hazard in the adjusting market. Value spikes can likewise prompt certain negative impacts, which might be unique in relation to what one would typically anticipate. Any agreement with a strike cost over this value level will result in misfortune for the aggregator and henceforth would not be worked out. Accordingly, this value level characterizes the greatest sum an aggregator will pay so as to modify the utilization of its clients. At last, when characterized by the model, this value level can likewise be utilized to educate of the fitting contract instalments made to the clients.

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