Added Value of Leveraging Demand Response Asset for Large Consumers by Dynamically Participating in the UK Spot and Balancing Markets

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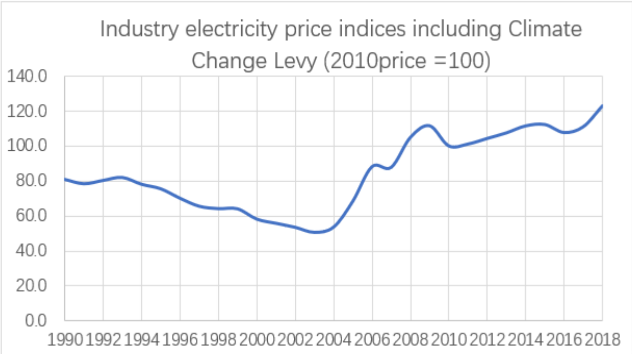
➢ Challenges: increasing electricity price and environment tariff



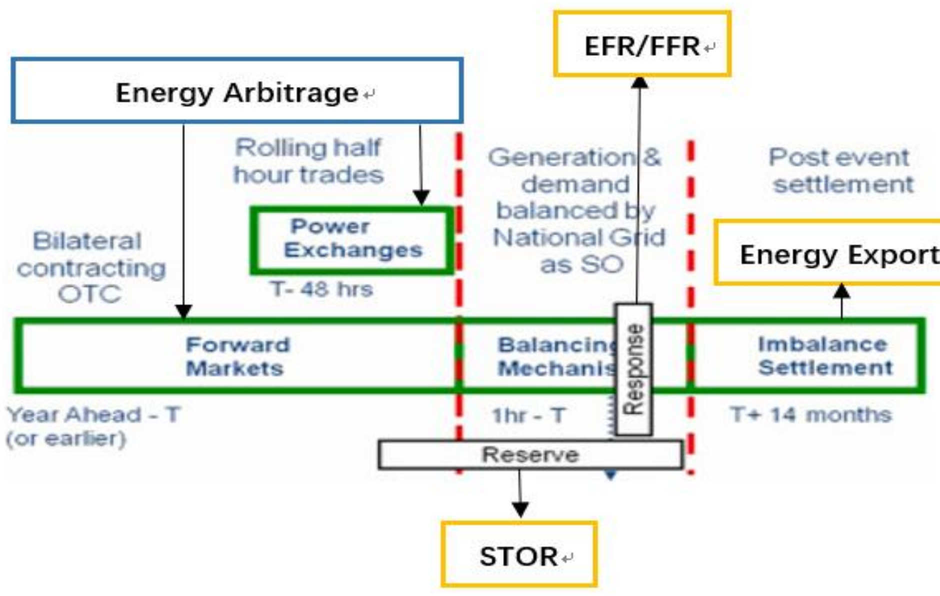
According to the BEIS price of the electricity procured, the electricity procurement price of large consumers whose annual consumption is higher than 20,00MWH had increased as much as 46% during the last decade.[1] Furthermore, The electricity cost and environmental tariff will increase the total operation cost for the energy-intensive industry by 4.9% in 2030.[2]

➢ Research objectives

Due to the regulatory framework of the carbon emission reduction and initiatives to operate a sustainable business, large consumers like Sainsbury have installed a large number of demand response assets like combined heat and power generators to save electricity cost while limiting their carbon emission. The thesis proposed strategies to rise the large consumers' profit margin by leveraging their demand response assets. This is achieve by

- *Sourcing the opportunities for large consumers to cut down the electricity bill*
- *Quantifying the opportunity cost of different alternatives*
- *Investigating the cost reduction ability of different demand response assets*
- *Proposing strategies for large consumers to reduce the electricity procurement cost*
- *Researching the impact of price fluctuation*

➢ Opportunities: revenue streams and cost reduction practices



Conventionally, most of the electricity demand is settled in long-term forward contract to secure the electricity price. Whereas, short term demand will be offered and bid in the power exchange market in a prompter time scale. Any imbalance between the market supply and demand caused by the uncertainty between the market prediction and actualities will be addressed by the Balancing Mechanism (BM) and associated reserve and frequency response services. After the delivery of the electricity, the penalty will be imposed on those who have a discrepancy between the scheduled electricity flow and the actual electricity transition.

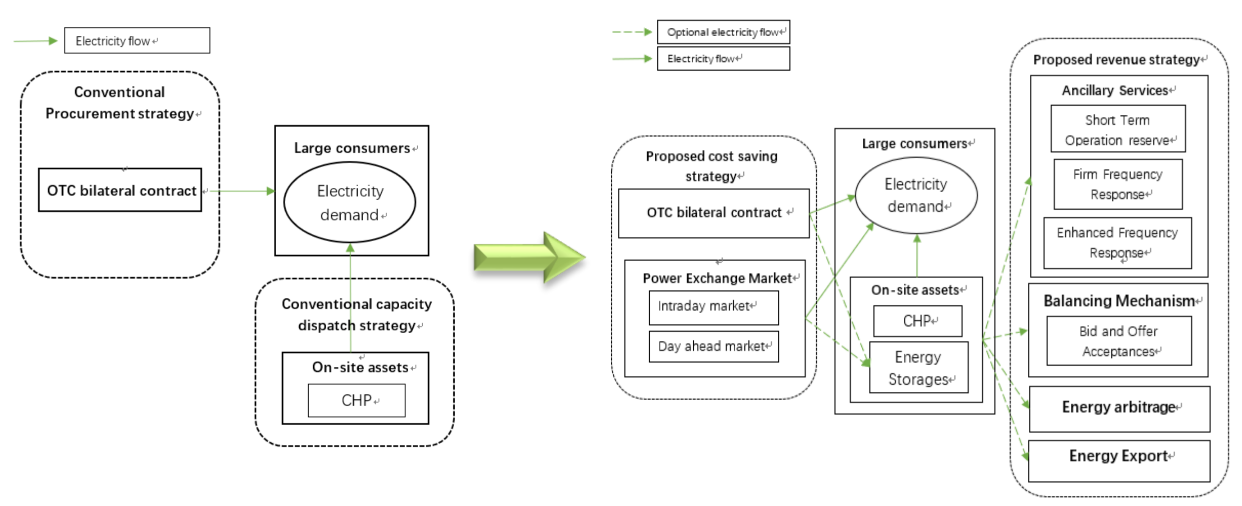
Revenue Streams

- ***Short Term Operating Reserve (STOR)***
  Reserve capacity for balancing the system demand uncertainty
- ***Enhanced Frequency Response(EFR)***
  System frequency maintenance service which provides service within 1 second or less
- ***Firm Frequency Response(FFR)***
  System frequency maintenance service which provides service within 2 seconds to 10 seconds services
- ***Balancing Mechanism(BM)***
  Tender for increasing or decreasing the demand

Cost Reduction Practices

- ***Energy Arbitrage***
  Charging battery at low electricity price and discharge it at high price
- ***Energy Export***
  Exporting the electricity to the grid
- ***Flexible procurement allocation***
  Purchase the energy from power exchange market to get the advantage of fluctuation of the electricity price

➢ Conventional strategy framework vs Proposed strategy framework



➢ Case Study: Sainsbury Leicester North Store

Scenarios

Analysis was performed under the following scenarios to deliver the insight of different strategies

◆ ***Business As Usual (BAU) scenario***

The Sainsbury Leicester north store has a CHP asset with 500MW and the electricity of last 3 years are shown in the following

Fiscal year	Cash out & import cost	CHP generation cost	TNuOs Tariff	Total cost
16/17	-433502	-105087	-31911	-570500
17/18	-491123	-98781	-29796	-619700
18/19	-572300	-98378	-29223	-699901

◆ ***CHP scenario***

This scenario tends to utilize the idle capacity of the CHP asset in participating revenue streams

◆ ***CHP with Energy Storage System scenario***

This scenario coupled the CHP asset with a battery which enables the coupling system for frequency response and energy arbitrage. The idle capacity of CHP was used to charge the battery in the morning

Optimal Strategies

Optimization models used price data from past three years to calculate the electricity cost at best case scenarios. The optimization results showed the minimum cost the store can get

Baseline Strategies

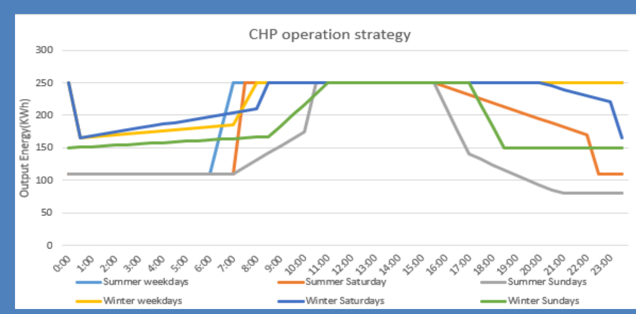
Preliminary analysis had revealed some common features for proposed strategies to reduce the electricity cost. These features working as baseline will not change with the alternation of revenue streams and practices

- *Proposed Electricity Procurement Strategy*

Short Term market (50%intraday+50%dayahead)		Long term contract （90%bilateral+10% cash out）
Winter Weekdays:	0:00(d)-6:00 23:00-0:00(d+1)	The rest of the time
Winter Weekends:	0:00(d)-7:00 23:00-0:00(d+1)	

The proposed electricity procurement strategy was derived by using the mutual inclusive method. The most competitive market within each settlement period was chosen to be **the** procurement market

- *Proposed CHP operation strategy*

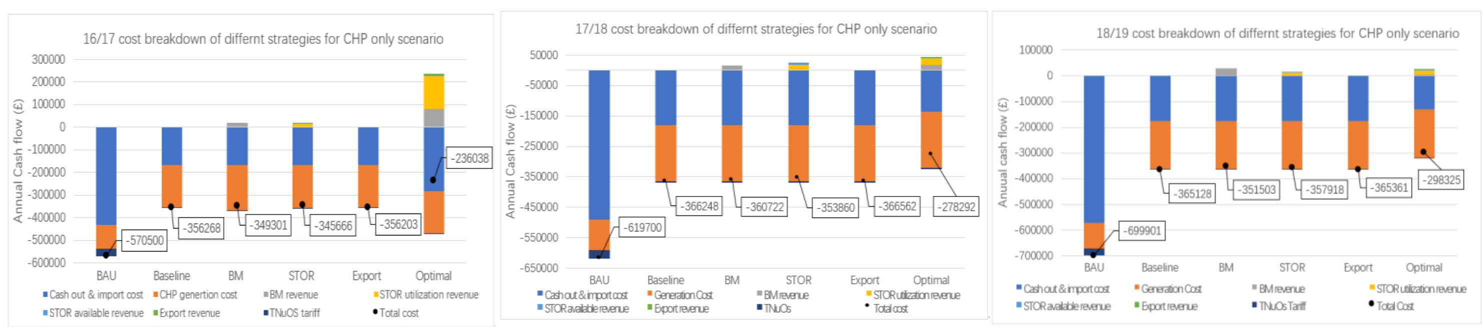


Compared to electricity import, the self generation has unbeatable advantage in reducing electricity procurement cost. Therefore, CHP assets should prior to fullfil the demand of store. This is achieved by operating the CHP at historical average demand level

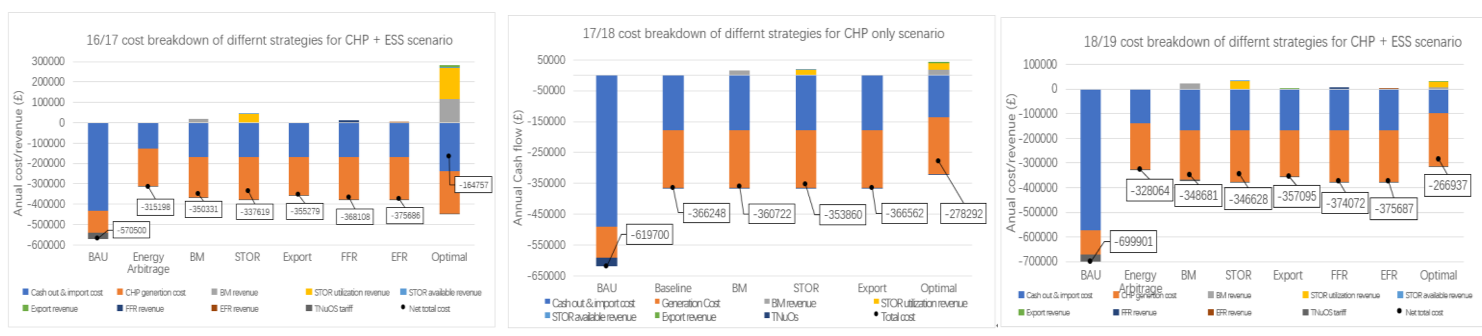
On the Basis of the Baseline strategies, the different revenue streams and cost reduction practices were implemented to evaluate the opportunity cost in each scenario

➢ Performances of the proposed strategies

CHP scenario

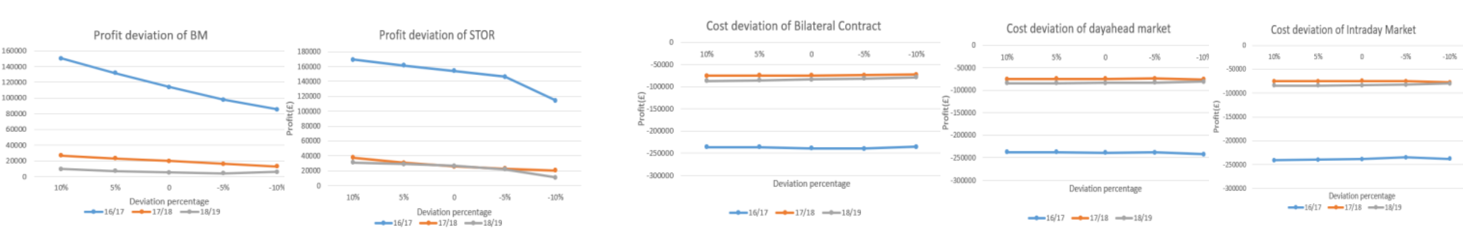


CHP with ESS scenario



➢ Sensitivity Analysis

Profitable Revenue Streams ***Energy Import***



The sensitivity analysis studies the impact of the price change in the profitable revenue streams and energy import sources to the total electricity procurement cost.

➢ Key findings

- The proposed baseline strategies are efficient in reducing the electricity import cost
- The ESS system can significantly reduce the electricity cost
- The top 3 approaches in reducing the total electricity cost are **Energy arbitrage** , **STOR** and **BM**, which have potentials to reduce **54%**, **51%** and **50%** of the total cost
- The profit of revenue streams are sensitive to the change of the price, whereas the change of the importing price has little effect on the total electricity cost

➢ References

[1]"Industrial energy price indices", GOV.UK, 2019. [Online]. Available: https://www.gov.uk/government/statistical-data-sets/industrial-energy-price-indices. [Accessed: 3-Sep- 2019].
[2] Committee on Climate Change, "Energy Prices and Bills-impacts of meeting carbon budgets", 2017.