AIM
To develop a simple algorithm to optimise the operation of a storage device for multiple revenue streams.

BACKGROUND
Renewables offer a solution to meet the UK’s carbon reduction targets of 80% by 2050. However their often inflexible and intermittent nature results in an increase in system costs. Electricity storage offers a solution to increase flexibility, with suggestions that by 2050, storage could provide total system savings of up to £1bn/year. However, currently it remains difficult to invest in commercially due to the costs of the technologies involved. Whilst cost have and are likely to continue to reduce, an alternative is to maximise the income a single device can achieve, by operating in multiple markets simultaneously.

The options include:
- Arbitrage – charging during off-peak and selling during peak prices
- Capacity – offering available generation capacity
- Ancillary services – Response, reserve, voltage support, black start
- Network upgrade deferral
- Demand management (triad avoidance) – limiting customer demand during periods of high national demand

The challenge however is how best to operate when faced with several income streams, with or without foresight of future market prices or developments.

This study specifically optimises for arbitrage and reserve, based on the UK short term operating reserve (STOR) market. STOR participants are required to remain in a state of readiness at certain times of the day, whereupon National Grid may instruct participants to start generating as part of it’s role in maintaining grid stability.

METHOD
Three scenarios were evaluated:

i. Arb Only - Arbitrage Only
ii. Arb+Av - Arbitrage with reserve, remunerated for availability but no utilisation (the worst case profit)
iii. Arb+Av+Ut - Arbitrage with reserve, including utilisation (the expected profit)

All were executed under perfect foresight (PF) and no foresight (NF) of future market prices and reserve utilisation volumes.

Additionally, arbitrage only was integrated with a wind farm to observe the value of time shifting delivery.

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REFERENCES

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RESULTS – The three scenarios
The specific profits obtained for a 3MW / 30MWh device under each scenario are presented in Fig. 2.

- Of the three scenarios, Arb+Av+Ut offers significantly greater profits of .
- No foresight is able to achieve between 88% and 98% of the profits of perfect foresight (for arb only and arb+av+ut respectively - at an efficiency of 1).
- Below a round trip efficiency of 72%, arbitrage is the least favourable option. This increases to 85% under no foresight, emphasising the importance of reserve

If a device with a larger discharge capacity is evaluated, only the specific profit from the Arb+Av+Ut scenario is affected (Fig. 3). Smaller devices exhibit higher specific profits as a result of being utilised more often (Fig. 4).

RESULTS – Integrating storage with wind
The current benefits of integrating storage with wind are minimal if used purely to shift the time of delivery. Figure 5 presents the annual rates of return, based on the use of a sodium sulphur battery. A maximum return of 1.65% may be achieved for a 8MW 20MWh device. This excludes the costs of capital.

SUCCESS – Integrating storage with wind
A simple algorithm to optimise storage under arbitrage and reserve was developed. Reserve was found to be highly favourable, increasing profits by up to 3x, however arbitrage alone is unlikely to produce acceptable returns on investment based on the current cost of storage.