Techno-economic optimisation of energy storage integrated with renewable energies to manage peak demand in UK grid

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Research framework

- The UK has set net-zero emission target by 2050

- National Grid's FES predicts Wind generation is the key to achieve this target.

- 5% (UK) & 16% (Scotland) wind curtailment (2016) due to Network congestion.

- Curtailment would be unnecessary if battery storage is used.

- Balancing technical and economical parameters to achieve most effective & commercially viable Battery Energy Storage Systems (BESS) co-located with wind farms is necessary.
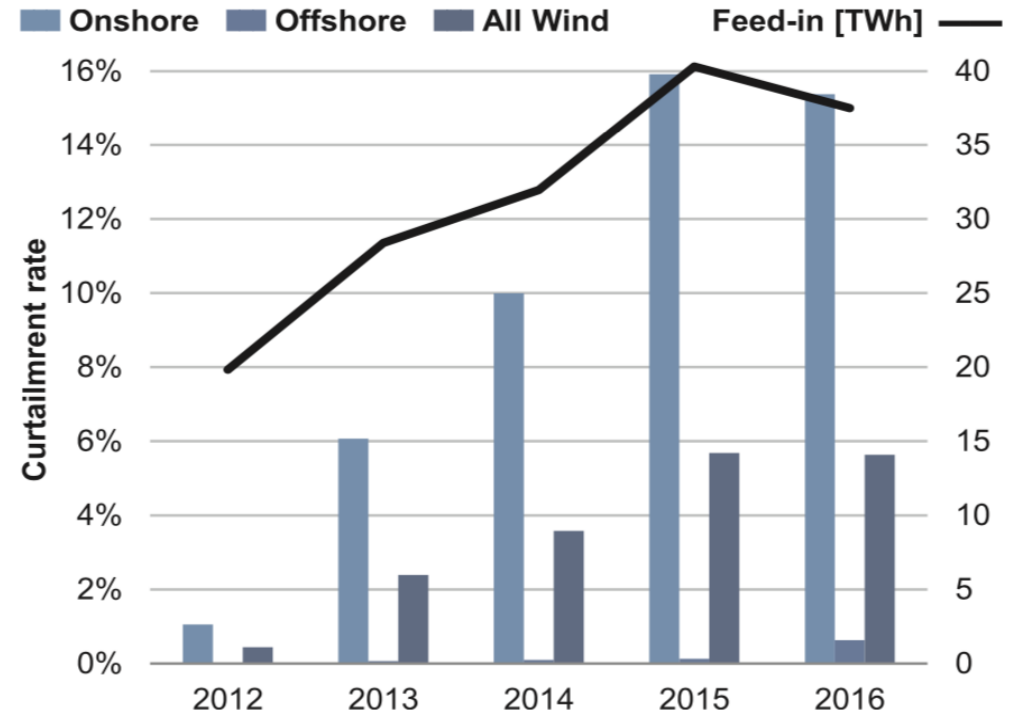


Wind curtailment in the UK, 2016

Method and objectives

Method:

- Grid level battery to be charged by curtail wind at night
- Stored energy will be discharged to the grid during the peak time
- Li-ion battery
- Batteries' energy application

Objectives:

- Develop technical model to determine the size requirement of BESS for the UK grid.
- Simulate BESS with 1 year electricity supply and demand data.
- Optimisation of BESS techno/economic parameters to demonstrate commercial viability.
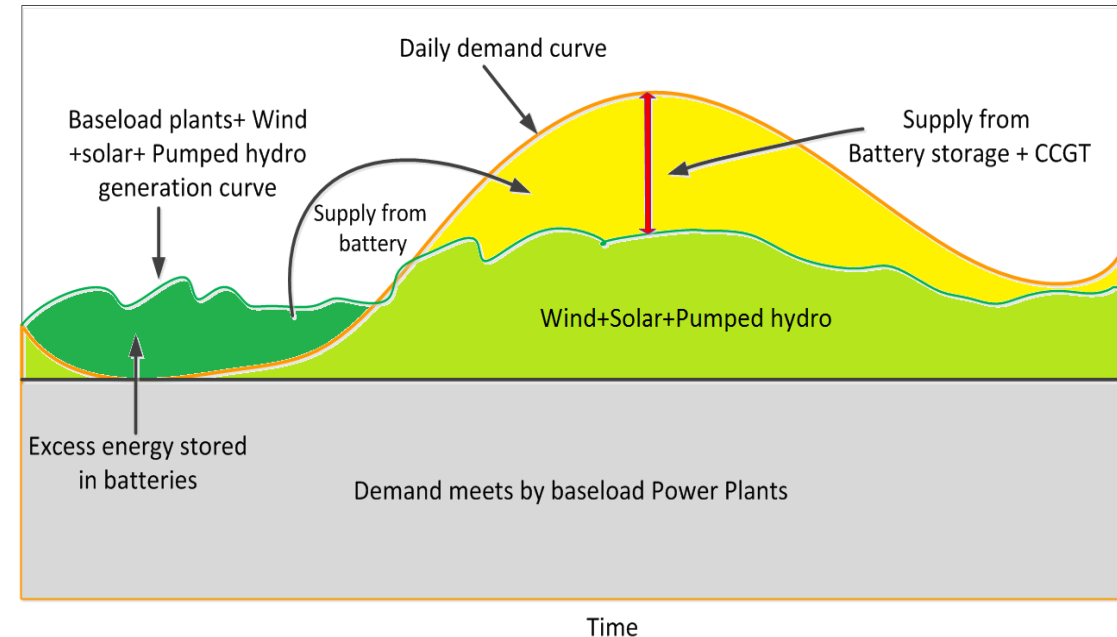
Electricity supply and demand management with storage

Techno-economic model

Simplified Techno-economic model
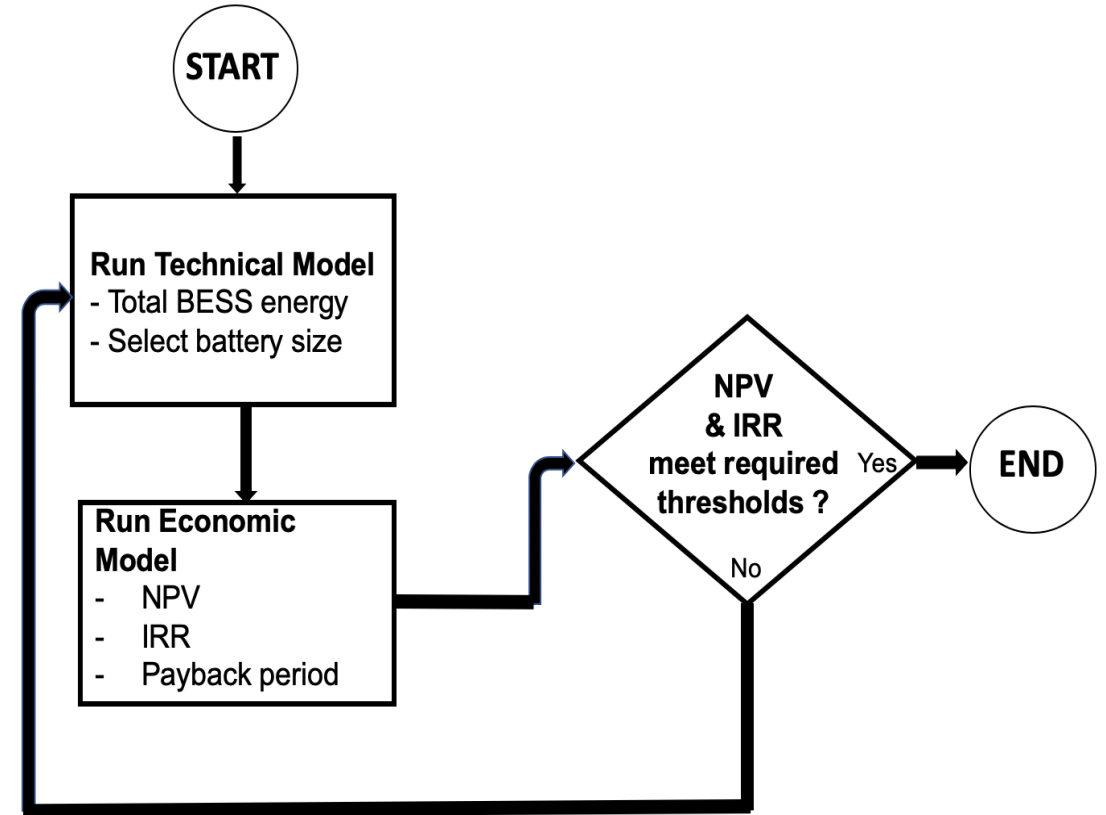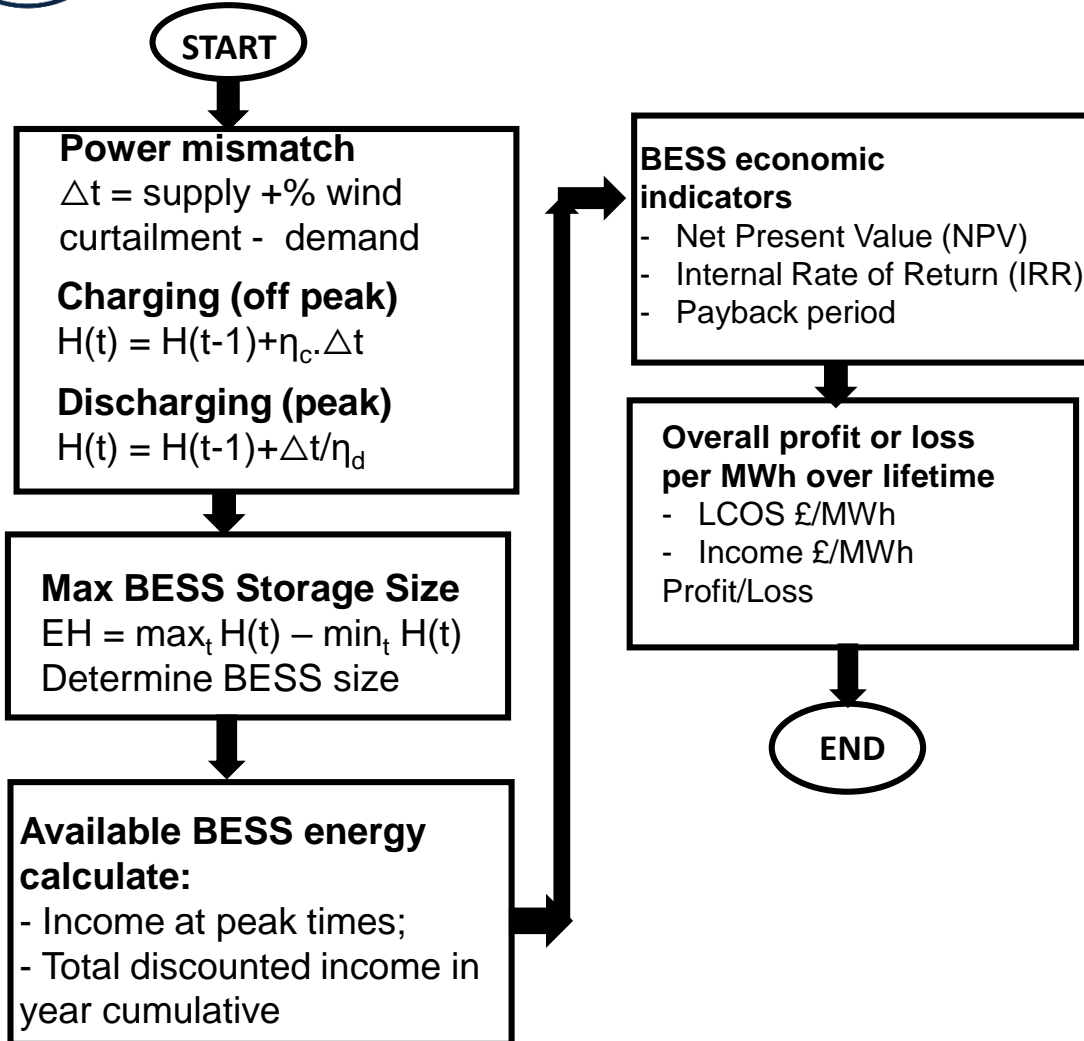
Techno-economic optimisation model

Model inputs

Technical model inputs

Parameter	Base case & units
Electricity supply & demand data for UK for 1 year	5 mins interval
Curtailed wind supply	15%
Time & duration of wind curtailment	21.00 to 06.00hrs
Discharging BESS time	07.00 to 08.00hrs & 17.00 to 21.00hrs
Battery charging and discharging efficiency	90%
Depth Of Discharge DOD	90%
Battery degradation	30%
Battery life time	15 years

Economic model inputs

Parameter	Cost (Base case)
Li-ion battery purchase costs	200 £/kWh
Inverters purchase cost	20 (10%)
Electrical & management systems	8 (4%)
Structural costs	6 (3%)
Operation and decommissioning cost	16 (8%)
Sub total	250 £/kWh
Loan/available capital split (%)	50/50 %
Discount rate (%)	5%
Interest rate for loan (%)	4%
Income	£74.75/MWh
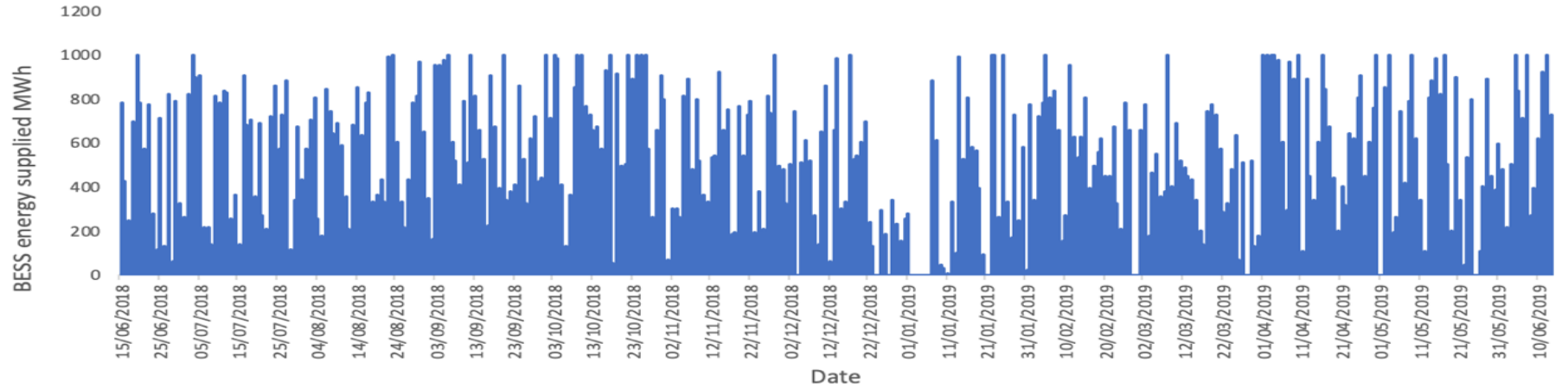
Results

Energy supplied by BESS to the grid over 1 year
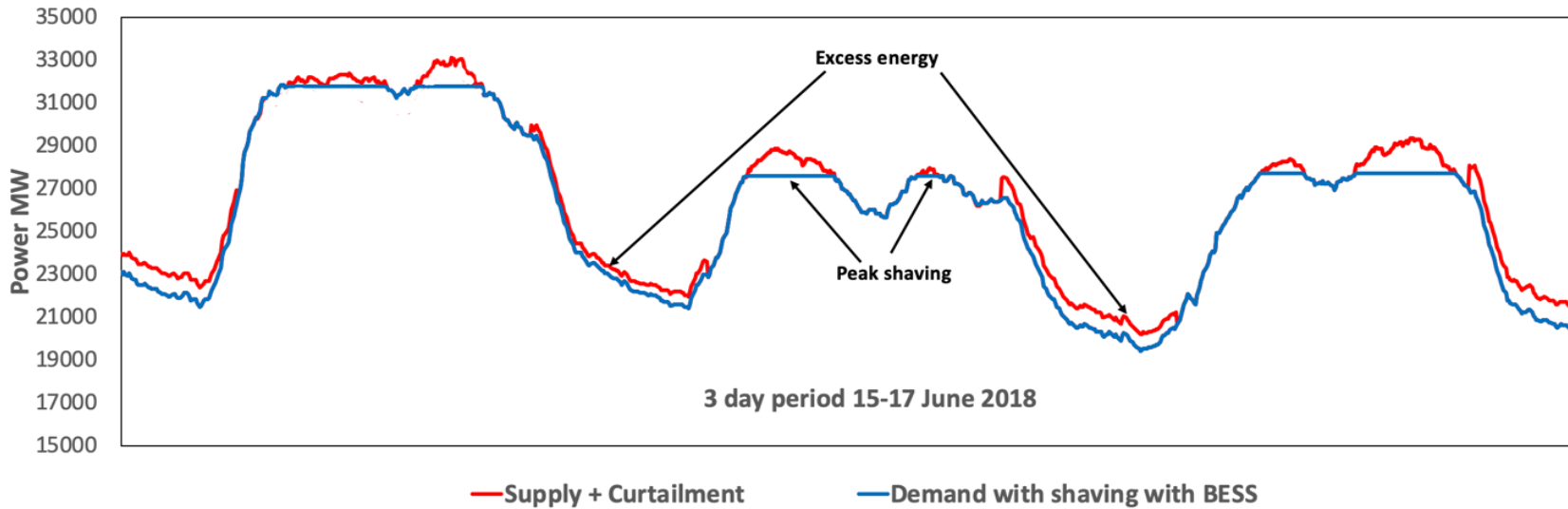
Illustration of peak shaving

Results

BESS Size Vs Total Energy Supplied by BESS, NPV & IRR
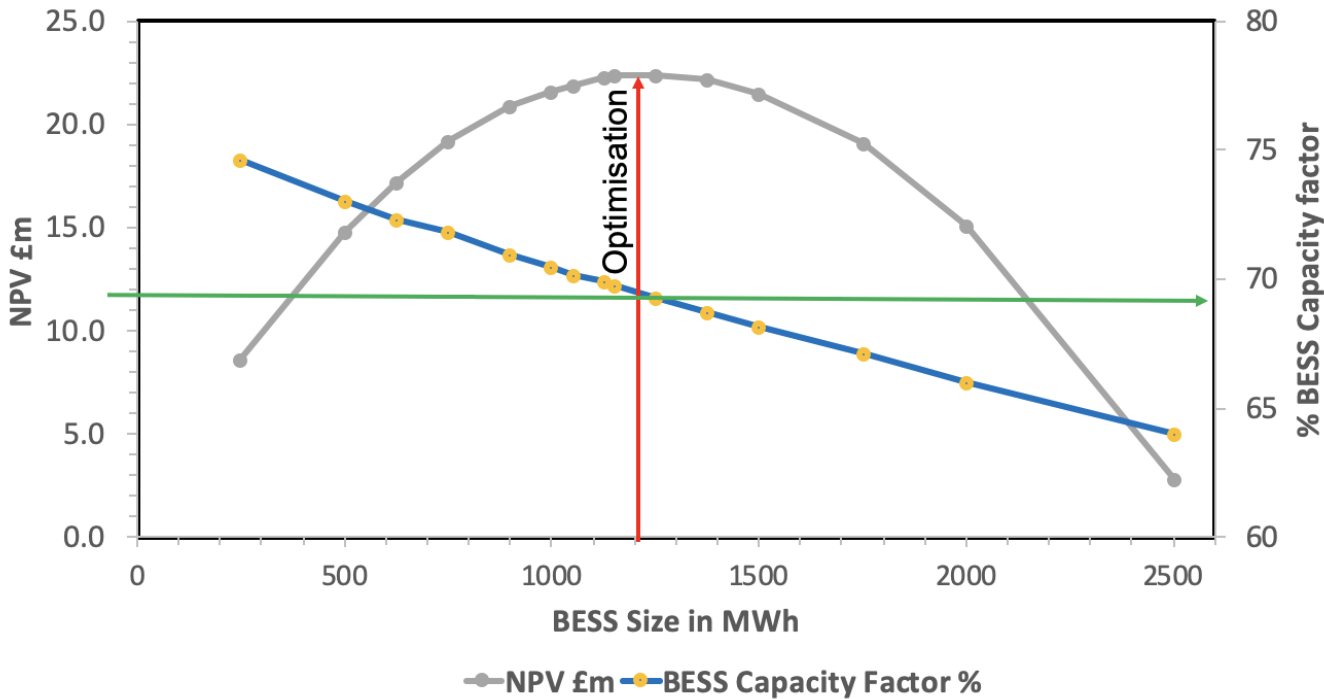
Results of optimised battery size

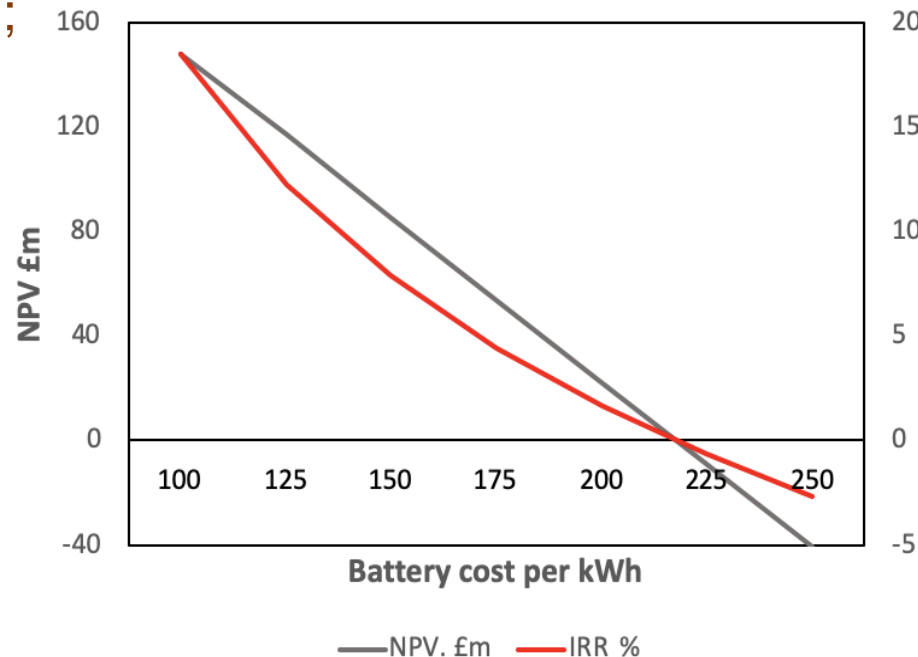|	
Optimised BESS size	1.25 GWh
Total energy supplied by BESS	285 GWh
Total CCGT offset by BESS	285 GWh
BESS capacity factor	69%
NPV & IRR	£22.4m &1.7%
Payback period	14 years
LCOS per kWh	£0.037/kWh

Sensitivity analysis
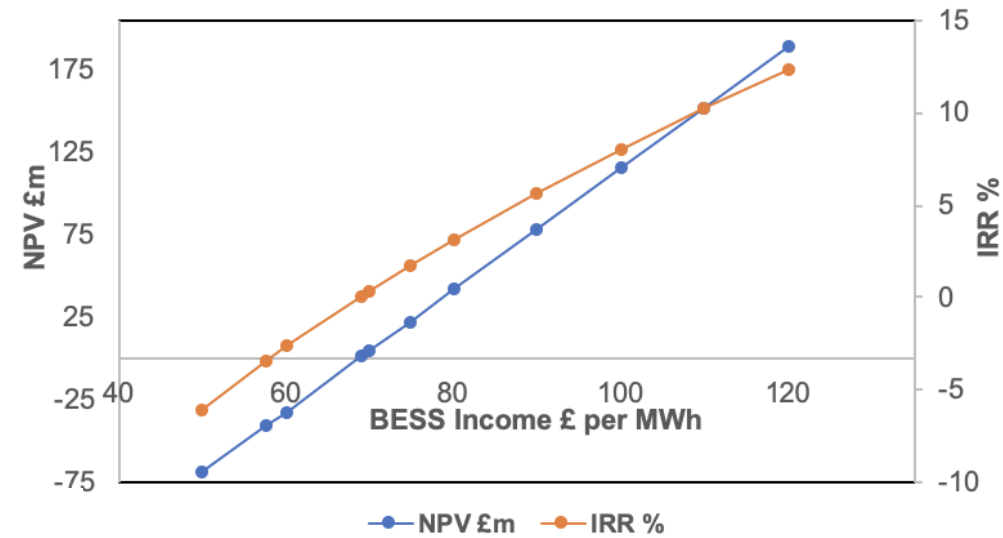
Sensitivity analysis on optimised BESS (1.25 GWh):

- Curtailed wind energy %;
- DOD %;
- Battery efficiencies %
- Battery costs £/kWh;
- BESS income.

Sensitivity analysis with battery's income

Sensitivity analysis with battery cost

Summary

- Wind curtailment can be avoided with grid-scale battery storage

- Batteries grid use for energy application is technically possible

- Low cost of batteries will make the economic case very attractive

- Other factors acting as barriers

  - Lack of clarity on income from storage

  - Lack of clarity in regulation & incentives to underpin rollout of BESS

THANK YOU