PhD Plan

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# Problem:

Is it possible to achieve both financial and environmental sustainability in using batteries to expand renewable generation capacity within a constrained network, without subsidies?



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To the Grid 🡪

# System:

PV farm,   
capacity *PPV* (MW)

Grid export limit

*gridlim* (MW)

(2nd-life) Batteries, energy meter

Capacity *EB* (MWh)

Plant trades on N2EX day-ahead market during the day and is contracted for EFR (*gridlim* MW) during the night. ‘Day’ is between hours ending *h1* and *hend*, and ‘night’ are other hours.

# Task 1:

Develop code to schedule day-mode dispatch (power export, battery charge and discharge) to maximise revenue, given *PPV*, *EB*, *gridlim*, *h1*, *hend*. EFR is modelled at this coarse resolution as a drain on battery SoC.

* Is linear programming the best option? (Lit. review)
* Meeting with George and Mahdi. (24/01)
* How can I make the code more efficient? (31/01)
* Test real-time operation issues (high-res simulation). (mid-Feb.)

# Task 2:

Literature review. (End of Feb.)

* Is linear programming the best option for optimal scheduling?
* What are my options for optimal sizing of components? (Genetic algorithm, particle swarm, etc.)
* What similar problems use these techniques, and what am I adding?

# Task 3:

Develop code to size system components to maximise NPV; conduct initial sensitivity analyses. (End of Mar.?) Optimisation variables: *PPV*, *EB*, *gridlim*, *h1*, *hend.* Define base case against which to compare costs and carbon.

* Decide on optimisation technique (from lit. review)
* Code in costs (PV, 2nd-life battery and replacements, O&M, electricity bought, connection fee)
* Code in carbon costs (initially only estimating grid carbon intensity)
* How are optimal system size and carbon savings affected by varying rates of simple degradation that decrease *PPV*, *EB* and battery efficiency (straight-line decline, energy throughput)?

# Possible avenues for further exploration:

* Improve projections of grid carbon (and other) emissions intensity, including FFR spinning reserve emissions – depending on how sensitive carbon accounts are to these figures (Task 3).
* More detailed battery degradation (*EB* and efficiency changing in response to cycling, time, temperature, average SoC) – depending on how sensitive NPV-optimal sizing is to battery degradation (Task 3).
* What is the impact (if any) on NPV-optimal sizing, of accounting for imperfect forecasting? Persistence forecast gives lower bound; can try combining schedules that optimise yesterday and day before etc.
* What is the impact (if any) of time resolution of PV forecasting?
* What is the impact (if any) of modelling the battery and power electronics in more detail? (Efficiency and *EB* depend on charge/discharge rate, temperature, etc.)
* Real options analysis? (When will it be best to start investing?)

18-month deadline: 21/03/18. Abstract deadline for Energy Systems Conference (London, 19-20 June): 09/02/18.