Modelling grid and distribution-scale energy storage

RESTLESS
Realising Energy Storage Technologies in Low-carbon Energy Systems

Paul Dodds[1], James Robertson[2], Graeme Hawker[3], Waqquas Bukhsh[3], Tiziano Gallo Cassarino[1], Daniel Scamman[1]
[1] University College London; [2] University of Edinburgh; [3] University of Strathclyde

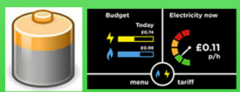
Introduction

Renewables and nuclear are generating ever increasing shares of UK electricity. Renewable output varies with weather, while nuclear is inflexible. Electricity demand could also become much more variable in the future as heating and transport are electrified. This could lead to supply greatly exceeding demand, or vice versa, at different times through the year.

Technologies offering *flexibility*, such as energy storage, are likely to become increasingly valuable in the future as balancing supply and demand becomes more challenging. Energy storage will need to compete with several other approaches.

RESTLESS is comparing the value of energy storage against these other technologies.

Interconnection – moving energy through space.



Energy storage and demand-side response – moving energy in time.

Flexible generation and hydrogen production – different methods for supply and demand peaks.

Step 1: Planning future scenarios

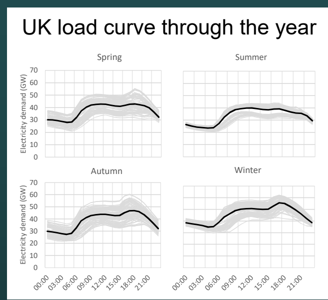
How much electricity might we use in the future? How might the load curve change? How much, and what type, of energy storage will we need?

We use the UK TIMES energy system optimisation model to produce scenarios of the UK energy system in the future.

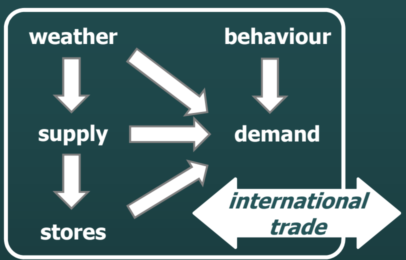
UK TIMES is a *planning* model, so it can optimise the amount of storage for the electricity system. It models the entire energy system so can identify the relative benefits of electrical and heat storage, and other flexibility options. However, UK TIMES has a very low temporal resolution – 16 timeslices per year – so it tends to underestimate the need for storage. We have created a higher-resolution version with 192 timeslices so it can resolve variations in renewable demand by simulating typical days.

Step 2: Value of interconnection

We use the ANTARES European dispatch model to find the costs of electricity in other European countries, and to provide interconnector flows and prices for our UK models as an alternative to storage.



Step 3: Electricity load curves



The **ESTIMO** model calculates future electricity load curves using information from UK TIMES scenarios. These account for the impacts of weather on energy demand, for the potential benefits of demand-side response, and for both electrical and heat storage, at hourly resolution for multiple years.

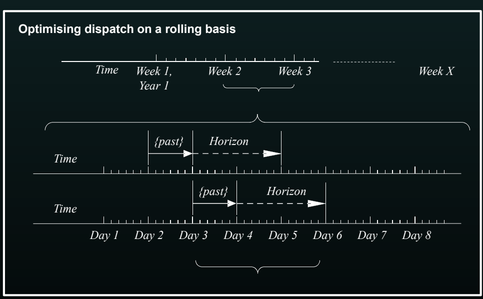
Step 4: Grid-scale modelling

Our grid-scale dispatch modelling determines the day-to-day role of energy storage technologies in the electricity system.

Dispatch is performed hourly. For *future* scenarios, we model the impacts of the same weather variations on both electricity demand and renewable supply, using load curves from ESTIMO. We are examining several years of weather data to ensure our results are robust.

The modelling determines a day-ahead optimisation that is used to simulate the wholesale electricity market:

- The receding-horizon modelling approach increases the opportunity to maximise the economic value of energy storage technologies.
- Detailed information on individual generating units gives a good evaluation of the instantaneous and marginal greenhouse gas emissions.

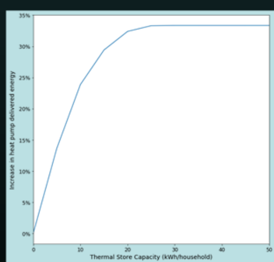


Step 5: Distribution-scale modelling

Our distribution-scale storage model helps us to understand the potential benefits of embedding energy storage in communities.

We simulate three local energy systems (urban; suburban; rural) with high spatial and temporal detail for different future energy usage scenarios, considering costs/options in:

- Grid-level electricity / gas decarbonisation.
- Last mile network reinforcement.
- Opportunity value of PV and embedded wind.
- Thermal and electrical domestic-scale storage.



Localised storage can be dispatched to increase the seasonal performance factor of heat pumps, decrease utilisation of higher carbon sources in hybrid systems, and minimise household expenditure.

Least-cost and least-emissions dispatch give very different scheduling, but broadly assist in: (i) overcoming lower voltage network constraints; and, (ii) enabling local demand to decrease the curtailment of community-based renewable generation.

For more information: p.dodds@ucl.ac.uk

UCL Energy Institute, Central House, 14
Upper Woburn Place, London WC1H 0NN, UK

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