Storage and transmission using the "Energy Space Time Integrated Model Optimiser" (ESTIMO)

Prof. Mark Barrett, Dr. Tiziano Gallo Cassarino

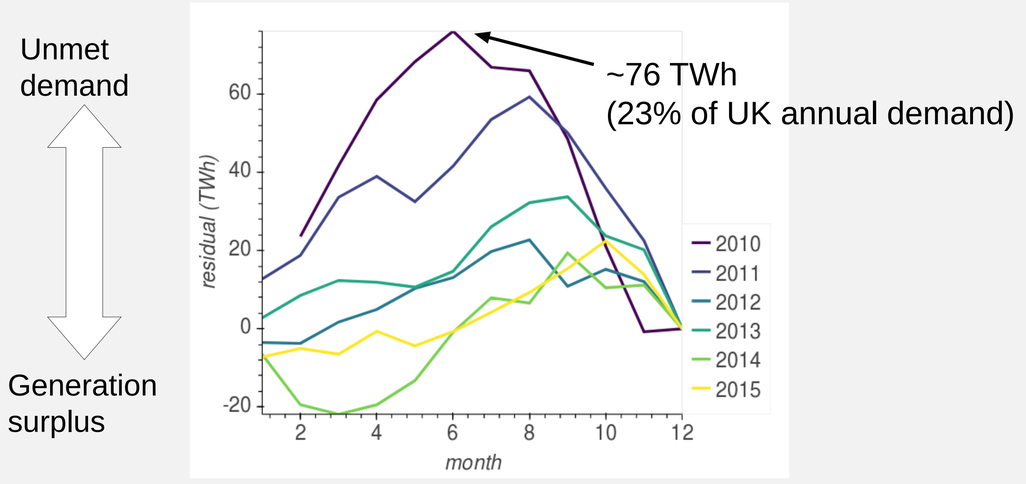
RESTLESS
Realising Energy Storage Technologies in Low-carbon Energy Systems

UCL

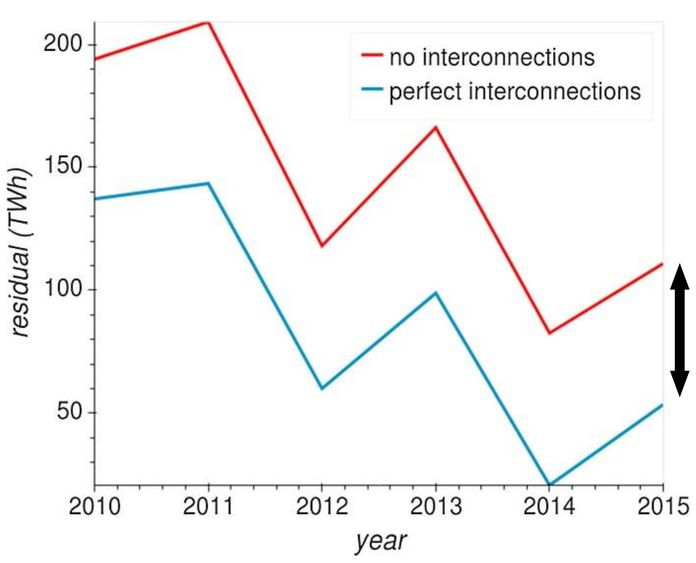
Challenge
Meet variable demand with renewable energy sources

Meeting variable demand is currently mostly done by using primary energy storage from fossil and nuclear fuels. Future energy systems will have a higher fraction of renewable energy sources, with wind and solar in particular having significant variability and no integrated storage.

How could future energy systems match such a variable demand?



Variation in electricity cumulative residual demand (= demand - generation) for UK from 2010 to 2015, assuming only wind and solar generation



Storage requirements at the European level (theoretical boundaries) between no transmission and perfect interconnection. The arrow indicates a difference of ~25%

Modelling approach
Optimal mix of storage and transmission

Technologies for storing electricity are more expensive than fossil and nuclear fuels. Therefore, it is crucial to balance storage with transmission. We found that perfect transmission means ~25% (50 TWh) less storage needed.

Our model **ESTIMO** aims to find this optimal balance by using social patterns and weather data to simulate multi-vector hourly demand and supply. **ESTIMO** takes into account a range of technologies, including individual and district heating (e.g. heat pumps, gas boilers, and CHP with heat stores), as well as electric transport (i.e. trains and battery EVs).

Results taken from *"**The impact of social and weather drivers on the historical electricity demand in Europe**"*, by Gallo Cassarino T., Barrett M., *Applied Energy 2018*.

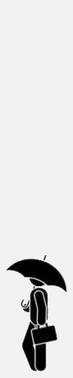
Simulation results for RESTLESS
Climate impact on supply, demand, and storage

Starting from the UKTM scenario for 2030, **ESTIMO** simulated the UK energy system without interconnections, accounting for different energy service demands.

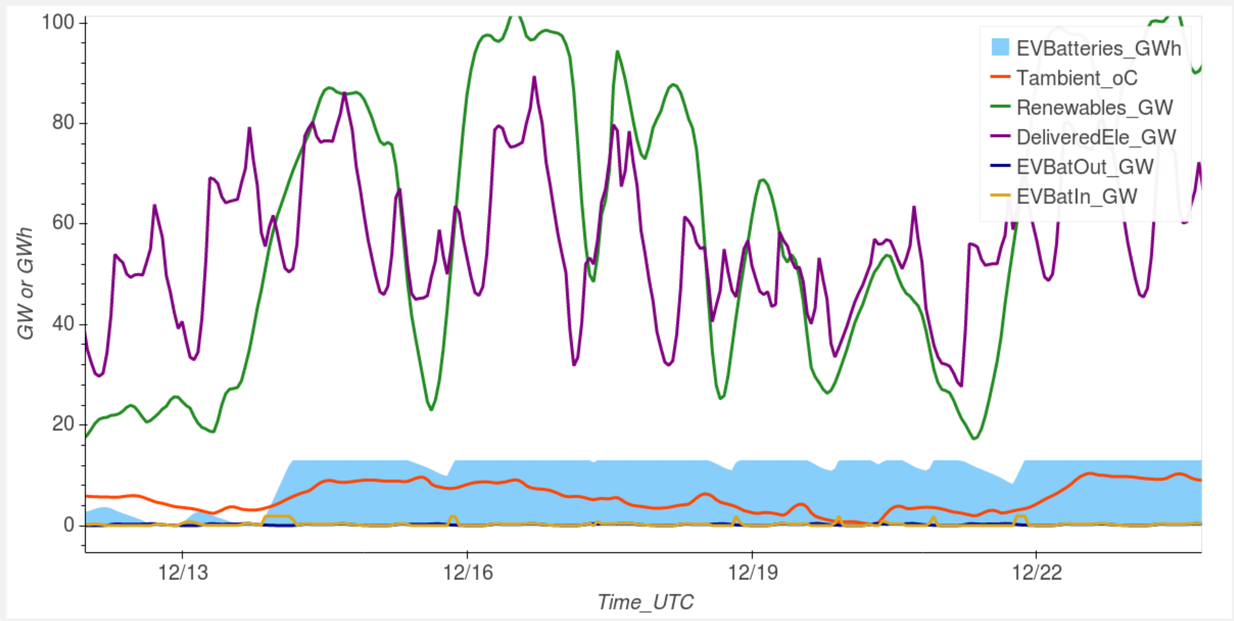
In case of extreme weather events – like low winds and low temperatures – renewable generation could be low for several days and might not be able to meet electricity demand. The plots on the right show how changes in social and climate heavily influence the UK energy system.

During the 10 days in December shown by the plots, in a typical winter weather (as in 2004), EV batteries were used only partially (light blue area). Instead, in case of extreme weather (as in 2010), EV batteries were fully used several days in a row to manage electricity demand. The inset shows simulated batteries usage (**yellow** and **blue** lines). In cases like these, storage would be essential to balance the deficit.

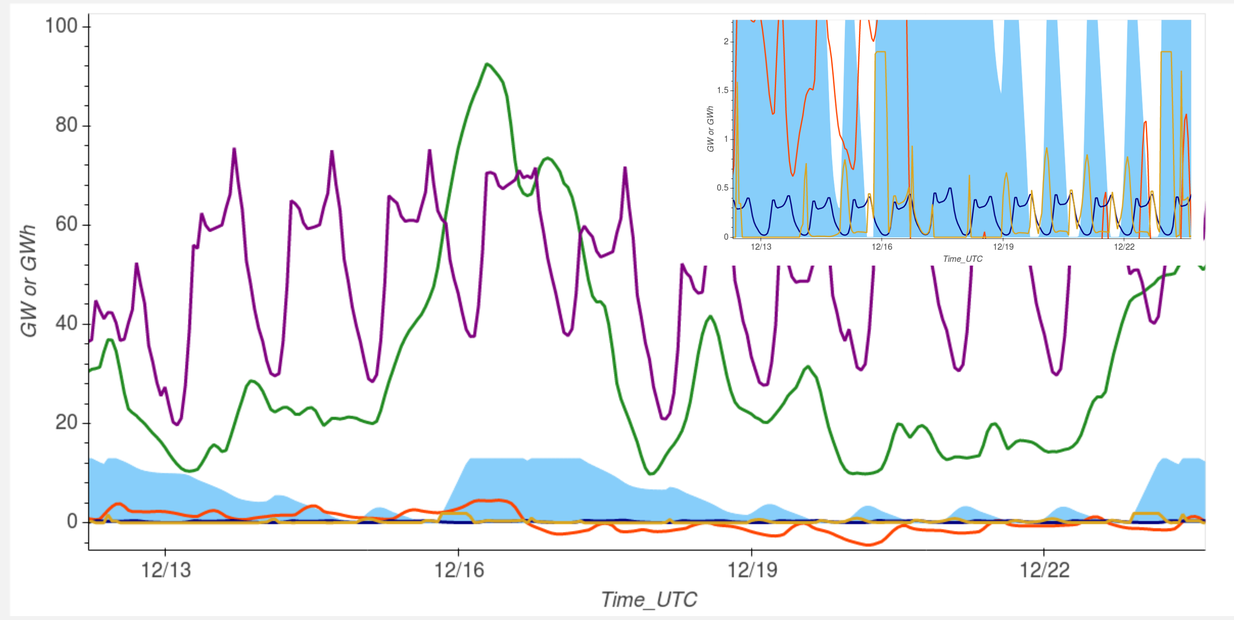
Therefore, an optimal mix of storage and interconnections will be fundamental to meet demand in future highly electrified energy systems with high variable generation.



Typical weather (2004)



Extreme weather (2010)



For more information: **m.barrett@ucl.ac.uk**, **t.cassarino@ucl.ac.uk**

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

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