THE UNIVERSITY of EDINBURGH
School of Engineering

Data-driven exploration of the carbon emissions impact of grid energy storage deployment and dispatch

University of Edinburgh Team Introduction

Thomas Morstyn, Iacopo Savelli, and Mostafa Nosratabadi

Institute for Energy System
School of Engineering
University of Edinburgh
thomas.morstyn@ed.ac.uk

Overview

- University of Edinburgh team
- Why are we excited about the project?
- Relevant previous work
- Questions for further discussion

Edinburgh Project Team

Dr Thomas Morstyn

- Edinburgh co-investigator
- Thomas.mortyn@ed.ac.uk

Dr Mostafa Nosratabadi

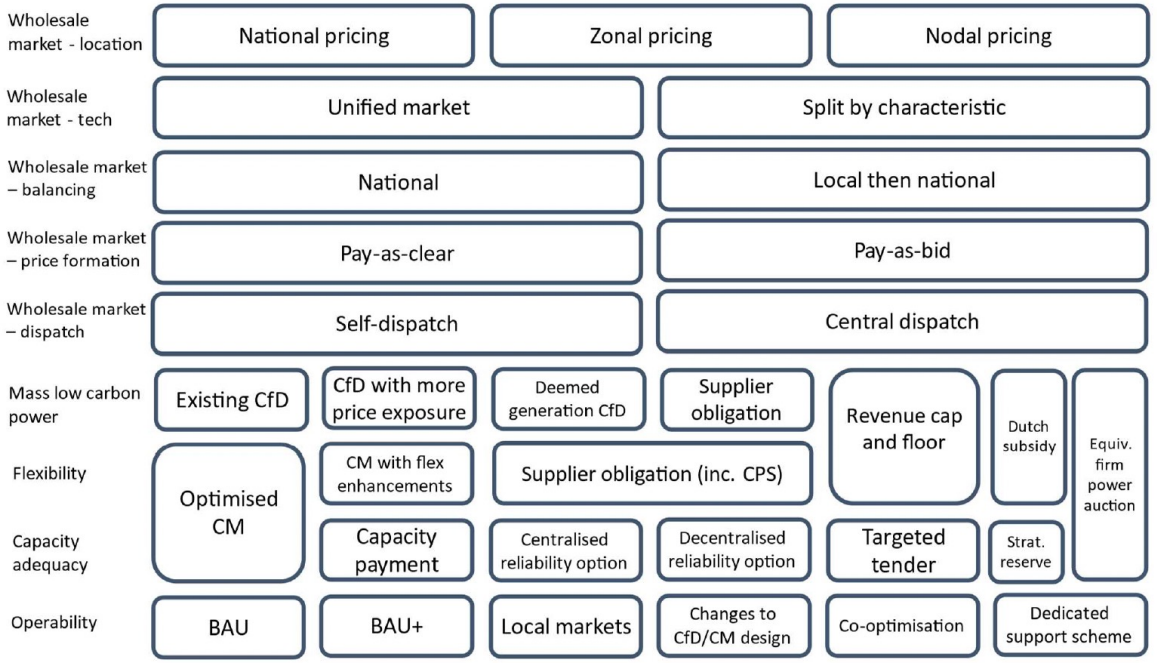
- Power System Modelling & Optimisation
- sm.nosratabadi@ed.ac.uk

Dr Iacopo Savelli

- Energy Economics & Market Design
- isavelli@exseed.ed.ac.uk

Why are we excited about the project?

- Key gap for the UK power system is clean low-cost flexibility:
  - Renewables supply 40% of demand
  - Despite this, gas prices dictate energy prices and balancing costs (up 48% to £2.65 bn in 2021)
- We know we need clean flexibility for net-zero, but where, what technology, how much, and delivered through what mechanisms?
- Opportunity for impact due to BEIS's Review of Energy Market Arrangements (REMA)

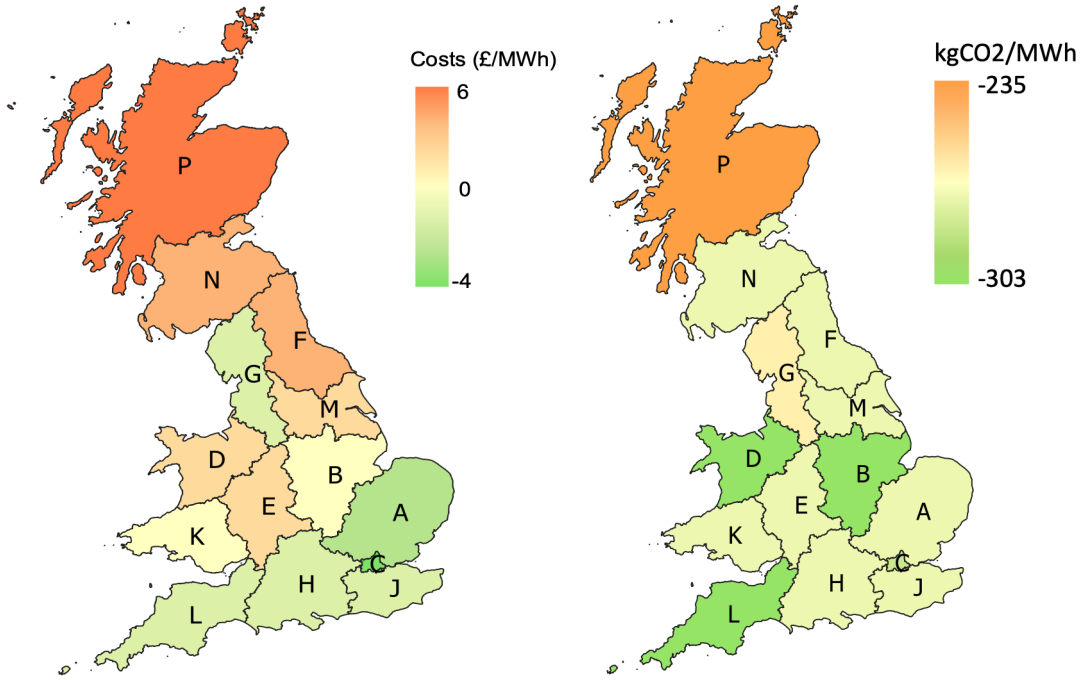


Review of Energy Market Arrangements Options Under Consideration

REMA Consultation Document, 2022

Relevant Work: National Transmission System and Market Modelling

- High-fidelity 3000 node GB transmission network model integrated with a Balancing Mechanism model and Elexon unit-level data
- Example: Enhanced Contracts-for-Difference (CfD) accounting for system-level externalities
  - Collaboration: Department for Business, Energy & Industrial Strategy (BEIS)
  - Depending on region, can reduce marginal congestion costs by 9% of the 2019 CfD price (or increase by 14%) and amplify carbon reduction by 17% (or dampen by 9%).

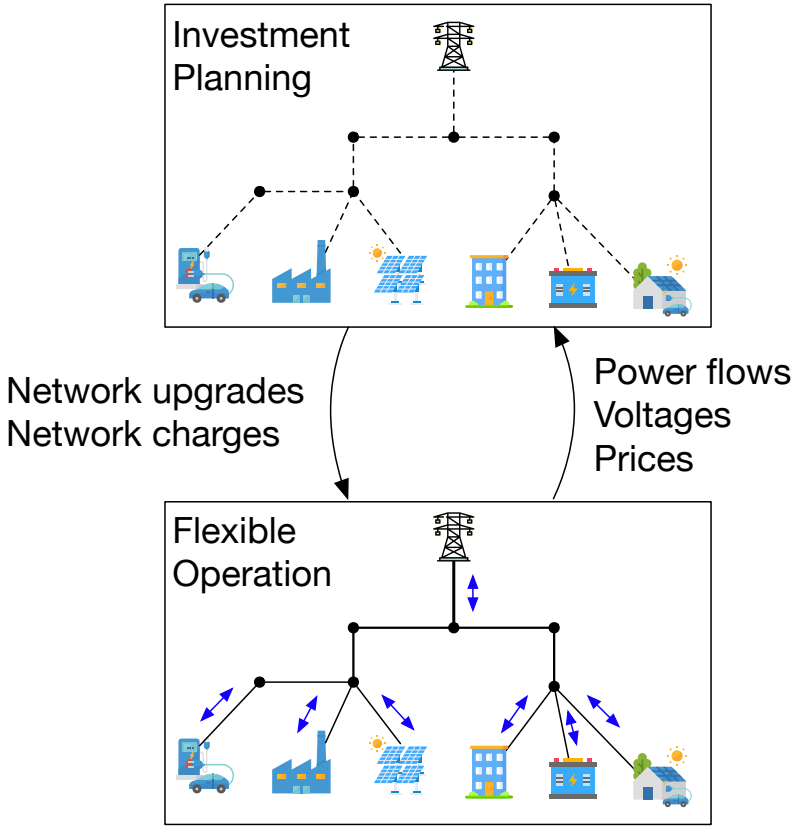


Marginal balancing cost change and emissions reduction (accounting for redispatch) caused by an extra MW of wind in different GB regions.

Savelli, Hardy, Hepburn, Morstyn, "Putting wind and solar in their place: Internalising congestion and other system-wide costs with enhanced CfDs in GB", *Energy Economics*, 2022

Relevant Work: Co-Optimised Operation and Investment

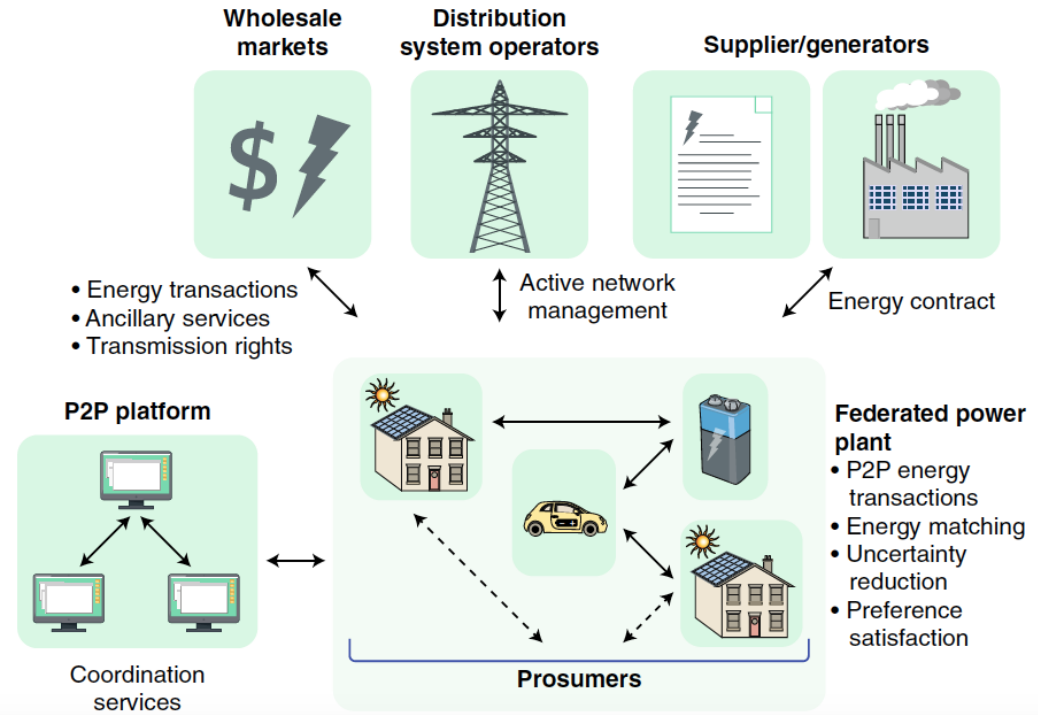
- Integrating flexible operation into network investment planning and cost recovery:
  - Alleviates need for reinforcements
  - Increases utilisation of flexible resources
  - Lowers network charges
  - Now extending to the transmission level
- Projects:
  - EPSRC IAA Perth West Smart City Development
  - EPSRC IAA Scottish Borders Council Energy Plan
  - With Ionate: Coordinating Smart Hybrid Distribution Transformers



I. Savelli, T. Morstyn, "Electricity prices and tariffs to keep everyone happy: a framework for fixed and nodal prices coexistence in distribution grids with optimal tariffs for investment cost recovery," *Omega*, 2021.

Relevant Work: Multiscale Market Design for Smart Energy Systems

- New local and system-level market designs to incentivise the adoption and coordination of flexible energy resources
- Areas of focus:
  - Computational scalability
  - Managing network constraints and uncertainty
  - Multi-market integration of flexibility
  - Fairness in the allocation of costs/benefits
- Projects:
  - EnergyREV – Market Design for Scaling Up Local Clean Energy Systems
  - REMA Challenge Group



T. Morstyn, A. Teytelboym, C. Hepburn, M. D. McCulloch, "Integrating P2P Energy Trading With Probabilistic Distribution Locational Marginal Pricing," *IEEE Transactions on Smart Grid*, 2020.

Questions for Further Discussion

1. How should carbon emission reduction targets affect energy storage investment and operation?

2. How should long-term uncertainty and competing/complementary technology options (e.g. generation, network upgrades, demand-side flexibility) impact investment decisions in energy storage?

3. What should future markets look like to incentivise efficient energy storage investment and maximize the value of storage across flexibility services?