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Engineering and Physical Sciences
Research Council

CESI

National Centre for Energy Systems Integration

Newcastle University

Durham University

Heriot Watt University

University of Sussex

The University of Edinburgh

National Centre for Energy Systems Integration

Newcastle University

The First Flexible Research Funds

Laura Brown, CESI Centre Manager
MSc CEng MIET MWES
Newcastle University

CESI Flexible Research Fund

Flex Fund Research Call – 1st Round

- 7 projects funded
- 3 are led by female Professors
- Of the pool of 24 PI's and Co-Is - 33% are female
- 4 new University Partners
- 22 new and existing industrial and governmental partners involved
- Cabinet Office, Scot Gov, UK Committee on Climate Change, Energy Systems Catapult all partners

https://www.ncl.ac.uk/cesi/cesiflexfund/firstcesiflexfundprojects/

Decision support tool for the operation of public sector multi-energy systems

Control Rooms of the Future: Coordinating Supply and Demand in Integrated Energy

Modelling the Distribution of Costs from Network Upgrades for Electric Vehicles

Repurposing Hydrocarbon Wells for Geothermal Energy Production and Storage

Using storage to decarbonise electricity consumption

Interdisciplinary research for energy systems integration: understanding and

Peer to Peer trading in the real world and exploring the potential of blockchain technologies in integrated

FFC1 Principal Investigators

FFC1-020
Decision support tool for the operation of public sector multi-energy systems
Principle Investigator:
Mr Abeysekera Cardiff University

FFC1-002
Control Rooms of the Future: Coordinating Supply and Demand in Integrated Energy Systems
Principle Investigator:
Professor Abram Durham University

FFC1-031
Modelling the Distribution of Costs from Network Upgrades for Electric Vehicles (EVs)
Principle Investigator
Professor Turner University of Strathclyde

Project Title:
Using storage to decarbonise electricity consumption
Principle Investigator:
Professor Cockerill University of Leeds

FFC1-024
Repurposing Hydrocarbon Wells for Geothermal Energy Production and Storage
Principle Investigator
Professor Falcone University of Glasgow

Project Title
Interdisciplinary research for energy systems integration: understanding and promoting good practice
Principle Investigator
Dr Winskel University of Edinburgh

Project Title
Peer to Peer trading in the real world and exploring the potential of blockchain technologies in integrated energy systems
Principle Investigator:
Dr Cross University of Edinburgh

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FFC1 Schedule

- Projects range from 6 to 12 months in length
- Start dates range from Oct-2018 to Feb-2019

ACTIVITY	Start Month	Last Month	#mon		PERIODS 1 Oct-18	2 Nov-18	3 Dec-18	4 Jan-19	5 Feb-19	6 Mar-19	7 Apr-19	8 May-19	9 Jun-19	10 Jul-19	11 Aug-19	12 Sep-19	13 Oct-19	14 Nov-19	15 Dec-19	16 Jan-20	17 Feb-20
FFC1-001 Peer-to-Peer - Cross - EDI	Jan-19	Jun-19	6	17%																	
FFC1-002 Control Rooms of the Future - Abram - DUR	Jan-19	Aug-19	9	11%																	
FFC1-020 Decision Support for ESI - Abeysekera - CAR	Jan-19	Dec-19	12	8%																	
FFC1-022 Interdisciplinary research for ESI - Winskel - EDI	Jan-19	Jun-19	6	17%																	
FFC1-024 Repurpose Hydrocarbon wells - Falcone - GLA	Jan-19	Jun-19	6	17%																	
FFC1-026 Storage for electricty consumption - Cockerill - LEE	Feb-19	Sep-19	9	0%																	
FFC1-031 Modelling Dist costs for EV - Turner - STR	Oct-18	Mar-19	6	50%																	

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FFC1-001: Peer to Peer trading in the real world and exploring the potential of blockchain technologies in integrated energy systems

29th January 2019

Merlinda Andoni, Valentin Robu, David Flynn
School of Engineering & Physical Sciences
Heriot-Watt University
m.andoni@hw.ac.uk; v.robu@hw.ac.uk; d.flynn@hw.ac.uk;

Project PI:

Dr. Jamie Cross
School of Social and Political Science
University of Edinburgh
jamie.cross@ed.ac.uk;

Project information

National Centre for Energy Systems Integration

Multi-disciplinary collaboration across academic and industrial partners

Two main threads:

I. Exploring the potential of blockchain technologies in integrated energy systems (led by Dr. Valentin Robu)

II. Peer-to-peer trading in the real world (led by Dr. Jamie Cross)

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Blockchain technology and emerging local energy markets

National Centre for Energy Systems Integration

Blockchain promises secure, verifiable and transparent recording of *peer-to-peer* (P2P) digital transactions and automated execution of *smart contracts* in P2P networks.

- Systematic review on more than 140 international R&D and commercial activities published in November (>10,000 views according to Mendeley)

- P2P energy trading in local energy markets

Consumers generate, use, share and trade their own energy

✓Local matching of demand to supply
✓Resilience and support of ageing systems
✓Consumer participation in energy markets
✓Potential for cost savings

Renewable and Sustainable Energy Reviews 100 (2019) 143–174

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Blockchain technology in the energy sector: A systematic review of challenges and opportunities

Merlinda Andoni[a,*], Valentin Robu[a], David Flynn[a], Simone Abram[b], Dale Geach[c], David Jenkins[d], Peter McCallum[d], Andrew Peacock[d]

[a] Institute of Sensors, Signals and Systems, Heriot-Watt University, Edinburgh, UK
[b] Department of Anthropology, Durham University, Durham, UK
[c] Siemens Energy Management, Hebburn, Tyne and Wear, UK
[d] School of Energy, Geoscience, Infrastructure and Society, Heriot-Watt University, Edinburgh, UK

ARTICLE INFO

Keywords:
Blockchain
Distributed ledger
Energy decentralisation
Peer-to-peer energy trading
Prosumer
Renewable energy

ABSTRACT

Blockchains or distributed ledgers are an emerging technology that has drawn considerable interest from energy supply firms, startups, technology developers, financial institutions, national governments and the academic community. Numerous sources coming from these backgrounds identify blockchains as having the potential to bring significant benefits and innovation. Blockchains promise transparent, tamper-proof and secure systems that can enable novel business solutions, especially when combined with smart contracts. This work provides a comprehensive overview of fundamental principles that underpin blockchain technologies, such as system architectures and distributed consensus algorithms. Next, we focus on blockchain solutions for the energy industry and inform the state-of-the-art by thoroughly reviewing the literature and current business cases. To our knowledge, this is one of the first academic, peer-reviewed works to provide a systematic review of blockchain activities and initiatives in the energy sector. Our study reviews 140 blockchain research projects and startups from which we construct a map of the potential and relevance of blockchains for energy applications. These initiatives were systematically classified into different groups according to the field of activity, implementation platform and consensus strategy used.[1] Opportunities, potential challenges and limitations for a number of use cases are discussed, ranging from emerging peer-to-peer (P2P) energy trading and Internet of Things (IoT) applications, to decentralised marketplaces, electric vehicle charging and e-mobility. For each of these use cases, our contribution is twofold: first, in identifying the technical challenges that blockchain technology can solve for that application as well as its potential drawbacks, and second in briefly presenting the research and industrial projects and startups that are currently applying blockchain technology to that area. The paper ends with a discussion of challenges and market barriers the technology needs to overcome to get past the hype phase, prove its commercial viability and finally be adopted in the mainstream.

1. Introduction

Energy systems are undergoing rapid changes to accommodate the increasing volumes of embedded renewable generation, such as wind and solar PV. Renewable energy sources (RES) have undergone massive development in recent years, enabled by privatisation, unbundling of the energy sector and boosted by financial incentives and energy policy initiatives. In 2016, 24.6% of the UK gross electricity consumption was generated by RES, mainly from onshore and offshore wind farms and PV solar plants, accounting for 44.9% and 12.5% of the total 35.7 GW installed RES capacity, respectively [1]. RES are variable, difficult to predict and depend on weather conditions, hence raise new challenges in management and operation of electricity systems, as more flexibility measures are required to ensure safe operation and stability [2]. Flexibility measures include the integration of fast-acting supply, demand response and energy storage services [3]. Adding to the transformational change caused by distributed energy resources (DERs) and renewables, energy systems are on the brink of entering the digital era as shown by the massive deployment of smart meters in numerous countries [4]. In the UK alone, 53 million electricity and gas smart meters

* Correspondence to: School of Engineering and Physical Sciences, Earl Mountbatten Building 3.32, Gait 2, Heriot-Watt University, EH14 4AS Edinburgh, UK.
E-mail addresses: m.andoni@hw.ac.uk (M. Andoni), v.robu@hw.ac.uk (V. Robu), d.flynn@hw.ac.uk (D. Flynn), simone.abram@durham.ac.uk (S. Abram), dale.geach@siemens.com (D. Geach), d.p.jenkins@hw.ac.uk (D. Jenkins), p.mccallum@hw.ac.uk (P. McCallum), a.d.peacock@hw.ac.uk (A. Peacock).

[1] A summary of the research projects reviewed in this study can be found in the Appendix A.

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Available online 03 November 2018

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I. Exploring the potential of blockchain technologies in integrated energy systems - Plan

- Requirements of industrial partners in using blockchains in energy systems
- Input from other academic partners in CESI
  - Collaboration with Dr. Sara Walker on consumer energy trading practices and P2P
- Model of a local energy community that uses blockchains for local energy trading
  - Multi-vector energy aspects
  - Dynamic loads such as EVs
- Proof of concept validation using a real case-study (Findhorn)

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Local energy community model

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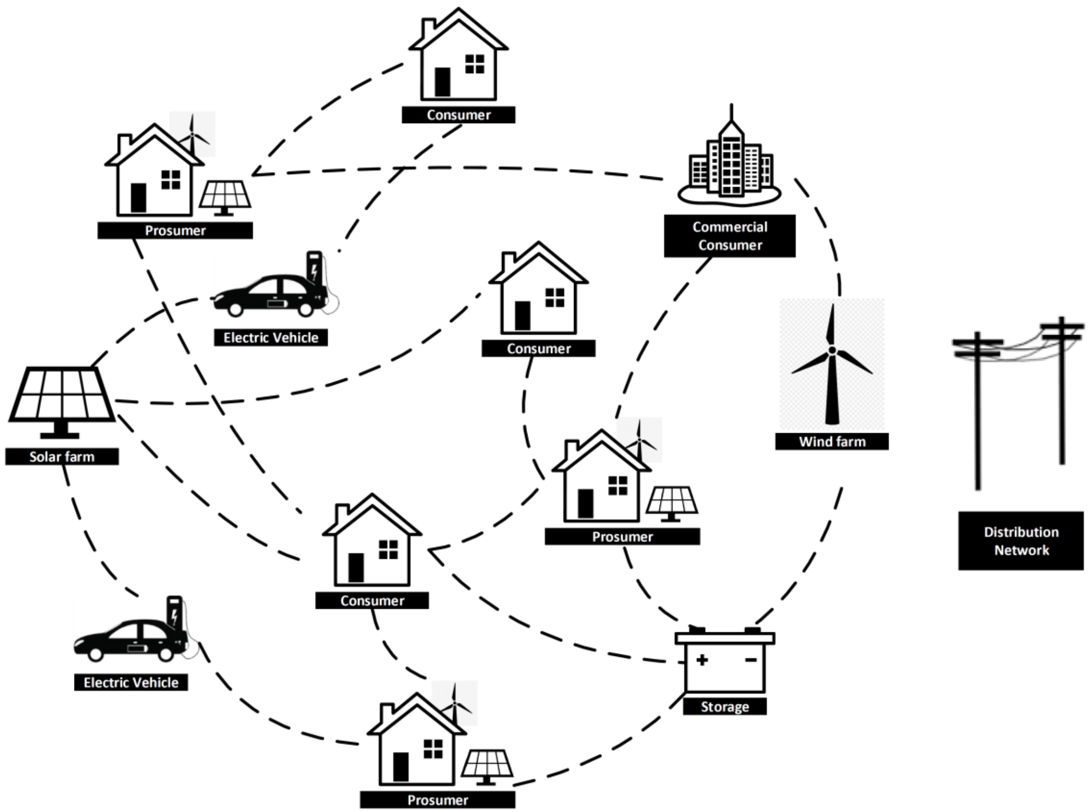
- ✓ Study the use of smart contracts and P2P trading in achieving optimal operation of decentralised systems
- ✓ How this can inform modelling and operational tools being developed in CESI

Investigation of 3 main scenarios that allow prosumer trading:

- With utility companies
- Within a community coalition
- P2P

- ✓ Socio-economic aspects and human behaviour in energy usage and demand



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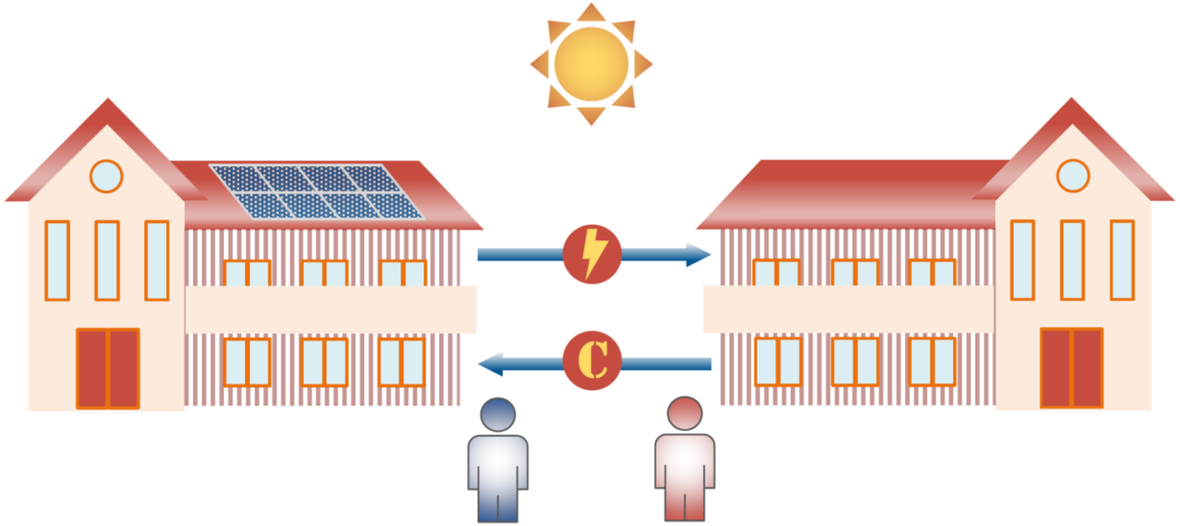
II. P2P trading in the real world - Plan

National Centre for Energy Systems Integration (CESI)

- Review literature on P2P electricity trading and real world application
- Methodology for comparative study of P2P pilot projects under development
- Field-based, ethnographic studies of P2P electricity trading pilots in the Netherlands and Bangladesh



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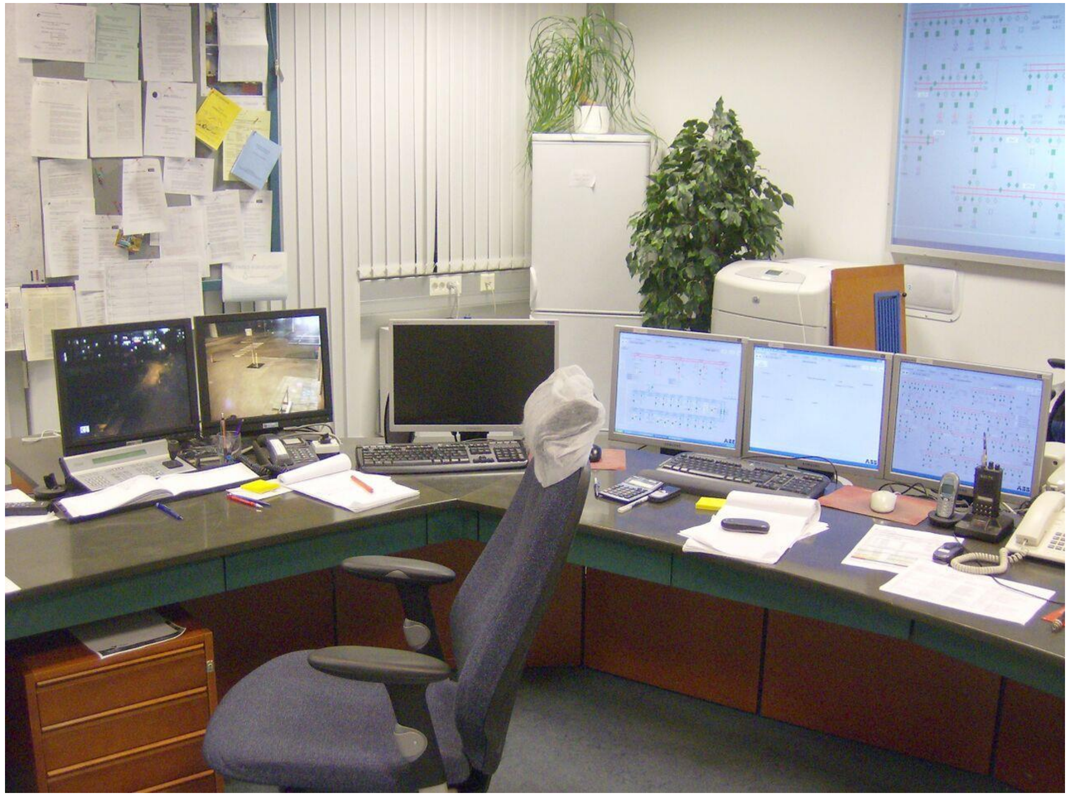
Control Rooms of the Future: Coordinating Supply and Demand in Integrated Energy Systems

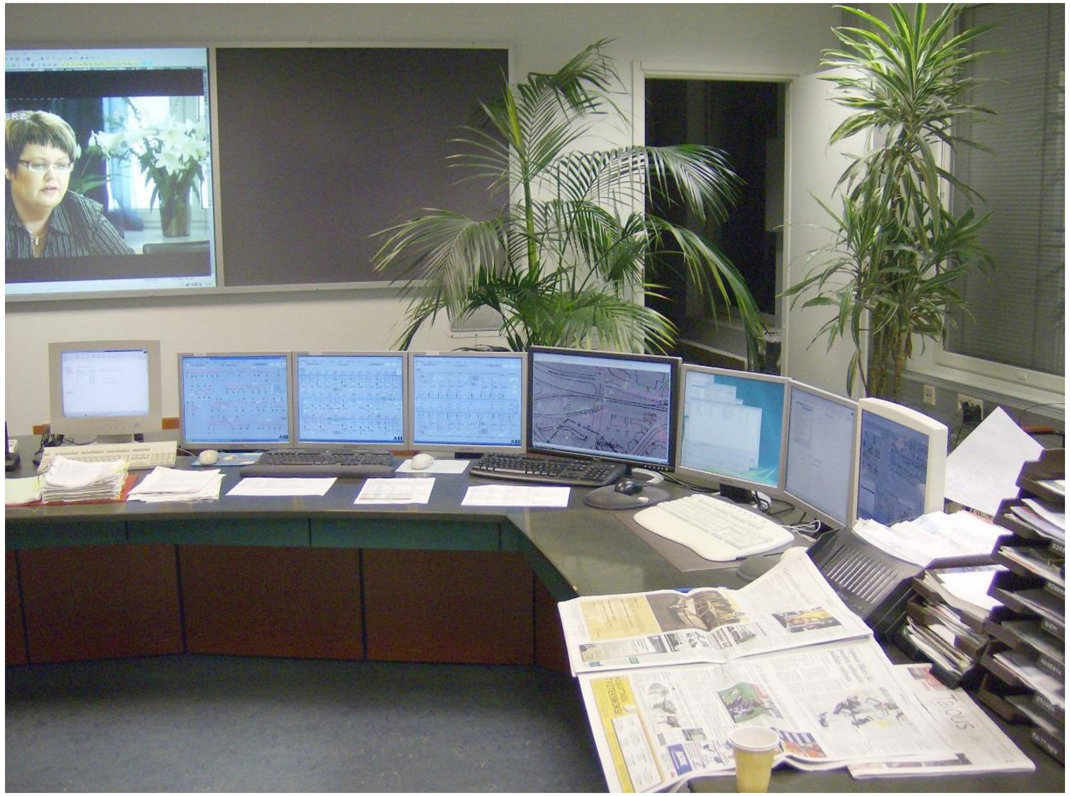
Simone Abram, Andrew Wright, and Antti Silvast (Durham University)

CESI International Scientific Advisory Board, 29 January 2019

National Centre for Energy Systems Integration

Organisational study of control rooms





Silvast, A. (2017). *Making Electricity Resilient: Risk and Security in a Liberalized Infrastructure*. London: Routledge

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What are control rooms for?

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"The aim of a control room is managing a critical service reliably and safely, in real time, given their system definitions and the specifics of their governing reliability standards."

Roe, E. & Schulman, P. R. (2018). A reliability & risk framework for the assessment and management of system risks in critical infrastructures with central control rooms. *Safety Science*, 110, 80-88.

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Research questions

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1. Does integration of control-rooms across vectors enhance efficiency or generate new or additional difficulties?
2. How do institutional and regulatory categories and boundaries impact on the integration of control systems?
3. Are there different ‘cultures of control’ that might affect the operation of integrated control rooms?
4. How does the control room relate to other integrative practices: energy storage and aggregators, or AI-based automation?

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Aims and methods

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- Legislative and regulatory frameworks for UK electricity and gas distribution networks (AW)
- Observations of workplace activities in gas and electricity control rooms (SA/AS)
- How are control rooms changing (All)
- Collaboration with: a modelled scenario where control room operators at both control rooms may wish to cooperate (HP/AA/HH)

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Milestones and deliverables

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- Month 4: Interviews with industry professionals
- Month 6: Overview of institutional challenges
- Month 8: Observational fieldwork
- Month 9: Final report

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CESI – FLEX Fund

Decision support tool for the operation of public sector multi-energy systems

Dr Muditha Abeysekera, Prof Jianzhong Wu, Prof Nick Jenkins

Cardiff University

Kick off - January 1st 2019

https://www.ncl.ac.uk/cesi/cesiflexfund/firstcesiflexfundprojects/abey/

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Research Context

- The public sector is the largest single buyer of gas and electricity in the UK.
- Public organisations such as hospitals and universities often own and operate an on-site multi-energy supply system.
- UK Government expects a 30% reduction in greenhouse gas emissions by 2020/21 (against a 2009/10 baseline) across the public estate
- Currently, there are no tools available to improve the day to day operation of these energy supply systems.
- The gap between sophisticated academic research and the simple approaches required by site energy mangers hinders the potential benefits of local multi energy systems from being realised

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Research objectives

1. Review the current practices used for the operation of public sector energy facilities. Identify challenges to implementing changes in the operation and control schemes of existing energy supply systems
2. Develop a simplified methodology for the optimal planning of day to day operation of public sector multi energy supply systems.
3. Develop a spreadsheet based decision support tool.
4. Test and validate the methodology and decision support tool using real case studies

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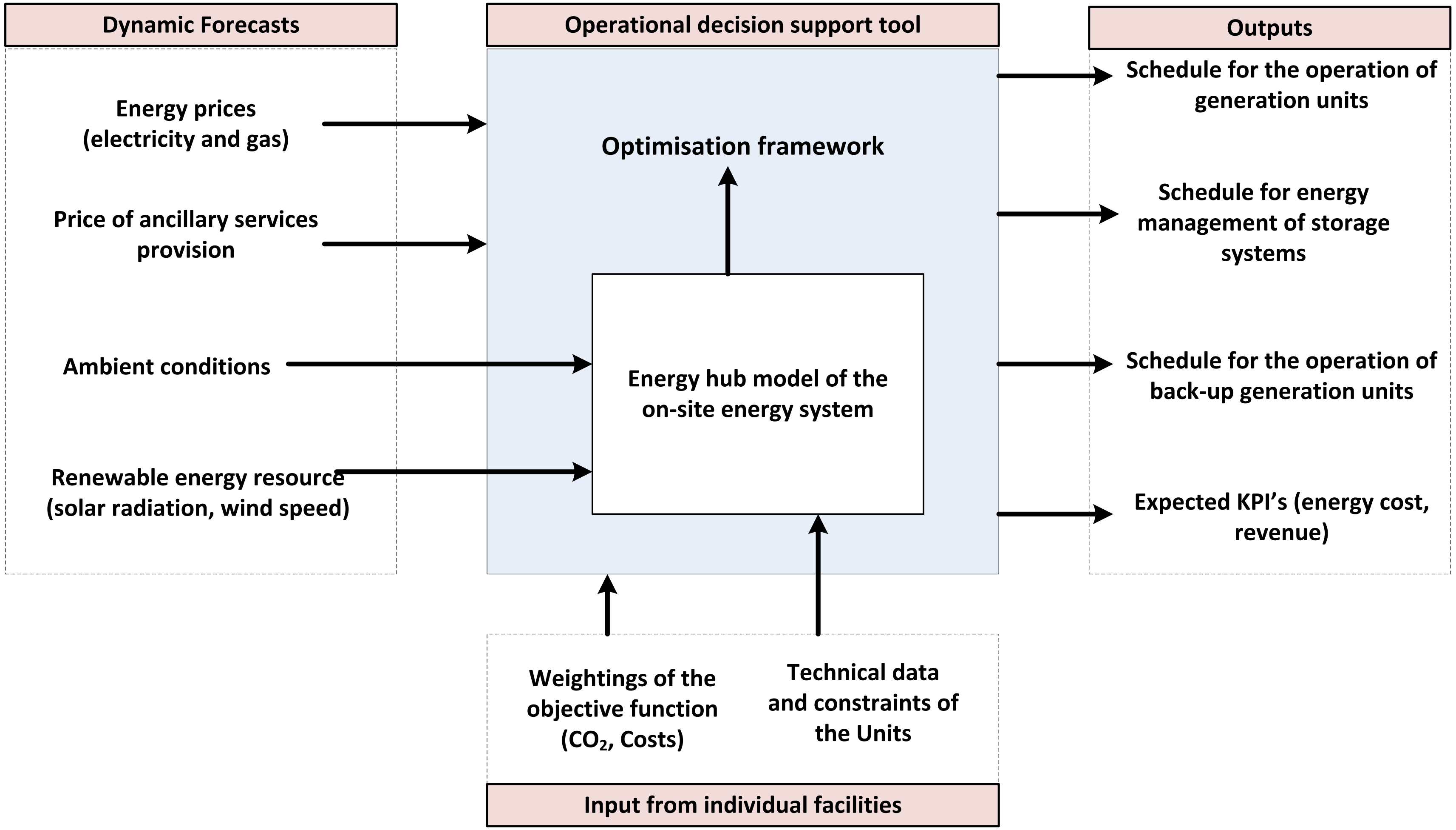
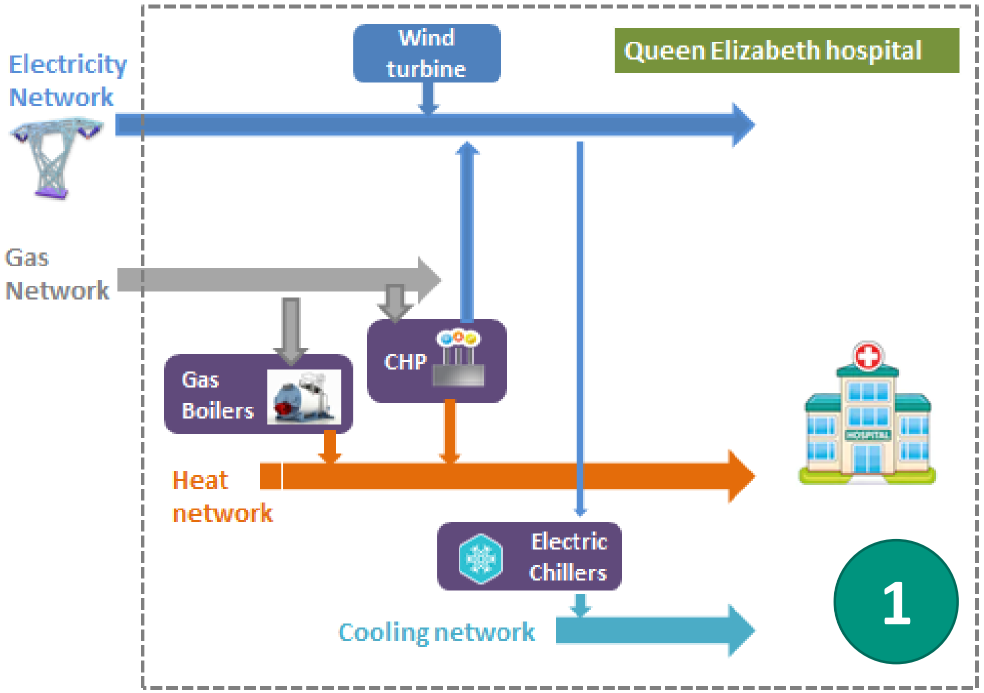
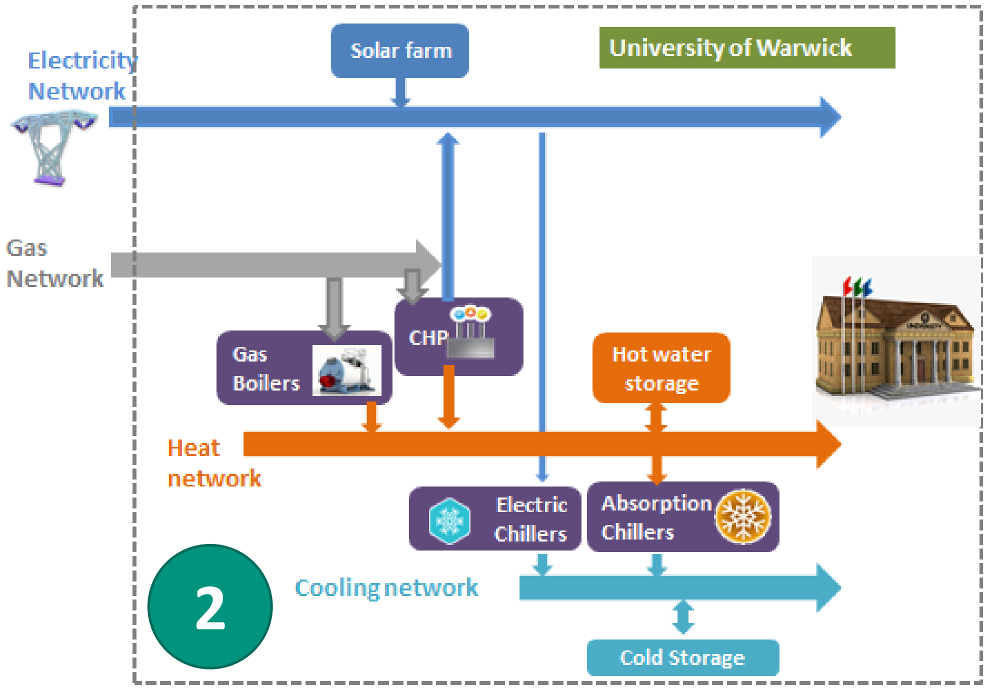
Proposed decision support tool schematic



Case studies





Electricity   Gas   Hot water   Cold Water   Network coupling components

Project partners

- Crown commercial service – Fuel and Utilities (UK Cabinet office)
- Queen Elizabeth Hospital, Kings Lynn
- Estates office, University of Warwick
- Energy Systems Catapult

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Deliverables and Milestones

- ***Milestone 1:*** Stakeholder workshop on current practices and challenges for operational planning in public estate multi energy systems
- ***Deliverable 1:*** A briefing paper discussing the findings on current practices and challenges for optimising energy systems in the public sector.
- ***Deliverable 2:*** Spread sheet based decision support tool for the operation planning of public sector multi energy systems.
- ***Deliverable 3:*** Final project report and Dissemination event

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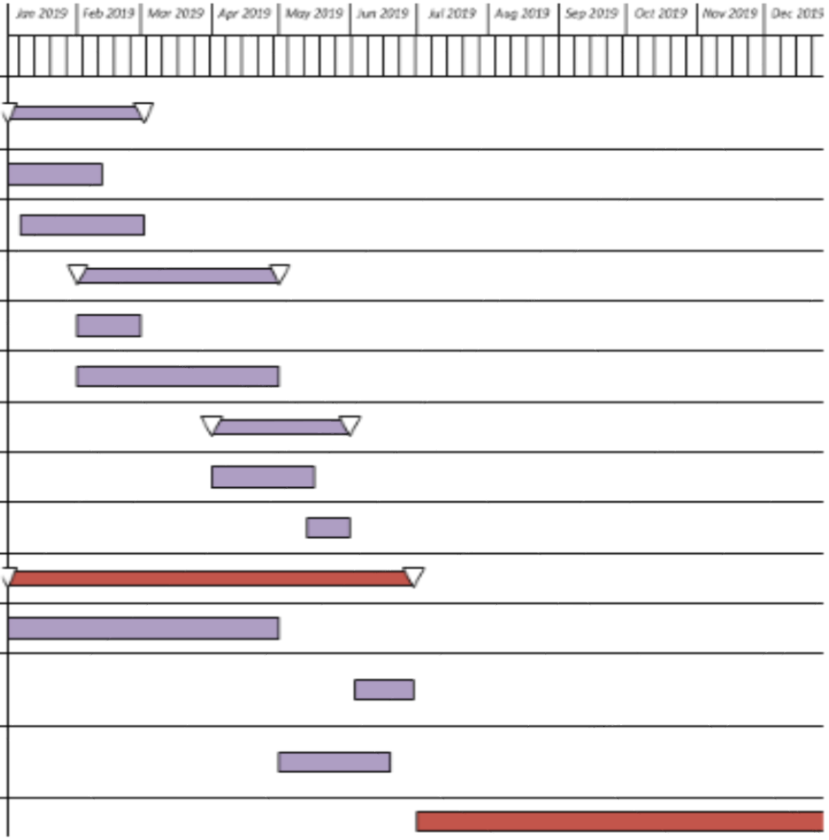
Project timeline

ID	Task Name	Start	Finish	Duration
1	**RT1: Review of the current practices for improving day to day operation in public sector energy facilities**	**01/01/2019**	**01/03/2019**	**44d**
2	RT1.1: Review of literature	01/01/2019	11/02/2019	30d
3	RT2.2: Stakeholder interviews	07/01/2019	01/03/2019	40d
4	**RT2: Generic methodology for operation planning in public sector energy systems**	**01/02/2019**	**30/04/2019**	**63d**
5	RT2.1: Develop template of the spread sheet tool	01/02/2019	28/02/2019	20d
6	RT2.2: Develop methods to simplify the optimisation problem	01/02/2019	30/04/2019	63d
7	**RT3: Develop the decision support tool for optimal operation planning**	**01/04/2019**	**31/05/2019**	**45d**
8	RT3.1: Programming the spread sheet tool	01/04/2019	15/05/2019	33d
9	RT3.2: Develop API's	13/05/2019	31/05/2019	15d
10	**IT: Testing, validation and case studies**	**01/01/2019**	**28/06/2019**	**129d**
11	IT1.1 Collecting case study data	01/01/2019	30/04/2019	86d
12	IT2: Test and validation of the tool using the case study of Queen Elizabeth at King's Lynn	03/06/2019	28/06/2019	20d
13	IT3: Test and validate the tool using the case study of University of Warwick	01/05/2019	18/06/2019	35d
14	Interactions with other relevant projects (e.g. Supergen Energy Networks)	01/07/2019	31/12/2019	132d



Interdisciplinary Research for Energy Systems Integration: Understanding and Promoting Good Practice

Mark Winskel (University of Edinburgh), Matthew Hannon and Ragne Low (University of Strathclyde), and Antti Silvast (Durham University)

CESI International Scientific Advisory Board, 29 January 2019

Background

- Increasing support for interdisciplinary whole systems research (WSR) in the UK energy sector.

- Combining different research disciplines and working across academic-stakeholder divides promises more rounded, robust and relevant research

- … and CESI has a distinctive commitment to such research.

Research issues

- Interdisciplinary WSR faces a number of challenges and trade-offs (Winskel, 2018):
  - managing diverse knowledge bases across different disciplines
  - developing integrative research designs and outputs
  - balancing between academic independence and stakeholder collaboration
- These challenges are often under-acknowledged by researchers, funders and others
- There are missed opportunities for shared learning across different initiatives in the UK and wider

Comparing earlier UK interdisciplinary WSR initiatives

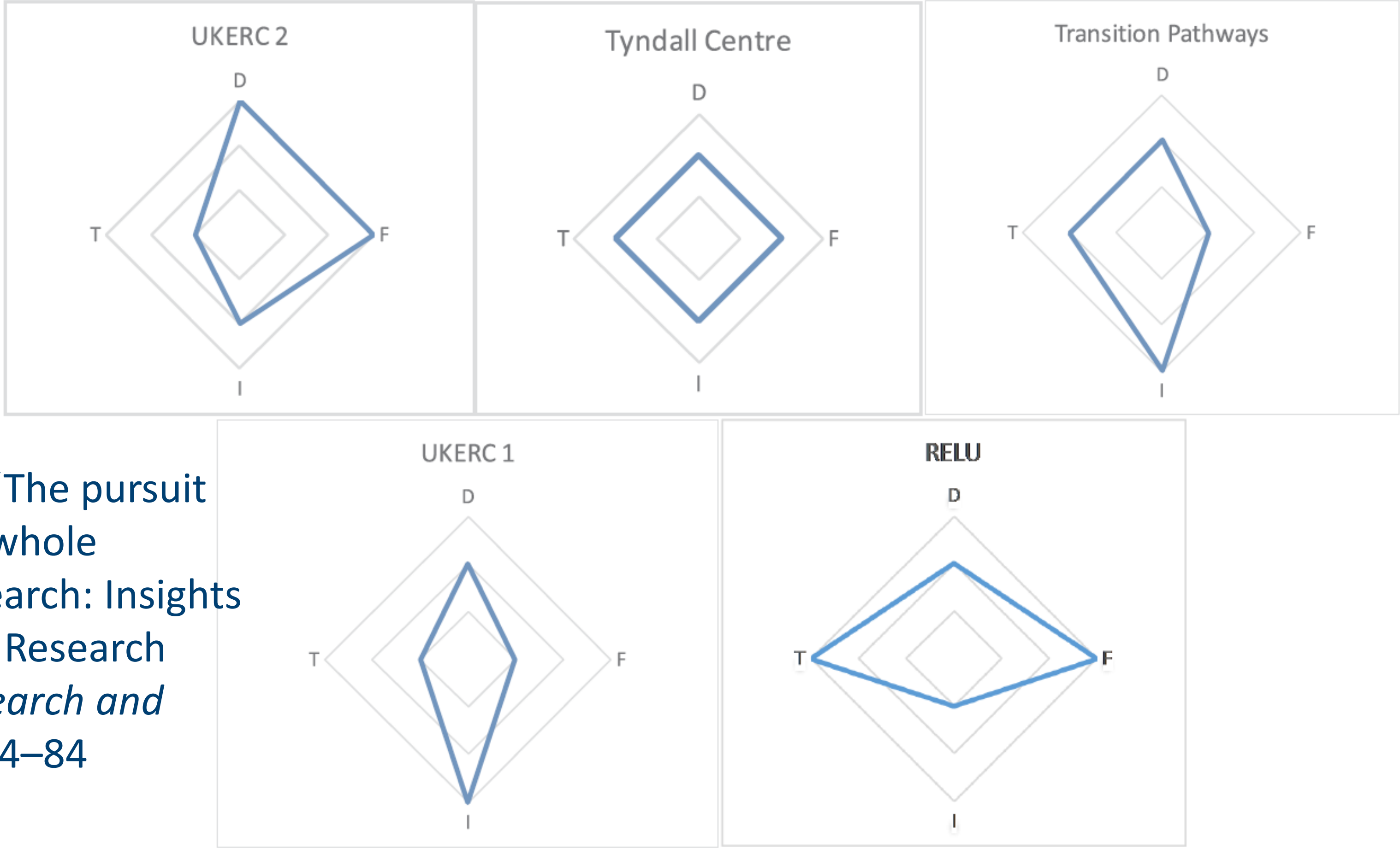


Fig. 5. Mapping UK Interdisciplinary WSR Energy Related Research Initiatives.
(D = Diversity; F = Flexibility; I = Integration; T = Transdisciplinarity).

Winskel, M. (2018) ‘The pursuit of interdisciplinary whole systems energy research: Insights from the UK Energy Research Centre’, *Energy Research and Social Science*, 37, 74–84

Research questions

- What are the specific research designs and methods by which different disciplines and stakeholders can be effectively combined for energy systems integration research?
- What are the strengths and weaknesses of different designs and methods?
- What good practice guidelines for interdisciplinary WSR emerge from UK and international experience?

Methods and Outputs

- Desk-based systematic review of recent interdisciplinary whole energy systems research
- Semi-structured interviews with researchers stakeholders with experience of interdisciplinary energy systems research design and practice
- Researcher and stakeholder workshops:
    - CESI Facilitated Group Discussion: 28th February 2019, Newcastle
    - Wider stakeholders and researchers workshops (including ISAB members) April-June 2019
- Outputs include: good practice guidelines, project final report, interdisciplinary energy studies journal paper

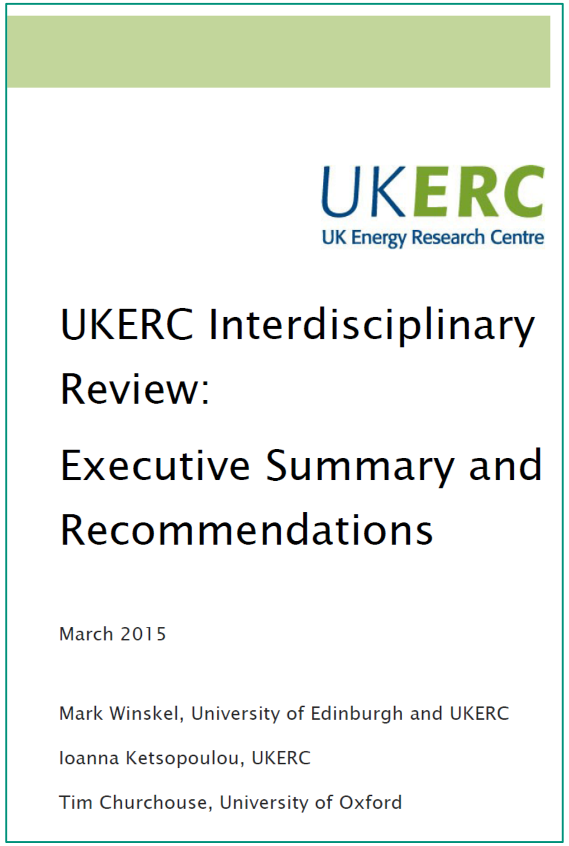
Thank you!

Questions? Comments?

For further questions or comments please contact:

mark.winskel@ed.ac.uk

(and see earlier UKERC Review, available from www.ukerc.ac.uk)


UKERC
UK Energy Research Centre

UKERC Interdisciplinary Review:

Executive Summary and Recommendations

March 2015

Mark Winskel, University of Edinburgh and UKERC

Ioanna Ketsopoulou, UKERC

Tim Churchouse, University of Oxford

Repurposing Hydrocarbon Wells for Geothermal Energy Production and Storage

Professor Falcone, Dr Westaway

University of Glasgow

Kick off - January 28th 2019

https://www.ncl.ac.uk/cesi/cesiflexfund/firstcesiflexfundprojects/falc/

Research Context and Scope

- An interdisciplinary approach to deep geothermal systems is key to decarbonising heat in the UK (~50% of total energy demand) to honour emissions-reduction commitments
- High technical and economic risk at the exploration stage is a major constraint on the development of deep geothermal energy projects. Targeting well-characterised hydrocarbon reservoirs can reduce risk and drilling costs.
- Starting with public-domain data in the UK, potential candidate wells and sites will be screened.
- A selection of case studies will be analysed to assess the feasibility of various repurposing concepts; social feasibility will also be assessed by engagement with potential end-users.

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Project partners

- Perenco UK
- Schlumberger Cambridge Research Ltd

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National Centre for Energy Systems Integration

Deliverables and Milestones

- Overlap maps of onshore hydrocarbon wells, temperature at depth and local heat demand.
- Preliminary estimates of P10-P50-P90 geothermal energy resources
- Assessment of public acceptance of this hybrid energy concept, based on direct engagement with local end-users.
- Reporting to be completed by end of month 6
- Presentation of the research findings at key conference (provisionally, the 2019 UK Geothermal Symposium)

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Using Storage To Decarbonise Electricity Consumption

Prof. Tim Cockerill, Dr Jan Palczewski and Dr Andrew Pimm

CESI International Scientific Advisory Board Meeting 3

Newcastle University

29/01/2019

Introduction

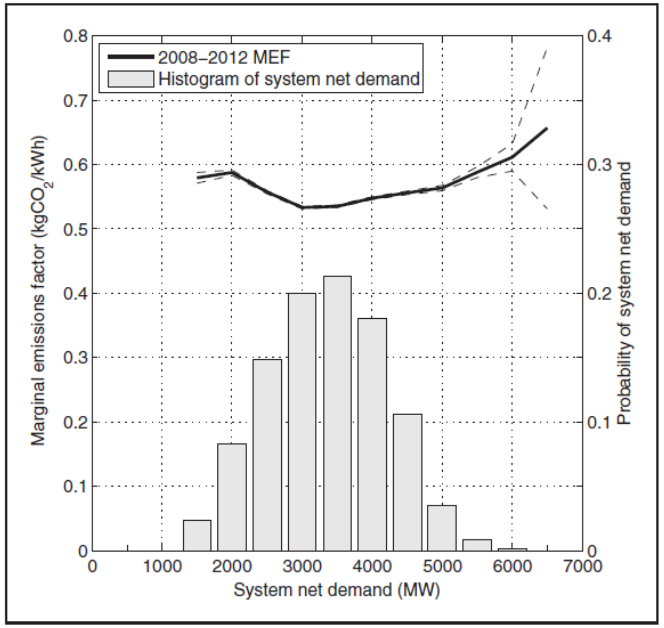
- Energy storage essential to enable a zero carbon future at low cost
- Passing energy through storage typically results in losses of >10%
- Tensions between economic and environmental objectives for storage
- 8 month, £95k project funded by the Centre for Energy Systems Integration (CESI): '**Using Storage To Decarbonise Electricity Consumption**'
- Builds on research from the C-MADEnS project (Consortium for Modelling and Analysis of Decentralised Energy Storage: www.c-madens.org) and a Living Lab project on storage at UoL campus
- Leveraging tools created by project partners, and potentially demonstrator sites made available by CESI

The Challenge

Short-run impact of electricity storage on CO_2 emissions in power systems with high penetrations of wind power: A case study of Ireland

McKenna, Barton & Thomson
DOI: 10.1177/0957650916671432

"Operating storage in a peak shaving trough filling mode can....increase overall carbon emissions"



How can energy storage be operated to prioritise GHG reductions?

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Project Overview

1. Develop operational approaches for electricity storage to minimise GHG emissions, while still achieving economic viability.
2. Explore ways of incentivising operation of electricity storage such that GHG reduction potentials can be achieved, without overly impacting on economic performance.
3. Validate our methodologies using a pilot-scale battery storage facility to be installed at the University of Leeds, using capital funding from the University's Facilities Directorate.
4. Consider the impact of future changes in demand patterns (e.g. widespread EV charging) and generation mixes. Such changes may alter the correlation between electricity GHG emissions and prices, with important implications.

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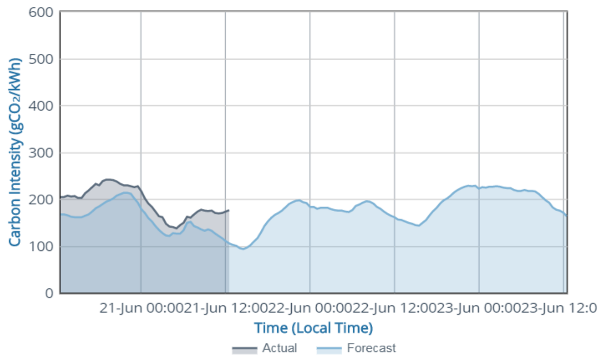
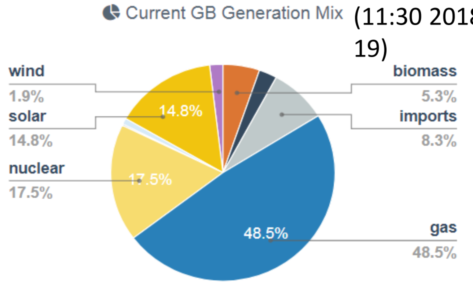
Reducing GHG Emissions

- Installing pilot-scale battery storage system on UoL campus within a **Living Lab project**, to test algorithms to minimise carbon emissions / costs, and gain confidence in storage… potential for much larger systems

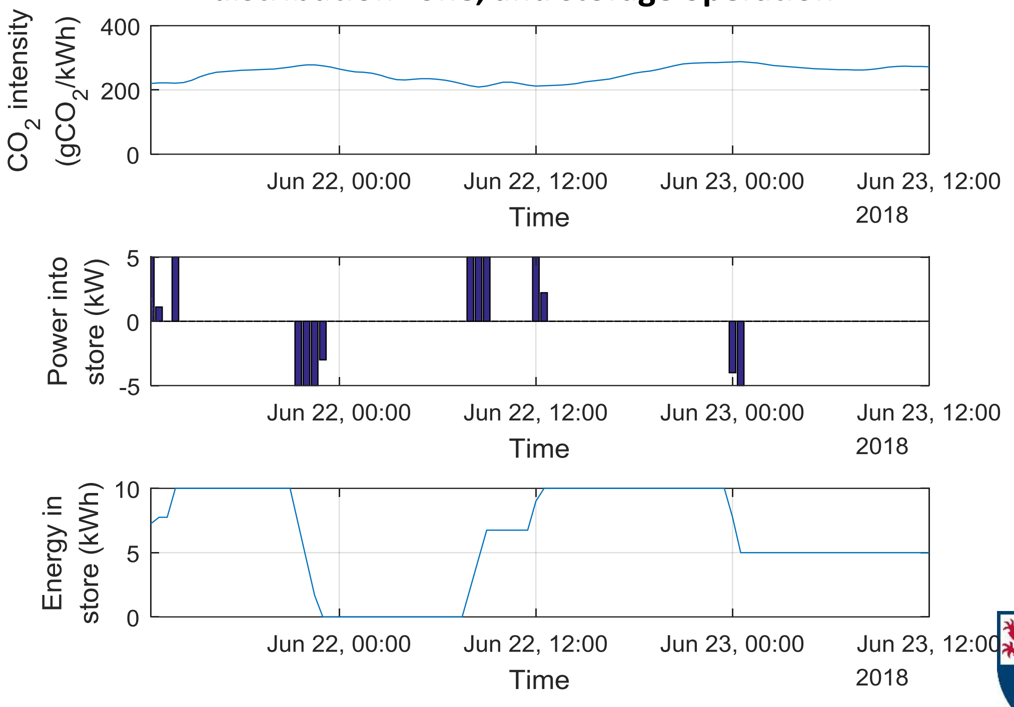
National Carbon Intensity Forecast (-24hrs to +48hrs)
Source: carbonintensity.org.uk





(11:30 2018-07-19)

Carbon intensity forecast in Yorkshire distribution zone, and storage operation



Project Overview

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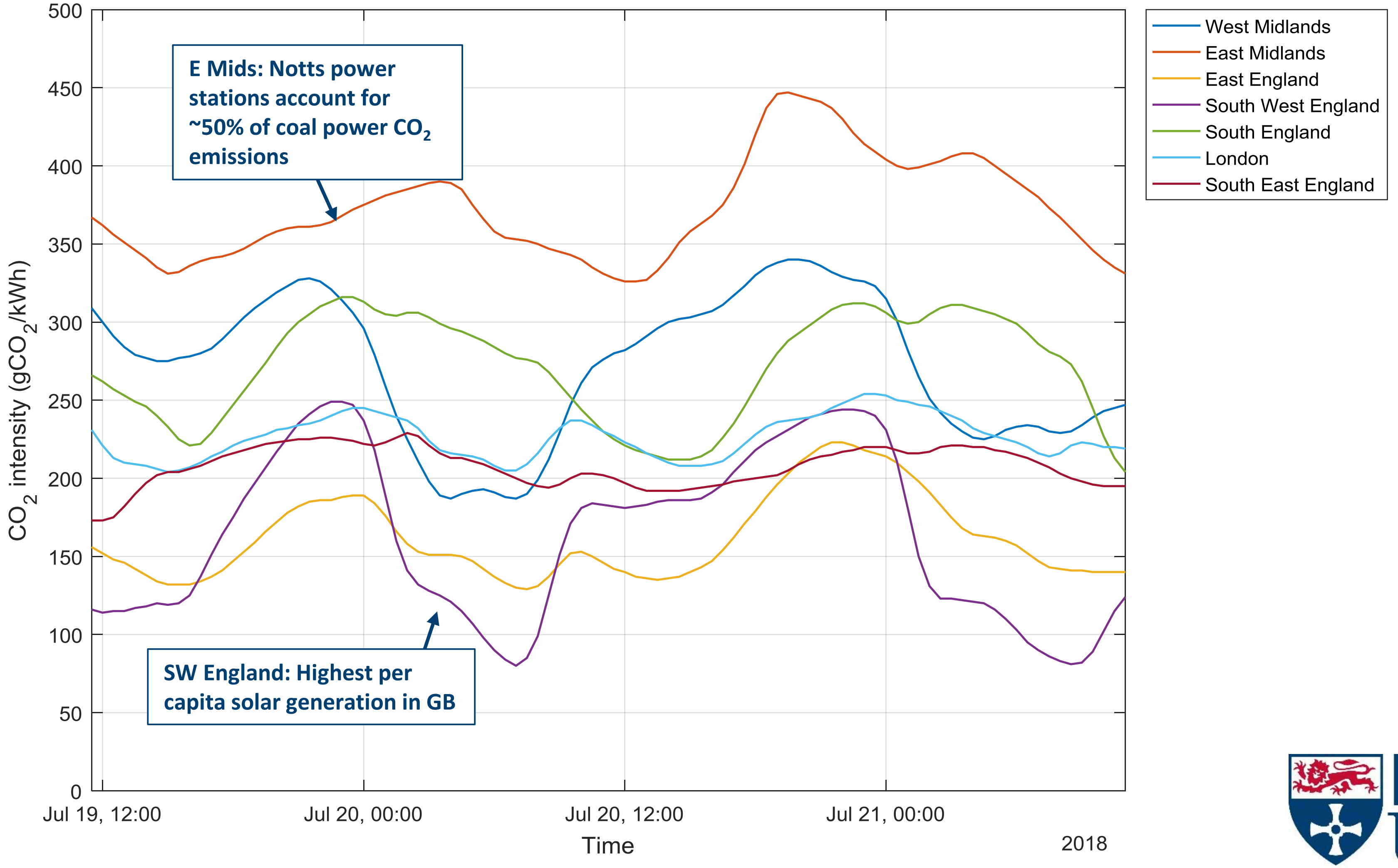
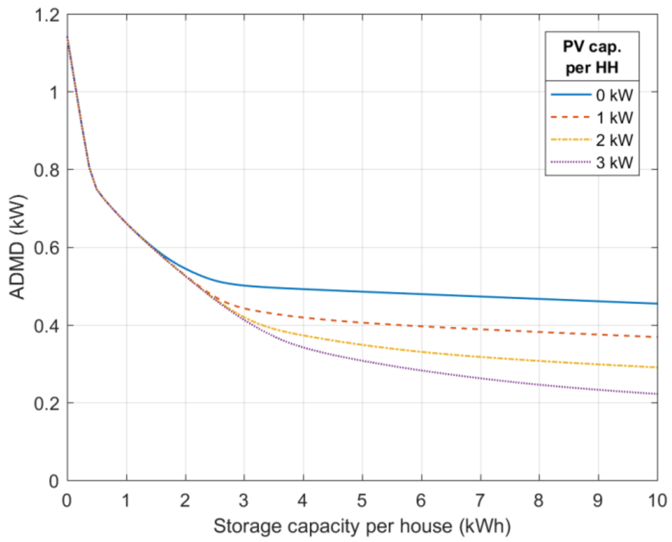
Regional Variation In Intensity Forecasts



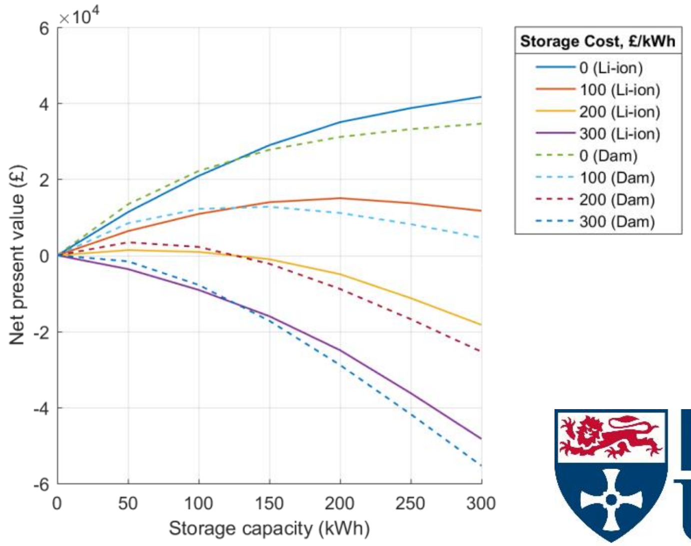
Approach

- Use C-MADEnS storage models (for objectives 1,2,4)
- Time simulation of the operation of electricity storage
- Applied to distributed storage, but focused on the techno-economics
- Modify to focus on GHG emissions

Peak shaving benefits



NPV for householders when combined with small scale hydro



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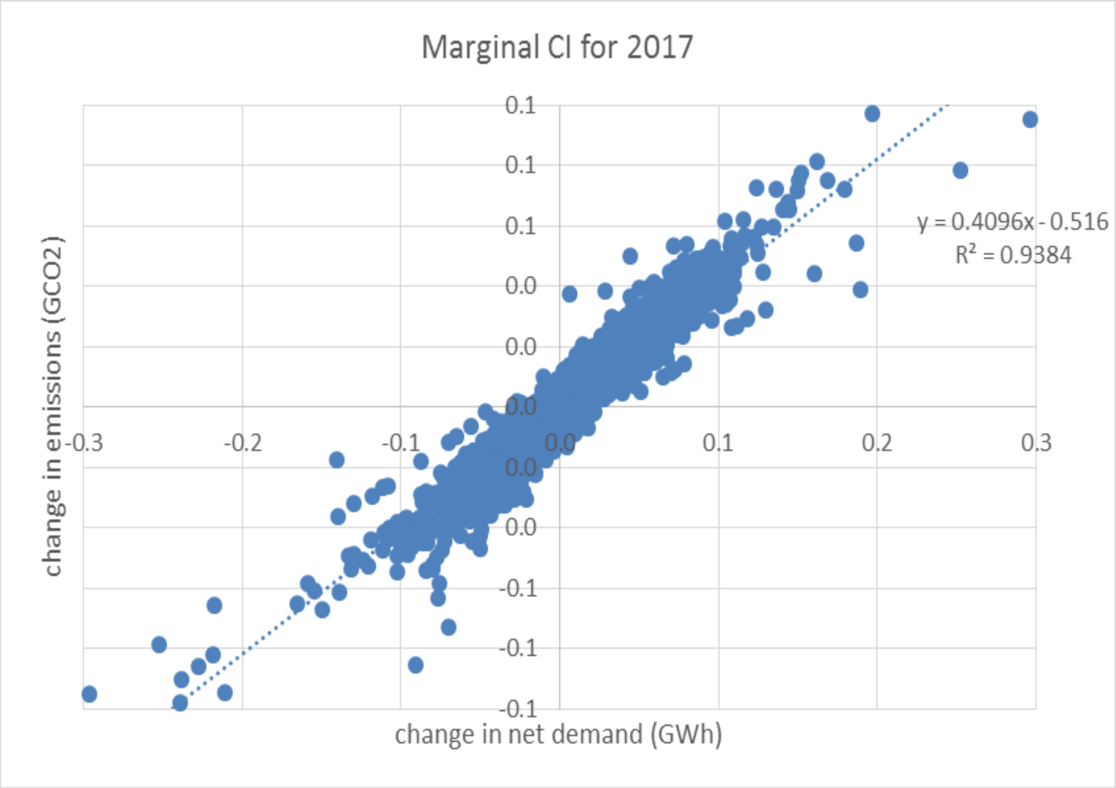
Demand and GHG Emissions



Good historic data for the UK…

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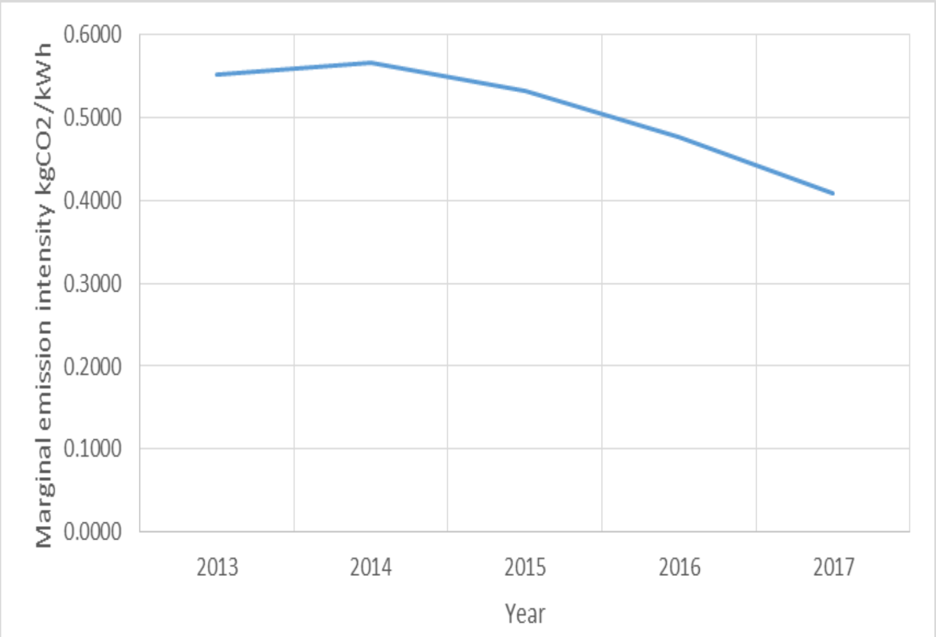
National Centre for Energy Systems Integration

Demand and GHG Emissions



Year	2013	2014	2015	2016	2017
Marginal emission intensity ($kgCO_2/kWh$)	0.5531	0.5673	0.5333	0.4762	0.4096
Total Wind energy generation (kWh)	1.86E+10	2.11E+10	2.33E+10	2.71E+10	3.23E+10
Total energy consumption (kWh)	3.16E+11	3.00E+11	2.886E+11	2.82E+11	2.786E+11
Net demand (kWh)	2.05E+11	1.83E+11	1.59E+11	1.54E+11	1.40E+11

Though the situation changes from year to year as renewables are further deployed

Developing the Models

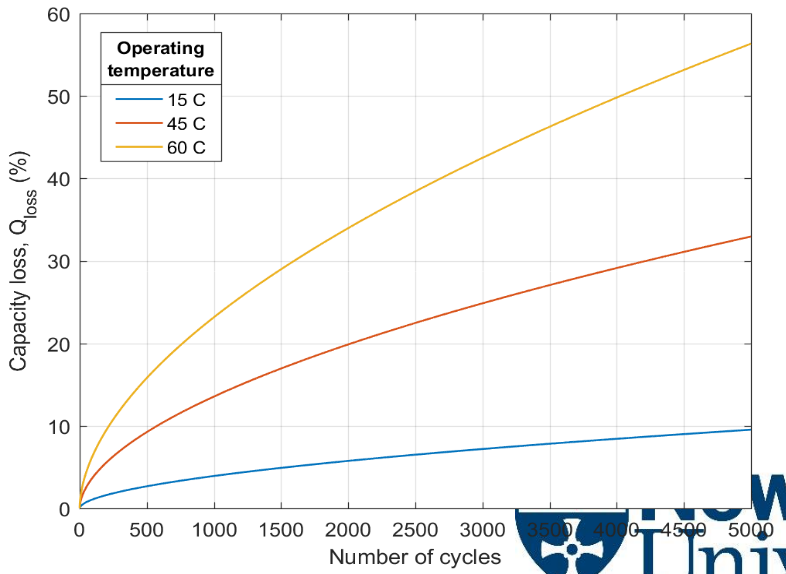
- Currently using versatile bespoke code for optimising storage operating schedule. Uses model predictive control and linear programming for speed
- Includes inefficiencies, battery degradation, grid constraints

- Can calculate CO_2 emissions using $\Phi = \boldsymbol{c}^T \boldsymbol{p}^+$, where $\boldsymbol{c}$ is vector of regional carbon intensity of generation (in gCO_2/kWh) and $\boldsymbol{p}^+$ is vector of grid import (in kWh)

- Can then include cost of carbon in optimisation

- Can modify generation mix, emissions factors and demand profiles to consider different future scenarios

Cycling-induced capacity fade in a $LiFePO_4$ battery



Time Plan

Task	Week																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Develop forecasting methodology for marginal GHG emissions	■	■	■	■	■	■																
Investigate the tradeoffs between minimising GHG emissions and maximising economic value							■	■	■	■												
Deploy and validate control algorithms for emissions reduction on the UoL battery storage system											■	■	■	■	■	■	■	■	■	■	■	■
Investigate the regional potentials for emissions reduction using storage, and the effects of financial incentives													■	■	■	■	■					
Extend the developed approaches to study the possible effects of EV smart charging and V2G																		■	■	■	■	■

Deliverables

- Open-source tool for evaluating effect of storage / DSR operation on GHG emissions
- Validation of storage operation based on forecasted marginal emissions, using UoL battery system (and potentially also a CESI demonstration system)
- Research paper on the potential for reduction of GHG emissions using storage and tension between economic and environmental goals, inc. the effects of increased carbon prices and nodal carbon pricing

Modelling the Distribution of Costs from Network Upgrade for Electric Vehicles (EVs)

Professor Karen Turner
Director, Centre for Energy Policy, University of Strathclyde

National Centre for Energy Systems Integration

Professor Karen Turner
Centre for Energy Policy, University of Strathclyde

UNIVERSITY of STRATHCLYDE INTERNATIONAL PUBLIC POLICY INSTITUTE
CENTRE FOR ENERGY POLICY

Project details

- This project **integrates energy and economic system modelling** approaches to investigate the crucial question of **'who ultimately pays'** for the costs of upgrading the power network to facilitate the intended roll out of EVs

- Our approach facilitates **consideration of a range of indirect, and possibly unanticipated and unintended, consequences of network development for EVs through impacts on markets, prices and incomes across the economy.** Such effects may affect both the actual pathway of the roll out, and who ultimately pays for required actions

- The project involves collaboration between the **Centre for Energy Policy, University of Strathclyde and Scottish Power Energy Networks**

https://www.ncl.ac.uk/cesi/cesiflexfund/firstcesiflexfundprojects/

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Professor Karen Turner
Centre for Energy Policy, University of Strathclyde

UNIVERSITY of STRATHCLYDE INTERNATIONAL PUBLIC POLICY INSTITUTE
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Methods

- Multi-sector economy-wide model (CGE) – used in research and by policy (Scot Govt, HM Treasury) to consider how wider economy impacts are transmitted via prices, incomes, markets
- Investigating interaction with energy systems models – use of TIMES for scenario modelling (smart vs. dumb charging, centralised vs. decentralised), taking results, particularly on investment costs, as input data to economy-wide CGE model

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Professor Karen Turner
Centre for Energy Policy, University of Strathclyde

Modelling Approach

Three underpinning principles in analysing 'who ultimately pays' for the network upgrade required for EVs:

1. To fund the necessary investment, costs are passed on to consumers through their bills
2. Commercial customers are likely to pass on their increased costs though their own prices
3. The process of large scale investment in electricity network infrastructure could cause price increases and negative wider impacts across the economy as the construction sector in particular draws in additional labour and capital resources

https://www.ncl.ac.uk/cesi/cesiflexfund/firstcesiflexfundprojects/

Key results/findings to date

- Lowest income households would suffer the least if the economy contracts as a result of the investment in electricity network. This is because lower income households get less income from the economy

- The highest income households would also suffer less where they have an ownership stake in construction activity through their investments

- Middle income families would be likely to be the biggest losers because of their reliance on wage incomes earned across all sectors of the economy

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Next stage

- Explore how the costs of the network upgrade may be increasingly offset for many UK households as the roll-out and uptake of EVs gains pace
- Scenarios will be framed, and subject to sensitivity analyses, in terms of assumptions around levels of EV penetration, availability of storage options etc – mapping to National Grid FES sims
- Engaging with a broad range of stakeholders to inform our scenarios and to ensure our project outputs are as useful as possible

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Timetable and deliverables

- Oct.18. 2-page Project Description Briefing Paper
- Nov.18. Completion of stakeholder mapping and engagement planning
- Dec.18: 4-page Initial Project Results and Progress Briefing paper/presentation
  - (opportunities with Dec meetings of CEP Advisory Board and planned ETP meeting with senior CCC representatives)
- Jan.19: Long abstracts of academic papers for conference submission
- Feb.19: Updated Project Results Briefing Paper and presentation to SPEN Strategic Stakeholder Group
- March 19. Working paper versions of intended peer reviewed journal submissions

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Initial Outputs …

- Briefing paper

Who ultimately pays for the electricity network upgrade for EVs?

University of Strathclyde Glasgow

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Research Briefing

Who ultimately pays for the electricity network upgrade for EVs?

Karen Turner, Oluwafisayo Alabi, Christian Calvillo and Ragne Low

Introduction

The UK and Scottish Governments have set ambitious targets for the roll out of electric vehicles (EVs). The predicted rapid expansion in EV ownership over the next couple of decades will see a shift in demand away from petrol and diesel fuels and towards electricity. The mass roll out of EVs is likely to require upgrades to the electricity network itself, which will carry significant costs. The Centre for Energy Policy is partnering with SP Energy Networks in a National Centre for Energy Systems Integration (CESI) project that integrates energy and economic system modelling approaches to investigate the crucial question of who ultimately pays for the costs of upgrading the power network to facilitate the intended roll out of EVs.

What do we mean when we ask 'who ultimately pays?'

We propose three underpinning principles in analysing 'who ultimately pays' for the network upgrade required for EVs:

1. **To fund the necessary investment, costs are passed on to consumers through their bills.** The cost can be recovered over a relatively long (multi-year) time period, and may ultimately be recovered more directly from EV users as uptake increases.
2. **Commercial customers are likely to pass on their increased costs though their own prices.** Ultimately this will ripple through to domestic consumers in prices of other goods and services. Where firms export their output, the impact on UK households may be less direct, through the employment and income effects of any loss in competitiveness.
3. **The process of large scale investment in electricity network infrastructure could cause price increases and negative wider across the economy as the construction sector in particular draws in additional labour and capital resources.** The nature and extent of any negative impacts will depend on the extent and time period over which the investment activity to upgrade the network takes place.

Focusing on this latter point to start with, our initial analysis suggests that the lowest income households would suffer the least if the economy contracted in this way. This is because lower income households get less income from the economy. The highest income households would also suffer less where they have an ownership stake in construction activity through their investments. Middle income families would be likely to be the biggest losers because of their reliance on wage incomes earned across all sectors of the economy.

The next stage of our project investigates this further considering a range of investment scenarios, initially up to 2050.

We will also begin to explore how the costs of the network upgrade may be increasingly offset for many UK households as the roll-out and uptake of EVs gains pace.

Next Steps

We are engaging with a broad range of stakeholders to inform our scenarios and to ensure our project outputs are as useful as possible. Anyone interested in engaging directly with the project should contact ragne.low@strath.ac.uk. We published a project Research Briefing in November 2018. This current paper will be followed by a report of our final conclusions in Spring 2019.

https://strathprints.strath.ac.uk/65981/

Newcastle University

National Centre for Energy Systems Integration

Website : http://www.cesienergy.org.uk
Twitter : @cesienergy
Email : cesi@ncl.ac.uk