Institution: Newcastle University

Unit of Assessment: 12

Title of case study: Smartening the Energy Grid: The Customer-Led Network Revolution.

Period when the underpinning research was undertaken: 2011-2014

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
• Prof Phil Taylor	• Professor of Power Systems	• 2013-2020
• Dr David Greenwood	• Research Associate/Senior Research Associate/NUAcT Fellow	• 2014-present
• Dr Myriam Neaimeh	• Research Assistant/Research Associate/Senior Research Associate/ Turing Fellow	• 2011-present
• Dr Padraig Lyons	• Senior Research Associate/Lecturer	• 2013-2016
• Dr Simon Blake	• Senior Research Associate	• 2013-2017
• Dr Jialiang Yi	• PhD Student, Research Associate	• 2013-2018
• Dr Peter Davison	• PhD Student, Research Associate	• 2013-2020

Period when the claimed impact occurred: 2014-2020

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact (indicative maximum 100 words)

The £54m Customer-Led Network Revolution project is one of the largest multi-disciplinary smart grid projects ever undertaken, with 13,000 customers involved in the trial of new products and technologies, resulting in one of the most sophisticated active network management systems in Europe. The research has directly kick-started the deployment of low carbon technologies, underpinned the business plans of every Distribution Network Operator in the UK (directing £17bn of investment over an 8-year period), updated regulations covering the planning and design of the electricity network, and led to a successful court case against the regulator Ofgem – the first time an appeal against a pricing regime in the energy market has been successful.

2. Underpinning research (indicative maximum 500 words)

‘Smart grids’ have been cited as one way to achieve a low carbon energy system, facilitating two-way flows of information between utilities and end consumers and facilitating the deployment of a range of smart technologies and renewable electricity generation sources. However, while the individual technologies of a smart grid are well understood in isolation, their widespread and combined deployment in a real-world setting is not, and previous research suggests a successful smart grid may necessitate a fundamental re-engineering of the entire electricity industry. This case study focuses on the Customer-Led Network Revolution (CLNR) project, one of the most extensive network technology integration trials ever undertaken.

The CLNR project (2011 to 2014) involved a range of partners (Northern Powergrid, Siemens, British Gas, EA Technology, Durham University and Newcastle University) and was an interdisciplinary mix of qualitative and quantitative research methods that trialled new technologies and business models with 13,000 customers (11,000 domestic and 2,000 SME, industrial, commercial and distributed generation customers). While smart technologies, demand response and network management practices are well known, they had not been deployed together at a distribution level in a vertically separated market such as Great Britain. The multi-disciplinary academic team (engineering, anthropology, geography and statistics) assessed customer-side solutions (new tariffs, solar PVs, electric vehicles, heat pumps and load control incentives [R2,

R3]) in isolation and in combination with network-side technology (voltage control, energy storage and real-time thermal rating [R1, R5, R6]). The active network management system that was deployed remains one of the most sophisticated control schemes in operation in Europe. In addition to the integration of people, processes, and technology, this is one of the most significant trials undertaken of customer electricity practices and attitudes (particularly domestic and small and medium enterprises).

Newcastle University's research arises from the Newcastle Institute for Research on Sustainability (NIReS) under the academic leadership of CLNR project lead Prof Phil Taylor. Academics at Newcastle University created advanced modelling techniques that predicted and validated the physical trials and facilitated the scaling up of the learning outcomes. Monitoring devices were installed across the Northern Powergrid network, with the data gathered being used to run real-time simulations, allowing Newcastle researchers to anticipate network constraints, improvise and adapt solutions ahead of time [R1, R2]. The diverse trial zones selected for the CLNR allows the results to be replicated across all Distribution Network Operator regions within Great Britain and internationally [R3]. The research has demonstrated that simple, local solutions can be preferred over more complex, expensive and wide-spread schemes, reducing the amount of expenditure needed to deploy smart technologies on existing electricity networks, reducing consumer bills and facilitating the growth of a low carbon energy network [R4, R5, R6].

The CLNR research has helped Newcastle University receive £20m to develop the multi-disciplinary National Centre for Energy Systems Integration, which is primarily funded by the EPSRC and Siemens. The centre is continually developing flexible and smart energy technologies.

3. References to the research (indicative maximum of six references)

Publications

[R1] P. Wang, D. H. Liang, J. Yi, P. F. Lyons, P. J. Davison and P. C. Taylor, "Integrating Electrical Energy Storage Into Coordinated Voltage Control Schemes for Distribution Networks," in *IEEE Transactions on Smart Grid*, vol. 5, no. 2, pp. 1018-1032, March 2014. DOI: 10.1109/TSG.2013.2292530

[R2] P.F. Lyons, N.S. Wade, T. Jiang, P.C. Taylor, F. Hashiesh, M. Michel, D. Miller, Design and analysis of electrical energy storage demonstration projects on UK distribution networks, In Applied Energy, Volume 137, 2015, Pages 677-691. DOI:10.1016/j.apenergy.2014.09.027

[R3] M. Neaimeh, R. Wardle, A. Jenkins, J. Yi, G. Hill, P. F. Lyons, Y. Hübner, P. Blythe, P. Taylor, A probabilistic approach to combining smart meter and electric vehicle charging data to investigate distribution network impacts, In Applied Energy, Volume 157, 2015, Pages 688-698. DOI: 10.1016/j.apenergy.2015.01.144

[R4] C. J. Dent, A. Hernandez-Ortiz, S. R. Blake, D. Miller and D. Roberts, "Defining and Evaluating the Capacity Value of Distributed Generation," in *IEEE Transactions on Power Systems*, vol. 30, no. 5, pp. 2329-2337, Sept. 2015. DOI: 10.1109/TPWRS.2014.2363142

[R5] J. Yi, P. F. Lyons, P. J. Davison, P. Wang and P. C. Taylor, "Robust Scheduling Scheme for Energy Storage to Facilitate High Penetration of Renewables," in *IEEE Transactions on Sustainable Energy*, vol. 7, no. 2, pp. 797-807, April 2016. DOI: 10.1109/TSTE.2015.2498622

[R6] D. M. Greenwood and P. C. Taylor, "Investigating the Impact of Real-Time Thermal Ratings on Power Network Reliability," in IEEE Transactions on Power Systems, vol. 29, no. 5, pp. 2460-2468, Sept. 2014. DOI: 10.1109/TPWRS.2014.2305872

Grants

The Low Carbon Networks Fund, Ofgem – £27,587k.

Match funding from project partners (British Gas, Northern Powergrid, EA Technology) - £27,000k.

4. Details of the impact (indicative maximum 750 words)

As much of the underpinning research in this case study has been funded by the Low Carbon Networks Fund (and ultimately the UK taxpayer), all Distribution Network Operators (DNOs) in Great Britain are contractually obliged to incorporate the 'best practice' developed through the CLNR into their own investment plans. Outputs arising from the CLNR provided a justification to invest in smart grid technologies now, in anticipation for a greater uptake in low carbon technologies in the future. As a result, Newcastle University research underpins around £17bn of DNO investment to renew, maintain and operate electricity networks (through the RIIO-ED1 2015 to 2023 period) with CLNR directly influencing the £476m currently being spent on 'smart and innovative solutions' [S2,S7]. Northern Powergrid (the DNO for the North East and Yorkshire with 8 million customers) state that the CLNR research "has resulted in a rich body of knowledge completed at end December 2014 with net benefits estimated in the range £5bn to £26bn in the period 2020 to 2050" [S1: page 2,S2]. Northern Powergrid has created a 'smarter powergrid' plan to allocate £139m to new technologies and upgrades, which include CNLR trial technologies such as real-time thermal rating and voltage control [S2, S3, S4].

Competition and Markets Authority (CMA) court case

As natural monopolies, DNOs have price controls imposed on them by the government regulator Ofgem, which is tasked to ensure DNOs earn a fair return on their activities while controlling the cost to end users. In 2015, Ofgem imposed strict price controls based on assumptions that the benefits from a bespoke smart grid technique in one area could be extrapolated out to the whole country, significantly overestimating the savings that could be made by DNOs and causing regulatory constraints based on unrealistic savings. Northern Powergrid appealed the decision to the CMA and, as a direct result of CLNR research showing that smart grids need context-specific solutions, was successful. This was the first time a DNO has successfully appealed a judgement by Ofgem. As a result, Northern Powergrid's cost allowance for the 2015 to 2023 period was increased by £32m, with the allowable revenue increasing by around £11m [S2,S8].

Products

Two sets of products have arisen from the CLNR project. First is the creation of 'solution templates' that could be incorporated into EA Technology's Transform Model software [S5a]. The Transform Model is a tool used by network operators, Ofgem, DECC and organisations internationally to optimise investments in smart grid technologies. The software produces a variety of 'what if' scenarios for low carbon technology uptake and assesses the consequential network investment. Importantly, the quality of the model's outputs is dependent upon the quality of the solution templates used to create the scenarios, with CLNR work providing real-world data on low carbon costs and benefits. The modelling identified that CLNR smart solutions provided over 70% of the financial benefits where the model deemed that a smart solution was more appropriate than a traditional reinforcement option [S1: page 119]. The model is used by Ofgem and the Department for Business, Energy and Industrial Strategy for evaluation[S5b]. It is also used by DNOs in New Zealand and Northern Ireland.

Second, the CLNR project led to the creation of the 'Grand Unified Scheme' control software, which has been further developed by Siemens as an extension of 'Spectrum Power', and applied within the Western Power Distribution 'Equilibrium' project [S6]. Siemens Microgrid Management System and Microgrid Controller were also influenced by the work completed on CLNR. Siemens are now applying the findings, methods, and approach of CLNR to their flagship Smart Energy Network Demonstrator project at Keele University [S6], which encourages co-optimisation of electricity, heat, gas and transport.

Regulatory Changes

The CLNR project has directly led to changes in the regulations governing electricity systems within Great Britain, with some laws dating back to the 1950s and 1960s when electricity provision was expanded considerably to meet the UK's growing demand.

Changes include updated guidance on ACE 49 (covering how the industry categorises customers) and ETR 130 (providing guidance on how to assess the capability of a network containing distributed generation) [R4, S11], P2/7 (Security of supply) [S9], P5 (Design methods for LV underground networks) [S10], and Engineering Recommendation G59 (to include electrical energy storage technologies in guidance on connecting generating plants to distribution systems) [S11]. These changes are designed to encourage the deployment of low carbon technologies, which the previous regulations would have prohibited, highlighting the need to respond at the planning and design stage with revised standards.

5. Sources to corroborate the impact (indicative maximum of 10 references)

[S1] CLNR Project Closedown Report. Online at http://www.networkrevolution.co.uk/project-library/project-closedown-report-2/	The project closedown report submitted to ofgem by Northern Powergrid. This details the value of the impact to GB distribution networks.
[S2] Support letter from Northern Powergrid	A letter which details the impacts of the Newcastle University research within Northern Powergrid including the value of the knowledge; the impact on future investment; the role of the research in Northern Powergrid's appeal to the CMA; the impact of CLNR on industry standards, and the continued involvement of Newcastle University in Northern Powergrid innovation.
[S3] Customer-led Network Revolution – Project Learning. Online at https://www.yourpowergridplan.com/som_download.cfm?t=media:documentmedia&i=1694&p=file	This report details the significant impact that CLNR had on Northern Powergrid's business plan from 2015-2023
[S4] Our Business Plan 2015 – 2023, Northern Powergid. Online at https://www.yourpowergridplan.com/som_download.cfm?t=media:documentmedia&i=1698&p=file#page=0	Northern Powergrid's business plan which details the £139M Smarter Powergrid plan
[S5] EA Technology reports: a) CLNR Cost Benefit Analysis report, available at: http://www.networkrevolution.co.uk/wp-content/uploads/2015/01/CLNR-L144-Cost-Benefit-Assessment-of-the-CLNR-Project.pdf and; b) the brochure for the Transform Model: https://www.eatechnology.com/wp-content/uploads/sites/5/2017/04/The-Transform-Model-Brochure.pdf	A report which links the new Transform solution templates to reports describing the trial results completed by Newcastle University. The Transform Model's product brochure directly mentions ofgem and DECC (Now BEIS) as customers.
[S6] Support letter from Siemens	This letter describes the impact that Newcastle University's work through CLNR project has had at Siemens.
[S7] Ofgem (2014) RIIO-ED1: Final determinations for the slow-track electricity distribution companies.	This document evidences the £476M of savings through smart-grid interventions, and the claim that significant additional savings could be made which was the subject of the determination in [S8]

[S8] Northern Powergrid (Northeast) Limited and Northern Powergrid (Yorkshire) plc v the Gas and Electricity Markets Authority: Final Determination.	The ruling from the Competition and Markets Authority. "It upheld one ground in relation to Ofgem's adjustments to reflect potential savings available from the introduction of smart grids and other technological innovations". The case from Northern Powergrid included a witness statement from Prof. Phil Taylor which drew heavily from the research conducted at Newcastle University on the CLNR project.
[S9] Review of Distribution Security Standards, Imperial College for the Energy Networks Association, Report March 2015. Online at: http://www.dcode.org.uk/assets/uploads/IC_Report_main_report_-_red.pdf	A review of the distribution network security of supply standards which fed into the development of the current regulations (P2/7). The report directly references Newcastle research by Blake, Greenwood and Taylor [R6]
[S10] Engineering Recommendation P5: Design methods for LV underground networks for new housing developments, Issue 6 2017, Energy Networks Association.	An industry standard on design methods for LV underground networks The document states: "This document has been developed from the learnings and recommendations of the following Innovation Projects: Northern Powergrid – Customer-Led Network Revolution" and cites seven reports from the CLNR project. Several of these cite the underlying research ([R4] and a conference paper which was a precursor to [R3]).
[S11] Review of the Distribution Network Planning and Design Standards for the Future Low Carbon Electricity System, document number CLNR-L186, 31/10/2014. Available online at: http://www.networkrevolution.co.uk/wp-content/uploads/2014/12/ACE49-Report-1.1.pdf	A report drawing on CLNR underpinning research to review and make recommendations to distribution network planning and design standards. It refers to [R4].