

Institution: Loughborough University		
Unit of Assessment: B12: Engineering		
Title of case study: Improving Industry Quality, Consumer Protection and Policy Development for the UK's Solar Power Sector		
Period when the underpinning research was undertaken: 2009 – 2016		
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:
Murray Thomson	Reader in Electrical Networks & Systems	1998 – present
Paul Rowley	Senior Lecturer in Renewable Energy	2008 – present
Philip Leicester	Research Associate	2013 – present
Ian Richardson	Research Associate	2010 – 2012
Period when the claimed impact occurred: 2017 – 2020		
Is this case study continued from a case study submitted in 2014? No		
1. Summary of the impact (indicative maximum 100 words)		
<p>The UK's solar photovoltaic (PV) sector has grown to a value of £30Bn in the last decade. Despite this investment, the ongoing performance of the 1 million domestic installations is poorly quantified, particularly around the level of on-site energy self-consumption, the export of surplus energy and the benefits of battery storage. Working with MCS Certified (the UK's PV standards organisation), Solar Energy UK (the industry's trade association), IChoosr (the UK's largest PV group buying expert), and government policy makers, Loughborough's modelling and simulation research has 1) led to the development of a UK-wide Solar PV Standard with guidance for improved consumer confidence and protection; 2) supported the development of new PV and storage products and services, and 3) influenced UK Government policy on the value of 'Smart Solar Homes' for the UK economy.</p>		
2. Underpinning research (indicative maximum 500 words)		
<p>The UK's domestic-scale PV sector has grown massively over the last decade, but problems have emerged with regards to consumer mis-selling and lack of ongoing performance quality data for over one million household systems installed to date. Having gained an international reputation since 1993 for its research quality in PV technology, in 2017 Loughborough University's Centre for Renewable Energy Systems Technology (CREST) was invited by MCS (the UK PV industry standards body) to support the roll-out of a new sector support package comprising a PV with battery storage standard, installer guidelines and a consumer code of practice.</p> <p>The underpinning research originated from work that was carried from 2009-2012 by Drs Richardson (PDRA), and Thomson (PI/CI) [R1]. The research involved empirically derived stochastic modelling methods which were applied to deliver much improved insights into patterns of electricity use in domestic dwellings. This EPSRC-funded work (EP/G031681/1; £4,177,322) resulted in an open-source tool now used widely worldwide for analysing how household occupancy and behaviour impacts domestic electricity demand [R1, R2].</p> <p>From 2013-16 with further EPSRC funding (EP/K02227X/1; £1,023,088) the work was extended by Drs Leicester (PDRA) and Rowley (PI/CI) to predict concurrent electricity demand and PV generation datasets for multiple household occupancy archetypes, based on the number of household occupants and their activity patterns [R4, R5]. For the first time, this provided a means to simulate location-specific concurrent time-series datasets for both electricity demand and PV generation, and thus evaluate on-site PV energy usage (known as 'PV self-consumption'). Further EPSRC-sponsored work (EP/K022229/1; £1,139,185) incorporated battery models to investigate the additional benefits of combining PV with energy storage systems. This work focused on the development of performance calculations and analyses for a wide variety of possible household 'use cases'. The resulting datasets were subsequently used to construct Bayesian graphical probabilistic models [R3] to yield new insights under uncertainty into the benefits of PV for householders, including financial</p>		

returns and CO₂ savings. The work also yielded policy-related insights into the impacts of PV upon household fuel poverty levels for different regions of the UK.

Prior to this work, the extent to which domestic PV generation is 'self-consumed' (rather than exported to the grid) was highly contested with figures from 15% to 65% commonly used. The application of Drs Leicester and Rowley's approach enabled the sources of uncertainty to be uncovered for the first time, and the complex interplays of PV system size, household energy demand and occupant behaviours to be examined in detail [R5]. Taken together, the underpinning research described above provides the platform upon which the development of the UK National Standard and Guidelines for Domestic Photovoltaic (PV) Installations was built. It also provided the basis for ongoing collaboration with industrial and policy sector stakeholders.

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

- R1** Richardson, I., Thomson, M., Infield, D. and Clifford, C., 2010. Domestic electricity use: A high-resolution energy demand model. *Energy and Buildings*, 42 (10), pp. 1878-87. DOI: <https://doi.org/10.1016/j.enbuild.2010.05.023>
- R2** Richardson, I. and Thomson, M., 2012. Integrated simulation of photovoltaic micro-generation and domestic electricity demand: a one-minute resolution open-source model. *Proceedings of the Institution of Mechanical Engineers, Part A: Journal of Power and Energy*, 227 (1), pp. 73-81. DOI: <https://doi.org/10.1177/0957650912454989>
- R3** Rowley, P., Leicester, P., Palmer, D., Westacott, P., Candelise, C., Betts, T. and Gottschalg, R., 2015. Multi-domain analysis of photovoltaic impacts via integrated spatial and probabilistic modelling. *IET Renewable Power Generation*, 9 (5), pp. 424-31. DOI: <https://doi.org/10.1049/iet-rpg.2014.0374>.
- R4** Leicester, P. A., Rowley, P. N. and Goodier, C. I., (2015). Probabilistic analysis of solar photovoltaic self-consumption using Bayesian network models. *IET Renewable Power Generation*, 10 (4), pp. 448-55. DOI: <https://doi.org/10.1049/iet-rpg.2015.0360>.
- R5** Leicester, P.A., Goodier, C.I. and Rowley, P.N. (2016). Probabilistic evaluation of solar photovoltaic systems using Bayesian networks: a discounted cash flow assessment. *Progress in Photovoltaics*. 24 (12), pp. 1592-605. DOI: <http://dx.doi.org/10.1002/ppv.2754>.

The papers referenced are all published in peer-reviewed journals. All the papers were published as a result of the EPSRC funded research detailed in Section 2. R5 was an invited paper following a successful international conference paper and oral presentation.

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

The UK's challenging climate change obligations include parliament's 'net zero' legislation to eliminate the UK's net emissions of greenhouse gases by 2050. Loughborough's detailed modelling methodologies and open-source tools have enabled the rapid wide-scale adoption of PV and energy storage technologies across the UK. EPSRC Impact Acceleration funding enabled close collaboration, via knowledge-transfer secondments, industry workshops and presentations to policy makers, with key sector stakeholders including:

- The Microgeneration Certification Scheme (MCS) & MCS Charitable Foundation, the industry's quality assurance body. Set up by the UK Government (DECC now BEIS) in 2007, MCS provides the framework for the certification and compliance of small-scale renewable technologies, installations and installer companies.
- Solar Energy UK (formerly STA), the sector's trade association, which engages in research, policy-development and lobbying to shape Government policy and regulation for the benefit of its 200+-strong company membership comprising installers, manufacturers, distributors, large-scale developers and investors.
- iChoosr, an international company which works with more than 150 local councils across the UK to deliver group energy switching and group purchasing of over 3,000 solar PV systems to date.
- Larkfleet Smart Homes, the innovation arm of The Larkfleet Group, an award-winning housebuilding and development company based in Lincolnshire. The company is currently

developing a range of 'smart' energy services for householders that combine comfort, value for money and sustainability.

As a result, three key impacts are described in detail below:

Impact 1: A New UK-wide Solar PV Standard with Guidance for Improved Consumer Confidence & Protection

The Loughborough model [R1,2,4] underpinned a new installation and performance standard for all UK domestic solar PV installations with Battery Energy Storage (BES), as well as a related industry guidance document [S11]. The new standard and guidance contain performance benchmarks for PV with BES derived from Loughborough's modelling and applies to all domestic installations carried out by the over 1,100 certified installers across the UK [S1]. In terms of consumer confidence and protection, Ian Rippin, CEO of MCS, states that the new standard and guidance are

“fundamental to our ability to create consumer confidence in renewable technologies and also for their wide-scale adoption in the UK. It is, therefore, key to achieving the legal target of achieving net zero carbon by 2050, if not sooner” [S1].

Virginia Graham, CEO of Renewable Energy Consumer Code (the key consumer advocate for renewables in the UK) adds *“Loughborough's work extends consumer standards and reduces opportunities for mis-selling, which will help the sector expand sustainably” [S4].* Solar Energy UK's CEO Chris Hewitt described the reach and impact of Loughborough's work to their 200+ company membership:

“the standard and guidance give clarity to consumers, reassuring them that the technologies are benchmarked, and prevents or ameliorates mis-selling, ensuring installers deliver a reputable, high-quality product and service” [S3].

The business impacts have also been welcomed. MCS welcomed the standard's applicability to all household types which *“makes the standard accessible and enables installers to see the world through the data” [S1].* A feared slump, following the end of the FiT PV subsidy in March 2019, did not occur; rather, sector growth has been robust with 4,000-4,500 sales per month on average. MCS largely attributes this market confidence to the new Loughborough model-based standard and guidance, which has *“fundamentally delivered trust and a level playing field” for the industry [S1].* Solar Energy UK's reported that

“having a standard supported and contributed to by the industry along with your academic rigour has ensured the best possible start for the increasingly important combination of battery energy storage with solar PV” [S3].

Loughborough's research has also impacted MCS' future business strategy for new standards development. These are viewed by the sector as being essential for driving ongoing innovation and growth across the wider renewable and low carbon technology sector. This outcome-focussed approach (a result of the collaboration with Loughborough) *“has become the model for how MCS thinks about standards development and collaboration” [S1].*

Impact 2: Supported the Development of new PV and Storage Products and Services

Trust in new low-carbon technologies is improved when their efficacy in real applications is demonstrated by objective high-quality evidence presented in a clear and accessible way to technology manufacturers, suppliers and consumers. This is exemplified by the application of Loughborough's PV with storage modelling research [R3,4,5] in collaborative work with industry.

[iChoosr](#) operates group buying schemes across Europe, Asia and North America, with a focus on energy supply switching and solar PV installations. Since 2012, the company has worked with over 160 UK councils to roll out bulk purchase schemes, with their solar PV auctions averaging 27,000 registrants, resulting in over 3,000 PV systems being installed in the UK since 2018. In 2019, iChoosr partnered with the mayors of London, Manchester and the Eastern Counties Councils to launch their new PV and battery storage offer.

Loughborough's modelling and simulation work underpins iChoosr's new consumer-focused online calculator toolkit, which enables assessment of the effectiveness of solar PV both with and without storage. In iChoosr's view, the Loughborough collaboration on development of the toolkit has delivered greater trust by consumers and has significantly increased their sales of BES with PV across the UK, with an average of 30% of residents – 1,800 direct purchases – adding a battery to their solar PV system. iChoosr expects this to triple in 2021 [S2]. Ruud Frijstei, iChoosr's Development Manager, said:

“by giving a fair assessment and straightforward advice based on the Loughborough model, they (the customers) trust the ‘channel’. This is an extremely significant impact of the work because this can only drive the adoption of battery storage in an upward direction, from a smaller group of innovators and early adopters in to the majority” [S2].

iChoosr's intention now is to expand the use of the model, standard and guidance to its wider international markets, stating *“this is essential for a business model founded on trust. It is one we are very keen to replicate in other European countries, and also Japan. Links have already been made between researchers in Loughborough and Belgium” [S2].*

The [Larkfleet Group of Companies](#) is an award-winning housebuilder with a history of sustainable innovation, As part of their research and development activity, during 2019-20 they co-funded work which has extended the application of Loughborough's modelling research to the benefit of their 'Larkfleet Smart Homes' business brand roll-out. Larkfleet Group Chairman, Karl Hick, said *“Loughborough's work serves to underpin and support our R&D work to develop a smart home offer for our future customers. As such, the research is an integral part of the business case for the development of leading-edge technologies and business models for domestic housing” [S5].* Larkfleet Smart Homes' Director of Operations (Simon Evans) adds that,

“as a result of the research work by Loughborough, we are now considering larger batteries so that homes have greater potential to be able to participate in grid services and generate additional revenue streams. This work has had a marked impact on our road map for the development of Smart low carbon homes in the UK that we see as essential to decarbonise our building stock” [S7].

Impact 3: Influenced UK Government Policy on the Value of 'Smart Solar Homes' for the UK Economy

In 2019, our ongoing collaboration with the wider UK PV sector resulted in discussions on how Loughborough's research tools and outputs could be used to influence the policy and regulatory landscape, and help deliver the low carbon transition. These discussions, led by Solar Energy UK, resulted in the 'Smart Solar Homes' project, co-funded by SEUK's members, including the MCS Foundation and the Larkfleet Group.

The work involved Loughborough applying their models to develop an expanded evidence base on whole-system technical, economic and societal benefits of wide-scale adoption of home-based solar PV with battery energy storage (BES). The intention was to

“reveal the vital contribution homes can make in the journey to net zero. By using real world data to identify, analyse, and compare four generations of smart homes with the average UK home today, the work demonstrates the numerous consumer and system wide benefits of reducing energy poverty, cutting carbon and supporting the power system” [S5].

The resulting report, and its recommendations, were widely reported in the trade media [S6] and were integral to SEUK's lobbying efforts throughout 2020 [S10].

As a result, focussed and significant policy debate was stimulated within industry, UK Government departments and Parliament. Specifically, SEUK made significant use of the report's key recommendations shaped by Loughborough's research. CEO Chris Hewett stated *“[there] was a real gap in the knowledge for regulators and policymakers which we were keen to fill, so this work delivered by Loughborough has really done an excellent job for*

us. We continue to use the facts and figures from the report which inform how we shape our policy recommendations and how we make the case to Government and network providers for the advancement of decentralised energy” [S3]. STA Senior Policy Analyst, Kevin McCann, explains that “the report has directly shaped the narrative the STA is now able to promote as part of its policy and advocacy agenda, engaging with government, regulators, and broader solar sector stakeholders” [S10].

The Department for Business, Energy and Industrial Strategy (BEIS) currently has a work stream on barriers affecting the deployment of domestic battery energy storage. Drawing on evidence from Loughborough’s application of its modelling in the Smart Solar Homes report, SEUK has highlighted in their discussions with BEIS the contribution that the UK’s residential housing stock can make to decarbonisation goals. The findings in the report have also been used by SEUK in four Government consultations, including Ofgem’s RII0-2 draft electricity network price control proposals. Furthermore, in its extensive discussions with National Grid around its [Future Energy Scenarios](#) work, SEUK has also used Loughborough’s work to inform NG’s assumptions around future grid infrastructure investment, and to alert NG to the possibility that its assumptions on domestic solar deployment might be too conservative in the light of the research [S10].

Loughborough’s Smart Solar Homes work has also directly stimulated policy debate by parliamentarians [S9]. Peter Aldous MP, current vice-chair of PRASEG (Parliamentary Renewable and Sustainable Energy Group) and Chair of the Intelligent Energy All-Party Parliamentary Group has written that the Smart Solar Homes report’s findings are of

“direct significant relevance to several commitments outlined in the Government’s 2020 Energy White Paper ‘Powering Our Net Zero Future’. The potential contribution of 4.2 million smart solar homes as described in your report, can make a cost-effective contribution to the smart flexible energy system that we need to develop in the UK. Your recommendation for greater technical interoperability to allow a range of market solutions to compete effectively is also very helpful”.

He has also stated that the findings in the report are of direct relevance to the Local Electricity Supply Bill currently making passage through Parliament to “bring down the cost of the Net Zero transition” and “shape the new business models needed in an energy system”. Likewise, Alan Whitehead MP (Shadow Minister for Energy and the Green New Deal) has expressed his support for the work’s importance and intends to further promote it in Parliament [S9, S10].

In their policy advocacy for microgeneration technology, the MCS Charitable Foundation’s CEO confirms that the report provides a key aspect of their external affairs strategy to push for the policy framework needed to realise UK decarbonisation targets. He states: “*We have been particularly proactive with BEIS at both political & officer level and are leading discussions with stakeholders such as National Grid, OFGEM and the Regional Energy Hubs. The findings in the ‘Smart Solar Homes’ report are an extremely useful lever in our toolbox, providing the sort of direct evidence we can refer to directly in policy advocacy*” [S8].

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

- S1** MCS Testimonial Letter from CEO
- S2** iCHOOSR Testimonial Letter from New Product Development Manager
- S3** SEUK Testimonial Letter from CEO
- S4** Renewable Energy Consumer Code - Press Release
- S5** Smart Solar Homes: Journey to Net Zero (Report)
- S6** Trade Media Coverage for the Smart Solar Home Report
- S7** Larkfleet Group Testimonial Letter from Director of Operations
- S8** MCS Charitable Foundation Testimonial Letter from CEO
- S9** Parliamentary Impact Evidence from Peter Aldous MP and Dr Alan Whitehead MP
- S10** STA Testimonial from Senior Policy Analyst
- S11** MCS National Guidance Note on Self-consumption and the Solar PV Standard