Institution: University of Salford		
Unit of Assessment: 13		
Title of case study: Shaping the domestic low carbon energy transition		
Period when the underpinning research was undertaken: January 2010 – December 2020		
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. Will Swan	Director of Energy House Laboratories	June 1997 – Present
Dr Richard Fitton	Lecturer in Energy Efficiency	July 2011 – Present
Period when the claimed impact occurred: August 2013 – December 2020		
Is this case study continued from a case study submitted in 2014? N		

1. Summary of the impact

The climate emergency is simultaneously global and close to home, with buildings accounting for 17.5% of all emissions. Eco-friendly and well-insulated homes, with clear consumption information and better control mechanisms to pay for fuel, would help to reduce carbon emissions and moderate fuel poverty. Salford's Energy House Laboratories are working to support this by researching ways to make energy and emissions savings in new and existing homes in the UK and Europe. The unique Energy House facility supports innovators to rapidly bring new products to market, creating economic growth and competitiveness. Salford's team has been instrumental in delivering CO_2 savings of 35,000,000t across its research and commercial partnerships, has worked with 23 companies and helped test 22 energy-saving products, leading to business revenues of GBP103,000,000, creating approximately 200 new jobs and resulting in the improvement of 1,842 Greater Manchester homes.

2. Underpinning research

The issues of decarbonisation and energy efficiency in the domestic sector are complex, involving policy, occupants and technology. Since 2010, Salford's Energy House Laboratories (EHL) team has focused on the performance of homes driven by technological interventions, as well as the supporting policy and regulation around products **[3.1]**, such as Building Regulations and the regulatory energy model for the UK, known as the Standard Assessment Procedure, which can strongly shape technical decisions in our homes. In 2011, EHL completed the facility known as the **Salford Energy House (SEH) [3.2, 3.3, 3.4]**.

SEH is a Victorian house in a climate-controlled chamber, which allows research that had traditionally been done in the field to be undertaken rapidly in repeatable controlled conditions. A traditional field trial may take up to 2 years to allow for issues such as climate or occupancy, which make analysis complex. This facility allows for unique experiments, such as the phased retrofit of a property **[3.2]** and the testing of heating controls **[3.3]**. These early studies led to a model of the 'experimental demonstrator' that has allowed products to be rapidly tested in a structured way. The application of the experimental demonstrator method means that, under controlled conditions, not only can a product be quickly evaluated, if minor changes are required, it may also be tested again under nearly identical conditions over a period of a few weeks. This approach means innovators can get to market much quicker with a strong evidence base for actual performance, creating benefits for marketing, regulatory approval and real energy and carbon saving impact.

In establishing the performance of products, it was recognised that controlled conditions provided a unique proposition to understand different building performance techniques. Methods, such as quick u-building (QUB), which is a whole house energy loss method **[3.2]**, and innovative approaches to thermography were used that moved it from a qualitative to quantitative approach **[e.g. 3.4]**. This has led to a wider number of co-designed research projects such as rapid U-Values (BRE Group prize winner), Heat 3D and Smart Meter Enabled Thermal Efficiency Ratings (SMETERS). The accurate measurement of building performance is essential to address a well-recognised phenomenon known as the 'performance gap' **[3.5]**, where the modelled performance of a building or product is much lower than the predicted or modelled performance, often because models do not reflect measured values. This means that the work around effective performance measurement is an essential part of the evidence base produced by SEH.

The final area of underpinning research is our engagement with the smart meter infrastructure, which is a key component of future domestic energy systems, as more people move to electrical heating and transport, and employ renewable and battery technology **[3.6]** and as digitally controlled domestic energy systems become more complex. This change creates both decarbonisation and clean growth innovation opportunities around digital products and services. In 2018, EHL developed the **Smart Meters Lab**, which was supported by the Data Communications Company, Octopus Energy and a number of manufacturers, to provide an innovation sandpit established under similar principles to the SEH.

The systemic approach to innovation infrastructure has led to the commissioning of **Energy House 2.0** (currently under construction as of December 2020). This is a GBP16,000,000 research facility designed to apply the experimental demonstrator model to new buildings.

3. References to the research

3.1. Swan, W., Ruddock, L., Smith, L. and **Fitton, R.**, 2013. Adoption of sustainable retrofit in UK social housing, *Structural Survey*, 31(3), pp. 181-193. https://doi.org/10.1108/SS-12-2012-0039

3.2. Alzetto, F., Farmer, D., **Fitton, R.**, Hughes, T. and **Swan, W.**, 2018. Comparison of whole house heat loss test methods under controlled conditions in six distinct retrofit scenarios, *Energy and Buildings*, 168, pp. 35-41. https://doi.org/10.1016/j.enbuild.2018.03.024 **(REF2)**

3.3. Fitton, R., **Swan, W.,** Hughes, T., Benjaber, M. and Todd, S., 2016. Assessing the performance of domestic heating controls in a whole house test facility, *Building Services Engineering Research and Technology*, 37(5), pp. 539-554. https://doi.org/10.1177/0143624416634070

3.4. Marshall, A., Francou, J., **Fitton, R**., **Swan, W.**, Owen, J. and Benjaber, M., 2018. Variations in the U-Value measurement of a whole dwelling using infrared thermography under controlled conditions, *Buildings*, *8*(3), pp. 1–17. https://doi.org/10.3390/buildings8030046

3.5. Marshall, A., **Fitton, R**., **Swan, W.,** Farmer, D., Johnston, D., Benjaber, M. and Ji, Y., 2017. Domestic building fabric performance: closing the gap between the *in situ* measured and modelled performance, *Energy and Buildings*, 150, pp. 307-317. https://doi.org/10.1016/j.enbuild.2017.06.028 **(REF2)**

3.6. Paraskevas, I., **Fitton, R.**, Marshall, A., **Swan, W**. and Alan, D., 2019. The role of smart meters in energy and cost efficiency in the smart home ecosystem - research in progress. In Proceedings of the *IET Living in the Internet of Things*, May 2019, London, UK. https://digital-library.theiet.org/content/conferences/10.1049/cp.2019.0172

A total of GBP11,330,778 funding is associated with the underpinning research, including grants from commercial organisations (e.g. Energy Systems Catapult Ltd. grants totalling GBP214,712;

Saint Gobain grant for GBP132,650; BEAMA grant for GBP65,000) and from external funding bodies (e.g. European Regional Development Fund (ERDF) grants totalling GBP10,011,468).

4. Details of the impact

The work undertaken by EHL has informed standards and regulations across the industry, driven product innovation and generated benefits from installation of these products in homes. This has subsequently led to reductions in CO_2, increased economic output and lowered fuel poverty levels.

4.1. Informing policies and standards in the UK and EU

From late 2013 onwards, six studies were carried out in SEH with the British Electrotechnical Manufacturer's Alliance (BEAMA), the UK trade association which represents more than 200 companies who provide systems and products to the energy system. These studies identified **significant cost efficiencies** afforded by the use of room thermostats and thermostatic radiator valves (TRVs), saving **up to 41% on household energy bills,** equating to approximately **GBP409.86 per household per annum** and therefore paying back its initial investment within 15 months **[5.1]**. These findings led to **changes in the European Union (EU) Energy Performance of Buildings Directive (2018/844),** creating approximately **29MtCO_2 emission savings per annum** in EU homes alone **[5.1]**. BEAMA's Director of Member Services confirmed that the SEH facility and Salford's expertise had been *'invaluable'* in driving the energy system transition to ultimately deliver net zero emissions, with SEH and the forthcoming Energy House 2.0 being an *'essential part of the UK and EU infrastructure'* **[5.1]**. A related study of advanced boiler heating controls with Viessmann Ltd., a manufacturer of boilers and heating systems, led directly to the **introduction of 'boiler plus' controls as part of UK Building Regulations [5.2]**. Approximately **3,600,000 boiler installations** were impacted by this change (2018 – 2020), generating a saving of **6.19MtCO_2 emissions [5.2]**.

Dr Richard Fitton is a member of the CEN/BSi/ISO working groups, who were consulted on the **development of the national standard BS EN 16012:2012** (Thermal insulation for buildings - Reflective insulation products - Determination of declared thermal performance), which **informs the next version of the joint CEN and ISO standard BS EN ISO 22097 [5.3]**. This defines a set of procedures for using **standardised test methods** to determine the thermal performance of reflective insulation products, a **market worth GBP211,000,000 per annum in the EU [5.3]**. The Convener of the working groups stated that Fitton's involvement as a UK nominated expert had brought *'a significant impartial voice to […] a complex scientific debate'*, highlighting that without this input from SEH *'the proposals would be heavily influenced by the industry that such standards intend to regulate. Thus, independent contributions […] help to* ***protect the consumer*** *and* ***validate the eventual published performance data*** *on these products'* **[5.3]**.

At a regional level, SEH is identified in three strategies for Greater Manchester (GM): the Greater Manchester Local Industrial Strategy (GMLiS), Sustainable Urban Development Strategy, and Whole System Smart Energy Plan. Professor Will Swan is the current chair of the *Low Carbon Buildings Challenge Group* for GM, leading the **retrofit strategy for 1,100,000 homes, 98,000 commercial and 2,700 public buildings** and helping to shape the Energy Transition Region (LiS) through the development of the Energy Innovation Agency **[5.4]**.

4.2. Improving sustainability through retrofit

With 70% of UK building stock in 2010 expected to still be in use in 2050, low-carbon standards for new builds cannot meet carbon reduction targets alone and therefore retrofitting the current stock is a crucial part of mitigation. The Energy Company Obligation (ECO) is a government scheme to reduce CO_2 emissions and tackle fuel poverty. Professor Swan sat on the ECO Framework Board for GM and has provided technical monitoring and evaluation on two key projects in partnership with the Greater Manchester Combined Authority (GMCA):

- *Green Deal Go Early (2013 – 2014)* was a GBP7,700,000 retrofit project that installed **928 energy-saving measures** (146 boilers, 300 windows and doors, 482 solid wall insulations) across all ten boroughs in GM
- *Green Deal Communities (2015 – 2017)* was funded by GBP6,100,000 from the Department of Energy and Climate Change to install **1,432 retrofit measures in 1,302 households** across GM **[5.4]**.

The Director of Environment at GMCA confirmed that Salford's technical advice had **supported the delivery of 1,842 retrofit homes** in total, leading to **savings of approximately 2,500t in CO_2 emissions** and creating **approximately 100 jobs within the city-region,** with over 20 companies engaged in the supply chain and a further four local companies supported to become PAS20/30 accredited **[5.4, 5.5]**. An additional **700 retrofits** were provided as a result of Salford's technical support through the GBP20,000,000 Homes as Energy Systems ERDF project **[5.4].**

Saint-Gobain, one of the top 100 industrial groups in the world, is another organisation that has worked with the EHL team since 2013 and benefitted from two retrofit projects (2013 – 2015) using the controlled conditions of SEH. This has enabled the group to validate and take forward their patented building product technology to drive real rather than modelled performance in buildings, thereby **closing the performance gap** and **providing measurable CO_2 emission reductions [5.6]**. Saint-Gobain UK's Head of Development emphasises that the findings from work with EHL researchers have *'helped shape the strategic view of our business. […] We have applied the findings to both **UK residential new build and retrofit market strategies** […] to influence more sustainable design moving forward'* **[5.6]**.

The Mayor of Greater Manchester has been a strong advocate of the retrofit work undertaken by the EHL team with GMCA, commenting that: '*A key part of delivering Greater Manchester's target to be carbon neutral by 2038 is in reducing emissions from our homes'*, adding in relation to the ongoing work on Energy House 2.0 that *'we need our buildings to become more energy efficient and use renewable energy more effectively, and **Energy House 2.0 will help us define how to achieve this'*** **[5.5]**. An independent report by British construction services company Bowmer and Kirkland confirms that the current Energy House 2.0 research facility has created approximately **GBP3,900,000 of social value impact** (as of December 2020) for Greater Manchester during construction **[5.7]**. This measures the promotion of local skills and employment, opportunities for disadvantaged people, volunteering hours, growth of responsible regional business and ethical procurement among other metrics, using social value proxies **[5.7]**.

4.3. Driving business and smart meter innovation

In addition to its research partnerships with industry **[see 4.1 and 4.2]**, the EHL team has worked with **23 commercial organisations** since August 2013 and tested **22 energy-saving products [5.8]**. SEH as a testing facility is unique in that research and development times can be compressed into weeks, as opposed to lengthy and complex field trials, saving significant costs and identifying any issues in design before products go to market. Between August 2013 and December 2020 a total of **17 products were sold** with an approximate **value of GBP1,740,000** and approximate **saving of 1,317MtCO_2 [5.8]**.

Surveyed organisations also commented on the benefits of working with the EHL team:

- *'The most beneficial thing was that [the team] understood the needs of businesses and organisations, which is unusual for an academic institution'*
- *'Energy House extends ability to understand models and the impact of products that work in the real world'*
- *'We regarded EH as unique […] not just a lab, the staff are experts. It is an ideal arrangement when you have a commercial entity, trying to invent and deliver innovative things […] there's a shared vision around societal impact. It is a classic win-win'* **[5.8]**.

In the field of **smart meters**, the EHL team has worked with **16 companies** in total since 2015 to create the Smart Meters Laboratory, which was designed to provide an innovation sandpit for developers across a number of projects and which has **directly impacted on businesses [5.9]**.

Hildebrand Technology Ltd. worked with Salford's researchers on a key strategic GBP450,000 project (NDSEMIC) that reached **approximately 200 small and medium-sized enterprises [5.9]**. This resulted in one energy company **productising an energy dashboard for smart meter customers**, with data and analysis being conducted on approximately 3,000 smart meters and another customer using the tool and techniques developed through the project to **achieve GBP250,000 reduction in energy spend** on an annual budget of GBP8,000,000 **[5.9]**. Hildebrand's Chief Executive Officer emphasised Salford's *'excellent research expertise'* that has been *'invaluable'* in helping the company bring products to market, confirming that Salford is *'a vital piece of the UK's innovation infrastructure'* and praising Salford's ***'ability to convene business and Government around the smart meters and smart homes agenda'*** **[5.9]**.

Trilliant Networks Operations (UK) Ltd. is a further company that has benefitted from a partnership with the EHL team on smart meters innovations, with its Vice-President Sales confirming that the company's success has been *'**significantly advanced by integrating academia** to prove that innovations, from concept to planning, construction, deployment, testing, and result[ing] evaluation […] mirror the expected savings of energy consumption for our clients' customer base'* **[5.10]**. On one smart meters project alone, this work has generated **an additional minimum 50,000 connected endpoints** to the Trilliant platform for a large utility customer, resulting in an **additional GBP3,300,000 worth of business** for Trilliant and creating **approximately 20 new jobs [5.10]**. Trilliant has also signed a long-term partnership agreement with a major multinational infrastructure group, **exceeding GBP100,000,000** and this is directly attributed to the sandpit test environment created with EHL **[5.10]**.

Overall, the smart meters partnerships have created **53,000 customer engagements** and **95 jobs** in this new field of research, as well as **generating sales of approximately GBP103,000,000 [5.8, 5.9, 5.10]**.

5. Sources to corroborate the impact

5.1. Testimonial: British Electrotechnical Manufacturer's Alliance (BEAMA) (February 2021), on the studies resulting in changes to EU Directive 2018/844 and EU household cost efficiencies and emissions reduction (4.1)
5.2. Testimonial: Viessmann Ltd. (February 2021), on the impact of EHL research on boiler installations in the UK (4.1)
5.3. Testimonial: Convener of CEN/TC 89/WG 12 (February 2021), on the work leading to standard BS EN ISO 22097 (4.1)
5.4. Testimonial: Director Environment, Greater Manchester Combined Authority (February 2021), on the GM strategies (4.1), including retrofit of households across GM (4.2)
5.5. Blog: GMCA infographic (9 December 2020), on the impact delivered by EHL between August 2013 and December 2020 (jobs, retrofit, emissions) and quote from GM Mayor (4.2)
5.6. Testimonial: St Gobain Offsite Solutions UK (February 2021), on the closing the performance gap and the retrofit strategies informed by SEH (4.2)
5.7. Social Value Report: Issue 1 Q4 2020 Bowmer and Kirkland (December 2020), on the social value added by Energy House 2.0 during construction (4.2)
5.8. Independent Report: Energy House Business Survey (January 2021), to assess the impact of EHL in terms of energy saving products, with quotes from key customers (4.3)
5.9. Testimonial: Hildebrand Technology Ltd. (February 2021), on the impact of Smart Meters/Smart Homes Laboratory from 2015 onwards to reduce energy spend (4.3)
5.10. Testimonial: Trilliant Networks Operations (UK) Ltd. (February 2021), on the impact of Smart Meters/Smart Homes Laboratory in generating new business and jobs (4.3)