Institution: **Leeds Beckett University**

Unit of Assessment: Unit 13

Title of case study: Improving the energy efficiency of homes

Period when the underpinning research was undertaken: 2007 - 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:
Professor Christopher Gorse	Director of LSI	2000 - Present
Professor David Johnston	Professor	2000 - Present
Dr Jim Parker	Reader	2013 - Present
Dr David Glew	Reader	2013 - Present
Dr Fiona Fylan	Reader	2010 - Present
Dominic Miles-Shenton	Senior Research Fellow	2000 - Present
Dr Matthew Brooke-Peat	Course Director	2000 - Present
Dr Martin Fletcher	Research Fellow	2012 - Present
Dr Adam Hardy	Research Fellow	2017 – Present
Professor Malcolm Bell	Professor	2000 - 2013
Professor Rob Lowe	Professor	2000 - 2011
Dr Jez Winfield	Senior Research Fellow	2000 - 2011

Period when the claimed impact occurred: 2014 - 2020

Is this case study continued from a case study submitted in 2014? No

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

Leeds Sustainability Institute (LSI) insights have led to changes to UK Building Regulations to improve the energy efficiency of homes. These changes are estimated to have prevented up to 120,000 tonnes of CO_2 entering the atmosphere due to the reduction in energy used to heat homes and resulted in lower fuel bills for hundreds of thousands of homes worth over £66 million pounds during this REF period. The “co-heating” research method developed by the LSI has been adopted as the de-facto approach to understand the true energy efficiency of buildings by the International Energy Agency (IEA) and the UK Government.

2. Underpinning research (indicative maximum 500 words)

Discovering the performance gap in homes

This case study builds on underpinning research carried out for the Office of the Deputy Prime Minister (ODPM) and the Joseph Rowntree Foundation (JRF) by Leeds Beckett University (LBU). This research identified that the actual energy used in homes was greater than their designs intended. The research suggested that all 27 million homes in the UK had higher fuel bills and greater carbon emissions than was previously thought (3.1). Since 2003, LBU have characterised, measured, and investigated the causes and implications of this domestic energy performance gap through various building performance evaluation (BPE) research projects.

Establishing heat loss through party walls in new build homes

Research was carried out by LBU during the Stamford Brook project, a development of around 700 masonry dwellings, between 2004 and 2010, in partnership with the Department of Communities and Local Government (CLG), National Trust and housebuilders Redrow and Bryant Homes (3.4). This evaluated the impact of an enhanced energy performance standard designed for possible incorporation into an amendment to the new build element of Part L of the Building Regulations. Using co-heating tests, whole house heat transfer coefficients were measured to be up to 100% higher than predicted, a significant finding with large implications for national carbon policy and householder bills (3.2). Further investigations revealed, a thermal bypass operating in the party wall cavity. This phenomenon involves cold air entering the edges of an uninsulated and unsealed cavity party wall being heated by the conduction of heat through the party wall. The resultant hot air rises through the cavity and then escapes through the cold loft space, increasing the heat lost from the dwelling thermal envelope. This was a significant finding, as previous design and regulatory practice assumed that the heat loss from party walls was insignificant and hence had been ignored in the calculation of dwelling carbon emissions (3.2).

Developing methods for measuring true building performance; the Co-heating test

Between 2007 and 2010, LBU undertook the Elm Tree Mews project, also funded by JRF. LBU again measured significant underperformance in both fabric and services, with dwelling heat loss measured to be 54% higher than designed (3.3). The electric co-heating test for measuring the real performance of buildings, called the heat transfer coefficient (HTC), were significantly refined and developed during this project. One meta-study published by the group summarised the data specifically for a range of 25 new dwellings, indicating that homes consume on average over 1.6 times their predicted values (3.5).

Reducing heat loss through existing party cavity walls

The Core Cities Green Deal funded by the Department for Energy and Climate Change (DECC), between 2013 and 2017, LBU further explored the party wall bypass phenomenon, identifying its presence this time in existing dwellings, not just new build dwellings. It was identified that a cavity party wall full-fill retrofit could reduce whole house heat loss by 8% in some instances (3.6). Following this discovery, LBU undertook another project in 2017 with the Department for Business Energy and Industrial Strategy (BEIS) to characterise and measure heat loss through a variety of cavity party walls. This work identified that the mean measured party wall U-values varied greatly from 0.21 to 0.81 W/m^2K (5.5), indicating that party wall insulation retrofits could meaningfully reduce heating consumption and fuel bills.

Identifying the performance gap in retrofits of existing buildings

These projects also identified more broadly that the domestic performance gap relates not only to new build homes but also retrofits taking place in existing homes. In the Core Cities Green Deal project, the energy efficiency of 65 homes was measured before and after they underwent retrofits. The research measured a performance gap in wall U values of up to 21%, and identified causes and implications of underperformance, for existing homes were similar to those observed in new build homes (3.6).

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

3.1 Bell, M., Smith, M. and Miles-Shenton, D. (2005) Condensation risk — impact of improvements to Part L and Robust Details on Part C. Report Number 7 -Final report on project Field work. IN Oreszczyn, T. Mumovic, D, Davies, Ridley, I. Bell, M., Smith, M., Miles-Shenton, D. (2011) Condensation risk — impact of improvements to Part L and robust details on Part C: Final report: BD2414. Communities and Local Government, HMSO, London. [ISBN: 978 1 4098 2882 2 UK]

3.2 Lowe, R.J., Wingfield, J. Bell, M. and Bell, J.M. (2007). Evidence for heat losses via party wall cavities in masonry construction. Building Services Engineering Research and Technology, Vol 28 No. 2, pp.161-181

3.3 Bell, M., Black, M., Davies, H., Partington, R., Ross, D., Pannell, R. And Adams, D. (2010) Carbon compliance for tomorrow's new homes: A review of the modelling tool and assumptions. — Topic 4: Closing the Gap Between Designed and Built Performance. Report number ZCHD130210, Zero Carbon Hub, London. www.zerocarbonhub.org

3.4 Wingfield, J., Bell, M., Miles-Shenton, D., South, T. and Lowe, R.J. (2011). Evaluating the impact of an enhanced energy performance standard on load-bearing masonry domestic construction: Understanding the gap between designed and real performance: lessons from Stamford Brook. Communities and Local Government, HMSO, London. [ISBN: 978 1 4098 2891 4] http://webarchive.nationalarchives.gov.uk/20120919132719/http://www.communities.gov.uk/documents/corporate/pdf/2219033.pdf

3.5 Johnston, D., and Miles-Shenton, D., and Farmer, D., (2015) Quantifying the domestic building fabric 'performance gap'. Building Services Engineering Research and Technology, 36 (5). 614 – 627

3.6 Gorse C, Glew D, Johnston D, Fylan F, Miles-Shenton D, Smith M, Brooke-Peat M, Farmer D, Stafford A, Fletcher M (2017) Core cities Green Deal monitoring project, Leeds, Department of Energy and Climate Change. https://www.gov.uk/government/publications/core-cities-green-deal-monitoring-project-leeds

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

Lowering household fuel bills

Following LBU research, party wall heat loss was incorporated into the 2010 Part L of the UK Building Regulations (5.1). This has led to substantial impact in this REF cycle, specifically all new homes built after 2014 have fuel lower bills. Removing the party wall bypass in existing dwellings may reduce whole house heat loss by up to 8% (3.6), when a party cavity wall is not capped. This may be used as a proxy to quantify the impact of the regulatory changes for new build homes. The average annual gas bill in England and Wales in 2019 was £588 (5.2), and of this around 2/3rds may be used for space heating. Thus, removing the party wall heat loss mechanism could equate to a maximum of £31 per home, per year. 53.5% of homes are terraced or semi-detached properties (5.3) and therefore, contain at least one-party wall, and there have been just over 1 million homes built 2013 and 2019 (5.4). Assuming the same proportion (53.5%) of these have a cavity party wall, this equates to cumulative maximum savings of £66 million during this period alone, assuming these party walls would have otherwise been poorly performing. Even if only a fraction these party walls would have been poorly performing this still equates to millions of pounds of fuel bill savings.

In addition, data suggests that 1,724 existing homes have had party cavity wall insulation (PCWI) retrofits funded via the Energy Company Obligation (ECO) during this period (5.5), resulting in a further maximum saving of £53,000 per annum collectively for these homes. It is important to recognise that these savings will be achieved every year as long as the insulation remains installed in the homes, which could be many decades. These savings are based on heat loss reduction measured from the retrofit of a single party wall. However, even if the national average savings indicated here were only half this per house (i.e. some party walls were better performing), this still represents a huge financial saving of millions of pounds to UK households every year.

New markets for domestic construction businesses

Incorporation of the party wall bypass for new build homes has increased the sales of insulation substantially. Cavity wall insulation can cost £10 per m^2 (5.6) and party walls may be $25m^2$ representing a new build market of up to £250 million for the million new homes built during the 2014 to 2020 REF period. This will grow year on year as new homes are added to the housing stock. The party wall bypass is also now being addressed through retrofitting existing homes. There are estimated to be 7.3 million existing homes in the UK with cavity party walls with potential to be insulated, though the extent of the party wall bypass in these homes is not known (5.7). Assuming only half of these homes could have a cavity party wall retrofit and considering that the average cost of a retrofit is £350 per home (5.6), LBU findings have unlocked a market worth up to £1.2 billion. Following LBU research, party cavity wall retrofits were adopted into the Energy Company Obligations (ECO) policy in 2013, a government energy efficiency scheme to help reduce carbon emissions, with the impact that these now make up 0.7% of all ECO funded retrofits taking place (5.5).

Reducing Fuel Consumption for low-income households

In this REF period, the Government's fuel poverty policy (ECO), has funded 1,724 party cavity wall insulation retrofits. People in fuel poverty are more at risk of health problems resulting from cold homes, party wall retrofits can improve thermal comfort and make homes easier to heat. The discovery of the bypass by LBU has therefore contributed to health and wellbeing of thousands of occupants in these retrofitted homes.

Preventing Carbon Emissions

The impact of party cavity wall insulation in new build and existing homes also means fewer carbon emissions. The maximum estimated national fuel bill savings, previously mentioned of £66 million, means that, assuming gas sells at 4p per kWh, up to 2.6 GWh of gas use may have been avoided in this REF period. At the Government's conversion rate of 1.83 $kgCO_2eq$ per kWh of gas, we can estimate up to 120,000 tonnes of CO_2eq for the qualifying period was avoided by insulating party cavity walls, assuming they would have otherwise been poorly performing. The significance of this saving is further enhanced in that these savings will continue to be achieved each year, and every new home built in the UK in the future will also benefit.

Leading policy reform around domestic construction performance gap

Bell was chair and lead author for several Zero Carbon Hub repots, a public private partnership, set up to review industry practice, academic research, and state of the art of UK construction, including the highly acclaimed End of Term Route Map for achieving zero carbon homes in this REF period (5.8).

This led to LBU research being recognized in national press for establishing and quantifying the building fabric thermal "performance gap" and contributing to a U-turn in the acceptance of UK housebuilders to this phenomenon (5.9).

The LBU co-heating protocol has been promoted by the IEA and is in the process of being developed into an international standard by the European Committee for Standardization (CEN). The protocol has also been adopted by the UK Government in multiple research projects worth over £10 million during this REF period and is recognised as the '*best currently available and proven measurement option for calculating the heat transfer coefficient of homes*" (5.10).

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

5.1 HM Government, (2016), Building Regulations for England and Wales, Part L - Conservation of fuel and power, Approved Document L1A: Conservation of fuel and power in new dwellings, https://www.planningportal.co.uk/info/200135/approved_documents/74/part_l_-_conservation_of_fuel_and_power

5.2 BEIS, (2020), Annual domestic energy bills, Statistical data set https://www.gov.uk/government/statistical-data-sets/annual-domestic-energy-price-statistics

5.3 BEIS, (2019), English Housing Survey 2017: stock condition, National Statistics https://www.gov.uk/government/statistics/english-housing-survey-2017-stock-condition

5.4 MHCLG (2020), House building; new build dwellings, England: December Quarter 2019, Statistical release, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/875361/House_Building_Release_December_2019.pdf

5.5 BEIS (2020), Household Energy Efficiency Statistics, headline release (March 2020), https://www.gov.uk/government/statistics/household-energy-efficiency-statistics-headline-release-march-2020

5.6 Palmer, Livingstone, Adams, (2017), What does it cost to retrofit homes, Updating the Cost Assumptions for BEIS's Energy Efficiency Modelling, Cambridge Architectural Research, BEIS, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/656866/BEIS_Update_of_Domestic_Cost_Assumptions_031017.pdf

5.7 Jason Palmer, Nicola Terry, David Johnston, Dominic Miles-Shenton, Christopher Gorse, Peter Pope (2019) Cavity party walls: measuring U-values, www.gov.uk/government/publications/cavity-party-walls-measuring-u-values

5.8 Zero Carbon Hub, (2014), Closing the Gap Between Design & As-Built Performance, End Of Term Report, Zero Carbon Hub, London, www.zerocarbonhub.org/sites/default/files/resources/reports/Design_vs_As_Built_Performance_Gap_End_of_Term_Report_0.pdf

5.9 A load of hot air, (2015), Sunday Times, 22nd November, Page 6

5.10 BEIS (2019), Smart Meter Enabled Thermal Efficiency Ratings (SMETER) Innovation Competition: Phase 2 Application Guidance Notes. [online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/826330/SMETER_Innovation_Competition_Phase_2_-_Application_Guidance_Notes.pdf.