Institution: Leeds Metropolitan University

Unit of Assessment: Unit 16 Architecture, Built Environment and Planning

Title of case study: : Improving the as-constructed energy performance of dwellings through building forensics

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

The group's forensic research into housing energy and carbon performance has established the existence of "performance gap" between designed energy performance and that achieved in completed dwellings. This seminal work has led to revisions in Building Regulations, shaped Government policy on zero carbon housing standards and is enabling the house building industry, including its supply chain, to re-evaluate technology and processes. Considerable benefit will flow from government and industry actions to close the gap, leading to the realisation of significant reductions in greenhouse gas emissions, improved processes & technology, improved skills & knowledge, lower energy bills and more comfortable homes.

2. Underpinning research (indicative maximum 500 words)

The origins of this work lie in a review by Bell and Lowe of the energy efficiency regulatory standards for the 21st century. The review, undertaken for Joseph Rowntree Foundation and the Office of the Deputy Prime Minister established the importance of not only raising standards but also establishing the extent to which improved standards could be achieved in main-stream house building.

This work led to a number of housing field studies aimed at understanding the issues involved in the production of low energy/carbon housing. The key underpinning studies are set out below:

1. An investigation of the implementation of Part L robust details undertaken for CLG from 2003 to 2005 (Bell et al. 2005). This project established through a series of design and construction site studies a wide range of design and construction defects that would lead to energy and condensation underperformance. Subsequent hygrothermal modelling work at UCL confirmed an increased risk of surface and interstitial condensation as a result of insulation placement and other defects. The field work also identified significant issues relating to levels of understanding, skills and design & construction processes.
2. The Stamford Brook Field trial (Wingfield et al., 2011), conducted from 2001 to 2008, was an action research study of the implementation of advanced regulatory standards. It involved a partnership between two major house builders, the National Trust and CLG in the construction of a large housing development of some 700 dwellings. This was probably the first study that measured not only the extent of energy underperformance but also identified many of the technological and process issues that explained the performance observed. Of particular significance was the characterisation of a thermal bypass in party wall cavities (Lowe et al. 2007), a hitherto unrecognised heat loss mechanism that is now recognised and incorporated into building regulation and the regulatory national calculation methodology (SAP).
3. The Elm Tree Mews project (Bell et al. 2010) led on from the pivotal work at Stamford Brook by applying and improving on the action research approach. This project was funded by the Joseph Rowntree Foundation and sought to explore the issues involved in constructing to a standard that addressed the zero carbon trajectory set out by the Government in 2006. It also enabled an exploration of modern off-site technology. Significant underperformance was again observed not only in the fabric but also in the configuration of a communal heat pump.
4. Collaboration in the Carbon, Comfort and Control project (EPSRC funded) extended the scope of the group's work by addressing performance gap issues involving controls, design and occupant behaviour associated with heat pumps (Stafford 2011). Findings demonstrated the complex interplay between the control of low carbon technologies, behaviour and the performance of the envelope. The findings are being adopted by manufacturers.

The group's work has continued with numerous subsequent projects designed to improve

understanding of performance (for example; Wingfield et al.2009), enabling the group to continue to lead research into the performance gap and shape industrial and government policy.

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

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]. http://webarchive.nationalarchives.gov.uk/20110110150002/ http:/www.communities.gov.uk/publications/planningandbuilding/reviewimplementationpartl
2. 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. 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 (2007) pp.161-181.
4. Bell, M., Wingfield, J., Miles-Shenton, D. and Seavers, J. (2010) Low Carbon Housing: Lessons from Elm Tree Mews. Joseph Rowntree Foundation, York. ISBN: 978-1-85935-766-8 http://www.jrf.org.uk/publications
5. Stafford, A. (2011) Long-term monitoring and performance of ground source heat pumps. A. Stafford: Buildings Research and Information, Vol 39, Issue 6, pp566-573.
6. Wingfield, J., Miles-Shenton, D., Bell, M. and South, T. (2009) Investigations of the Party Wall Thermal Bypass in Masonry Dwellings. Final Report to the Mineral Wool Insulation Manufacturer's Association (MIMA). Client Report, October 2009, Leeds Metropolitan University, Leeds UK.

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

The group's research has had major impacts in three areas:

Building Regulations: The group is at the forefront of regulatory development, Bell served on the CLG's regulatory teams for the 2006 review and following this, work at Stamford Brook (Wingfield et al. 2011), Elm Tree Mews (Bell et al., 2010) and work funded by the Mineral Wool Insulation Manufacturer's Association (MIMA – Wingfield et al., 2009) highlighted, as never before, a performance gap that could undermine regulation and the Government's 2016 zero carbon housing targets. Bell was invited again, as convenor and technical author, to lead industry working parties and advise ministers for both 2010 and 2013 reviews. The contribution was recognised in a National Audit Office report (NAO, 2008) and in evidence to the House of Commons Public Accounts Committee (PAC 2009) in addition to citations in the consultation documents for the 2010 (CLG 2009) and 2013 (CLG 2012) reviews. Crucially, the work on the party wall thermal bypass (Wingfield et al., 2009 and Lowe et al., 2007) led to regulatory change in 2010 to ensure bypasses were fully accounted for in the national calculation methodology (SAP) and the Approved Documents (HM Government, 2010). In addition, the government's Green Deal is set to include party wall installation as an accredited improvement measure in existing dwellings with cavity party walls. This will ensure that the group's research will have application in both new build and existing dwellings. Although the full carbon impact remains uncertain it is likely that carbon savings could be in the millions of tonnes per year.

Low and zero carbon housing policy: Bell provides leadership on the Zero Carbon Hub (ZCH) which, inter alia, cited performance gap studies from the group (Bell et al. 2010) and was

instrumental in providing the clearest policy statement to date; over 90% of new dwellings as-constructed should be zero carbon as verified by effective measurement (ZCH 2011, recommendation 4a). Work is on-going through a government/industry project to develop solutions (ZCH 2013) Bell is a steering group member. In addition, Bell's membership of the DECC Expert Measures Group advises on In-Use factors for DECC's Green Deal program (driven largely by work at Leeds Met). The award of £526,800 to research the Leeds Green Deal Pilot Project (led by Gorse and Stafford) shows recognition by government. Further awards by TSB on their Building Performance and Evaluation and Retrofit Programmes represent a significant body of work (value in excess of £700,000 led by Johnston and Gorse) which continue to identify methods of improving building performance and efficiency.

The group's identification of the performance gap prompted the Technology Strategy Board's (TSB) programme on Building Performance Evaluation (BPE) which adopts the group's Co-heating Test protocol. This standard has also been embraced by the IEA Annex 58 programme on whole building performance, for which the group are leaders in whole house heat loss (see Johnston et al. 2012). Thus the group is changing the way the construction industry deals with as built energy efficiency internationally, as well as in the UK.

The house building industry and manufacturers: The group advises the Home Builders Federation and National Home Builders Council and individual developers through the Good Homes Aliance, ZCH, TSB and DECC programmes. Dissemination work through CPD (LowCarb4Real –Bell et al. 2009, Green Vision) has engaged hundreds of professionals over the last 4 years; over 150 were reached through the Green Visions program, and over 200 professionals attended meetings hosted by the group for the Leeds Sustainability Institute, the IEA's annex 58 and the Association of Researchers in Construction Management. As an indication of the wider interest in the group's research the group website which provides details on projects and their outputs was visited by over 5,300 unique visitors between August 2012 and September 2013 whilst the Low Carbon Housing Virtual Site developed by the group was visited almost 11,000 times.

Commissions from MIMA (Wingfield et al., 2009 and Bell, 2012) and collaborations with Knauf have led to the development of products specifically for the new insulation market in the party wall bypass worth £millions. Research into heat pumps has resulted in manufacturers (IVT) adopting new commercial control settings and providing guidance for installers on how to size systems so as to improve efficiencies and reduce householder bills (Stafford and Lilley., 2012).

Thanks to the group's work it is now accepted that failure to address the performance gap carries significant commercial risks and undermines energy and carbon reduction policy.

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

1. CLG (2009) Proposals for amending Part L and Part F of the Building Regulations – Consultation, Reference number: 08BD 05287, June 2009, London, Department for Communities and Local Government, ISBN: 978-1-4098-1532-7.

2. CLG (2012) 2012 consultation on changes to the Building Regulations in England: Section two - Part L (Conservation of fuel and power). January 2012 London, Department for Communities and Local Government, ISBN: 978-1-4098-3324-6,

3. Bell, M., Lowe, R.J., Wingfield, J. Miles-Shenton, D. and Chiu, L.F. (2009) LowCarb4Real; Working together to build low carbon homes. [In] O'Rourke, J. [managing editor] The Complete Urban Buzz, London, University College London. ISBN 0-9561323-0-8.

4. 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

5. NAO (2008) Programmes to reduce household energy consumption. Report By The Comptroller And Auditor General | HC 1164 Session 2007-2008 | 11 November 2008, The

National Audit Office, LONDON: The Stationery Office.

6. PAC (2009) Programmes to reduce household energy consumption. Fifth Report of Session 2008–09 Report, together with formal minutes, oral and written evidence. House of Commons Public Accounts Committee, London: The Stationery Office Limited.

7. Zero Carbon Hub. (2011) Carbon Compliance: setting an appropriate limit for zero carbon new homes. Report number ZCHD210211, Zero Carbon Hub, London. www.zerocarbonhub.org

8. Zero Carbon Hub (2013) Low carbon homes: The Performance Challenge, A programme to close the gap between designed and as-built performance. Project description. Zero Carbon Hub. London. www.zerocarbonhub.org

9. A. Stafford and D. Lilley. (2012) Predicting In-situ Heat Pump Performance: An Investigation into a Single Ground-Source Heat Pump system in the context of 10 similar systems. Energy and Buildings.

10. Johnston, D. Miles-Shenton, D. Wingfield, J. Farmer, D. And Bell, M. (2012) Whole House Heat Loss Test Method (Coheating). A report for the IEA Energy Conservation in Buildings and Community Systems Programme Annex 58: Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurement. Leeds, UK, Centre for the Built Environment, Leeds Metropolitan University.