THE HISTORIC ENVIRONMENT, Vol. 5 No. 2, July 2014, 167–81

Building with History: Exploring the Relationship between Heritage and Energy in Institutionally Managed Buildings

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Drawing on interdisciplinary research focusing on Durham University estate, we describe how buildings constructed as part of an eighteenth century transition to a high carbon coal-based economy, are used and understood by their current inhabitants. Applied heritage research has tended to focus on the thermal and energetic properties of historic buildings, as distinct from their social meaning and use. A similar separation between the physical building and its social use is inherent in methodologies such as energy audits that constitute key devices through which buildings are institutionally managed. We argue that these perspectives have overlooked how a significant element of energy use arises from the complex practical interactions between people and infrastructure. From this perspective we argue that better outcomes for energy and heritage would result if greater contextual consideration was given to the existing possibilities afforded by historic buildings and their users.

KEYWORDS heritage, buildings, energy, retrofit, archaeology, anthropology, engineering

 DOI 10.1179/1756750514Z.00000000053

Introduction: situating heritage and energy

Environmental conservation and heritage conservation emerged as linked movements in the nineteenth century, both animated by a desire to protect elements of the natural and built environment threatened by the destructive powers of modernist industrial capitalism.[1] However in the context of widespread recognition of global climate change, measures to promote energy efficiency in buildings have often been seen to conflict with the preservation of buildings as 'heritage'.[2] In the UK and internationally, government policies promote improved energy conservation of historic buildings entailing profound modification through various forms of retro-fitted technologies that may be visually intrusive and disruptive to historic fabric.[3] At the same time a range of legislative instruments promote protection of heritage which may constrain the kinds of modification that are possible.[4] Consequently, while the aims of heritage conservation and energy conservation need not in principle conflict, practitioners responsible for the management, maintenance, repair and modification of historic buildings often experience a tension between governance devices intended to conserve historic buildings, and those intended to promote energy conservation. Such tensions are significant because at least 70% of the housing stock likely to exist in England in 2050 has already been built[5] and 63% of the UK's energy consumption can be attributed to the built environment.[6]

Applied heritage research has tended to focus on the thermal and energetic properties of historic buildings, as distinct from their social meaning and use.[7] A similar separation between the physical building and its social use is inherent in methodologies such as energy audits that constitute key devices through which buildings are institutionally managed. These perspectives have overlooked how a significant element of energy use arises from the complex practical interactions between people and infrastructure. In order to adequately understand these processes, we argue, it is necessary to appreciate how buildings, technologies and people mutually shape one another through their interactions in particular social and historical contexts.[8] Building on recent work,[9] we aim to demonstrate how energy use is configured in historic buildings through specific relationships between people, materials and technologies. Our account highlights how buildings physically embody earlier regimes of energy use, and shows how such physical structures in turn frame and are re-worked, in relation to subsequent social practices. We suggest in conclusion that greater attention needs to be given to understanding energy use and heritage value, not as intrinsic physical properties but rather as indissolubly social and material components of buildings-in-use. From this perspective we argue that better outcomes for energy and heritage would result from giving greater attention to the existing, contextually specific, possibilities afforded by historic buildings and their users.

This paper draws on interdisciplinary research, combining methods and perspectives from history, archaeology, anthropology and engineering. Methodologies relating to these different disciplinary approaches foreground distinct material and temporal dimensions to the relationships between buildings and their inhabitants. Using archival and secondary sources, historical approaches help us understand how present built environments are constructed through various past activities; qualitative interviews focus on attitudes of present occupants and show how the past is constructed from their various perspectives; the energy audit approach starts from a

physical assessment of the building and helps us to understand the infrastructural consequences of past and future interventions.

Our account focuses on three Georgian houses in the city of Durham, in the United Kingdom. Originally built as domestic residences they were subsequently knocked together to house the History Department at Durham University and are now owned, used and managed by the University Estate. Although the University occupies a modern estate to the south of Durham City and has a campus at Stockton, many of its academic Departments and residential Colleges occupy the central area of Durham, on the iconic Peninsula and in the historic district known as Elvet. Durham City is dominated by its 1,000 year-old Cathedral and Castle, which were 'inscribed' as a World Heritage Site of 'universal value' in 1986, which is owned and managed by the University in partnership with Durham Cathedral. However, the majority of 'heritage' buildings owned and occupied by Durham University were built in the 17th and 18th Centuries. These buildings were created when the North-East economy enjoyed unparalleled prosperity on the back of the region's coal trade. Subsequently, in the 19th and 20th Centuries, when these buildings were incrementally converted from private residences into University Colleges and Departments, there was little money or motivation to alter their material fabric. Most Colleges and Departments occupy a range of houses, knocked through internally. Over the 20th Century these buildings were protected by Listings (the UK statutory regulation, protecting all buildings built before 1700 and most before 1840, especially those of special historical significance). The buildings of our study provide the built infrastructure for an institution that is characterised by transitory groups of people: students, academic staff, and visitors, present for periods of days, months and years.[10]

Our account has three linked sections. In the first we describe how historical and archaeological perspectives illuminate how these buildings originally developed in relation to energy infrastructures based on coal. In the second, we present findings from qualitative research to reveal how these buildings are used and understood in the context of contemporary social practice. In the third section we outline how these social and historical processes result in a specific built and technological infrastructure in the energy management of the university estate today.

Building energy histories

Durham as a place to live, visit and work is characterised to a considerable degree by its built heritage. Despite the City's world-famous medieval architecture, few buildings erected before 1650 remain in use today. The Cathedral and Castle are a thousand years old, but the majority of Listed historic buildings occupied by Durham University, and in the City as a whole, were last substantially rebuilt during the later 17th and 18th Centuries[11] — a period referred to by historians and historical archaeologists as the Georgian Era.[12] Even modifications and new buildings made in the 19th and 20th Centuries generally occurred within the built framework established during the Georgian period.

In this section we use an historical perspective to explore how energy regimes have framed and then been re-worked through subsequent social practice at a variety of scales. We (QL and AG) investigated the historical backgrounds of the buildings themselves, in their architectural layout, occupation, and subsequent re-configuration

as University structures. We also drew on secondary sources, in order to locate those buildings as social artefacts within broader patterns in energy management and consumption through time. Finally, we investigated the household materiality of one such Georgian building by analyzing the account books of a wealthy 18th Century widow, the results of which are described elsewhere.[13] This methodology highlights the ways in which, at given historical moments, energy, objects, and social relations are indissolubly intertwined. But because rebuilding of the housing stock only occurs at intervals (related to economic cycles), previous — and now supposedly outdated — energy regimes can remain embedded in the building stock of today. The buildings created by earlier energy regimes are even protected from future alteration by regulatory frameworks designed to protect their heritage value. In Durham, these Georgian structures are largely a product of a transition to industrial-capitalist modernity, rather than being a timeless, authentic remainder of a traditional past. Because of its location on the North-East coal field, Durham itself was an epicentre of this transition, and its building stock is a material manifestation of the high-carbon energy regime from which we are now seeking to retreat.

We begin just off the Palace Green on the streets of North and South Bailey, which wrap around Durham's world famous Cathedral and Castle (Figure 1). Along this connected street sits a whole series of buildings which are today owned and occupied by Durham University, including St John's College, and the History Department. The houses have been connected by corridors, and one of the three was listed in May 1952. By that time, it was already in use as a University department, with teaching rooms and offices in what were once drawing rooms and bedrooms. Some of the buildings incorporate pre-1650 fabric, but all were substantially renovated (or built afresh) in the 17th and 18th centuries. The county gentry families which originally built and renovated the St John's College buildings, the Bowes and Eden families, were seeking to break with older architectural traditions or reconfigure them in new ways. They used then modern and fashionable materials of brick and dressed stone to construct these houses; the prestige of brick and stone differentiating these houses from the majority of the town, which was up to 1650 built of timber-frame construction. Both buildings erected for the Bowes and Eden families are fronted with numerous large sash-windows, and multiple brick chimneys crown the tile roofs. The interiors of these buildings currently house institutional offices, educational spaces, and student accommodation but would have been striking and modern-looking in the 18th century. The Bowes House, home to one of the wealthiest families in England in the 17th and 18th centuries,[14] had provision for numerous servants, discrete dining rooms, bedrooms, and work areas, and was filled with fashionable items that rivalled wealthy gentry families in taste and fashion anywhere in Britain.[15] Both families were deeply involved in the burgeoning Northeast coal trade and these buildings served as fashionable town-houses from which the families could manage their substantial landholdings and coal pits. The History Department building, while not originally built exclusively for domestic use, was also built as part of the wealth generated by the coal boom in Durham in its Georgian heyday. The Georgian houses now occupied by the History Department offered amenities to wealthy coal magnates, serving as a coffee house in the 17th Century, also as a private residence, and as part of a large complex housing a legal practice in the 18th Century. These buildings look the way they did in the Georgian era, and do today, as a result of the explosive growth of

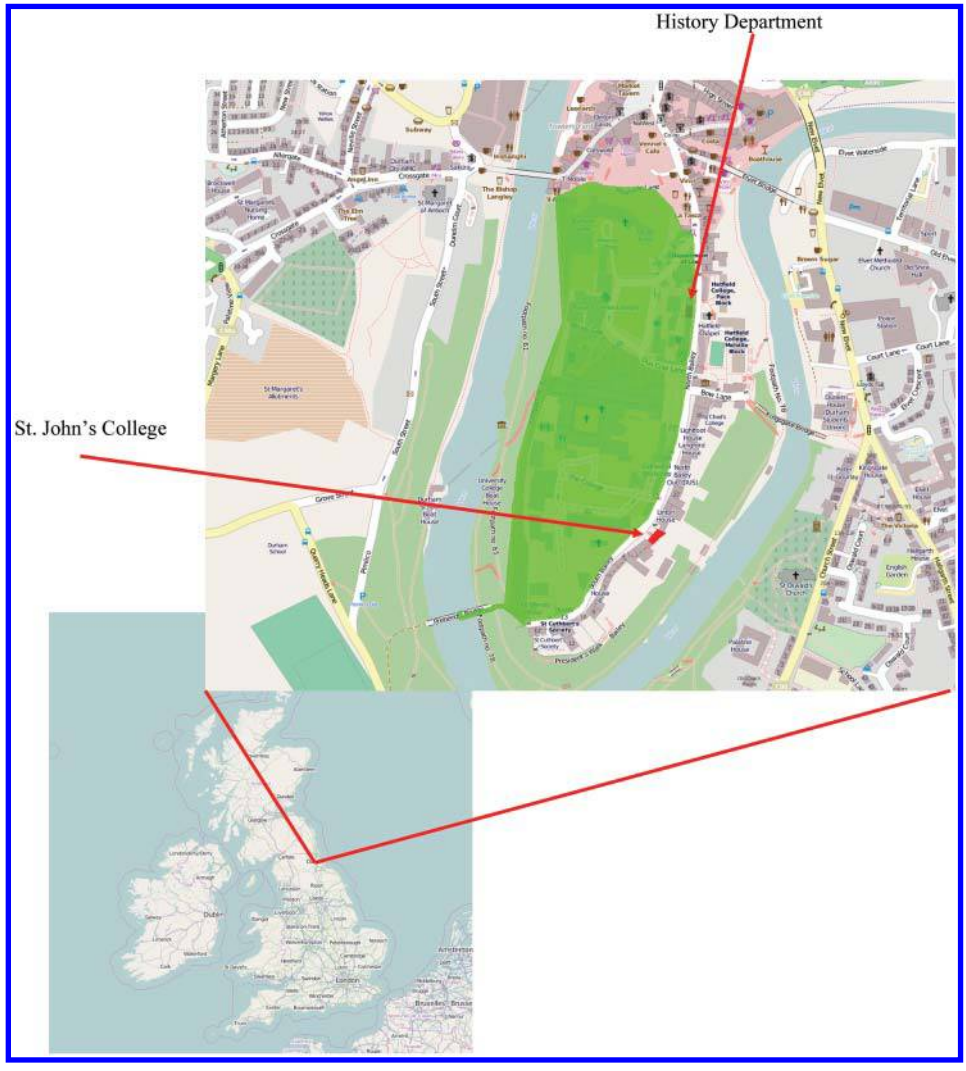

FIGURE 1 Location of History Department and St. John's College in Durham City in the United Kingdom. The shaded area in the centre is the Durham World Heritage site.
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coal as an energy source and the social relations which arose around that change in energy regime.

Coal had been utilized in Britain since at least Roman times,[16] but remained marginal as its acquisition was more costly than then-plentiful wood. From the sixteenth century onwards, there was an acute timber shortage in Britain, and by contrast with today coal provided the only viable energy option. Coal resolved a complex and poorly understood environmental crisis brought on by the reliance on wood and the social relations surrounding its procurement.[17] Coal mines were already operating around Durham in the 14th century, but by 1700, Durham collieries were shipping over 800,000 tons of coal per year.[18] Between 1600 and 1800 an early Industrial

Revolution occurred in the Durham region, with coal mined along the Rivers Tyne and Wear exported primarily for fuel in houses and industrial processes elsewhere in Britain, especially London. North-east coal provided the energy that enabled London to become one of the largest cities in the world over the 17th and 18th Centuries[19] and transformed England from an 'advanced organic' late medieval economy, into a coal and class-based industrial society.[20] Although Newcastle upon Tyne and Sunderland on the River Wear were the major coal ports, Durham City was the administrative, legal, and polite urban centre for the elites prospering from the regional coal economy, and these groups built or renovated town houses with profits from that economy. It is these town houses, and the facilities which their affluent residents required, which now house the University — especially the buildings around the Cathedral and Castle on the Peninsula, including St John's college, and the History Department building, the focus of this paper.

Durham's Georgian houses, today labelled as 'heritage', are now widely seen as embodiments of 'tradition' but were modern and forward-looking when built. They used new materials, organized in new ways. Brick and glass sash-windows, two key components of the Georgian house, both emerged out of the coal era. The coal pits provided the source for brick earth and coal was used as fuel to produce the patented 'Newcastle-upon-Tyne Crown Glass' for use in the newly fashionable sash windows and Georgian shop frontages. Additionally, from the 17th century, coal-burning fires required enclosed fireplaces and chimneys, rather than the 'open' medieval hearths and braziers. Chimney technology had been known for centuries, and was adopted sporadically in Northwestern Europe, particularly by the clergy.[21] Only with the adoption of coal were chimneys incorporated as a standard feature of English houses — so successfully, in fact, that the English state instituted a Chimney Tax in the late 17th Century.[22] Thus, Georgian modernity represented a turn towards the byproducts of coal mining in its construction methods. Though seemingly innocuous, the very material structure of Georgian houses in Durham was bound up with this coal extraction.

Likewise, the shift to a high-carbon coal-based energy regime was an indissolubly social and material transition, constituted by changes in architectural structure, and affected by changing social practice. The forms and layouts of Georgian houses were novel in their organization, and reliant upon changing sensibilities wrought by the new energy regime. Although beginning somewhat earlier than the decisive shift to coal in the 17th Century, there was a complex of cultural and social changes over the 15th and 16th centuries that Matthew Johnson refers to as a process of 'closure'.[23] Generalized interior spaces, typified by the medieval open hall, were increasingly segmented into rooms associated with specific tasks, and ceilings were inserted to conceal open timber-framed roofs. This 'closure' of the internal space within the home also involved a growing symbolic distinction between interior and exterior space. Interior domestic space became associated with the modern concept of 'comfort', an aesthetic and emotional category predicated upon the enclosure of interior spaces from the 'natural' world outside.[24] We live with the legacy of that cultural change today, in the expectations for warmth and furnishings in our domestic, work and, in the case of a university such as Durham, institutional, environments. This theme of comfort and its contemporary repercussions is analysed in the section to come.

The new energy regime proceeded with changes in social relations, especially labour. While wood had been procured and circulated through a variety of kinship, tributary, and mercantile social networks, the acquisition of coal was almost entirely commercial, and required new forms of labour.[25] It required men to mine and move it; required women to move it around households and to keep the house clean of coal-burning by-products. The shift towards enclosed agriculture in the region (where the open fields worked in common, were rationalised into ring-fenced farms) was equally commercial, and geared to providing the coal workforce with caloric energy.[26] This, in turn, had a relationship to the energy source for light in Durham houses, after dark. A key product from the region's farms was the animal fat turned into tallow from Durham's sheep and cattle herds. Utilising a by-product from the livestock raised to provide coal miners with cheap meat and butter (and the calorific energy needed to mine and move coal), this tallow-fat became the primary source of candles for interior lighting — another key requirement of the new sensibility of interior comfort established in Georgian England. Thus social and economic relations in the Durham region during the Georgian era formed a system based on energy-use from coal.

Durham's heritage buildings, including St John's College and the History Department building exist in their current material form as a by-product of the transition to a high-carbon, coal based energy regime. They were built from the profits of coal, in a style and using materials derived from coal extraction, and to suit the tastes and social organization of families and individuals who were invested in and enmeshed into the industrial-capitalist modernity that coal powered.

Since these buildings were acquired by Durham University they have been modified to function as a space in which academics work and teach. Internally the layout has been modified to enable what were originally three domestic buildings to act as a single institutional space, that inhabitants describe as 'warren like'. In response to health and safety requirements fire doors and fire escapes have been added. Energy infrastructures have also been upgraded, including the installation of modern central heating, and strip lighting in rooms. The majority of infrastructural changes have been driven by institutional requirements, undertaken in order to make these spaces functional as offices, meeting rooms and teaching spaces, compliant with relevant legislation on health and safety and working environments. While aspects of the building have been protected by the building's listed status, changes to other parts of the building have been undertaken with little consideration of the building's historic character.

Despite these modifications, the basic fabric and layout of the building remains relatively unaffected. Thus the historic processes described above remain materially embedded in Durham's heritage housing stock, providing a physical legacy that users and managers of these buildings interact with today.

The past in the present

Where historical accounts help us to understand the emergence of buildings as the physical sedimentation of social processes over time, we employ qualitative social research methods to highlight how the material traces of these processes are understood by present users of these buildings. Over three months at the start of 2013, RDJ

interviewed and observed ten members of the University's academic staff, seven University employees in energy management and administration and six employees of contractors engaged by the University (electrical and mechanical engineers). Three of the interviews also included tours of departments, or 'energy walks' so that areas of concern could be observed. Among the University interviewees were six departmental and two college based 'Energy Champions' tasked with decreasing the energy consumption of their peers. As a piece of qualitative research, the aim was to illuminate through detailed conversation and observation the range of attitudes and practices that characterise inhabitants' understandings of their interactions with historic buildings. In this section we focus on attitudes and perspectives emerging from semi-structured interviews with the Energy Champion and academics who work in the History Department of Durham University. These interviews addressed concerns about their own general energy use, everyday energy practices, attitudes towards energy in an historic, academic building and their perceptions of the attitudes of their colleagues. We contextualise the responses through a broader range of perspectives from users of other historic buildings across the estate and use the combined data to explore the contemporary lived energy regimes of these buildings and their occupants.

The history Building is today inhabited by a range of people. Academic staff have individual offices in which they undertake research and some small group teaching. Postdoctoral researchers and graduate students have shared office space, as do department administrators. Students have a more transient relationship to these buildings, through interactions with academic members of staff and administrators. As for other Higher Education Institutes, Durham University attaches explicit significance to the reduction of energy consumption both for environmental and economic reasons. Energy reduction targets are pursued through ongoing processes of infrastructural upgrading, undertaken by the University Estates department, including retrofitting low-energy lighting, improving thermal insulation and improving efficiency of heating. Working in parallel 'Greenspace', exists as a department dedicated to reduction of energy through explicitly targeting 'behavioural change'. From this perspective they seek to promote energy reduction by raising awareness of 'wasteful' behavior. The head of Greenspace explained the problem of lack of consciousness and ownership of these problems, relating this to the need for a fundamental change in mentality of building occupants:

> If you came into this room and that chair had a leg missing, you'd probably report it. You'd say 'I sat on that chair and it had a leg missing, it's not safe'. But if you're in the toilet and there's a tap dripping, do you report it? No. We report things that are broken, but not things that aren't working efficiently or properly. [. . .] We need to build it in people's minds that they're allowed to comment, they're allowed to say something.

Staff in the History Building, as elsewhere, are encouraged to be conscious of the energy impact of their activities, including though emails and posters seeking to reduce waste by encouraging occupants to turn off lights, heating, computers and other key appliances when not in use. Additionally Energy Champions provide a link between departments and the Estate, as departmental members tasked with helping to change the behavior of other building occupants, through awareness-raising. University management structures relating to energy therefore institutionalize a distinction between physical infrastructure and behavior.

The heritage context of Durham University is also given explicit value in institutional discourses. In particular the architecture and history of Durham are central to promotional materials for various students and publics that often stress the connection between the physical environment of Durham and the institutions longstanding tradition of scholarship. For those involved in the management of the estate, these different forms of institutional value are often seen to be in conflict. Historic buildings are characterized as 'old and leaky' and heritage designations are seen to protect elements of built infrastructure in ways that can constrain energy-related retrofit.

For inhabitants of the History Building ideas about heat and comfort were informed by the complex evaluative and emotional connections developed through experience in the places they worked. Though few demonstrated detailed knowledge of the chronologies, dates or eras of these buildings, many expressed satisfaction at the sense of 'history' they understood them to embody. Notably, researchers in historic buildings commented positively their 'character'. John, an American academic, demonstrates the complex evaluative and emotional connections people develop through experience in the places they work.

> [The building gives] a sense of being part of some sort of continuity [. . .] it gives you a sense of peace and purpose. You've got it all around [. . .] it counts for something.

Thus the complex and specific historic processes outlined in the previous section are largely reduced to a generalized sense of 'pastness' for modern occupants and users.[27] Occupants appreciate these buildings as embodiments of 'tradition', and for the ways in which they index continuity with the past. As embodiments of this past, historic buildings are positively connected to a range of emotions and identities in the present. As the previous quote illustrates, these include feelings of peace and tranquillity and the sense of 'purpose' that comes from working in a place inhabited by generations of previous scholars. Described as having 'character', these university buildings are thus thought to embody a broader set of ideas about the university as an historic place, prompting their occupants to draw links to scholarship in the past. From this perspective one member of staff explained: "As an academic, there is a historical aspect to an act of scholarship, entering into something greater than the self, and in a building that is physically tangible".

Academic staff raised concerns about levels of heat or light in the historic buildings they worked in. Their relationship to the building was mediated by its role as a place of work and as employees they came to these buildings with certain expectations of comfort. From this perspective the lack of specific features including uniform and reliable heating, double glazing and numerous light switches was sometimes seen as a problem. A researcher working in an attic office in another nearby Georgian building commented positively on the character of the building, but made explicit how historic preservation of buildings intersects with the considerations of building users:

> If people here are studying and they're freezing, we need to make changes. Health is more important and more of a priority than preserving the historical site. No historical site should be preserved at the risk of endangering us. . . . I put the intrinsic value of a person above the state of a building.

In some cases interviewees prioritised concerns such as health and safety in a working environment over the preservation of buildings. Others voiced concerns about

inefficiency and lack of environmental sustainability. From this perspective, most were willing to accommodate some degree of change, for example replacing windows to improve energy efficiency and comfort.

Interviewees balanced their complaints about what historic buildings lacked with an appreciation of the sense of place they felt these Georgian era buildings generated. In many cases appreciation of these positive benefits was accompanied by a willingness to compromise on inconveniences and minor discomforts. On a visit to John, a junior researcher originally from the US, we found his boots were on the radiator and he was warming his socks. During the course of the interview, he put these on, and remarked that now his feet were warm he was 'good to go'. Asked about his attitude to the building, John responded that 'despite all its warts and bruises, I like it'. Later he elaborated:

> Yes, I complain [about the temperature] but in the US we don't have such old, historic faculties, most of the ones I studied in were from the 80s and 90s. . .But I look at it as, by being here, I'm preserving a piece of the past and continuing what it is like to study here, in this place, for the past hundred years. So there are comforts that aren't there, but the historical value outweighs it.

In this sense the attributed historic value of the building informs the way in which comfort is understood.

Research by the Sustainable Traditional Buildings Alliance in 2012 found that 'there is no work on user behaviour focused specifically on traditional buildings, [nor] on whether the behaviour of users of traditional buildings might be any different to that of occupants of any other types of building stock'.[28] Our research begins to illuminate this issues. While expectations of appropriate levels of heating and light are partly configured in relation ideas about acceptable standards for modern working environments, we have shown how building users' understandings of the material infrastructure of historic buildings effects their assessments of 'appropriate' levels of light or heat. As we elaborate in the concluding section this has implications for the management of these buildings, suggesting the potential for interventions to modify practices relating to energy use by altering occupants understandings of the buildings they inhabit.

Energy infrastructures

Energy audits are used to understand the physical and technological properties of buildings, in order to identify improvements in energy usage.[29] They range from detailed real time monitoring of energy consumption to the inspection of consumption data or a walk through the premises to observe energy systems in use. In this section, we describe a walk through energy audit as applied to our case study, the History Building and argue that the findings highlight a broader set of issues that result when historic buildings are modified, used and managed as part of institutional estates.

Employing standard methodologies,[30] an energy audit was undertaken on the buildings that make up the university's History Department. This entailed description and assessment of the physical properties of the building, energy consumption data and of technical infrastructure pertaining to heating, lighting and energy use within the building.

As is common in historic buildings, the History Department buildings have been subject to a range of interventions having taken place at different times. This often results from institutional budgetary constraints, allowing only certain areas to be targeted. Over time, elements such as heating plants, radiators, electric lighting and power supplies have been added and taken away as they become obsolete or beyond repair. The energy infrastructure of the History Department is therefore produced through a series of piecemeal interventions, resulting in an overall system that is less than optimally efficient in technical terms, and which also creates a range of operational interfaces that are confusing for users.

The energy audit reveals how the lack of capacity for inhabitants to adapt existing heating technologies, promotes energy inefficient user-led adaptations in forms of behaviour that allow heating or cooling. The heating system is linked to a centralised boiler plant over which building users have no control resulting in some rooms being overheated. Open windows were observed when the audit was undertaken in March when there were freezing temperatures and snow lying outside. Lighting technologies similarly resulted in waste as a consequence of poor adaptation to user needs. Motion sensors for lighting were only installed in some of the communal areas resulting in lights switched on in stairwells and corridors when not necessary.

Built during a period in which internal lighting technologies were limited, the buildings now used by the History Department were originally built to allow natural lighting and ventilation. In respect to their current use as office spaces, and in response to shifting attitudes and regulations, most rooms are now routinely lit by overhead electrical lighting during daylight hours. As discussed in the previous section, electrical lighting in this sense represents a response to the expediencies of contemporary institutional realities. However the energy audit reveals how the configuration of these spaces has tended to work against rather than with the possibilities afforded by the existing building. As well as highlighting the possibility for more responsive and more efficient forms of lighting, the energy audit therefore also suggests greater consideration of how existing natural light can best be utilised.

Our research employs the energy audit as a methodological tool to help understand the energy infrastructure of our case study building. From this is evident that many of the elements of the system that would promote high energy usage are not inherent in the historic structure and fabric of the building. Rather these relate to the ways in which it is used and managed as part of an estate. Expectations of the university, embedded in wider legislative frameworks relating to health and safety and minimum working standards, coincide in a view of 'space' as a resource to be managed. From this perspective technical solutions have been applied, often paying little attention to previous histories of intervention, and often with little consideration of how adaptations might effectively utilise existing architectural features.

Conclusion and recommendations

Our research highlights how buildings are socially and historically constructed through the intersecting practices of a range of people, in ways that are simultaneously material and social. In the context of Durham University Estate we have pointed to some of the different processes and perspectives that animate these processes, past and present. From an historical perspective we have argued that buildings change and

develop through processes that play out over long periods of time, and have described how people both shape and are shaped by the buildings they inhabit. We have suggested that buildings can be seen as a physical sedimentation of historic processes, and have explored through qualitative research how these structures are understood today as part of a university estate. Running through our account has been the insistence that energy use inheres in attitudes and practices that are socially and historically specific and that result from complex interrelationships between people and material infrastructures.

These findings have implications for the ways in which both energy and heritage are managed in institutional contexts. The designation of historic buildings and the management of energy have both tended to assume and perpetuate a distinction between buildings, understood as physical 'infrastructure', and people, understood as 'behaviour'. In line with the broader tenets of heritage conservation,[31] heritage designations give weight to the 'intrinsic' significance of buildings, and correspondingly give less significance to the values they are socially attributed. Institutional mechanisms to reduce energy consumption have tended to separate 'behavioural' from 'technological' factors, and have emphasized the latter over the former in targeting reduction of energy consumption. A related issue is that existing decision-making processes relating to the management of historic buildings are often driven by externally imposed targets and legislative frameworks, rather than the expediencies of specific buildings and users.[32]

Our research suggests that such approaches fail to recognise key factors determining energy use in historic buildings and that better outcomes could result for both heritage and energy conservation, through approaches that start instead from the perspective of specific buildings-in use. From this perspective the locus of intervention would shift from top-down attempts to modify 'behaviour' and 'infrastructure' to the facilitation of processes that aim to promote context specific accommodations between buildings and users. Concretely, this implies the need for shifts in institutional culture combined with the development of methodologies that take these context-specific social and historical considerations into account. Although such methodological considerations are beyond the scope of this paper, our research suggests some of the ways in which this broad approach might facilitate better outcomes for energy use and the preservation of historic buildings.

Greater understanding of the energy histories of buildings could inform the processes by which such buildings are modified and adapted as part of contemporary energy infrastructures. The architectural historian Alexander Brand writes of the need to 'learn' from buildings. Rather than impose top-down technological solutions, he advocates paying close attention to the potential afforded by historic architectural features for creative adaptation and re-use. Buildings designed for the requirements of Georgian industrialists, clearly need adaptation to meet the institutional requirements of a university in the twenty-first century. However an historical understanding of building's previous uses can help to inform how buildings are reconfigured for present requirements. For example, in the History Building the generous-sized panes of glass of 18th Century sash windows result in high levels of natural daylight. This could be more effectively utilised through careful consideration of the layout of rooms, and the use where necessary of low energy task-specific lighting. Similarly, sash windows if properly maintained allow effective ventilation that could be better utilised alongside mechanical methods of heating and cooling.

While building fabric and the behaviour of inhabitants are both important determinants of energy usage, we have argued that the relationship between these is often complex. Historic buildings may be given a range of positive and negative meanings by their occupants and these in turn relate to different forms of inhabitation and use.[33] These have consequences for energy consumption, for example relating to different understandings of appropriate levels of ambient heating, ventilation and light. One practical implication of this finding is that if understanding of the significance of a building effects user evaluations of appropriate levels of comfort, there may be scope to reduce energy usage through modifying awareness of a building's history and significance. Currently staff who use the Georgian buildings in Durham University estate have little understanding of their historic importance beyond a generic sense of 'character' and 'tradition'. By increasing awareness of the historic features of these buildings, specifically as they relate to energy use, it might be possible to engender attitudes that promote more effective use of the infrastructural legacies of the past.

Finally, our research suggests that inefficiencies relating to energy use in historic buildings may derive less from their intrinsic physical characteristics than from the ways in which institutional contexts produce energy infrastructures that leave little room for user adaptation. By contrast to domestic settings, inhabitants have very little control of energy infrastructures, notably those that relate to heating and lighting. In these circumstances people may seek to regulate their environment through a range of energy inefficient improvised adaptations. As with other kinds of buildings,[34] targeting such behaviour is unlikely to be successful unless this is tackled in relation to the physical infrastructure and institutional contexts in which this arises. Brand highlights how historic buildings have by their very nature been adapted to different uses over long periods of time. The key to improving energy efficiency in institutionally managed buildings may thus, to a large extent, depend on facilitating these processes of adaptation, allowing buildings to 'learn' from their inhabitants by effectively adapting to them.

Acknowledgements

The research was funded by the Durham Energy Institute and the EPSRC (EP/K503368/1). The paper was written with the assistance of an AHRC fellowship (AH/L000032/1 'Building on the Past: understanding contested heritage futures through a study of renovation and retrofit of historic buildings'). The project benefited from guidance and support from Catherine Alexander, Sandra Bell, Harriet Bulkeley, Robin Coningham, Pam Graves and Simon Marvin. We are grateful to those at Durham University who agreed to be interviewed, those who attended our project workshop and all who otherwise assisted our research. We extend thanks to Sian Jones and two anonymous peer-reviewers for their constructive comments on the manuscript. Thanks also to May Cassar and Kalliopi Fouseki for helpful editorial guidance.

Notes

[1] Skoglund, P. & Svensson, E. 2010. Discourses of Nature Conservation and Heritage Management in the Past, Present and Future: Discussing Heritage and Sustainable Development from Swedish Experiences. *European Journal of Archaeology*, 13(3): 368–85; S. Thurley, *Men from the Ministry: How Britain Saved Its Heritage*. (Yale University Press: New Haven and London, 2013).

[2] For example, see Davoudi, S. 2012. Climate Risk and Security: New Meanings of 'The Environment'

in the English Planning System. *European Planning Studies*, 20(1): 49–69; Skoglund, P. & Svensson, E. 2010. Discourses of Nature Conservation and Heritage Management in the Past, Present and Future: Discussing Heritage and Sustainable Development from Swedish Experiences. *European Journal of Archaeology*, 13(3): 368–85; Cassar, M. 2005. Climate Change and the Historic Environment. London: UCL Centre for Sustainable Heritage; Strange, I. & Whitney, D. 2003. The Changing Roles and Purposes of Heritage Conservation in the UK. *Planning Practice & Research*, 18(2/3): 219–29.

[3] Judson, P. and Iyer-Raniga, U. 2010. Reinterpreting the value of built heritage for sustainable development. In: R. Amoeda, S. Lira, & C. Pinheiro, eds. *Green Lines Institute for Sustainable Development Report*. Barcelos; De Berardinis, P. and Rotilio, M. 'The promotion of energy efficiency of the building envelope in the rehabilitation process. Case study: a minor centre in Abruzzo', in Brebbia, C.A. & Mammoli, A.A. *Energy and Sustainability Ii* (Southampton: Wit Press, 2009), 437–48.

[4] Yung, E.H.K. & Chan, E.H.W. 2012. Implementation Challenges to the Adaptive Reuse of Heritage Buildings: Towards the Goals of Sustainable, Low Carbon Cities. *Habitat International* 36(3): 352–61; Norrstrom, H. and Eden, M. 2010. Energy efficiency and preservation in our cultural heritage in Halland, Sweden. In: R. Amoeda, S. Lira & C. Pinheiro, eds. *Green Lines Institute for Sustainable Development Report*. Barcelos; Strange, I & Whitney, D. 2003. The Changing Roles and Purposes of Heritage Conservation in the UK. *Planning Practice & Research*, 18(2/3): 219–29.

[5] English Heritage. 2012. Energy Efficiency and Historic Buildings: Application of Part L of the Building Regulations to Historic and Traditionally Constructed Buildings. London: English Heritage; see also: Roberts, S. 2008. Altering Existing Buildings in the UK. *Energy Policy*, 36(12): 4482–6.

[6] Lyndhurst, B. 2007. Energy and the Built Environment, fact sheet. Report prepared for Royal Institution of Chartered Surveyors (RICS). London, U.K.

[7] See reviews by the ESRC 2012 and Sustainable Traditional Buildings Alliance (STBA). 2012. *Responsible Retrofit of Traditional Buildings: A Report on Existing Research and Guidance with Recommendations*. London: STBA; Crawford, Jenny. 2012. Retrofitting Sustainably in the Build Environment. Newcastle Institute for Research on Sustainability. Newcastle Institute for Research on Sustainability: Newcastle. Working Paper, June 2012.

[8] Brand, S. 1994. *How Buildings Learn: What Happens After They're Built*. New York: Penguin; Shove, E. 2003. Converging Conventions of Comfort, Cleanliness and Convenience. *Journal of Consumer Policy*, 26(4): 395–418; Strebel, I. 2011. The Living Building: Towards a Geography of Maintenance Work. *Social and Cultural Geography*, 12(3): 223–42; Jones, S. & Yarrow, T. 2013. Crafting Authenticity: An Ethnography of Heritage Conservation. *Journal of Material Culture*, 18(1): 3–26; Jenkins, L. 2002. 11, rue du Conservatoire and the Permeability of Buildings. *Space and Culture*, 5(3): 222–36.

[9] Jacobs, J., Cairns, S. & Strebel, I. 2007. 'A Tall Storey . . . But a Fact Just the Same': The Red Road High-Rise as a Black Box. *Urban Studies*, 44(3): 609–29; Edensor, T. 2011. Entangled Agencies, Material Networks and Repair in a Building Assemblage: The Mutable Stone of St Ann's Church, Manchester. *Transactions of the Institute of British Geographers*, 36(2): 238–52; Jones, S. & Yarrow, T. 2013. Crafting Authenticity: An Ethnography of Heritage Conservation. *Journal of Material Culture*, 18(1): 3–26; Delafons, J. 1997. Sustainable Conservation. *Built Environment (1978–)* 23(2): 111–120.

[10] Roberts, M. 2003. *Durham: 1000 Years of History*. Stroud: Tempus; Roberts, M. 2013. *The Buildings and landscapes of Durham University*. Durham: Durham University.

[11] For surveys of Durham's architectural changes, see Green, A. 2000. Houses and Households in County Durham and Newcastle upon Tyne, *c.* 1570–1730. PhD dissertation, Durham University; Roberts, M. 2003. *Durham: 1000 Years of History*. Stroud: Tempus; Lowther, P., Ebbatson, L., Ellison, M. & Millett, M. The City of Durham: an archaeological survey. *Durham Archaeological Journal* 9: 73–6.

[12] General discussions of the materiality and architecture of the Georgian era can be found in Glassie, H. 1975. *Folk Housing in Middle Virginia: A Structural Analysis of Historic Artifacts*. Nashville: University of Tennessee Press; Deetz, J. 1977. *In Small Things Forgotten: The Archaeology of Early American Life*. New York: Anchor Press; Johnson, M.H. 1996. *An Archaeology of Capitalism*. Oxford: Blackwell.

[13] Lewis, Q., Green, A. & Yarrow, T. 2014. Towards an Archaeology of Energy: The Materiality of Heat and Light in 17th and 18th century Durham, England (Paper presented at the Society for Historical Archaeology Quebec City, Canada, 2014).

[14] Wills, M. 1995. *Gibside and the Bowes Family*. Chichester: Philimore.

[15] Berry, H. 2003. Prudent Luxury: The Metropolitan Tastes of Judith Baker, Durham Gentlewoman. In: R. Sweet & P. Lane, eds. *Women and Urban Life in Eighteenth-Century England: 'On the Town'*. Aldershot: Ashgate, pp. 131–56; Green, A. 2004. 'A Clumsey Countrey Girl': The Material and Print Culture of Betty Bowes. In: H. Berry and J. Gregory, eds. *Creating and Consuming Culture*. Aldershot: Ashgate, pp. 72–97.

[16] Hatcher, J. 1993. *The History of the British Coal Industry. Vol. 1, Before 1700: Towards the Age of Coal*. Oxford: Clarendon Press, pp. 16–17.

[17] Spufford, M. 2006. Chimneys, Wood and Coal. In: P. Barnwell & M. Airs, eds. *Houses and the Hearth Tax*. Research Report 150. York: Council for British Archaeology, pp. 22–31; Hatcher; Pomeranz, K. 2000. *The Great Divergence: Europe, China and the Making of the Modern World Economy*. Princeton and Oxford: Princeton University Press, pp. 57, 59–61.

[18] Hatcher, pp. 46, 72.

[19] Wrigley, E. 1967. A Simple Model of London's Importance in Changing English Society and Economy, 1650–1750, *Past & Present*, No. 37: 44–70.

[20] Wrigley, E. 1988. *Continuity, Chance and Change: The Character of the Industrial Revolution in England*. Cambridge: Cambridge University Press.

[21] Crowley, J. 2001. *The Invention of Comfort: Sensibilities and Design in Early Modern Britain & Early America*. Baltimore: Johns Hopkins University Press, pp. 22–33.

[22] Green, A., Parkinson, E. & Spufford, M. 2006. *Durham Hearth Tax, Lady Day 1666*. London: British Record Society, Index Library 119; Barnwell, P. & Airs, M. 2006. *Houses and the Hearth Tax: The Later Stuart House and Society*. York: Council for British Archaeology, Research Report 150.

[23] Johnson, M.H. 1993. *Housing Culture: Traditional Architecture in an English Landscape*. London: UCL Press, p. 106.

[24] Crowley.

[25] Levine, D. & Wrightson, K. 1991. *The Making of an Industrial Society: Whickham 1560–1765*. Oxford: Clarendon Press.

[26] Muldrew, C. 2011. *Food, Energy and the Creation of Industriousness: Work and Material Culture in Agrarian England, 1550–1780*. Cambridge: Cambridge University Press.

[27] Holtorf, C. 2013. On Pastness: A reconsideration of Materiality in Archaeological Object Authenticity. *Anthropological Quaterly* 86(2): 427–43.

[28] Sustainable Traditional Bulidings Alliance. 2012. *Responsible Retrofit of Traditional Buildings: A report on existing research and guidance with recommendations*. London: STBA.

[29] Beggs, C. 2002. Energy Management, Supply and Conservation. Butterworth-Heineman: Oxford. 73–91.

[30] Krarti, M. 2011. *Energy audit of building systems: an engineering approach*. Taylor & Francis.

[31] Pendelbury, J. 2008. *Conservation in the Age of Consensus* (London: Routledge, 2008); Smith, L.-J. 2006. *The Uses of Heritage*. New York: Routledge.

[32] Brand.

[33] Judson, E.P. 2012. Reconciling environmental performance and heritage significance. *The Historic Environment* 24(2): 19–24.

[34] Shove E. 2003. Converging Conventions of Comfort, Cleanliness and Convenience. *Journal of Consumer Policy* 26: 395–418.

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