
Book Section:
Macrorie, R.M., Foulds, C. and Hargreaves, T. (2015) Governing and governed by practices: Exploring interventions in low-carbon housing policy and practice. In: Strengers, Y. and Maller, C., (eds.) Social Practices, Intervention and Sustainability: Beyond behaviour change. Routledge Studies in Sustainability . Earthscan: Routledge , Abingdon , pp. 95-111. ISBN 9781138693043

Governing and governed by practices: Exploring interventions in low-carbon housing policy and practice

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Abstract

In this chapter we conceptualise low-carbon housing as an intervention in a system of interconnected practices, performed both by housing professionals and householders. This understanding distinctly contrast to commonly accepted approaches that rely on the simple introduction of low-carbon materials and technologies to households. We analyse the low-carbon housing system using two UK case studies focused on contrasting building performance standards (Code for Sustainable Homes; Passivhaus standard). We argue that links, flows and relations within such a system need further exploration to better understand the governance of sustainability interventions.

1. Introduction

Throughout the affluent West, domestic energy use is a major contributor to total end-use energy consumption and carbon dioxide emissions. In this context, attempts to reduce and decarbonise domestic energy use are a key focus of energy policies. In the UK, home energy consumption makes-up roughly a third of all UK energy use (DECC 2013a) and 15% of total UK carbon emissions (DECC 2013b). As a governance response, construction of new, low-carbon buildings – such as those installed with 'smart' technologies and electricity generation capabilities, and/or designed with high energy efficiency – has formed a central plank of policy approaches to date (Reid and Houston 2013). The importance of these low-carbon buildings is lent added significance given that these infrastructures will shape how we live in years to come, thereby contributing to future energy use and associated carbon emissions. This importance is widely recognised by policy, and in the UK alone, recent years have seen increasing stringency of statutory standards (e.g. Building Regulations), growth in voluntary standards (e.g. Code for Sustainable Homes, Passivhaus, BREEAM) and associated professional accreditation courses, new financial incentives (e.g. Feed-in-Tariffs; Renewable Heat Incentive; Green Deal), and new institutions (e.g. Zero Carbon Hub; Passivhaus Institute). Together, these developments have been made manifest in a burgeoning number of pilot projects around low-carbon

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housing (e.g. Brown *et al.* 2003, Lovell 2004, 2007a, 2007b). Nevertheless, there remains much work to be done before low-carbon homes constitute the norm for housing practice.

Research, policy and industry activity on low-carbon housing remains underpinned by a mode of problem framing labelled by Guy and Shove (2000) as the 'techno-rational paradigm'. This approach assumes that technological interventions alone will guarantee energy and carbon savings. According to this view, once technological design has been optimised, focus shifts to technology transfer and ensuring the rapid diffusion and 'correct' use of technologies by individual consumers. Persistent 'energy performance gaps' – where realised savings fall short of predicted savings (Shove 1998) – have however meant that increasing attention is paid to the activities of householders. In the majority of cases, focus has remained fixed on removing 'barriers' to technology diffusion and educating users to encourage 'correct' technical operation (e.g. Leaman *et al.* 2010, Whitmarsh *et al.* 2011, DECC 2013c).

Recently, social practice theorists have begun to develop a distinct approach to this issue that, far from treating technologies and behaviours as separate, sees them instead as intertwined and embedded within social practices (e.g. Gram-Hanssen, 2010). Instead of optimising and diffusing new technologies, or educating or exhorting users to change their behaviour, focus turns to practices, which might include everyday routines like cooking and showering, or home renovation (Wilson *et al.* 2013). Researchers in this domain seek to interrogate how these practices are made up of interrelated elements, and how they evolve and change over time. Whilst this research has generated important insights into everyday routines and associated demand for energy services, it has also highlighted that practices themselves are never isolated. Instead, they should be understood as always inter-connected and constituting 'systems of practice' (Shove *et al.* 2012). Understanding change in practices, therefore, demands attention not only to specific and located practices, but also to those to which they are connected across both space and time (Watson 2012). Consequently, the micro-scale focus on how low-carbon technologies do or do not influence domestic activity seen to date (e.g. Hargreaves *et al.,* 2010, 2013; Foulds *et al*., 2012; Gram-Hanssen *et al*. 2012), seems peculiarly narrow. Concomitantly, the relative lack of attention given to how housing professionals' practices and interventions in housing infrastructure appears as a glaring omission (although see Shaw and Ozaki 2013). What is needed is an understanding of low-carbon housing as an intervention in a whole system of practice, that includes the working practices of housing professionals', outcomes of the design and build process, and interrelations with householders' dwelling practices. This contrasts with conceptualisations of low-carbon housing as merely an attempt to introduce new technologies to households.

In this chapter we begin to address this challenge by turning our attention to the, to date, largely overlooked practices of housing professionals involved in the delivery of new low-carbon homes, including designers and architects, construction teams, social housing landlords and project managers. The working practices of these professionals include: implementing low-carbon building standards; managing the build process, researching and procuring low-carbon building materials, heating technologies and 'smart' energy technologies; arranging connection to infrastructure systems; and building homes equipped with an insulated fabric and low-carbon technologies that may enable (but may not necessarily seek) accreditation to low-carbon construction standards. Specifically, we explore the experiences of these professionals as they are first exposed to the low-carbon (social) housing context. As such, we also consider low carbon housing practices to include tenant management and the maintenance of housing stock. We combine this analysis with consideration of the implications of low-carbon housing for everyday dwelling practices. Our analysis draws upon two empirical case studies of low-carbon housing developments in the UK.

Building on Spurling *et al*.'s (2013) practice-oriented framework for policy interventions, as well as their contribution to this edited collection (Spurling and McMeekin, this volume), we conduct empirical investigation of how the practices of housing professionals (and indirectly householders' dwelling practices) become shaped through changes to i) the elements of practice, ii) the relations between practices, and iii) the recruitment of carriers. We argue that in order to govern the sustainability of housing design and construction practices, it is crucial not only to intervene in practice-as-entity but also to generate opportunities to reproduce sustainable practices through more or less faithful performances over the long-term. Such coming together of alternative practice entities and the repeated performance required to sustain new, or modified, practices necessarily occurs within a dynamic 'system of practice' (Watson, 2012).

We begin this chapter by reviewing the systems of practice concept, particularly in relation to the governance of interventions in practice. We then present our two case studies, focusing respectively on the Code for Sustainable Homes and Passivhaus. Analysis focuses on how efforts to make housing practices 'low-carbon' were experienced by these professionals, (although attention could equally be paid to householders' dwelling practices). Specifically, we appraise how the developments changed the elements of practices, interrelations between practices, and the recruitment of carriers to relevant practices. We finish by reflecting on the implications for low-carbon housing, social practice theory, and interventions in practice.

2. Intervening in Systems of Practice

Social Practice Theory (SPT) positions practices themselves, what they consist of and how they evolve and change, at the centre of analyses of social life. In so doing, and in contrast to the techno-rational paradigm outlined above, SPT simultaneously decentres both technologies and individuals, seeing both as secondary to, whilst still comprising important components of, practices. Specifically, SPT positions individuals as 'carriers' of practice (Reckwitz 2002) who more or less faithfully reproduce and perform them across time and space and are thus crucial to their survival, whilst technologies (e.g. materials, tools, artefacts, infrastructures) are positioned as but one important element of practice amongst others. Whilst different theorists emphasise slightly different lists of elements (e.g. Gram-Hanssen 2009), within work on sustainability, Shove and Pantzar's (2005) formulation of practices as composed of materials (stuff, artefacts), meanings (images, social expectations) and competences (skills, practical know-how), has arguably been most influential.

Much early work within SPT focused on analysing the make-up and evolution of specific, individual practices – for instance, cycling (Watson 2013, McHardy 2013) or showering (Hand *et al.* 2005). More recent work has responded to the critique that SPT is suitable only for micro-scale analyses of the 'everyday' (e.g. Geels 2010) by emphasising that individual practices are always and inseparably bound-up in wider systems of practice that extend across space and time. In this view, specific practices are connected to, shape and are shaped by, practices that they precede or follow in time, those they co-exist with in space, as well as those they are connected to more distantly. This might include practices they are dependent on (for instance, to produce or distribute practice elements) or practices that seek to govern or regulate them (e.g. Watson 2012, Shove and Walker 2010, Shove *et al.* 2012).

This understanding of practices, as embedded within spatially and temporally dispersed systems of practice, has been particularly important in generating insights for interventions in practice aimed at delivering change towards sustainability. Spurling *et al.* (2013), for example, set out three key ways in which interventions in practice might proceed. First, 'recrafting' practices involves changing the elements of a practice in order to reduce its overall resource intensity. With respect to low-carbon housing, this might entail replacing inefficient 'leaky' building materials with super-insulated fabric, or changing the meaning of a warm and comfortable home such that it no longer demands mechanical heating or cooling. Second, 'substituting' practices involves replacing unsustainable practice entities with more sustainable alternatives. This might involve designing communities that encourage defection from unsustainable practices and recruitment to more sustainable alternatives. For

example, installing bicycle racks rather than providing car parking spaces in new housing developments might encourage a shift from driving to cycling practices. Alternatively, more sustainable versions of existing practices might be encouraged, for instance by designing homes without facilities for tumble-drying but with in-built air-drying amenities (Spurling *et al.* 2013). Third, and finally, Spurling *et al.* highlight the potential to 'change how practices interlock' by intervening in how practices are sequenced or synchronised. This could mean seeking to reduce evening energy demand peaks by encouraging flexible working hours. Crucially, acknowledging that specific practices are connected into more extensive systems of practice leads to the recognition that any intervention in any single practice - whether intentional or not – will have ripple effects throughout the whole system of practices of which it is a part. As Watson observes: "Processes of change, whether to the elements of a practice or to the patterns of recruitment and defection of practitioners to it, are rarely endogenous to the practice concerned. Rather they arise because of the shifting relative location of a practice within broader *systems of practice*" (2012, p491, emphasis in original).

Recognising the importance of systems of practice is thus an important first step in understanding how practices evolve and therefore how they might be intervened in. As well as bringing many more practices (and their elements) into view than just the initial 'target' practice, it also introduces a wider range of potential points for, and agents of, intervention. Critically, in relation to low-carbon housing, it reveals the shortcomings of studies that focus solely on houses themselves and the practices performed within them. Rather, research should attend to how homes form one potential intervention site among many and how householders are merely one set of carriers among many others in systems of practice. A systems of practice framing encourages practice-based research that moves beyond a prevalent focus on the doings and sayings of everyday life. Instead, this approach enables increased attention to be paid to those practitioners seeking to govern the systems of practice of which they are a part.

Here, it is important to emphasise the distinction in the SPT literature between practice-as-entity and practice-as-performance (Schatzki 1996, 2002). Spurling *et al.* suggest that practices-as-performances "are the observable actions of individuals often referred to as 'behaviours'" (2013, p21). In contrast, practices-as-entities exist beyond and between their instantiation in specific performances, they have a history and trajectory of their own and involve socially-shared meanings, materials and competences. Crucially, Spurling *et al.* argue that interventions in practice should move beyond attempts to reshape practice-as-performance, what they see as "just the tip of the iceberg" and should focus on trying to change practices-as-entities as a more appropriate "target for sustainability policy" (2013, p21). This view implies that attention should be

directed away from those who incrementally change practices-as-performances through their more or less faithful reproduction in everyday life, and towards those who arguably are able to intervene at the level of practices-as-entities. Such intervention attempts might include producing and circulating new elements, introducing new or more sustainable variants of existing practices, or acting to change the relations between practice on a societal scale. At the same time, it is recognised that policymakers face considerable challenges as individual practices are likely to cut across different areas of policy making, the extent or scale of a practice is unlikely to be confined, interventions can only affect processes that are already underway and the scale of transformational change required may lie beyond that which is politically feasible (Spurling *et al*. 2013).

As Watson notes, "Practices recruit carriers in board rooms, the physical spaces of futures trading and government offices as much as they do on streets and in homes" (2012, p496). To date, however, despite the growing interest in how to intervene in practices, the practices of these would-be governors – potentially capable of intervening at the level of practice-as-entities – have received scant attention. In this chapter we seek to address this gap by focusing on the practices of housing professionals. Specifically we examine housing professionals involved in two low-carbon housing developments, where the delivery of homes centres around the ambition to reduce levels of carbon emissions generated by the everyday practices of residents.

3. Housing professionals and low-carbon developments: two case studies

Our discussion draws on two case studies of low-carbon social housing developments in the UK. The first example was built to be 'zero carbon' (also termed 'Code level 6') under the UK Code for Sustainable Homes (hereafter CSH). The second example was built to the German Passivhaus energy efficiency building standard. Research, including a longitudinal series of qualitative in-depth householder interviews, audio-tours and research diaries, and real-time building energy performance data, has already been conducted on how these developments influenced the everyday lives of the householders themselves (e.g. Foulds *et al.,* 2013; Macrorie, 2012). Here, we place greater emphasis on how the housing professionals involved – including designers and architects, construction teams, social housing landlords and project managers - sought to deliver the low-carbon developments. The working practices of these professionals span; planning, design, construction, technological installation, infrastructural services, tenant management and maintenance and repair. Specifically, the CSH case draws on 12 interviews with housing professionals whilst the Passivhaus case draws on participant observation (from construction site visits, training events, visitor days), documentary evidence and interviews with the lead architect and construction auditor. Analysis of these discussions

builds on Spurling *et al*.'s (2013) practice-oriented framework for policy interventions, as well as their contribution to this edited collection (Spurling and McMeekin, this volume), to undertake empirical investigation of how the practices of housing professionals (and indirectly householders' dwelling practices) were shaped through changes to i) the elements of practice, ii) the relations between practices, and iii) the recruitment of carriers. Boxes 1. and 2. provide key details about the aims and implementation of each of the housing developments.

BOX 1: Code for Sustainable Homes (CSH) development: Norwich, Norfolk.

This development, sought to develop 12 social housing dwellings to Code level 6 (i.e. negative net CO_2 emissions and zero carbon rating (DECC, 2006; Zero Carbon Hub, 2011). It aimed to demonstrate the viability of low-carbon housing to the mainstream construction industry and local residents, in order to generate support for development of a proposed 'eco-town' in the area.

The development used a traditional build aesthetic aiming to keep residents' existing lifestyles intact. Involvement of householders was limited to the provision of home-user guides and electricity metering display units, intended to promote low-carbon behaviours. In accordance with CSH methodology, a technologically focused approach was used including air-source heat pumps, mechanical ventilation with heat recovery systems (MVHR), and roof-mounted solar photovoltaic panels. Use of these technologies required the design and construction team to utilise new materials, learn innovative skills and revise their ways of thinking about house building.

The development was successfully accredited to Code level 6 and received national commendation, however, post-occupancy electricity demand levels were highly variable, preventing carbon-neutrality. Changes to the UK political administration led to withdrawal of support for the eco-town proposal, whilst the economic downturn led to a shift in focus away from low-carbon and toward cheaper approaches (encouraged by the introduction of the New Homes Bonus and National Planning Policy Framework). Consequently, Phase 2 of the development saw a scaling-back of sustainability aspirations. Whilst planning permission has been obtained for 14 further properties, this development will be constructed to Code level 4 (one level above current statutory requirements), rather than the more ambitious Code level 6.

BOX 2: Passivhaus standard ('Passivhaus') development, East Anglia.

This small-sized (fewer than 25) UK social housing development was designed and constructed to the Passivhaus standard (see The Passive House Institute (PHI) website). This approach assumes that energy savings will be achieved without the need for households to change what they do at home. Specifically a fabric first approach was employed, focusing on airtightness, super insulation, and solar thermal and MVHR. Further, the project sought to demonstrate the energy saving potential of Passivhaus to the UK design, construction and social housing industries.

Whilst the development achieved the Passivhaus standard, challenges were encountered regarding how the technologies were delivered by industry. For instance, mould growth occurred within the properties due to inadequate ventilation and 'correct' use of the technologies by householders proved challenging (e.g. confusion ensued over heating/ventilation controls). Furthermore, anticipated energy savings were not achieved; there was no reduction in electricity consumption (compared to previous homes) and gas savings were less than predicted.

These problems were blamed on a lack of experience and relevant skills among professionals working on the project rather than on any problems with the technologies themselves. The professionals rapidly learnt new skills 'on the job' during the build process whilst reliance on technologies (and belief in the Passivhaus standard) continued after the project. Yet beyond this specific development, few opportunities exist for the professionals to apply their new skills. As such, their newly accrued experience risks going to waste.

4. Analysing low-carbon interventions in housing practice.

As Boxes 1 and 2 show, both developments were successfully constructed and accredited to their respective standards. Post-occupancy, however, neither scheme was entirely successful in meeting its anticipated energy or carbon savings. Rather than focus on technical performance targets, we focus instead on broader conceptual issues relating to systems of practice that transcend these specific developments and that have implications for the future delivery of low-carbon housing. In particular, we discuss how the practices of housing professionals were shaped through changes to i) the elements of practice, ii) the relations between practices, and iii) the recruitment of carriers.

4.1 Recrafting practices: Changing the elements

In practice terms, the aim of both interventions was to enhance the environmental sustainability of social housing infrastructure, by inserting new low-carbon technologies and energy-efficient building materials into the everyday working practices of the housing professionals. The professional practitioners researched, procured, installed, and learnt to operate and maintain a wide range of new technical equipment and devices. The housing professionals also required new 'competences' – delivered through training courses or learnt 'on the job'. They were also required to embrace new 'meanings' around housing. Such new understandings included recognition that the respective developments were built to achieve carbon neutrality, rather than solely economic profitability.

Whilst the two building standards provided quite explicit roadmaps for the implementation of low-carbon housing design and construction, it proved difficult for the professionals themselves to modify their ingrained 'ways of doing' as low-carbon housing skills and meanings lagged behind the newly acquired technical devices and materials. For example. whilst the Passivhaus development gained accreditation, the project was delayed due to disagreements between the housing construction practitioners as they attempted to determine the exact requirements of the standard (in particular in relation to airtightness levels). Previous skills and experience – learnt through engagement with 'leaky' conventional builds – could also no longer be relied upon. For instance, whilst traditional bricklaying requires only the external face to be flush (for aesthetic purposes), Passivhaus builds demand flush surfaces both externally and internally for air tightness purposes. In addition, the new materials themselves struggled to align with the requirements of the Passivhaus standard. Mould growth occurred as a consequence of the housing construction practitioners' lack of familiarity with assisted ventilation in super-insulated properties. Similarly, as well as struggling to use new materials and to employ new technical skills, interviewees from the CSH project described how it took time for the

project team to switch from an economics-driven logic to a sustainability-driven housing construction rationale.

As these examples show, by focusing intently on the promise of technical solutions, both initiatives gave considerable attention to sourcing, correctly installing, and operating low and zero carbon (LZC) materials and technologies. As a consequence associated practice meanings and competences were largely overlooked. Our examples clearly demonstrate that in order for new low-carbon housing practice entities to be formed and sustained, prerequisite practice elements need to come together and be combined. A focus on only one element in isolation is insufficient, leading to a failure to realise and sustain the modified practice. As Spurling and McMeekin (this volume) discuss, it follows that policy makers can seek to make these elements the targets of sustainable (low-carbon housing) interventions. Rather than relying on building standards, which predominantly address the material element, attention should be placed on developing design and construction skills through training, and challenging established rationales informing house building. Similarly innovation in housing may not always stem from new technical solutions, and opportunities for social innovation in housing infrastructure should also be pursued. For instance, co-housing schemes are designed intentionally around the concept of community and incorporate facilities for communal living.

Although not conceptualised as such in the developments themselves, and ultimately proving far from straightforward to enact, it is clear how, in principle, these low-carbon exemplars represent distinct interventions in the practice-as-entities of housing professionals. At the same time, the design and delivery of the two developments sought to keep the dwelling practices of householders largely intact (i.e. 'non-interventions in householders' practice'). It was assumed that householders would only minimally reflect on the energy implications of their daily domestic routines, if at all, and that their everyday practices would proceed as normal around the newly installed technologies. Both developments were designed to look as 'normal' as possible so as not to challenge cultural expectations around domestic living and energy use. As one interviewee from the CSH case described, "*there was a clear steer from [Council] members that they wanted what they would describe as a traditional build…*", whilst another interviewee stated "*we don't want to interfere in peoples' lives too much"*.

Despite aiming for 'non-intervention' in householders' practices, post-occupancy observations reveal that many householders failed to use the LZC technologies as anticipated (for instance, opening and closing windows and doors to control their thermal comfort as opposed to using the MVHR). Similarly, fearful of negative repercussions, some householders avoided using the LZC equipment (for example, turning off the installed thermostatic control panel and bringing in

electric fan heaters). The technologies also led some households to change their practices in ways not envisaged. Unable to control the heating system, some householders restricted their practices to particular rooms or shifted them to communal spaces outside of their home. These examples suggest that non-intervention in practice is an unrealistic goal. Introducing new practice elements necessarily has knock-on effects on other elements that play out in often unexpected ways. Adopting a narrow focus on only technology or behaviour – as associated with the techno-rational paradigm – seems destined therefore to run into difficulties by failing to account for knock-on effects on other practice elements, or from connected practices. Building on Spurling *et al.* (2013), these observations shift attention from a predominant focus on the material, and open up opportunities for intervention in other practice elements. They also suggest that 're-crafting', or replacing the elements of individual practices, may be unlikely to succeed unless wider systems of practice are taken into account. We develop this observation further in the next section.

4.2 Changing how practices interlock: Modifying practice relations

In addition to changing the elements of specific practices, both initiatives can be seen as attempts to insert a set of interconnected low-carbon practices into the housing system, creating a wholly new housing system. As Boxes 1 and 2 show, like many others (Brown *et al.* 2003, Lovell 2004, 2007a, 2007b), both developments were seen as exemplars designed to demonstrate how low-carbon housing could be achieved in an effort to make it more mainstream. For the project teams, the chance to be involved in such flagship developments, and potentially gain competitive advantage, was a major reason for their involvement. The Passivhaus project team, for example, recognised the initiative as a unique opportunity to develop new skills for what they, and others (e.g. Feist in McCabe (2012) and Boardman (2012)), considered as the future housing industry standard. As one interviewee stated, "*give it 10 to 15 years and every building [in the UK] will be Passivhaus or equivalent*".

The effort to construct new systems of practice was also enshrined in the standards themselves, which often contained stringent specifications for exactly how the low-carbon builds could or should be achieved. Several interviewees from the CSH project team described how the build specification for the properties was *"dictated by the Code"* and how they felt *"bound by"* meeting the requirements of the standard. Similarly in the Passivhaus case, whenever new technologies were sourced, professionals checked their compliance with the Passivhaus standard by running them through the Passive House Planning Package (PHPP) Excel- based building model. The PHPP not only provided professionals with the competence required to ensure that they could meet the Passivhaus standard, it also determined compatability with the new system of practice. The standards therefore sought to generate connections between

housing-related practices and practitioners that would encourage the professionals away from conventional build approaches, whilst simultaneously constructing a new system of low-carbon housing practices.

Despite these intentions, instituting new systems of practice is hardly straightforward and, unsurprisingly, both developments encountered problems. Sourcing appropriate technologies was one key challenge. Without the necessary (low-carbon) competences, the professionals struggled to source, and receive advice on, specified building materials, a challenge exacerbated by the nascent UK low-carbon housing supply chain. Many Passivhaus technologies (e.g. airtight loft hatch; triple glazed windows; solar gain blinds; *brise soleil*) had to be sourced from Germany or Austria, where the standard held a more dominant position in housing practices. Similarly, one interviewee from the CSH case raised concerns about how the standard connected with recent planning policymaking practices. He commented that *"With the NPPF [National Planning Policy Framework] being produced last year by this Government… the main thrust of sustainability is economic sustainability… approve [new housing developments], build things [and that'll get the country moving…".* As such, dependencies and interconnections with policymaking and market related practices had distinct implications for the low-carbon housing system.

Nonetheless despite these initial challenges, as the initiatives proceeded new systems of practice began slowly to emerge. As one interviewee in the Passivhaus case commented: *"[at the start of the project] there were fundamentally two windows that we felt we could use that would give us the performance… Two years on, [following market developments], and I've probably got fifty windows that I can choose between in the UK*". Alongside the development of new low-carbon supply chains, interviewees commented on the accompanying growth in LZC product development, numbers of accredited properties, and practitioner familiarity with the requirements of the respective building standards. In short, in order for the housing professionals to adopt and successfully perform their new low-carbon practices-as-entities, there needed also to be a system of practice in place to support and maintain them.

The housing professionals we spoke to and observed arguably occupied privileged positions – that is they have the potential capacity to intervene directly in the practices-as-entities of householders. Such interventions may be achieved through a range of measures that challenge expectations of accepted everyday domestic life through housing design. The remit for our two case studies however was to keep householders' daily practices very much intact. Low-carbon technologies were selected that would do the work of saving energy and carbon emissions, and it was anticipated that the tenants would only be passively engaged in managing their energy demand. Where explicit instructions

were given to the tenants, they revolved around ensuring correct operation of the installed technologies. As such, any inter-relations between the housing professionals' practices, the outcomes of their interventions, and householders' dwelling practices, were largely overlooked.

In contrast, our analysis reveals that housing professionals' practices are always embedded within and dependent on broader systems of practice. Any effort at intervention (or even non-intervention) in any single practice is always likely to encounter resistance and to have unintended effects as it ripples across interconnected systems of practice. This reinforces the importance of examining whole systems of practice rather than focusing on single practices in isolation, and emphasises how no single actor can ever be in sole charge of a system of practice. The challenge for successful interventions in practice, is then one of, first, identifying the mesh of interconnected practices relevant for the intervention in question. Second, honing in on the flows between practices that are of most significance whilst also keeping sight of other links and connections that may lead to resistance or unintended consequences. Arguably, this suggests that rather than seeking to change practices-as-entities in and of themselves, the focus of practice-based interventions should instead be more systemic, seeking to modulate the significant relations and 'circuits of (re)production' (Shove *et al.* 2012) between interconnected practices. Rather than isolated attempts to insert low-carbon materials into housing contractors' house building practices, interventions in housing practices need to be undertaken with reference to shifting cultural conventions, a developing low-carbon technology supply chain, and supportive infrastructural planning decisions.

4.3 Substituting practices: Recruiting and keeping carriers

The third core observation from our case studies relates to the importance of not only recruiting carriers to new practices-as-entities, but also holding onto them, by allowing their newly adopted practices to be faithfully and regularly performed. As sections 4.1 and 4.2 have shown, as our case studies progressed, low-carbon housing practices-as-entities were nurtured, and nascent supporting systems of practice began to emerge. For our housing professionals, new competences were acquired as they developed experience in working with low-carbon materials. Despite these showcase schemes however, low-carbon housing practices have yet failed to gain a stronghold within the UK, neither building standard has been mandated and attention has, for now, shifted towards economic development and away from innovations in low-carbon housing infrastructure. Our two initiatives must therefore be understood, essentially, as ''one-off' experimental projects' (Lovell 2007b), as both sets of practitioners were prevented from repeating their newly acquired practices.

In the CSH example, the professional practitioners quickly recognised a failure of the techno-rational paradigm to take into account householders' practices. Whilst there was an overall desire among the project team to engage with householders, this option was shut down by wider shifts in the UK political administration, associated changes in the regulatory environment, and the economic downturn. These inter-related shifts served to turn attention away from low-carbon construction and towards more profitable techniques. The result was that not only were householders 'designed-out' of the development, but also the original ambitious aims to achieve the highest Code level 6 were abandoned for Phase 2 of the development in favour of building fourteen units to Code level 4 – only one step above statutory building requirements. This translated into pursuit of a more fabric-first housing design approach, abandoning 'add-on' LZCs, and a continued approach that sought minimal impact on householders' everyday lives. Regardless of the learning that the professional practitioners experienced, shifts in the systems of practice, of which they were but a small component, served to prevent further reproduction of low-carbon housing practices.

In the Passivhaus example, the story is different but the result is the same. Again the professional practitioners learnt a great deal and gradually began to adopt new housing practices. Unlike the CSH development belief in the standard never wavered, and the modified housing practices were reinforced by Passivhaus experts as well as the PHPP model that confirmed that the scheme was on track to achieve accreditation. Despite this, opportunities for the professionals to apply their learning in subsequent developments were constrained. The Housing Association took the decision that each of its local housing providers should have equal opportunities to learn how to build Passivhaus. Whilst certainly a positive move in attempting to diffuse low-carbon housing practices beyond specialist providers, at the same time, the specific housing professionals involved in this example, had to return to work on more conventional 'leaky' dwellings. This action served to instil Passivhaus as something unusual and difficult. Further still, ongoing limited recognition of Passivhaus in policy circles meant that adoption of the standard remained voluntary whilst higher build costs mean that Passivhaus appears unattractive to developers faced with the current period of austerity. In short, despite the new practices they acquired and the new systems of practice they helped to construct, the housing professionals involved in this case appear unlikely to be able to replicate these practices any time soon.

Whilst we agree with Spurling *et al.* (2013) that practices-as-entities are a more appropriate target for sustainability interventions than practices-as-performances, our case studies show that practices-as-performances must not be forgotten in the effort to achieve lasting practice change. In order to govern the sustainability of housing design and construction practices, it is crucial not only

to intervene in practice-as-entity but also to generate opportunities to reproduce these practices through more or less faithful performances over the long-term. Housing industry award schemes or site visits that connect up learning from successful low-carbon developments, could provide opportunities to sustain low-carbon housing practices. However, a shift in performance also requires broader systemic change than that practiced as part of isolated initiatives. This empirical work has demonstrated how opportunities for repeated modified practice performances are clearly linked to broader social practices, policymaking practices, and practices of the market. As such, changes to Government funding schemes and incentive structures, to enable experimentation with technical, as well as social, innovations in low-carbon housing are also critically required. Both these cases have emphasised that whilst the practice-as-entity may begin to change, a limited scope for professionals to perform their modified practices, can threaten their continued longevity.

5. Conclusion

This chapter has sought empirically to move practice theory beyond its focus with the everyday and to instead reframe low-carbon housing as an intervention in a whole system of practice, that includes the working practices of housing professionals', outcomes of the design and build process, and interrelations with householders' dwelling practices. In considering the implementation of two exemplar low-carbon (social) housing developments, the practices of housing professionals have been revealed as crucial in leading the transformation to a less energy-intensive residential sector. Empirical observations have also demonstrated how the implementation of two contrasting low-carbon building standards involves similar, yet subtly different, alterations to the composition and performance of professionals' practices. In analysing these cases, we have applied Watson (2012)'s conceptualisation of the 'system of practice' to the UK housing domain and built upon Spurling *et al*. (2013)'s three practice intervention framings.

What, how, and the extent to which, new meanings and competences are incorporated into housing professionals' practices has critical implications for how future homes are designed, built, and lived-in, as well as the overall carbon footprint of the residential sector. More importantly however, our analysis emphasises that these professionals are situated within broader systems of practice. Therefore, whilst interventions in practice may be attempted – including replacing practice elements, shifting relations between practices, and altering carrier recruitment/defection levels – they can go awry, or operate in unexpected ways, because no single actor is ever in charge. Rather than shifting attention from household practitioners to would-be governors of practice, we would argue for attention to be placed on how actors and their practices

interrelate, feedback and might spin-off as part of more extensive systems of practice. Adopting this systemic approach reveals that every action can be conceived as a potential intervention in practice and that attempting non-interventions in practice (such as by using technologies to 'design-out' householders) is unrealistic. The challenge for practice theorists therefore is to identify the links, flows and relations within systems of practice that have the most relevance to the particular sustainability intervention in question.

What then are the real-world implications for the governance of low-carbon housing and interventions in practice? The first challenge, working outwards from the specific practice of interest, is to 'map the system' and delimit the network of practitioners. This conceptual mapping approach, which would consider both actors and agents (for instance the low-carbon home itself, construction training materials, or voluntary/ mandatory building standards), would seek to enable identification of the links within a practice system that are most important to the target practice or intervention in question, as well as the most closely involved actors or agents. Secondly, and given that no single actor is in charge, a systems of practice approach seems likely to generate multi-actor and multi-pronged interventions. Such an approach would look beyond the narrow technical and building energy performance prescriptions of CSH or Passivhaus. Instead it would advocate looking across whole systems of practice and joining-up distributed sources of evidence from right across the system, including from specific practices that might initially seem only distantly connected. Third, and finally, such an approach demands that attention is paid to how flows within and between practices change over time (strength/direction/speed of links), requiring constant attention to how interventions generate reactions, interactions and resistances throughout practice systems.

Whilst offering a critical step forward, we would argue that recently suggested practice-oriented frameworks for policy interventions (e.g. Spurling *et al.* 2013) could be usefully extended in two ways. Firstly, by acknowledging the importance of providing opportunities to nurture and sustain modified, practice-as-entities, through more or less faithful performances over the long-term. And secondly, rather than honing in on specific practices, or on certain actors in isolation, we instead advocate that attempts to intervene in practice prioritise understanding of the flows and relations within and between the practices in question. Using practice-oriented policy-making tools demands an appreciation of how their actions and outcomes mesh and fit within systems of practice. Such an appreciation would involve focusing not only on the practice-as-entity, but also on generating and sustaining opportunities for repeated performance of modified practices. In developing this conceptual approach further, research is needed that goes beyond the UK low-carbon housing domain, to explore

alternative international and cultural contexts as well as contrasting policies that target other forms of consumption (e.g. water, food, waste etc.).

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