
Proceedings Paper:
Faulconbridge, J., Cass, N. orcid.org/0000-0003-2652-1931 and Connaughten, J. (2016) Standards, design and energy demand: the case of commercial offices. In: DEMAND Conference 2016 Papers. DEMAND Centre Conference, 13-15 Apr 2016, Lancaster, UK. Demand Centre

---

Standards, design and energy demand: the case of commercial offices

James Faulconbridge*, Lancaster University and DEMAND Centre

Noel Cass, Lancaster University and DEMAND Centre

John Connaughton, University of Reading and DEMAND Centre

* Corresponding author: **j.faulconbridge@lancaster.ac.uk**

Paper prepared for DEMAND Centre Conference, Lancaster, 13-15 April 2016

Standards, design and energy demand: the case of commercial offices

Abstract

In this paper we examine the influence of what we call market standards on design. We do this using the case of the design of commercial offices and the effects of standards on moves towards less energy demanding designs. Theoretically the paper builds on concepts drawn from a range of literatures examining standards, including science and technology studies and the sociology of standards. We argue that standards do important 'work' in design processes that require closer scrutiny. We show that in the case of commercial offices this affect the likelihood of the incorporation of low energy technologies. Our analysis reveals: the importance of taking greater account of normative and cultural forms of market standards and their role in design; the value of explaining how standards break the relationship between design and social practice, in our case this meaning that low energy technologies that might adequately cater for office work much of the time are considered inappropriate due to a lack of understanding of office work practices; how standards interlock to legitimate incumbent (higher energy) technologies, and in turn de-legitimise (lower energy) alternatives, through the way they define what is 'needed'; the value of tactics within energy and sustainability policies designed to govern non-regulatory standards and their effects. The paper thus makes an important contribution to understanding the 'work' of standards, and more broadly the production of energy demand in offices.

Introduction

In this paper we use the case of commercial offices in the UK to enhance understanding of the way standards affect design. In particular we consider the implications for the incorporation of low energy technologies into new and refurbished buildings. Our concern is the 'work' that standards do in design processes and the way this creates a context in which the incorporation of low energy technologies is rendered less likely. We seek to better understand the way different standards, in both defining what is 'needed' and part of the dominant paradigm (Walker et al., 2015), and by interlocking with one-another, influence "powerful social processes shaping energy-related decisions which tend to lead development actors to make seemingly 'irrational' choices" (Guy and Henneberry, 2000: 2409); these irrational choices being the adoption of incumbent technologies that are more energy intensive than alternative varieties.

In discussing standards we are referring to "agreed-upon rules for the production of (textual or material) objects" (Bowker and Star, 2000: 150). In particular, following Timmermans and Epstein (2010: 71) we are interested in the array of different types of "agreed-upon rules" which are intended to allow coordination (in our case of the design process) and create "uniformities across time and space". Each standard is policed more or less formally through sanctions, yet may be relatively invisible. As we show through our analysis, this invisibility requires addressing. Rendering the 'work' of standards visible elucidates the important ways they affect what is incorporated into designs of new buildings, and in turn the extent to which opportunities exist to reduce energy demand as part of sustainability agendas.

Our choice of empirical foci is strategic, given that there have been significant efforts stretching back to at least the 1980s to reduce electricity used in commercial offices for cooling, heating, and ventilation as well as lighting (see, for example, Bunz et al., 2006; Guy and Moore, 2007). We focus our analysis on these sources of demand given that in commercial offices they account for 71 % of energy consumption (ACE, 2000). Designs that maximise natural light whilst minimising solar heat gain, and the use of low energy cooling technologies such as chilled beams and ceilings, displacement and natural ventilation in lieu of air conditioning through four pipe fan coils (the 'orthodox' and higher energy cooling solution), have become widely recognised responses to the imperative to reduce energy demand. However, as we demonstrate, standards have a significant effect on the extent to which such technologies are incorporated into designs.

We seek through this paper to enhance theoretical understanding of the 'work' of standards in design processes, and the implications for energy demand reduction, in a number of ways. First, we reveal the characteristics of the standards that matter as far as design is concerned. Timmermans and Epstein (2010: 72) identify four types of standard, one of which they label design standards, the others being performance, terminological, and process standards. As Bowker and Star (2000) note, these standards often become regulatory standards to ensure compatibility and safety. We highlight an additional category that is somewhat neglected and involves normative and cultural forms of governance of the design processes. We empirically examine what we call *market standards* and the way these comprise an important part of the institutional regime affecting commercial office design. Adherence to market standards is associated with socially sanctioned forms of field-level control that reduce the agency of building designers and create pressures for conformance with approaches legitimised by socially constructed ideas about 'quality' and 'need'.

Second, we show that the work of standards in two related ways makes it unlikely that low energy technologies will be incorporated into designs. Existing studies highlight how design standards influence technologies by either maintaining the dominance of incumbents (Markard and Truffer, 2006) or providing the pre-conditions for change (Schmidt and Werle, 1992). We develop this understanding by detailing the way standards break the relationship between design and social practice, this meaning that low energy technologies that might adequately cater for most office work much of the time are considered inappropriate due to a lack of understanding of office work practices. Relatedly, we also show that standards legitimate incumbent (higher energy) technologies, and in turn de-legitimise lower energy alternatives, through the way they define what is 'needed'. The definition of 'need' constructed through standards has both technical and aesthetic dimensions which interlock in ways which render it far less likely that low energy technologies will be incorporated into designs. In concluding, we suggest that the importance of market standards in the diffusion of low energy technologies implies a potentially significant role for the governing of such standards as part of the policy process, the normative and cultural and not just the regulatory institutional environment being of policy concern.

Methodology

Our study of ten commercial offices in the UK is based on two related stages of analysis. We began with five exploratory interviews with different actors - architects, developers, engineers and planners - in the field of commercial office design. These interviews were wide ranging and considered a multitude of influences on energy demand in offices and the

incorporation of low energy technologies such as displacement ventilation and chilled beams. Amongst the issues highlighted, the role of standards stood out as a recurrent theme in explanations of why low energy technologies were often not incorporated.

Stage two of our research thus sought to focus in on the different standards relevant to commercial office design. To do this, ten office buildings, constructed (6 cases) or refurbished (4 cases) since 2010, were used as cases for empirical analysis. The aim was to identify across the cases common standards and associated mechanisms relevant to the enabling or inhibiting of energy demand reduction. Semi-structured interviews with actors involved in constructing or refurbishing the case study offices (the same actors as in stage one but with the addition of letting agents) were used to drill down into the rationales for specific decisions about design and infrastructure provision. The cases were selected to reflect a number of different categories of office buildings, including location, ownership and development models. All of the buildings were built or refurbished speculatively, meaning that the identity of occupiers was unknown at the early design phases. The rationale for focussing on speculative development is that offices are predominantly (c.80%: Deloitte 2014: 28) rented rather than owner occupied in the UK. This means that those designing a new or refurbishing an existing office are unlikely to know who will occupy the finished space. Indeed, an office is likely to have several tenants during its design lifetime. This has a significant influence on design and the role of standards. A total of 40 interviews were conducted, with at least 3 interviews per case study. Three interviews did not relate to specific case study buildings, being with members of associations representing actors in the field of commercial office design. Table 1 provides anonymised details of the case study buildings and interviewees for each.

Table 1. Case study buildings

Case study	Year of construction/ refurbishment	Key features	Interviewees
1	2013	New Build. City of London/West End CBD location.	Architects (x3), Engineer, Developer, Letting Agent
2	2011	New Build. City of London/West End CBD location.	Architects (x2), Engineer
3	2013	New Build. Mid-town edge of CBD location.	Architect, Engineer
4	2014	New Build. Mid-town edge of CBD location.	Architects (x2), Engineer, Developer
5	2014	New Build. Mid-town edge of CBD location.	Architect, Engineers (x2)
6	2014	New Build on old building's foundations. City of London/West End CBD location.	Architects (x2), Engineer, Letting Agent
7	2013	1960s refurbishment (previously refurbished once in 1980s). City of London/West End CBD location.	Architect, Engineer
8	2014	1980s refurbishment. City of London/West End CBD location.	Architect, Engineers (x2), Letting Agent
9	2014	1980s refurbishment. City of London/West End CBD location.	Architects (x2), Engineer, Developer, Letting Agent
10	2010	1980s refurbishment. Mid-town edge of CBD location.	Architect, Engineer, Developers (x2)

The role of market standards in commercial office design

Two types of market standard

The first market standard we are concerned with we label the *cultural standard of the marketable office*. The cultural standard is also, like a societal culture, not something that is formally codified and necessarily easy to describe. Rather it is something recognised by those part of the field of commercial office design, and is akin to what Polanyi (1966) describes as tacit knowledge; those in the field 'know more than they can tell' about the standard. This can make the standard somewhat slippery, most commonly being associated with the term 'Grade A' offices but with there being some difficulty in defining this term. For instance, one architect when asked about Grade A offices replied:

> "I'm never quite sure what the difference is between Grade A and grade B…it was always like loos, views and something else, the mantra, there was more to it. I suppose big windows deliver the views and obviously upper level roof terraces etc" (Architect, case study 2)

Nonetheless, as the final parts of the preceding quote imply, those socialized through experience tend when prompted to be able to begin to describe the standard with a degree of precision. Table 2 provides examples of how a Grade A building that conforms to the cultural standard of the marketable office is described by different actors in the field of commercial office design.

Importantly, as the quotations in table 2 indicate, the provision targeted by the cultural standard of the marketable office relates in particular to the *presence* of certain material-aesthetic features. Examples include the types of facade, walls, visible cooling system etc, certain variants being considered an essential part of a marketable building, in particular because of their effect on the look and feel of an office. Hence when a design conforms to Grade A cultural models, the expectation is that:

> "when we [letting agents] show people round the building…they're going to see an open plan, open floor…it will be the same as the last one they just looked at. So if we can make an impression in terms of the lobby, the lift experience is great, go in the loos and they think we can allow our clients to go in there and they won't feel embarrassed!" (Developer, exploratory interview)

The second market standard, which we label *the normative standard of the acceptable office*, is associated with definitions of a 'quality' office; 'quality' also in turn making an office marketable. The BCO as an organisation emerged in the 1990s as part of industry efforts to tame an 'arms race' that had developed between developers in terms of office specification. Its aim was to provide guidance about provision that would meet most if not all users' 'needs'; the idea being that this helped developers make sufficient but not excessive investments at the design stage. BCO Guidelines are thus based on extensive industry research about what level of technical provision is considered necessary in a high 'quality' office if occupants' needs' and expectations are to be met. Whilst not intended to be a standard – the BCO issues guidance – the guidelines published periodically, most recently in 2014, have become a powerful basis for the formation of a normative standard of the 'quality' office. Table 3 provides a summary of the key features of the BCO guidelines and the technical definitions of 'quality' provision provided.

As a result of its basis in the BCO guidelines, the normative standard has a more technical form than the previously discussed cultural standard. Particularly significant are standards relating to: occupational density (how many people the building can accommodate); cooling provision (capacity being defined by models of heat gain and cooling 'needed' to maintain temperatures within defined parameters); small power (the availability of electrical circuitry to power equipment, from computers to fridges); lift provision (a calculation taking account of density and defined maximum wait times for a lift); and airflow (litres of air, per minute per occupant). Most important for our argument here is the way that the BCO guidance has created clear understandings of what *ought* to be provided, and what performance levels *ought* be achieved. Hence interviewees made comments such as "it tends to be the BCO criteria is where we start" (Architect, case study 8), and "We base everything on the BCO guide and for any development we do that's the base" (Letting Agent, case study 8), this indicating the power of the normative standard in terms of defining what is on the 'wish list' of developers and letting agents.

Table 2. Key actors in the field of commercial office design and their understanding of the cultural standard of the marketable office.

Actor in building design	**Understanding of Grade A , or key component of it**
Architects	"reception spaces might be double height to get more light in but, and create a feeling of space and quality…modern buildings we're looking at the majority of them have a highly glazed, penthouse upper floor, terraces that kind of thing…starting point is four pipe fan coil, suspended ceilings, that's what the city wants, that's what we should be giving them. Maximum flexibility so it can be a cellular or open plan space layout, the façade on 1500 grid and you have these kind of set rules" (Architect, case study 8) "an image for the building I suppose, making it marketable…Once you're inside a standard spec A, Grade A office space that you let on the market has got white ceilings, raised access floors, white walls" (Architect, case study 3) "developers still like full to ceiling glass, they really are wedded to it" (Architect, case study 1)
Letting Agent	"central plants installed, all the services, on floor services, mechanical services in the ceiling. It would be air conditioned and there could be a number of different systems. You would have your suspended ceiling with recessed lighting and you would have your full accessible raised floor installed on the floor" (Letting Agent, case study 8)
Marketing	"Typically, office buildings within this bracket are brand new or have been recently redeveloped/experienced a thorough refurbishment within the last 15 years. They will be finished in order to compete for premier office users and will usually demand rents that are above average for the area … Full complement specification to contain: Raised floors and suspended ceilings … Lift … Air conditioning or similar" (http://www.yorkmeansbusiness.co.uk/media/33765/definitions_of_office_grades.pdf)
Owners/building managers	"Most prestigious buildings competing for premier office users with rents above average for the area. Buildings have high quality standard finishes, state of the art systems, exceptional accessibility and a definite market presence." Owners and Manager Association International (2015),

Table3: Summary of key components of the BCO Guide to office specification, which are the basis for the normative standard of the acceptable office

Key Parameters	Key elements of Guide 2014 specification
Occupational densities	1 person per 8m2- 13m2
Lifts	Lifts: Waiting time – up – peak: < 25 seconds; Time to destination: <90 seconds – up to 15 floors
Raised Floors	100mm: typical floors / refurbishment 300-500mm (trading floors)
Thermal Criteria	Mixed mode & Naturally ventilated offices: Summer: Not to exceed 25ºC for more than 5% of occupied hours. Not to exceed 28ºC for more than 1% of occupied hours Winter: 20ºC (±2ºC)
Fresh air standard (litres/sec/person)	12-15 l/s/person (It is recommended that at least 10% more air is added to account for meeting rooms and areas of high occupation density)
Lighting Standards (Office minimum average maintained illuminance VDT use / Paper based tasks / Task uniformity)	Average maintained illuminance: -VDU/general use: 300-500 lux; paper based tasks: 500 lux. Electrical load allowance: 10W/m2 (including task lighting and Cat B allowance). Lighting energy use: 12-22kWhr/ m2
Small power consumption	Small power: 20-25W/m2 (on floor distribution). For an area 1000m2, 13-15W/m2 (diversified load).

Source: taken from BCO (2014)

Together, the cultural standard of the marketable office and the normative standard of the 'quality' office interlock to powerfully shape designs, somewhat ironically as far as the intentions of the BCO are concerned in ways that lead to higher rather than lower levels of provision. In particular, the cultural and normative standards operate together as part of the institutional regime affecting commercial office design to promote certain technologies and not others. Thus, whilst it is analytically useful to draw attention to the two standards and their distinctions, in practice their effects are inter-mingled. Hence below as we consider in more detail the effects of market standards we draw attention both to distinctions between cultural and normative standards but also the interlocking and overall impacts on design.

Standardised and institutionalised

Market standards powerfully structure both design decisions and the assessment of designs. Interviewees confirmed this when they made observations such as the following: "You wouldn't design a building to less than BCO standards… it's a huge cross if your building doesn't meet BCO standards" (Engineer, case study 8) and "I can't be too bothered to go and challenge the establishment" (Developer, case study 4). Market standards act, then, as powerful elements of the institutional environment of the field of commercial office design and constrain the agency of office designers, creating structured parameters within which they must work. Hence:

> "Yes there is an explicit request from agents, they're like 'buildings with floor to ceiling glass will let better, you'll get higher rent for them, you'll get prestige', [so] that's what you do. And so that's what, in their mind that's what sells…Sometimes we have the backbone, as a client, to say we don't think that's appropriate in this location, but I can definitely tell you most of the time we don't, we just go ok and we pass that brief on to our architects" (Developer, exploratory interview)

As a result, "any consultant will move from them [market standards] at their peril" (Letting Agent, exploratory interview). Such effects correspond with the normative pressures that have been well-documented in research on institutions (DiMaggio and Powell, 1983). These as already noted relate to understandings of 'quality', compliance guaranteeing for those designing an office acceptance and legitimacy, given the focus on producing marketable buildings. net result is what is commonly referred to as the 'plain vanilla' office design; this being an office design that conforms to market standards, and because of the structuring effects of the standards, has a tendency to be somewhat formulaic. What, then, are the implications of such structuring effects of the characteristics of office designs, and on the incorporation of low energy technologies especially?

The standards-practice disconnect

Standards as part of the institutional environment of the field of commercial office design, exist as they do more generally (see Bowker and Star, 2000; Stinchcombe, 2001), to address the difficulties of handling all of the complexities associated with design processes. Hence there is a requirement for tools that simplify. In the case of offices, a key form of complexity driving the use of standards is the already mentioned unknown occupant problem. Tools are required that allow the design of an office that meets the 'needs' of a broad range of potential occupiers. Hence one interviewee, among many others, described market standards as helpful:

> "We use the BCO guide to specification…So I have a copy on my desk and when I sit down with architects we'll thumb through it from time to time and if we're particularly stuck on what we should be doing" (Letting Agent, case study 1)

Market standards do, however, as part of their role in simplifying complexity, 'black-box' (Latour 1999) many aspects of building design, and in particular relationships between the office work practices of future occupants and design. This aligns with what Hogle (2009) refers to as the 'objectivity' of standards. In dealing with uncertainty, standards become the focus of attention, rather than the object that is ultimately of concern: this being occupiers and their practices in the case of offices. As one interviewee articulated:

> "people go by those standards and I think most of the time they don't really know what they mean. It's a kind of a bit of a catch all…"you're not looking at what it means and you're not necessarily thinking 'but is some of that relevant to what you want? Is there something else better than that?' (Occupier, case study 4).

Market standards thus break the recursive relationship between technological change and social practice that is recognised in the existing literatures to be crucial. Specifically, technologies have been shown to co-evolve with the social in an inseparable two-way relationship (Bijker, 1995; Shove and Walker, 2010) as part of socio-technical regimes (Rip and Kemp, 1998). Market standards threaten to inhibit such co-evolution. They do this in

particular by reducing the input of 'experts' such as architects and building service engineers, and their ability to use their judgement when making decisions about the design specifications 'needed' to cater for office work practices in any particular building. Through their 'objectivity', market standards render experts' judgement as important in meeting standards, but not in interpreting fundamental questions of 'need' through knowledge of office work practices. This implies that those designing offices substitute an understanding of office work practice with an adherence to standards. As Stinchcombe (2001: 34) suggests, this is possible because "a gap in one's own abstractions [can] be filled by others' competent formal government, without having to go behind the certificate". Or, put another way, trust is placed in the standard as a sufficient substitute for knowledge of the object it represents (office work practices and hence provision and performance 'needs'). This leads, as a result of the institutional effects in the field described above, to slavish adherence to the standards; not only are there penalties for not adhering to the standards, but a lack of knowledge makes not following the standard impossible. But why does this matter?

Over-provision and performance

Market standards can lead to provision that exceeds the demands of the actual work practices of most office occupants most of the time. For instance, in our research all of the buildings studied were designed to be able to accommodate people at a density of 1 person per 10 metres square or denser. This conforms to the BCO standard. But the BCO's own research shows that 92% of buildings are actually occupied below this level (see BCO, 2013). This means buildings are being designed, for instance, to provide volumes of fresh cool air that is not essential at real life occupational densities. Indeed, in one case an interviewee noted a scenario in which such over provision became manifestly obvious (not in energy terms, but the implications for energy are clear in terms of excessive consumption):

> "the whole building was 1:10 but the fifth floor in particular you could fit 39 people on there if you did it 1:10. There are only seven people that are based there…So there were issues, they had originally because they were too cold because they had too much air coming in...it was quite weird in the summer time they were heating the space because the air was too cold coming in…So everything is lower, your small power loads are less, your lighting loads are going to be less, your occupancy load is going to be less, all that's going to be less" (Engineer, case study 2)

This dilemma relates to the above noted role of standards as tools for dealing with the unknown user problem. Indeed, it suggests that standards may in many cases be tools that lead to the over provisioning the BCO originally sought to avoid. This issue is exaggerated further by the way that, as a result of a lack of knowledge of who will occupy a building and what is sufficient to support their work practices, and because of the imperative for a building to compete for tenants in property markets, designing-in provision and performance that exceeds market standards is increasingly common. For instance, one interviewee noted how "[Developer x] are BCO+" (Architect, case study 9), this referring to the specification of BCO defined levels of provision and performance plus an extra allowance (often 10%). Others observed that

> "it tends to be BCO and add a bit. And then it's partly driven by agents and partly driven by tenants and then developers trying to predict the future, is how much do you add and where do you add it?" (Developer, case study 4)

> "We always design so the building can be operated slightly better than the average on all of that… We definitely talk about [our properties?] they're better than, they beat the BCO guide, better than the BCO guide" (Developer, exploratory interview)

The question raised in the first quotation about 'how much to add' is pertinent. When adopting an exceedance strategy, because of the black-boxing effect of standards, it is unclear as to why exceedance is beneficial, or how much might be beneficial for those occupying the office. Hence as two interviewees noted:

> "in actual fact representing your client you're probably perceived to be doing them a disservice if you're not screwing as much out of the selling party as possible. And in those terms 600 [lux of lighting] is better than 500, even if you don't need it" (Architect, case study 1)

> "you've got a potential client and you can say oh but we've got extra air, it's a better quality, it's a better environment, your workers will be not falling asleep and that kind of thing. And they may choose you over another building which has only got the bare minimum" (Engineer, case study 2)

At one level, the link between standards, design, and the incorporation of low energy technologies is, then, simple. By defining and homogenising levels of provision in offices, market standards lead to a certain amount of energy use being designed-in. This reflects the well-documented story of air conditioning and thermal comfort standards (Cooper, 1998; Walker et al., 2014) but also applies to the way standards demand levels of glazing, lighting, small power, fresh air and other aspects of provision associated with normative 'quality' and cultural models of 'need'. Specifically, once an office, due to pressures invoked by standards, has to be designed to enable a particular level of occupancy, with a particular level of small power and fresh air provision for each occupant, and to maintain thermal conditions within particular ranges, with culturally acceptable levels of glazing, atrium and other provision, then certain levels of energy demand are inscribed because of the systems that will be installed and run on a daily basis, whether the occupants want to use them.

As already noted, there are genuine questions about the way understandings of 'need' are constructed by market standards. Market standards move beyond what might be seen as a basic definition of 'need' in offices – i.e., the provision of a space which enables work by not exposing occupants to harm and sheltering them from the external environment. It does this in normative ways by technically specifying 'need' in terms of level of provision, which is arguably excessive for many occupiers. It also does this in cultural ways by defining what is 'needed' aesthetically to generate a pleasant environment. Cutting across both the normative and cultural constructions of 'need' are ideas about comfortable, convenient (Shove, 2003), and efficient and productive space (O'Neill and McGuirk, 2003).

Othering technologies

The effects of standards on the legitimacy of lower energy technologies emerge as a result of the 'work' described above. Normative standards and their technical definition of 'quality' are often difficult to achieve using systems such as heat pumps, displacement or natural ventilation, or chilled beams or ceilings, especially when the approach of providing 'more of what is standard' prevails. However, if the requirements of these standards are relaxed just a little - e.g. in terms of thermal comfort regimes and assumptions of occupational density -

these lower energy options become perfectly viable strategies. As one interviewee summarised:

> "What is a constant battle with district heating, which I go on and on about, it's that building service engineers always tend to over-estimate the energy they need. And so the district, and if you designed a network to support all those energy needs that are predicted it would never work commercially because you'd have to put far too much plant in" (Engineer, case study 7)

Hence, if lower energy technologies are to be incorporated into designs "the first step is get an acceptance that you can do something lesser as a base provision" (Engineer, case study 10). However, as already noted, the policing of standards within the field of commercial office design makes such concessions difficult, if not in most cases impossible to achieve. This means that at an early stage systems such as displacement ventilation get written-off as not able to deliver normative standards of the acceptable office. One interviewee complained about how:

> "their understanding of a new building is everyone's got their own air conditioning, everyone's got their own kitchen…But some of the people's faces, their jaws were dropping when I was saying that we're going to have a commitment to not heat or cool the building between 19c and 24c. They were like hang on a minute we're normally switching the air conditioning on at 21c. You can't do that" (Occupier, case study 4)

Underlying this is the way specific technologies also become taken for granted and locked-in as a result of the effects of market standards. In the case of offices the four pipe fan coil air conditioning system has become so tightly associated with the cultural model of the marketable office that when this system is absent an office design is viewed as illegitimate, particularly by developers and letting agents. As interviewees observed:

> "So the fan coil unit is great in the sense that it allows you to cater for any market, but it's the lowest common denominator … So the standard approach would be to achieve quite a high cooling load uniformly across the floor plate, which involves just doing a grid of fan coil units all the way across over there" (Architect, case study 10)

> "I've heard it said before that even though the fan coil isn't a particularly great technology it is a universal one and it's widely understood…it's always the unthinking choice and everybody understands it…So they're … understandably more comfortable with something that's very recognisable. And it has almost become an industry default standard" (Architect, case study 1)

Hence one interviewee noted that: "moving away from fully air conditioned buildings [is possible]…There are lots of clever techniques that can be used which are hardly ever adopted" (Architect, case study 2). But the lack of 'free choice' noted by the interviewee speaks to the argument made above about the powerful effects of market standards as part of the institutional environment of the field of commercial office design. Market standards result in known and viable low energy technologies being viewed as normatively sub-standard and culturally inappropriate in ways that limit the ability of commercial office designers to include them, despite their energy demand reducing benefits.

Conclusions

The contribution of the paper is to highlight the importance of further advancing understanding of the role of standards in design, and specifically in relation to the incorporation of low energy technologies into commercial office designs. Whilst the existing literature acknowledges the significance of standards in design (Bowker and Star, 2000; Imrie, 2004, 2007; Timmermans and Epstein, 2010) further exploration of the form and 'work' of standards is required to fully understand effects and their causes. This paper has made two important advances.

First, in identifying the role of market standards the paper demonstrates the importance of moving beyond a focus on what Timmermans and Epstein (2010: 72) call design standards, i.e., standards concerned with technical issues of compatibility, such standards often being policed through regulations and being formally codified. In particular our analysis adds the additional category of market standards. Such standards construct understandings of 'need' and in the process help define a 'quality' and legitimate office design that is marketable, i.e., sellable to potential occupiers and valued by investors and developers. Market standards are, then, distinct from design standards and other categories of standards highlighted by Timermans and Epstein (2010). They co-exist and in part draw upon such standards to define what is 'needed' and thus non-negotiable in the market.

Relatedly, and in line with institutional perspectives (Scott, 2008; Markard and Truffer, 2006), the power of social and cultural pressures for conformity as policing mechanisms has been elucidated. Normative and cultural market standards lead to what Thévenot (2009: 795) calls "the 'quietude' of conforming" whereby compliance with market standards is selected as the route of least resistance. In the world of commercial offices this means the adoption of incumbent technologies; the risk of disproval or illegitimacy if standards are not adhered to making incumbent technologies legitimate and low risk. This matters because the transgression of standards is required for change and the incorporation of low energy technologies. Hence those seeking to incorporate low energy technologies face the question "what does it mean to be nonstandard in a world where standards reign?" (Timmermans and Epstein, 2010: 70). As such, the social field of commercial office design as a community of interacting professionals is an important unit of analysis and concern, given the way powerful social and cultural standards within the field govern the agency of designers and effect technology choices.

Second, we have demonstrated that market standards matter because of two important forms of 'work' that they do in design processes. It is well recognised in the existing literature (Bowker and Star, 2000; Stinchcombe, 2001) that institutions, and standards as part of them, enable the reduction of complexity. We have shown here that in the case of commercial offices, reducing complexity by shifting attention onto standards and away from office occupiers and their diversity results in standardised over-provision and a failure to appreciate how constant evolutions in office work practices might be reflected in, for example, lower levels of provision through alternative technologies. This means standards replace important elements of expert knowledge. Knowledge of standards becomes more important that knowledge of what standards claim to represent. In our case this relates to diminishing knowledge of office work practices.

The black-boxing of office work practices and in turn the reification of 'need' by market standards results in existing technologies being held in place thanks to their legitimisation, and alternative, in our case low energy technologies' simultaneous de-

legitimisation. Malerba (2002: 251) argues that ”institutions, such as standards” are a crucial consideration in studies of technology and the way it changes. Indeed, for Werle (1998: 13-14) institutions provide a frame “that attributes meaning to a technical artefact. They also “supply a criteria to evaluate different positions”. Here we have demonstrated that market standards play a crucial role in such institutional work. Normative and cultural standards have been shown to operate in ways that lead respectively to technical and material-aesthetic understandings of ‘quality’ and’ needed’ provision and performance. This results in existing technologies being socially sanctioned within the field of commercial office design because of their ability to deliver what is defined as ‘needed’. At the same time lower energy technologies are viewed with disdain and deemed illegitimate because of their failure to conform with what market standards define as ‘quality’ and ‘needed’ provision and performance. This legitimisation-de-legitimisation nexus results in a reduction in the agency of office design professionals, hemming-in those seeking to incorporate low energy technologies because of the aforementioned difficulties associated with nonstandard design.

Acknowledgements

The research reported in this paper was completed as part of the DEMAND Centre programme, funded by the UK Research Council’s Energy Programme through the EPSRC, award P/K011723/1

References

ACE (2000)
Allen, R. H. & Sriram, R. D. (2000) 'The role of standards in innovation', *Technological Forecasting and Social Change,* 64, 171-81.
BCO (2013) *Occupier Density Study*. London, The British Council for Offices.
BCO (2014) *BCO Guide to Specification*. Lonodn, The British Council for Offices.
Bijker Wiebe, E. (1995) 'Of bicycles, bakelites, and bulbs: towards a theory of socio-technical change', MIT Press.
Bowker, G. C. & Star, S. L. (2000) *Sorting things out: Classification and its consequences,* Cambridge, Massachusetts, MIT press.
Bunz, K. R., Henze, G. P. & Tiller, D. K. (2006) 'Survey of sustainable building design practices in North America, Europe, and Asia', *Journal of architectural engineering,* 12, 33-62.
Busch, L. (2000) 'The moral economy of grades and standards', *Journal of Rural Studies,* 16, 273-83.
Cooper, G. (1998) *Air-conditioning America,* London, John Hopkins University Press.
Deloitte. (2014)
Dimaggio, P. J. & Powell, W. W. (1983) 'The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields', *American sociological review,* 48, 147-60.
Guy, S. (1998) 'Developing alternatives. Energy, offices and the environment', *International Journal of Urban and Regional Research,* 22, 264-82.
Guy, S. & Henneberry, J. (2000) 'Understanding urban development processes: integrating the economic and the social in property research', *Urban studies,* 37, 2399-416.
Guy, S. & Moore, S. (2007) 'Sustainable Architecture and the Pluralist Imagination', *Journal of Architectural Education,* 60, 15-23.
Hamza, N. & Greenwood, D. (2009) 'Energy conservation regulations: impacts on design and procurement of low energy buildings', *Building and environment,* 44, 929-36.
Hitchings, R. (2010) 'Seasonal climate change and the indoor city worker', *Transactions of the Institute of British Geographers,* 35, 282-98.
HM Government (2013) *'Conservation of fuel and power - Approved Document L2A, L2A Conservation of fuel and power in new buildings other than dwellings*', HM Government, London.

Hogle, L. F. (2009) 'Pragmatic objectivity and the standardization of engineered tissues', *Social Studies of Science,* 39, 717-42.
Imrie, R. (2004) 'The role of the building regulations in achieving housing quality', *Environment and Planning B,* 31, 419-38.
Imrie, R. (2007) 'The interrelationships between building regulations and architects' practices', *Environment and Planning B: Planning and Design,* 34, 925-43.
Latour, B. (1999) *Pandora's hope: essays on the reality of science studies,* Boston, MA, Harvard University Press.
Mackenzie, D. (1990) *Inventing accuracy,* Cambridge, MA, MIT Press.
Malerba, F. (2002) 'Sectoral systems of innovation and production', *Research policy,* 31, 247-64.
Markard, J. & Truffer, B. (2006) 'Innovation processes in large technical systems: Market liberalization as a driver for radical change?', *Research Policy,* 35, 609-25.
O'neill, P. M. & Mcguirk, P. (2003) 'Reconfiguring the CBD: work and discourses of design in Syndey's office space', *Urban Studies,* 40, 1751-67.
Pan, W. & Garmston, H. (2012) 'Building regulations in energy efficiency: Compliance in England and Wales', *Energy Policy,* 45, 594-605.
Pinder, J., Iii, R. S. & Saker, J. (2013) 'Stakeholder perspectives on developing more adaptable buildings', *Construction Management and Economics,* 31, 440-59.
Polanyi, M. (1966) *The Tacit Dimension,* London, Routledge & Kaufman Paul.
Rip, A. & Kemp, R. (1998) 'Technological change', *Human choice and climate change,* 2, 327-99.
Schmidt, S. & Werle, R. (1992) 'The development of compatibility standards in telecommu- nications: Conceptual framework and theoretical perspective', In Dierkes, M. & Hoffmann, U. (eds) *New technology at the outset: Social forces in the shaping of technological innovations.* New York, Campus Verlag.
Scott, W. R. (1994) 'Conceptualizing organizational fields: Linking organizations and societal systems', In Derlien, J., Gerhardt, U. & Scharpf, F. (eds) *Systems rationality and parcial interests.* Baden, Nomos.
Scott, W. R. (2008) *Institutions and organizations. Ideas and interests,* London, Sage.
Shove, E. (2003) *Comfort, cleanliness and convenience: the social organization of normality,* Oxford & New York, Berg publishers.
Shove, E., Pantzar, M. & Watson, M. (2012) *The dynamics of social practice. Everyday life and how it changes,* London, Sage.
Shove, E. & Walker, G. (2010) 'Governing transitions in the sustainability of everyday life', *Research policy,* 39, 471-76.
Stinchcombe, A. L. (2001) *When formality works: Authority and abstraction in law and organizations,* Chicago, University of Chicago Press.
Thévenot, L. (2009) 'Postscript to the Special Issue: Governing Life by Standards A View from Engagements', *Social Studies of Science,* 39, 793-813.
Timmermans, S. & Almeling, R. (2009) 'Objectification, standardization, and commodification in health care: a conceptual readjustment', *Social Science & Medicine,* 69, 21-27.
Timmermans, S. & Epstein, S. (2010) 'A world of standards but not a standard world: toward a sociology of standards and standardization*', *Annual review of Sociology,* 36, 69-89.
Van De Wetering, J. & Wyatt, P. (2011) 'Office sustainability: occupier perceptions and implementation of policy', *Journal of European Real Estate Research,* 4, 29-47.
Wade, J., Pett, J., Ramsay, L. & House, W. (2003) 'Energy efficiency in offices: assessing the situation', *London: Association for the Conservation of Energy*.
Walker, G., Karvonen, A. & Guy, S. (2015) 'Zero carbon homes and zero carbon living: sociomaterial interdependencies in carbon governance', *Transactions of the Institute of British Geographers,* 40, 494-506.
Walker, G., Shove, E. & Brown, S. (2014) 'How does air conditioning become 'needed'? A case study of routes, rationales and dynamics', *Energy Research & Social Science,* 4, 1-9.
Werle, R. (1998) 'An institutional approach to technology', *Science Studies,* 11, 3-18.