

Energy-related standards and UK speculative office development

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Abstract

Non-domestic buildings have great potential for energy-related emission reductions in response to climate change. However, high specification office buildings in the UK demonstrate that regulation, assessment and certification ('standards') have not incentivised the development of lower energy office buildings as expected. Making use of the concepts of 'qualculation' and 'calculative agency', qualitative case studies of 10 speculatively developed office buildings in London, UK provide new insight into why this is the case. Interview data (n = 57) are used to illustrate how 'market standards' substitute for user needs, and ratchet up the provision of building services to competitively maximise marketability. The examples of energy modelling and the market's (mis)use of British Council for Offices guidelines are used to explain how such standards perversely bolster energy-demanding levels of specification and building services, and militate against lower energy design, in the sector researched. The potentials for alternative, performance-based standards and new industry norms of quality are discussed. It is concluded that at least the London speculative office market by its very constitution and operation, including the reliance on standards, continues to create increasingly energy-demanding buildings.

Keywords

energy, design, low-energy buildings, markets, offices, performance-based specification, property market, qualculation, specification, standards

Introduction

In the context of the UK's Climate Change Act 2008 commitment to reduce greenhouse gas (GHG) emissions by at least 80% from a 1990 baseline by 2050 (HM Government, 2008), the decarbonisation of all sectors of the economy and society is a pressing task. Energy use in buildings is estimated to account for 42% (Skea, 2012), with commercial sector buildings responsible for 8% (Committee on Climate Change, 2016), of the UK's greenhouse gas emissions. This paper reports on research on a particular subset of non-domestic commercial sector buildings; 'Grade A' speculatively developed offices built or refurbished in London 2010-15. Commercial office space is estimated to be growing twice as fast as other non-domestic sectors (Green Construction Board, 2013), and its energy use and emissions are therefore especially significant.

In the commercial office sector, attention has been drawn to the 'unnecessarily' high energy demands (compared to known alternatives) and therefore environmental impacts, of offices built to what is described as an institutional specification (Guy, 1998), investment quality (Guertler, Pett, & Kaplan, 2005), or more simply over-specification (Pinder, Schmidt, & Saker, 2013; Van de Wetering & Wyatt, 2011; Wade, Pett, & Ramsay, 2003). In the UK's dominant mode of *speculative* office building development (Deloitte Real Estate, 2014; Pellegrini-Masini & Leishman, 2011), where buildings are built in advance of securing tenants, such buildings have historically been "over-specified in order to make them more attractive to institutional investors [and] ... easier to let to suitable tenants." (Van de Wetering and Wyatt, 2011, pp. 32) This has particularly required the 'over-specifying' of

"small-power provision and comfort cooling services ... promoted by property agents ... even though the specification did not bear any resemblance to what most occupiers actually needed from their office buildings ... This misguided attempt at designing in redundancy ... resulted in more expensive and more energy intensive office buildings" (Pinder et al., 2013, p. 442; see also Guy, 1998, pp. 268-271).

The subsector of prime or 'Grade A' office buildings therefore holds great technical potential (Moezzi & Janda, 2014) for energy or carbon savings.

In the UK a number of different regulatory and voluntary assessments of office buildings (guidelines, labelling and certification schemes) operate as energy efficiency or performance 'standards' in that they define acceptable, expected, normal, legitimate and uniform features and performance of buildings (Faulconbridge, Cass, & Connaughton, 2017). These include building regulations and Building Environmental Assessment Mechanisms (BEAMs: see Cole, 2005; Goulden, Erell, Garb, & Pearlmutter, 2015), analysis of which has focused "on technical features and building performance, with little emphasis on the questions of how and why they are used in practice" (Goulden et al., 2015, pp. 1-2; Schweber, 2013). Together their use standardises office designs, enabling the comparison of buildings as products in a market.

This is particularly the case in speculative development, where standards (of various types) are classically used to provide for unknown users, just as they enable markets to operate by providing standard and homogeneous commodities (Carruthers & Stinchcombe, 1999; Timmermans & Epstein, 2010). Given that several such 'standards' were intended to put a ceiling on energy-intensive quality specifications (British Council for Offices guidance: BCO), energy waste (Energy Performance Certificates: EPCs) and unsustainability and carbon emissions (Building Research Establishment Environmental Assessment Method: BREEAM), this paper considers how it is that such 'standards' do not deliver low energy office buildings.

This involves moving beyond narrow economic understandings of standards/labels as unambiguous market signals. Here it is proposed that qual/calculation (Callon & Law, 2005; Callon & Muniesa, 2005; Cochoy, 2002) is used as a way of thinking about a) the *role* of standards within a market environment, subsuming judgements and calculations of value, price etc., and b) 'calculative agency' as the ability to define which features of a product are paramount in the market.

From this perspective, the key questions are about how standards are used, 'perform', and make market exchanges possible. These questions were explored, empirically, in case studies of 10 London offices and semi-structured interviews with 57 actors in the buildings' design teams and the wider speculative development world. The results illustrate how processes of calculation in action have the perverse effect of escalating rather than containing energy demand, at least in the speculative office development market in London.

(Not) delivering speculatively built lower energy offices

Better understanding of the energy efficiency of specifically *commercial* office buildings has previously been identified as a research gap (C. Axon, S. Bright, T. J. Dixon, K. Janda, & M. Kolokotroni, 2012; Nicholls, 2014; Oreszczyn & Lowe, 2009), although recent studies have contributed much to knowledge, focussing particularly on benchmarking (Hsu, 2014), the performance gap (Cohen & Bordass, 2015; De Wilde, 2014; Fedoruk, Cole, Robinson, & Cayuela, 2015; Lewry, 2015; van Dronkelaar, Dowson, Spataru, & Mumovic, 2016), the accuracy of building assessment methods (see below), effects on rent and sale values (Kontokosta, 2013) and behavioural influences and interventions (Hong & Lin, 2014; Mulville, Jones, Huebner, & Powell-Greig, 2016; Tetlow, van Dronkelaar, Beaman, Elmualim, & Couling, 2015).

To justify the selection of the case study buildings, Schiellerup and Gwilliam (2009) suggest the commercial property market is:

“an important test case for society's capacity for change in the face of the challenges of climate change if for no other reason than the enormous economic value embodied in it and the comparatively large potential for savings.” (p. 812)

London contains 26% of the UK's office floor space and 48% of its rateable value (Guertler et al., 2005). The London office market has its unique features, particularly the City of London sub-market (Lizieri, Baum, & Scott, 2000), very short leases, and the high stress on exchange rather than use

value in comparison to European design (Guy, 1998). However in terms of the internationalisation of building design and development practices (Falconbridge & Grubbauer, 2015; MacLaran, 2014) and of real estate values over longer timescales, London office markets have been seen to function similarly to other global cities (Hendershott, Lizieri, & Matysiak, 1999), making it a suitable sample to study. Other studies of energy performance and standards have similarly compared across global samples (Cole & Jose Valdebenito, 2013; Roderick, McEwan, Wheatley, & Alonso, 2009). The findings presented apply specifically to the London sample and context, but the specific analysis of the processes of operation of a Grade A office building speculative development market could be generalizable to other comparable global cities. This confirmation is beyond the purview of the paper.

In looking at the failure to deliver lower energy offices it must be acknowledged that “[w]hat constitutes a lower energy office, given a widely variable office typology, is not easily defined” (Guertler et al., 2005, p. 295). This paper defines a lower energy office as one designed to minimise the amount of energy required in normal operation. This is not to deny the existence or importance of the ‘performance gap’ (Fedoruk et al., 2015) as an explanation of how energy performance can fail to manifest. It is clearly important that many energy demanding processes are unregulated, and that the ways in which tenants occupy buildings can be responsible for much energy use (Arup, 2013; Fedoruk et al., 2015; A. C. Menezes, Cripps, Bouchlaghem, & Buswell, 2012) Instead it is important to push similar enquiries into the design processes. Certain aspects of lower energy offices are known and identifiable, including for example form, structural features, and servicing arrangements that favour passive design and therefore allow passive or natural rather than mechanical Heating, Ventilation and Air-Conditioning (HVAC) (Bordass, 2000). As an example displacement ventilation supplanted at perimeters could provide lower energy cooling whilst satisfying the sub-sector’s demand for fresh air volumes for productivity and well-being (Seppänen, Fisk, & Lei, 2006). Numerous institutions issue guidelines on prioritising low-energy features in design (Energy Efficiency Office, 2000; RIBA, 2009; Wade, Pett, Ramsay, & House, 2003; Westminster

Sustainable Business Forum & Carbon Connect, 2013). However, taken together such features also including narrow and shallow floor-plates and high ceilings have been described as reflecting a (Northern) European genre of office design based on 'use' value and known user needs backed by regulation, rather than an Anglo-Saxon or American mode focussed on 'exchange value' and unknown future user needs (Duffy & Powell, 1997; Guy, 1998) dominant in the UK.

The origins of the various formal standards used in the UK are evidence of attempts to use regulation and market signals to incentivise the construction of more energy efficient buildings. The rationales for, and effects of the use of voluntary or market-based instruments *per se* is not the focus here, but has been analysed elsewhere (Van der Heijden, 2016). BREEAM is a credits-based voluntary certification scheme of broad 'sustainability' rather than energy performance, with 'Energy' being one category of 9 in which buildings can score assessment credits. However since its inception in 1990 it has been used successfully to convey 'green' value on buildings (Schiellerup & Gwilliam, 2009). Arising from a, now fully privatised, quasi-autonomous non-governmental organisation, the Buildings Research Establishment, its use has successfully internationalised from the UK to the world (Cole & Jose Valdebenito, 2013). EPCs are a UK specific regulatory requirement of rating the *modelled* energy efficiency of a building, and provided the UK's compliance with the EU's European Energy Performance of Buildings Directives of 2002 and 2010 (Economidou, 2012), although they do not set absolute performance targets, instead relying on modelled comparisons with a 'reference' building, in a similar way to the UK's mandatory energy efficiency building regulation, 'Part L' or properly Part L2A of the Building Regulations 2010. Their role is being transformed from a rating to a benchmark (i.e. legal minimum) standard, as from 2018 buildings must score A-F to be rented or sold. 'Part L' addresses the 'conservation of fuel and power in new buildings other than dwellings' (HM Government, 2013), and requires demonstrated improvements on the performance of a modelled building against a reference (Raslan & Davies, 2010). Increasing expectations of improvements mean the regulation should act as a ratchet of increased performance. The BCO's guidelines on office specification differ in their origin as 'trade organisation'

of office building developers whose interest is primarily in issues of quality benchmarking, to ensure comparability of products that achieve compliance. It has no specific energy focus, but was instituted to avoid an 'arms race' in energy demanding 'prime' specifications, as explained by an interviewee: *"something was needed to stop this ridiculous Dutch auction where more was always better even when manifestly it wasn't"* (Consultant).

The question that this paper seeks to address then is why, given that the efficacy and desirability of known features of a lower energy office buildings are enshrined in governmental and professional advice (as well as the suite of 'standards' explored here), have they not been more widely incorporated?

One explanation focuses on a 'cycle of blame' (Bordass, 2000) in which investors, developers, designers, landlords and tenants are *all* said to be dis-incentivised from producing energy efficient buildings by the lack of demand from the other actors. The commercial property world seems to subscribe to a model (Brown, Malmqvist, & Wintzell, 2016) in which markets provide information and choices amongst alternatives, and policy assists such decision making through "building codes and engineering standards, information and technical assistance, and financial incentives" (Biggart & Lutzenhiser, 2007, p. 1077). In short, the paucity of low energy offices is taken to be an example of market correction failure. The correctives prescribed are better pricing and valuing, and establishing a premium for energy efficient buildings; in the UK, primarily through using BREEAM as an indication of 'greenness' (Bordass, 2000; Schiellerup & Gwilliam, 2009). EPC ratings were also intended to fulfil a similar function as they "allow a differentiation in the market in terms of the energy performance of buildings ... address an information market failure and therefore permit ... the integration of energy performance into the market for buildings" (Schiellerup & Gwilliam, 2009, p. 802).

Another potential explanation is then that investors and developers might see no financial incentive to do so, as 'customers' (i.e. building investors, managers and tenants) might not pay a 'green premium' or avoid a 'grey discount' (De Jong & Parkinson, 2013; Elliott, Bull, & Mallaburn, 2015;

Kontokosta, 2013; Oyedokun, Jones, & Dunse, 2015; Surmann, Brunauer, & Bienert, 2015). The link between energy efficiency or green certification and higher rents is however taken-for-granted in the industry and evidenced as 'willingness to pay' for a certified 'eco-label' (Fuerst & van de Wetering, 2015). Such forms of green certification have indeed been found globally to correlate with a (small) rental price premium (Franz Fuerst & Patrick McAllister, 2011a; Wiley, Benefield, & Johnson, 2010) used to support this model (C. J. Axon, S. J. Bright, T. J. Dixon, K. B. Janda, & M. Kolokotroni, 2012; Fuerst, van de Wetering, & Wyatt, 2013). This willingness to pay is potentially self-fulfilling, with the most recent meta-analysis of US data (Fuerst, Gabrieli, & McAllister, 2017) finding that 'eco-investors' pay the most for environmentally certified properties. It might also be self-correcting, as its mainstreaming reduces the differentiation value (Chegut, Eichholtz, & Kok, 2013). These two qualities display that the market is 'performative', that is to say, the world of 'green building value' is brought into being through the enacting (and study) of this market differentiation (Callon, 2007). The existence of a 'green premium' linked specifically to EPCs and BREEAM certification in the UK has however been questioned (Fuerst & McAllister, 2008), and in the absence of performance data being required in certification, the premiums identified may not reflect performance as "the presence of an environmental label and superior environmental performance are not necessarily synonymous" (Franz Fuerst & Pat McAllister, 2011, 1220).

However, actual energy consumption of office buildings has been found to vary significantly across all EPC ratings of buildings in the UK (Better Buildings Partnership, 2012) and Leadership in Energy and Environmental Design (LEED) certified buildings abroad (Newsham, Mancini, & Birt, 2009). It has also been suggested that using such voluntary 'green labels' as LEED/BREEAM is strongly correlated with already high value buildings, meaning that the 'added value' or price signals conferred by such assessments and badging exercises are confounded and do not incentivise low energy buildings (Chegut et al., 2013; Franz Fuerst & Patrick McAllister, 2011b). Although common in business and policy, this economic framing of standards and labels as effective and unambiguous price signals represents a narrow understanding of how standards function in society and in markets

(Timmermans & Epstein, 2010), and how they are situated in a landscape of cultural, market, institutional, technical, and organisational influences that bear on this specific regime of speculative office building design and servicing. The multi-level perspective of socio-technical transitions (Gertz, 2005; Markard, Raven, & Truffer, 2012) is one alternative framing through which to view the mainstreaming of a 'niche' market such as low energy offices, in the context of an established regime of dominant interests.

UK office over-specification can also be seen as involving specific market features, organisational characteristics, shortening lease lengths, changing office typologies, space rationalisation and so forth (Biggart & Lutzenhiser, 2007). Such an historical, context specific understanding of different actors co-constructing offices as 'desirable space' (Schiellerup & Gwilliam, 2009), helps explain how key 'standards' such as Part L building regulations, EPCs, BCO guidance and BREEAM are used to translate, assume, anticipate and thus institutionalise understandings of user 'needs' whose satisfaction perpetuates conservative networks of design (Guy, 2002). In speculative modes of development these understandings become particularly powerful in producing homogeneous designs stressing marketability, flexibility, performance and quality, which together characterise desirable office space. Achieving these characteristics and displaying that this has been accomplished is achieved through adherence to, or exceeding, 'market standards' (Faulconbridge et al., 2017) often in ways that render lower energy alternatives illegitimate and unacceptable. However, the process through which such standards operate is not merely a reflection of the historical context of the UK property market: it is also a consequence of how standards are embedded in markets and performed at different stages of design and marketing. In producing various calculations about the value of different aspects of a building's design, those involved enact the conditions of a market of comparable goods, through drawing attention to their relevant qualities (MacKenzie, Muniesa, & Siu, 2007) through 'qualculation' and the exercise of 'calculative agency'.

The concept of qualculation introduced by Cochoy (2002) avoids the more limited understandings of calculations as being either the purely rational decision of agents in an economic model, or qualitative judgements, instead seeing these as extremes of a spectrum. The first understanding is well known, and Callon and Muniesa explain the latter as being a 'sociological' model of calculations as "at best an ex post rationalization for choices grounded in other logics ... a matter of pure judgement or conjecture or ... something originating in institutions or cultural norms." (2005, p. 1230) Qualculation as a concept asserts that market calculations are a performative admixture of fact and value, making qualculation distinct from simple quantification seen as a tool of governance and management (Lippert, 2015).

Callon and Muniesa's (2005) explanation of calculation encompasses Cochoy's qualculation, as they describe it as describing situations "in which the customer has to choose certain objects placed beforehand in the same spatial and temporal frame" (2005, p. 1232). This can be seen as a case of market calculation in general. They explain calculation's role in enabling and enacting a market by suggesting that for a market to be possible, a three-part process takes place in which:

"the entities taken into account have to be ... arranged and ordered in a single space ... then compared and manipulated on the basis of a common operating principle ... A third step is necessary ... a result has to be extracted ... that corresponds precisely to the manipulations effected ... it has to be able to leave the calculative space and circulate elsewhere in an acceptable way" (Callon & Muniesa, 2005, p. 1231)

This means that "market calculations are disentanglements that secure calculability" (Callon & Law, 2005, p. 722) – they extract specific aspects from a good in order to make the whole comparable with others, which inserts it into the market thus created. Such calculations happen at multiple points in the creation of a product or good as complex as a building. In different situations different qualities are drawn out for comparison, and others are obscured. In these simplifications, "because agents are faced with complicated tasks ... they conceive of tools, create rules and routines or set up

organizations to calculate for them” (Callon & Muniesa, 2005, p. 1237). It is argued here that the standards, guidelines, and assessment processes associated with designing office buildings are examples of such institutionalised calculations, distributed through time and space.

In essence the point is that ‘framing’ goods with others to which they can be compared, “is a process of classification, clustering and sorting that makes products both comparable and different. The consumer can make choices only if the goods have been endowed with properties that produce distinctions (Cochoy 2002).” Also known as ‘positioning’, this “linking up implies ... quality labels or, more generally, quality standards – that measure and objectify certain properties” (Callon & Muniesa, 2005, p. 1235). The ranking of different buildings against each other using chosen characteristics and matters of judgement is another such moment of calculation. The power to position and compare goods in this manner is named ‘calculative agency’ by Callon and Muniesa and in this case it is distributed between design teams, developers, the institutions that produce standards and guidelines (including the state) and intermediaries who perform calculations on behalf of these actors. However, the *critical* point of calculative agency is the moment of presenting a building (or design) as a product for valuation and comparison in a buying/letting market, drawing on its certifications, badges, and evidence of compliance with market standards; each themselves the product of other calculations.

Understanding the assessment and marketing of office buildings in these terms promises to shed some light on the failure to deliver low energy offices as the result of uneven and competing calculative agencies located across design and marketing, in which the rental market is the ultimately powerful calculation site towards which all other calculations are orientated.

Methods and research design

The research on which this paper draws worked with these ideas to understand the design of office buildings in London, UK, built or refurbished between 2010 and 2015, and how their energy demand

resulted from attempts to satisfy unknown users' needs and expectations. These were defined and assumed through design processes. To address rising energy demand, it is crucial to examine how these 'needs' were constructed. The data collection proceeded in 3 stages. Initial semi-structured interviews with highly influential consultants (n = 3), architects (n = 2) and building developers/managers (n = 6) to whom access was possible, explored the key influences at play. These confirmed initial hypotheses that a variety of standards, guidelines, rules of thumb, assessments and regulations (hereafter 'standards') are powerful factors. The coding of these interviews provided the detailed inductive coding framework for the subsequent interviews. A decision was made to examine speculative developments as the dominant mode of office developments in the London (Deloitte Real Estate, 2014), and after discussion with key stakeholders including the BCO the research concentrated on a portfolio of 10 case study buildings to explore how these influences, and key within them, standards, play out across different buildings. The portfolio was selected on the basis of an interviewee suggestion in one case, the remainder being identified by desk research. The criteria for selection were the availability online of space plans and specifications, and the desire for a comparable sample of buildings differentiated on a number of key features, e.g. age, tenancy, development modes, location, size and HVAC systems. The sample of buildings, and therefore interviewees, was thus random enough to avoid the potential for interviewer confirmation bias (Roulston & Shelton, 2015), but it is unavoidably biased towards buildings that were advertised to a wider public (and therefore may have been struggling to let space). The intention to pursue a mixed methods case study approach (Creswell, 2013) combined with advice from the initial interviews determined that in stage two, interviews with the actors most influential on design would help to interrogate the available documentary data. This determined that, at the least, interviews with the architects, mechanical and electrical (M&E) engineering consultants and letting agents for each case building were required. Investors and (at the time of design, unknown) tenants were excluded as their influence on design in speculative developments is mediated through agents.

Table 1 below summarises some of the building characteristics, and which stakeholders were interviewed for each of the 10 buildings. The interviews were designed to elicit how standards were used in design, and enacted certain understandings of user ‘need’ in the production of a marketable building. This involved comparing the specifications, standards, etc. that shaped the end form and therefore designed energy demand into the buildings, elicited through questions about general influences on design, and interrogating aspects of the buildings’ specifications and features identified through documentary material.

[Insert Table 1 here]

Towards the end of the interviews detailed in Table 1, meetings of the research team determined that the data collected was saturated for the 3 interviewer categories (Guest, Bunce, & Johnson, 2006) for example as responses confirming exploratory interpretive analysis were consistently highlighted (Ponelis, 2015). However the perspectives of developers, construction and real estate, and valuation actors had been characterised and considered important by the interviewees, but were not directly represented. This led to a decision to conduct follow up interviews with further individuals selected to represent these categories. Thirteen individuals were chosen based on their membership of key stakeholder representative groups, and having multiple associations i.e. they could talk about the perspective of their employer and of other stakeholder groups through their membership. Guarantees of anonymity prevent further explanation of sample selection processes.

A total of 57 individuals were interviewed: 17 architects; 11 M&E engineers; 8 letting agents; 9 developers; and 12 others including stakeholder representatives, consultants and one occupier. The anonymised interview data is the basis of much of the following analysis. References to the data appear in parenthesis in the analysis thus (A), and refer to the lettered quotes in Tables 2 and 3. The interviews were thematically coded by two researchers using Nvivo qualitative analysis software, using a mixture of deductive and inductive codes (see Appendix for a detailed explanation of the coding and analysis processes). This enabled the extraction of data segments coded with multiple

relevant codes, which were used as the material for analysis. The use of software to perform such analytical refinements in an interpretive mode of analysis (Bazeley & Jackson, 2013, pp. 242-265) is of course only possible with a deep familiarity with the data-set as a whole, and the selections of themes for analysis proceeded on the basis of discussions with the whole research team.

Interpretive qualitative research aims at producing a narrative that accurately reflects the meanings and understandings of the social world described, rather than statistical representation of views expressed.

In analysis, two key themes emerged. First, the processes through which compliance with standards were achieved, and second, the means by which the standards themselves function in the market, with implications for energy demand. The following sections elaborate on these themes, after an exploration of the main features of speculative office design through adherence to market standards.

Analysis

Speculative design for unknown future users

The speculative nature of the studied developments makes market standards an important means of substituting for known user needs. However their use consequently reproduces numerous standard assumptions which have important effects on building design that lock-in higher energy demand. To give two examples of over-provision to satisfy assumed needs, firstly there is the almost universal use of use of four-pipe fan-coil unit air-conditioning systems in 'Grade A' offices (see below), to deal with large imagined potential cooling needs. This was not justified primarily in terms of ventilation and its link with productivity (lower-energy ventilation systems can anyway deliver adequate fresh air (Cao et al., 2014; Feige, Wallbaum, Janser, & Windlinger, 2013)), but in terms of it providing 'flexibility' to unknown and therefore potentially high 'needs'. Secondly, the provision of capacity for occupiers to extract large amounts of 'small power' (the UK term for plug loads, or power

demanded by occupiers' appliances and devices: A. Menezes, Cripps, Buswell, Wright, & Bouchlaghem, 2014) - exceeds the loads regulated under the building's EPC ratings (Arup, 2013), and has consistently exceeded users' empirical needs (British Council for Offices, 2009, 2014).

In contrast to buildings commissioned by their occupants, speculatively developed offices are primarily built or refurbished to provide a return on investment; to be sold on immediately or let by the developer in order to recoup rents. This means that these buildings are financial or rental assets, 'products' whose designs must be marketable to potential owners or occupiers by letting agents. In the words of one architect interviewee, they *"are investment vehicles, they are all about providing a return for a pension or for some sort of insurance policy."*

Different interviews revealed different lists of design considerations that were considered important to produce a marketable building design (A in Table 2). The top-level market considerations were to: maximise NIA (Net Internal Area – the leasable floor-space: quote B); be of high (enough) quality; meet market expectations and norms; and provide flexibility for all potential occupiers.

Historically, maximising NIA has driven office design towards deep floor-plates arranged around a central services core in as high a building as permissible under e.g. planning regimes (Albrecht & Broikos, 2000: 22-23). Multiple interviews confirmed that speculative developments in general were designed to 'squeeze the [building services] core', to maximise NIA. A letting agent stressed that with every project they ask *"could we put two more floors on? ... is there any way of squeezing something?"*, and an M&E engineer explicitly suggested that *"the big reason a lot of developers from a speculative perspective wouldn't go down [the route of lower energy] displacement [ventilation] is ... the core area hit"*. Two other engineers stressed that stated that maximising NIA and *"making the core as efficient as you possible can ... applies to every building"*, and that *"the net lettable area ... that's what a spec[ulative] office developer wants to maximise."* Thus it should be noted that lower energy 'mixed mode' HVAC options and displacement ventilation require more riser (horizontal) or floor-to-ceiling (vertical) space; both aspects that conflict with maximising NIA.

Quality (often aesthetic) design expectations were said to manifest in: often glassy façades (C); spacious lobbies, swift lifts, and marble toilets (D); and an aesthetic of bright, light, airy openness (E). All these features were common for the buildings in the sample, with double-height lobbies, for example, in 7 out of 10 case buildings, and where they were not possible, heights were raised: “we created a much grander reception area ... single storey but ... it’s probably two, two and a half times the size of the previous reception” (M&E engineer).

These priorities of maximised NIA and quality contributed to *market expectations and norms* of what interviewees called ‘Grade A’ space. This specific phrase refers to a heuristic understanding of high rental value office space that has no strictly formal or institutional foundation: there is no explicit method of certifying a property as Grade A. However it is a concept shared across the market, including internationally (Chung & Hui, 2009), and encompassing several specific features even though “*there’s no definition, which is a strange one*” (West End Office Agents Society: WEOAS). Of 53 explicit mentions of Grade A features, 38 arose from letting agents and developers, displaying that the concept is rooted in marketing and valuation. Interviewees specified their understandings of a Grade A office in ‘their markets’ as comprising “*an air conditioned, raised floor, suspended ceilings with LED lighting conforming to BCO guidance*” (Office Agents Society) with “*a large grand impressive reception area ... four pipe fan coil air conditioning ... serviced in the basement by lockers, showers etc. and ... clear open plan floorplates*” (WEOAS). Grade A features also include prime locations, certain levels and qualities of provision (e.g. of toilets, stairways and lifts) and (theoretical) performance. Such features as location and quality materials are undeniably linked with high value buildings, but their influence is not the focus of this paper, which discusses buildings’ expected or modelled energy efficiency. It is in this area that the most detail regarding what have been treated elsewhere (Falconbridge et al., 2017) as different institutionally legitimated ‘market standards’ could be found.

The most important of these 'market standards' in the area of 'green performance' can be seen as comprising a 'tick-list' (F) of essential features for a marketable office, which were consistently listed as comprising:

- an EPC rating of A or B (see quote G)
- BCO guidance compliance (H)
- a BREEAM rating of 'Excellent' (I)

The quotations in **Table 2** show that the purpose of such 'tick-lists' is to produce an easily assessable building design, in terms of inserting it into a rental market and letting it out quickly and easily.

Schweber (2013, p. 134) similarly describes BREEAM tick-lists as "a substitute for technical or more detailed knowledge" for clients. The design priorities embedded in the lists are in turn based not primarily on a concern with energy efficiency *per se* but the market requirement for flexibility, as a speculatively developed office building needs to have a form, fabric and structure capable of accommodating different potential uses, *i.e.* no building should be designed and serviced in a way that might potentially rule out its being let to anyone.

Interviews confirmed increasing 'churn' (owner or occupier turnover) in the London office market, enabled by the steady shortening of leases and particularly of 'break' periods: the period of time, shorter than the lease length, after which the lease can be renegotiated or broken. All this means building design must be standardised ('generic' in quote J) to allow any potential tenant to fit-out the building to their own needs. Again, particular forms (deep plan), fabrics (high performance façade) along with four-pipe fan-coil unit HVAC systems are seen to provide this flexibility. A space with these features is seen as an idealised 'blank canvas' which potential tenants can move into and adapt for themselves (K, L). This drive for flexibility results in designing for imagined tenants with the highest potential occupational densities and/or small power requirements; each of which drive up modelled heat gain peaks, and thus cooling requirements. As the BCO (2013, p. 30) asks: "Should the optimum flexibility afforded by high specification, and required by a relatively small segment of the

demand market, justify its blanket provision?” Taking these forms of flexibility together, the building services and internal spatial organisation of London’s Grade A office buildings are driven by ‘the market’ to an energy-demanding one-size-fits-all model: highly standardised offices brightly lit and air conditioned with suspended ceilings and raised floors, and provided with small power capacity well above average needs.

The supervening consideration is achieving compliance with the set of market standards in the checklist given above. These are processes of calculation in which specific features of the designed building are foregrounded and manipulated as Callon and Muniesa (2005) describe, making it possible to compare the modelled building with others. Calculative agency is involved in proving these essential compliances for inserting a building into the market. This makes meeting standards subject to strategic action in order to hit necessary targets, as explored below.

[Insert table 2 here]

Strategies for meeting standards and demonstrating compliance

Historically, from 1994, the BCO’s guidelines represented an attempt to put a ceiling on ‘high specifications’ which were both expensive for developers and had undesirable environmental implications – specifically high energy use and CO₂ emissions (Guy, 1998). In theory, compliance with it, together with achieving high ratings in performance standards should result in buildings with lower energy consumption than might otherwise be the case, given that such standards demonstrate that the building should perform better in terms of reduced CO₂ emissions (BREEAM) or energy efficiency through e.g. insulation and reducing solar gains (EPC) than a standard, ‘reference’ building.

To take these aspects as examples, it is – ironically - possible to demonstrate that the designing of compliant and marketable buildings actually drives the designing of higher energy consumption into buildings. BREEAM has been analysed elsewhere for how its use resembles other multi-criteria

sustainability assessments that have found to not guarantee energy performance (Goulden et al., 2015; Newsham et al., 2009; John H. Scofield, 2013). It has been further suggested that BREEAM functions as a design guide similarly to a tick-list (Ding, 2008), whose very flexibility in achieving compliance may explain its uptake as a model for other assessments internationally (Cole & Jose Valdebenito, 2013; Ding, 2008). Its 'Energy' criterion is also primarily based on a building's EPC. Therefore the following analysis of how market standards fail to ensure energy performance focusses instead on how BCO guidance is used in building design, and first how energy modelling can be used strategically in achieving compliance through the exercise of calculative agency.

EPC ratings, Part L compliance, and the dark art of modelling

A 'performance gap' has been identified between EPC ratings and real-world energy consumption data (Better Buildings Partnership, 2012; Cohen & Bordass, 2015; A. C. Menezes et al., 2012). This is ascribed to the behaviour of building occupants, and a 'perception gap' in which calculations do not refer to all the energy a building uses. The perception gap has been shown to result in *e.g.* underestimating cooling energy consumption by 44% (Arup, 2013). The interviews identified an additional issue, of strategic action used to ensure that a building design achieves compliance with Part L and a high EPC rating. These strategic actions entail the exercise of calculative agency in creating a 'fact', the rating, whose "origins ha[ve] been 'forgotten' once the fact was used as a black box" (Latour & Woolgar, 1979; cited in Lynch, 1993). The calculation itself is black-boxed in the sense that only the output is considered - being fed into later calculations, particularly of rental value. Goulden et al (2015, p. 2) similarly describe the 'interpretative flexibility' of black-boxed BEAMs, and note that such standards "do not necessarily excel in or emphasize energy-efficient design" (Goulden et al., 2015, p. 9).

[Insert table 3 here]

The capacity to be strategic has several aspects. First, for designers/modellers there is the capacity to set the reference building (M: see **Table 3**), e.g. based on HVAC systems, as air-conditioned buildings have different targets in these models to lower energy naturally ventilated ones. Others include the strategic choices of modelling software (N) approved by the National Calculation Methodology (NCM) of Part L2A and feeding into the 'energy model' model used in assessing the EPC, or of different levels of accuracy within these models (O), in order to achieve the desired results primarily by adjusting models rather than the fabric or infrastructures of the building itself. The energy model can be adjusted to target different standards (P), meaning that it *"has become incredibly important because it drives the EPC, BREEAM compliance, all these things"* (Architect). The variability of both baselines and improved building models allowed by the use of NCM permitted software in the UK has been previously identified (Raslan & Davies, 2010). Studies (e.g. on the use of Standard Assessment Procedure modelling for UK residential buildings: Kelly, Crawford-Brown, & Pollitt, 2012)) have also suggested that models and assessments may have perverse effects, as *"ill-conceived building performance and evaluation criteria may actually incentivise an increase in CO₂ emissions in some circumstances"* (Kelly et al., 2013, p. 603). Expertise in these strategies builds knowledge of how to match inputs, parameters, and models to fulfil a marketable building's 'tick box' (Q), within the marketability demands imposed by e.g. unique and distinctive architecture. Agents were said to demand that designers calculate *"how they can get big windows to work ... we want big glass buildings ... you need a wow factor to be able to get to that level of rent and that level of yield for your property."* (Consultant) Thus in our sample, strategic action achieves both standards compliance and 'the wow factor' (R): two key ingredients of marketability in the most important calculation of rental value.

These examples involve strategically achieving 'badges' of performance potential. In the next section, standards themselves are shown to increase assumptions of need and provision, and then to be (ab)used by market actors, in using voluntary guidelines in a competitive manner.

How standards lead to escalating energy demand: 'BCO+' and ratcheting

In addition to 'gaming' compliance processes, the example of the BCO's guidance illustrates how 'standards' can be enacted with perverse consequences. The intended dampening nature of BCO guidance was transformed and arguably distorted in its use as a baseline: an example of calculative agency that again assesses certain qualities of the building to enable comparability and competition in the broader market.

BCO guidelines were cited as a baseline of provision against which both developers and potential tenants usually assess buildings; each being advised by agents. Aligning a building's specification with BCO guidance was an element of the identified checklist explained above, which over-rides other priorities such as environmental performance or occupier satisfaction:

"a lot of it is a tick box exercise of 'does this building comply with BCO?' ... whole life costs analysis might not be ... as important. The occupiers' enjoyment of the space perhaps isn't of utmost important because ... there's greater reliance upon ... benchmark industry standard for measuring the quality of the building." (Engineer)

This focus also leads to high specification and over-provision through ratcheting increases over time in minimum acceptable levels of some (energy demanding) services. Ventilation is a good example, in which there is not only a ratcheting of the 'standard' (BCO 1994: 8-12 litres of air/second/person; BCO 2009: 12-16l/s/person). Expectations exceed *regulative* (necessary) and *normative* (advisable) levels to satisfy *cultural* (essentially market) standards (S) when developers demand supplements typically 10% above BCO guidance. This was described by numerous interviewees as 'BCO+': "*BCO is the benchmark. But in London ... you get a BCO+ ... whatever the BCO says then the agents in London always want a little bit more*" (Engineer, see also quotes ☹).

Third, throughout discussion of specifications of e.g. small power capacity and fresh air there was a pervasive sense that that '*more is better*'. This was explained again as being driven by market

priorities; provision for marketability. Anticipating that agents representing potential tenants will demand extra provision in negotiations as a 'something for nothing' (T), developers feel obliged to provide it (U). Lying behind all this is the anticipation of comparisons being made against other properties in the market, in calculations of value: *"If you've got more than the building next door, in whatever way ... it makes it easy to sell."* (Engineer)

Fourth, in a ratcheting process one architect explicitly alleged is driven by letting agents (V), where the BCO provides a range of potential values (e.g. ventilation 12-16l/s/person), if the top end of the range is not provided, the building is suspected of being sub-standard: *"You compare to the best of BCO"* (Letting agent). In the case of cooling and ventilation, provided by air-conditioning 'as standard', needs are primarily constructed through modelling peak potential heat gains (Z) that arise particularly from assumptions of small power usage and occupational densities. The BCO themselves state (BCO, 2013, 2014) that in both areas, empirical research has identified that the majority of buildings' small power usage (W) and 'effective density' (workplace space as occupied at different levels of utilisation) are lower than their own guidance (X).

On small power capacity, as **Tables 4 and 5** show, the BCO guidance of 15W/m² (Pothitou, 2014) down from 25W/m² in the previous 5 guides, is being met and exceeded in the majority of the case buildings, which all provide 25W/m² with additional capacity, of c. 15W/m², usually up to 40W/m² but up to 45-60W/m² in one case. As quote W shows, the over-cooling of unrealistic power use levels is a trend which may worsen with more efficient device usage.

In the case of occupational densities - the key multiplier of heat gain and therefore cooling requirements - BCO guidance is that buildings should be designed assuming occupational density of 1 person per 10m² of NIA, flexible from 8-13m²; a figure that has dropped slowly to represent increasing densities (see Table 4). The BCO's empirical research highlights average desk-space design densities from just under 1:10m² to 1:13m², but note that when even unrealistically high assumptions of real-world utilisation (70%: see BCO, 2013, p. 25 and quotes X, Γ) are applied, this

equates to 95% of building space being occupied at densities of the guideline 1:10m² or lower. Buildings exceeding the guidance are essentially providing for less than 5% of likely occupation levels, a trend followed by the case buildings as shown in table 5. As quote Y shows, designing office buildings with these extreme assumptions of occupation is again a matter of competitive comparison, anticipating *potential* tenant demands no matter how high or unlikely. Organisational rhythms further affect ‘diversity’ and the provision of services for absent workers (quote T).

[Insert tables 4 and 5 here]

In terms of producing lower energy offices, avoiding high levels of buildings services (e.g. excessive cooling or small power provision) or using passive or mixed mode forms of ventilation are made almost impossible by this combination of competitive provision and unrealistic assumptions. Modelling heat gains and cooling requirements (in particular) using the upper values of competitive provision and in-built assumptions results in figures that cannot be satisfied with lower-energy systems or design options (Δ). The market ideal which equates quality with high levels of glazing, lighting, occupational density and small power capacities results almost inevitably in air-conditioned offices. Glazed façades’ solar gain can be mitigated through technical measures, meaning that small power, lighting and occupational densities are the main factors driving this ‘non-negotiable’ demand (Δ). This is a demand that some interviewees suggested does not reflect occupier preferences (Θ) and could be reduced in low energy building designs (Φ).

The findings suggest that the BCO’s attempts to limit over-specification are trumped in our sample by maximising and standardising processes promoting competitive marketability above other considerations. BCO guidance’s upper limits, are used not as a ceiling for provision but a floor below which it is inadvisable to go (see quote G). BCO compliance and now exceedance was criticised as using it as a baseline of provision (Ξ), and as a misuse of guidance for marketing purposes (Π), in which guidance is used instead as a tick-box which does not result in ‘intelligent’ design (Σ). Many informants acknowledged that the BCO guide offered accurate and suitable guidance, but it was

suggested that it was being misused as a prescriptive standard (see also Schindler, 2010, p. 334), a process of which the BCO say, by way of confirmation:

“We are aware ... that institutional purchasers of office buildings benchmark against similar properties ... irrespective of occupier needs ... favouring buildings with higher specification. The resulting higher value reinforces the cycle towards generally higher specification ... the Guide has become, in reality, more of a prescriptive standard than a guide.” (British Council for Offices, 2013, p. 30)

Although BCO guidance explicitly contains flexibility to allow fitting building specifications to diverse tenants, the speculative mode of development removes this possibility, and instead applies market pressures for flexibility and marketability. The guidance is written collectively but it was claimed that these calculative agencies of valuation have gained sway, and the expectations of the most demanding market have begun to be applied (quote Ψ), out of step with not only low energy design, but allegedly occupier preferences (Ω).

Summary

As the above has illustrated, speculative office building design is a matter of negotiating different processes of calculation as a cultural and technical accomplishment. Aimed at the ultimate market-enacting calculations of rent/price valuations and ‘the deal’, buildings/designs/models have different aspects extracted, manipulated and compared in processes of calculation, to insert them into markets as comparable and competitive goods. As shown, achieving various ‘standards’ is considered unavoidable, and exceeding them has become advisable, due to how such standards are embedded in building design practices and market exchanges. Thus strategic modelling and ratcheting provision as logical moves in calculation exercises materialise certain qualities in office designs. Positioning buildings as goods in a speculative development market means that despite the existence of energy performance standards and specification guidelines, the very processes of

market creation through calculation drive competition to provide quality, flexibility, and ever higher levels of building services, with predictable influences on designed-in energy demand.

The concepts of calculation and calculative agency help to explain the puzzle of why 'standards' of various types fail to deliver lower energy building designs in a competitive market. In the various modelling and evaluation processes of complying with 'Part L' and BCO, and achieving EPC A-B or BREEAM 'Excellent' the modelled performance of buildings is fluid, and reacts to and determines changes in those designs. The target for modelled performance is known and calculative agency is the ability to foreground particular qualities and quantities and obscure others to make the hypothetical building comparable with others and competitive according to other sites of calculation: particularly the valuation check-lists of agents. During the design process at least, the ability to manipulate building models and assessment processes such as BREEAM checklists is calculative agency insofar as it is fluid, the modelled building "never gives an accurate figure; because its figures are constantly undermining those that came before ... Instead, it's about keeping things open." (Callon & Law, 2005, p. 730). Strategic action enters into this space of openness, until a target is reached and the means of achieving it can be black-boxed away from sight: once BREEAM 'Excellent' has been reached "*nobody ever asks the question*" (quote 1).

At the end of the calculation processes through which the modelled building is made into a singular good and made marketable through its comparability and competitive ranking against others, the most important moment of calculation is the granting of 'Grade A' quality and the production of a rental value pegged against other similar and comparable properties and past deals. This calculative agency subsumes all previous instances of calculation within itself, which explains the considerable power of agents acting for owners, and for potential or assumed tenants and sellers, as the ultimate arbiters of 'Grade A' assignation. As Callon & Muniesa (2005) explain with reference to double entry book-keeping, technologies of calculation such as the tools and institutions of market standards join with the actions of the calculators to produce 'distributed calculative agency'. Between them, letting

agents and the institutions have created the concept of environmental comparability, along with the broader currents of environmentalism, building design, legislation and modelling. These contribute to a whole network of measures which are mobilised for the primary purpose of stabilizing a smaller set of properties that can be clearly identified and then 'sold' in a market. From this perspective, the tick-list of marketable features is the ultimate technology both of calculation and of market creation.

This explanation for how standards operate to perversely produce less energy efficient buildings in the UK speculative office market can then be thought of as comprising three types of work:

- achieving (regulatory) compliance with building regulations, linked to legal legitimacy for the building;
- achieving normative and cultural-cognitive legitimacy in the market (Scott, 2008) by providing a 'quality' building: defined through aesthetic, symbolic, and taken-for-granted features in a 'social production of desirable space' (Schiellerup & Gwilliam, 2009); and
- the distribution and integration of different sites and exercises of calculative agency. Different technologies of evaluation and assessment (such as collecting BREEAM 'points') and manipulations of these features (e.g. altering software models of buildings to achieve a better EPC rating) are strategically used to construct a relatively stable set of 'facts' about the building. These, once established, close off debate or discussion about its comparative virtues, and which do so in ways that confer market value.

The most important of these moments of calculative agency is that of establishing rental value or return on investment (ROI), and such valuations may be distributed in time throughout design and even construction in order to achieve the necessary calculations to justify continuing investment. A number of the case buildings were stalled for nearly a decade until the calculative agency to make the ROI figures stack up was reobtained.

In summary, in this sample almost all aspects of speculative office design were strongly standardised through conformity to these sets of regulations, guidelines and norms, which can be called 'market standards' (Faulconbridge et al., 2017). These have cumulative consequences in that they interlock and are backed by three forms of institutional legitimacy (Scott, 2008), with regulative standards demanding legal 'de minima', frequently backing up normative expectations of e.g. the environmental performance implied but not guaranteed by EPCs and BREEAM, and the cognitive-cultural demands of 'quality' represented by particular aesthetics but more concretely, BCO compliance and exceedance.

Discussion and conclusions

The findings of this study are not intended to displace more quantitative research into the effects of 'green certifications' on building design. Internationally it is suggested that the 'market leaders' have been adopted and adapted for their 'brand' value (Cole & Jose Valdebenito, 2013) and interpretive flexibility (Goulden et al., 2015) and to aid market transformation (Todd, Pyke, & Tufts, 2013).

However the efficacy of certification in producing energy efficient buildings has been questioned (Newsham et al., 2009; John H Scofield, 2009; John H. Scofield, 2013). Taken together this body of work already suggests that 'market standards' such as these fail to deliver meaningful energy efficiency due to tensions with their other more market-facing roles, offering some qualified support for the findings presented here. The analysis above has spelt out how and why this occurs, in more qualitative detail.

The pursuit of stable ROI from reliable rental streams requires long-term attractiveness, flexibility and competitiveness, all of which are somewhat guaranteed through over-specification and energy demanding building services provision. Investment decisions and rental deals both constitute and reflect 'the market' created through the calculative processes described above. Tracing the 'impact' of various green certifications, assessments and regulations as 'price signals' in a classical market is an established area of literature (Chegut et al., 2013; Fuerst et al., 2017; Franz Fuerst & Pat

McAllister, 2011; Fuerst & van de Wetering, 2015; Fuerst et al., 2013), which fails to fully capture the recursive effects of their use, along with less formal 'standards', in the creation of a market itself through calculations and deals (MacKenzie et al., 2007). Seeing decisions to invest in energy efficient buildings as being solely incentivised by their market value premium (De Jong & Parkinson, 2013) ignores "the powerful social processes shaping energy-related decisions which tend to lead development actors to make seemingly 'irrational' choices, building and buying energy-intensive offices beyond the 'needs' of actual occupiers" (Guy & Henneberry, 2000, p. 2409).

These are unintended outcomes. BCO guidance was introduced in part to put a ceiling on high specification with its environmental implications (Guy, 1998). EPCs were intended to incentivise highly energy efficient buildings, but are undone by the 'performance gap'. BREEAM's central market position as an indicator of sustainability does not mean that certification necessarily guarantees energy performance (De Wilde, 2014), something predicted by the 'Energy' credits being based on EPC ratings (Roderick et al., 2009), and confirmed in like-for-like post-occupancy comparison (Haroglu, 2012; Sawyer, de Wilde, & Turpin-Brooks, 2008).

Taken together, these factors suggest that standards are not currently functioning as intended either as technical best practice or as price signals to promote energy efficient designs and systems and therefore lower energy offices (De Jong & Parkinson, 2013; Deloitte Real Estate, 2014). They might, however: if calculative processes such as modelling, compliance demonstration and performance assessment were based on real buildings and performance data, rather than prospective models; if cultural understandings, of what a 'high quality/value' office looks and feels like, changes; or if government or key market institutions converted more realistic performance ratings into a mandatory benchmark. The latter is a potential direction for UK legislation as seen by the use of mandatory minimum EPC ratings to drive improvements (Hamilton, Huebner, & Griffiths, 2016), but these are still only improvements to *modelled* performance.

The first possibility is acknowledged in other countries, for example in the NABERS (National Australian Built Environment Rating System) assessment scheme used in Australia (Newell, MacFarlane, & Walker, 2014). Calls for UK green certification to be based on actual energy performance rather than models (Cohen & Bordass, 2015) are currently being explored through proposals for a change to 'design for performance' rather than for compliance, through 'commitment agreements' where buildings' assessments are conditional on achieving promised performance in occupation (Cohen, 2016). An anticipation of real performance testing *is* included in BREEAM 2014's 'Excellent' rating's minimum requirement for 'seasonal commissioning', where the building services are tested under peak and normal demand conditions and re-commissioned.

The second issue is illustrated by the acknowledgement (by interviewees and stakeholders in a dissemination activity) of the market potential of Derwent London's 'White Collar Factory' concept as a new model of a high quality yet (potentially) lower energy office. The concept combines re-use or emulation of industrial spaces, with a 'cool aesthetic' of exposed concrete and building services. These allow the exploitation of lower energy features such as thermal massing, displacement/passive ventilation (Yu, Heiselberg, Lei, Pomianowski, & Zhang, 2015), and natural lighting allowed by higher ceilings (Gago, Muneer, Knez, & Köster, 2015). More than a technical innovation alone this appears to be an example of tackling the more normative/cultural market standards that have reductively defined 'Grade A' value and perpetuated over-specification and high energy demand.

Thus this paper has argued that the concepts of qualculation and calculative agency help make sense of why standards linked to energy performance do not deliver lower energy speculative offices in London. But it also raises potentials for such an analysis to be used to devise research and policy that exploits calculative agency to transform the market for lower energy buildings. Such transformations must attend to cultural and professional norms as much as technical advice or understandings that appear taken-for-granted in the market. Further research such as an ethnographic study of design,

certification and assessment processes in operation might reveal the micro-sociological detail of calculation taking place, impossible in a *post hoc* study covering 10 case buildings.

What the above demonstrates is that the speculative development of lower energy commercial offices in the UK is hindered by a number of factors that arise not simply from market failure, the lack of technical solutions or knowledge about them or from socio-economic 'barriers' to their uptake. Rather we should understand that in this studied sector the production of unsustainable office spaces through design is structured by the perverse effects of a series of market standards. These standards appear to promise energy efficiency and sustainability, but instead deliver a form of marketability that relies on over-specification. Rather than functioning as pricing signals to make smooth the operation of an incentivised market for 'green buildings', the various standards at play have been utilised (sometimes) strategically by a constellation of actors to produce a 'modelled, flexible, marketable building' rather than the low energy office that one might hope that they would deliver. These perverse effects have been arrived at through the processes of fluid calculation enacted via black-boxed forms of assessment and modelling processes and through calculative processes of valuation organised by checklists of foregrounded features.

Of course, the highly competitive nature of global cities' prime property markets might be expected to privilege exchange value over environmental performance. Nevertheless the analysis presented has shown *how* processes of calculation and the exploitation of calculative agency operate in the UK speculative market at least, to reconcile the underlying pursuit of profit with an apparent satisfaction of international energy performance (EPC), sustainability (BREEAM), and quality (BCO) regulation and standards. Of course an analysis of a specific market enactment through calculation and calculative agencies does not suggest that this is a necessary outcome, or that it applies to all markets, for example internationally. It merely states that it is through such processes that goods are created, valued and traded. These outcomes can be understood through opening the black-boxes of individual standards, guidelines and assessment methods, and through understanding the

specific nature of the market being analysed. In the case of London, this is a speculative investment and development market focussed on high quality and value products in which certain design priorities (flexibility and quality) trump others (e.g. adaptability, energy efficiency). Nevertheless such an analysis identifies where calculative agency lies, and how it is exercised, which is the first step to rethinking how it *might* operate in this and other contexts.

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Appendix: a note on coding and analysis

The coding process that preceded analysis was as follows. First, parent codes in the coding framework of influences on office building design were developed by the research team combining design guidance from the building industry (Clark, 2013; Energy Efficiency Office, 2000; Gardiner & Theobald, 2014) with a socio-technical focus on infrastructure (Hughes, 1987; Star, 1999). The codes were designed to allow an 'Ethnography of Infrastructure' (Star, 1999), interrogating why the features focussed on came to be as they are. This treated the features in question as 'cultural artefacts' (Hughes, 1993) and sought to understand both their tangible effects on energy demand and their histories and relationships to rules, norms, cultures (i.e. institutions), knowledges, organizations and economic and political interests. During coding of the first tranche of 6 interviews with 9 key stakeholders, further sub-codes were developed inductively. In the main tranche of case study interviews, the 'Inductive' parent code was then used to hold sub-codes identified as important themes during coding, which were shared with the other coders, and used to refine coding of subsequent transcripts and to re-code existing ones (by the research associate). The final coding structure contains too many sub-codes to list, but as an example, 'User needs' contained the following sub-codes: Comfort, Cooling, Evidence (of explicit user needs), Light, Noise, Occupier preferences, Productivity, Symbolic office spaces, Well-being. Analysis for this and other pieces of writing began by extracting segments from the data-set based on relevant parent/sub codes, and after reading through these large data samples, extracting smaller samples of segments based their being multiply coded for relevant themes.

Building	Built or refurb'ed	Location and tenancy	Standards designed to	Occupancy density	HVAC	Small power provision: base and additional capacity	Interviewees
A	2013	City/West End CBD	BREEAM Excellent, EPC B	1:10m ² , 1:8m ² achievable	4 pipe fan coil air conditioning	25+15W/m ² : 40	Architects (3), M&E (1), Developer (1): 5
B	2011	City/West End CBD	BREEAM Excellent. BCO 2009	1:10m ²	Displacement ventilation mixed mode (openable windows)	15+10 W/m ² : 25	Architects (2), M&E (1), Letting Agent (1): 4
C	2013	Mid-town edge of CBD	BREEAM Excellent (2008). EPC B	1:10m ²	VRF (variable refrigerant flow) air-conditioning	25+15W/m ² : 40	Architect (1), M&E (1), Letting Agent (1): 3
D	2014	Mid-town edge of CBD, single pre-let	BREEAM Outstanding. BREEAM 2008	1:8m ²	Displacement ventilation, mixed mode	15W/m ²	Architects (2), M&E (1), Developer (1), Occupier (1): 5
E	2014	Mid-town edge of CBD	BREEAM Excellent 2011. EPC B	1:8m ²	Chilled ceilings and passive chilled beams.	25+10W/m ² : 35	Architect (1), M&E (2), Letting Agent (1): 4
F	2014	City/West End CBD	BREEAM Excellent	1:8m ²	Variable Air Volume (VAV) air-conditioning	25+20W/m ² (all floors except 1st and 2nd which are 25+40 W/m ²) : 45-65	Architects (2), M&E (1), Letting Agent (1): 4
G	'60s, refurb '80s, 2013	City/West End CBD	BREEAM Very Good	1:8-1:12m ²	4 pipe fan coil air conditioning	25W/m ²	Architect (1), M&E (1), Letting Agent (1): 3
H	'80s, refurb 2014	City/West End CBD	BREEAM Excellent	1:10m ²	4 pipe fan coil air conditioning	25+40W/m ² for 20% of NIA: 25-65	Architect (1), M&E (1), Letting Agent (1): 3
I	'80s, refurb 2014	City/West End CBD	BREEAM Excellent EPC B	1:10m ²	4 pipe fan coil air conditioning	15+25W/m ² : 40	Architects (2), M&E (1), Developer (1), Letting Agent (1): 5
J	'80s, refurb 2010	Mid-town edge of CBD	BREEAM Excellent	1:10m ²	Displacement ventilation, mixed mode, opening windows	30W/m ²	Architect (1), M&E (1), Developers (2): 4

Table 1 Case study building and interview summaries

Priorities	Quote	
'Grade A'	(A)	"the way I look at it is what lets a building it comes down to yes location, specification, floor plate, image, price." (Letting agent)
Max NIA	(B)	"they want to maximise the amount of space that's allocated as office space, because that's the selling point." (Buildings manager)
Quality (aesthetic)	Façade (C)	"there is an explicit request from agents, they' like buildings with floor to ceiling glass which let better, you'll get higher rent for them, you'll get prestige" (Developers); "there was just an acceptance that you're not going to do a fully glazed building in a conservation area ... Having said that floor to ceiling glazing I think is picked out in the spec." (Architect)
	Lobbies, lifts and loos (D)	"most office agents will say it's three things, three things that need to be really good, it's the lifts, lobbies and loos" (Buildings manager); "what you'll need is BCO spec, BREEAM Excellence, other than that it's up to you, marble, need marble these days." (Buildings manager)
	Bright light airiness (E)	"I think one thing that's quite important [...] just getting a more open, more airy thing ... Giving a sense of openness" (Architect Building D) "it feels better having greater height and space ... with a six metre column grid ... and a feeling of space and volume ... you're trying to maximise ... floor to ceiling heights ... It's a better feel within your floor plate." (Letting agent).
Market norms and expectations	Tick-box list (F)	"that tick box is very much, again when you're selling it...BCO standard, what's the EPC, how does this work, is it BREEAM Excellent? Tick, tick, tick, tick. And then you go right, you can value that quite easily" (Architect Building I); "BREEAM ... is anchored to ... the technical manuals ... The other part is the BCO standard for office specification ... You could leave everything else aside apart from building regs compliance or your EPC as part L calculation, ... those three bits there fundamentally drive everything that the architect, the M&E designer, structural engineer to a greater or lesser extent, and then the QS..." (Developer)
	EPC A or B (G)	"So it's BCO is the guidance and the market but the certificates we're seeking to satisfy are BREEAM and the EPC ... Obviously an EPC with B+ is a great advantage for marketing. It's not essential but it is an important requirement. A: So that's the norm basically, the industry norm. B: Yes for new buildings." (Office Agents Society); "A rated can use twice, three, four times what a C or D. So it's almost a nonsense if you look at it and say well A is better than B because its more energy efficient because it isn't necessarily." (M&E Engineer)
	BCO compliance (H)	"You wouldn't design a building to less than BCO standards ... You wouldn't be able to, it's a huge cross if your building doesn't meet BCO standards." (M&E Engineer)
	BREEAM Excellent (I)	"no one actually ever says is this BREEAM 14 or BREEAM...08? And nobody ever asks the question." (Letting agent) "we decided to go for 2008 because the 'Excellent' sounds better. No one questions what year it is, it's BREEAM Excellent" (M&E Engineer); "I'll be honest with you I don't think I've ever had a deal which has not happened because a building has not achieved a certain EPC level or a certain BREEAM rating level. But ... if an occupier is faced with a choice of two or three buildings and one of those buildings out of the three has the best sustainability rating ... that's how, from an agents point of view, that's how it's sold to the occupier." (West End Office Agents Society)
Flexibility	Generic (J)	"the space isn't going to suit everybody 100%. But it's amazing what they can do with the space planning ... the more generic boxy buildings ... you can make them work" (Buildings manager)
	Blank (K)	"the developers that are in it for the money [want] to give the best blank canvas for somebody to do anything with." (M&E Engineer)
	Fan coils (L)	"it all comes down to cost. So this industry standard everybody understands it, it's quite a cheap solution, fan coil units delivers you a flexible space for an incoming tenant at a reasonably cheap cost." (M&E Engineer)

Table 2 Design priorities of marketable buildings

Quote (n)	
Choice of reference building type (M)	“doing your reference model you can decide whether It’s naturally ventilated or air conditioned. And therefore ... up your reference [...] sufficiently for you to then get in” (M&E Engineer) “we’ve got different examples of how to achieve what we want to achieve using all the different M&E systems ... So when I get a model in that doesn’t work ... I know that this actually should generate us the correct output” (Architect)
Choice of software (N)	“comparing TAS and IES you could get a 20% difference depending what kind of building type you were looking for ... how you refine the factors which are used as defaults” (Consultant)
Choice of accuracy level (O)	“BREEAM Excellent requires an EPC of 47 or less. We got to a month before tender and the M&E consultant said ‘help I can only get to an EPC of 54’ ... we looked at several different ways of bettering the EPC ... What we did to achieve EPC was move from a level three model to a level five model, remodelled it and bang...47” (Architects)
Adjusting model for different purposes (P)	“we did different sums for different purposes ... a building energy model which would be run on one basis for BREEAM, another basis for planning and another basis for something else ... And they all give equally valid results.” (Developer)
Expertise in the input ingredients (Q)	“it’s all in a box, you put inputs in one end and you get something out at the bottom end, and a lot of [engineers] don’t know what are the secret ingredients ... The energy model has become inCREDibly important because it drives the EPC, BREEAM compliance, all these things. ... We have got different examples of how to achieve what we want to achieve using all the different M&E systems ... So when I get a model in that doesn’t work, I’ve actually got a benchmark to ... actually should generate the correct output” (Architect)
Maintaining ‘the wow factor’ (R)	“We got clients ... saying look we’ve got a signature architect here who wants to do some stunning architecture. I want to employ you ... on the basis you can come up with solutions or modelling solutions which will demonstrate compliance with a minimum of impact on the wow factor” (Consultant)
Ratcheting ventilation standards (S)	“So building regs for fresh air is 10 litres a second, but BCO recommends 12 litres to 16 litres...the client said 16 litres plus 10%. And on cooling loads it was plus 10%”(Architect)
Something for nothing tenant demands (T)	“If it’s there you’d take it wouldn’t you? It’s... Interviewer: Why is a higher air flow a better thing? There’s more fresh air coming into the building. It’s just more fresh air coming in, simple as that.” (Letting agent)
Demanding and providing market ‘norms’ (U)	“If you were to market a building in central London... you put in something less than 25 watts a square metre you’d have the agent on the purchasing side saying ‘hang on a minute what sort of building is this? Is it a low standard, it doesn’t conform with the market norm’. And they’ll demand an increase. And it will be provided ... why would you ... have an argument with a tenant’s representative? You just provide it. It’s the market norm that does it.” (Architect) “The agents will always ask for more of everything ... they tend to drive up standards unnecessarily ... all on the basis I think of ‘it’s easier to sell’” (M&E Engineer)
Agents driving the ratchet of standards (V)	“But very often it’s the Office Agents’ Society for example who are informing the BCO spec and saying ‘... It’s not enough anymore ... people are expecting so much more’.” (Buildings manager)
Small power over-provision (W)	“10 years ago ... no one was going over 15. So we are over spec-ing the air I think completely and everyone’s going to start to use more efficient tablets, you’re not going to have a big heat consuming PC on every desk.” (M&E Engineer)
Real world occupation levels (X)	“if you walk around any office where everyone’s got a fixed desk 50-60% of them have got someone at, the rest are empty because

	people are at meetings, in internal meetings or they're on site etc. etc." (Architect)
Competitive density provision (Y)	"it's an interesting sell to an occupier ... this building and it's 1:10 or you come to our building 1:8 and you can occupy at that and it's going to save you money ... a pricing benefit which some of the big landlords really try and sell."(Letting agent)
Provision for rare peaks (Z)	"there's some enormous peaks which dictates the choice of your systems which are applied universally ... 90% of your property doesn't need that, but the MD wants a room with glazing on two sides and double height, that is going to define your AC system and lo and behold you then have all of these hundreds of fans put in, grossly over-sized ... there's a number of slippery slopes ... which tend to drive you in a certain direction ... the client's happy, the architect is happy he's got a gee whizz building. Someone's told him its sustainable because we've ticked a box on BREEAM" (Consultant)
Temporal diversity of occupation (Γ)	"lots of empty desks on various floors. And that comes and goes ... a couple of months a year where ... we have a huge amount of empty space, floors completely empty. Except ...one or two people come in so all the lights come on, all the printers go on, all that set up." (Buildings manager)
Primary drivers of air-conditioning (Δ)	"The design IT loads drive you to air conditioning. Densities and IT loads are what drives you to an air conditioned building. If you can ... go back to something that's low density, low heat gain you can start to look at a more holistic approach." (M&E Engineer)
Occupier preference for natural ventilation (Θ)	"a lot of surveys of occupants that suggest occupants want natural ventilation, opening windows, that's 70-80% do, whereas that's not what the speculative market in particular provides" (Architect)
Adaptive comfort potential (Φ)	"in most standard offices now the heat gains are nowhere near what we expect them to be ... particularly with natural ventilation then people's [temperature] tolerance increases enormously. Whereas with four pipe fan coils people expect an incredibly narrow band of control ... you can go up to about 28 [degrees] with natural ventilation before people start complaining" (Architect)
Using the BCO as a benchmark (Ξ)	"Interviewer: where does the BCO guide to offices come into this? That's a minimum for us" (Letting agent) "You compare to the best of BCO. So when we're running through a spec the question must go 'what's the BCO standard?' So that's the benchmark" (Letting agent) "we'll spend more money and put in more base build flexibility here, which is way over and above what BCO are saying might be required, because we think it will be more attractive for an occupier." (Letting agent) "It's not used as a ceiling, it's almost used as the opposite, as a minimum guide ... you're the investor looking to buy an asset, well 'that's not even up to BCO standard so how can we buy that because the other option that you've put in front of me is investment grade notionally?'" (Letting agent) A point supported by engineers "what happens is that tenants, who are looking at different buildings, will use that to dismiss options ... it's not ticked the box, not achieved the requirement so it's dismissed. So there's a real paranoia about not hitting those targets because then... there's a penalty on the rent, the rent is, we're not paying the market rate for this building it doesn't meet BCO." (M&E Engineer)
BCO as market tool (Π)	"BCO is ... a tool for you to achieve what the market wants to see when they move into a building" (M&E Engineer)
Tick box not intelligent design (Σ)	"the kind of agent led approach, you just tick all the boxes and then you'll get a great building...You don't end up with an intelligent design just by following the BCO guide" (Architect)
Standard raised to the most demanding level (Ψ)	"when the BCO first came out we used to benchmark all the developers ... and the BCO was in the middle of it really ... It then became, or in my opinion anyway ... the highest level, it became the best council for offices if you like ... the standard has gone up

	from when it was first introduced" (Valuation)
Agent demands not occupier preferences (Ω)	"we're told by the agents a lot that the occupiers want this kind of building, that kind of building and all the rest of it. And it's counterintuitive and it isn't consistent with what you get when you actually get a chance to talk to people who sit at the desks, which isn't very often." (Architects)

Table 3 Perverse effects of market standard compliance

BCO Guides:	Guide 1994	Guide 1997	Guide 2000	Guide 2005	Guide 2009	Guide 2014
Occupational densities (workplace density/effective density)	1:14m ²	1:10m ² -12m ²	1:12m ² -17m ²	1:12m ² -17m ²	1: 8m ² - 13m ² Workplace density 1:10m ² Effective density: 1:12m ²	Workplace density 1:8-10m ² Effective density 1: 10-12m ²

Table 4 BCO guidelines on design occupational density

Building A	B	C	D	E	F	G	H	I	J
1:10 m ² - 1:8 m ²	1:10m ²	1:10 m ²	1:8 m ²	1:8 m ²	1:8 m ²	1:10m ² - 1:8m ²	1:10 m ²	1:10 m ²	1:10 m ²

Table 5 Occupancy densities designed to for each case building