Diversity and transition: conceptualising the production of cooled space in everyday life

Elizabeth Shove and Gordon Walker, Department of Sociology and Lancaster Environment Centre, Lancaster University, Lancaster. e.shove@lancaster.ac.uk

Introduction

Evolutionary biologists continue to argue about why humans and their fur parted company and about where and when this occurred (Wade 2003). Whatever the explanation, the consequences have been significant. Compared to other creatures, many of which are beautifully adapted to specific climatic niches, humans have managed to colonise the world in their remarkably uniform birthday suits. They have done so by constructing and occupying extensive urban habitats built to their own design, and by using variously resource intensive 'technologies' to mediate and modify the ravages and regularities of the weather.

The diffusion and maintenance of urban habitation involves the construction and reproduction of what we might usefully think of as a 'an indoor system' of interdependent elements including the body itself (complete with thermoregulatory functions, metabolism and mechanisms like those of sweating and shivering), building design and fabric, methods of space heating and cooling, along with clothing, furniture and other devices such as hand held fans, shades, hot water bottles etc..

Despite evident diversity in how indoor systems are configured around the world, we are currently at a point in history when the methods used to create what are taken to be comfortable human habitats are becoming evidently unsustainable. In this paper we discuss the development, persistence and potential demise of arrangements in which vast quantities energy are invested in mechanically cooling and artificially 'refrigerating' indoor environments in cities around the world. Theoretically, we seek to analyse these processes as 'transitions' – an exercise that calls aspects of the transition literature into question, obliging us to think through the spatial aspects of systemic change and to pay more explicit attention to processes not only of innovation but also of disappearance, emergence and re-emergence at specific locations and points in time.

Configuring comfort

In strongly seasonal climates the role and relative significance of clothing, heating, ventilating, air conditioning, body and building fabric change during the year, and at different times of day. Sometimes the functioning of the body is 'enough' and there is no 'need' for extra heating or cooling to be provided by other elements of the system. At other times the fabric and infrastructures of the building may be brought into action. If the heating is turned up high there is perhaps no 'need' for clothing – likewise, if the air conditioning is on full, clothing may be needed to maintain a 'warm enough' body. Some buildings and bodies are better insulated than others – and again this makes a difference to how and when complementary strategies are brought into play. In addition,

in any one society the range of options available to any one individual will vary widely: for those who cannot afford to use air-conditioning, or who simply do not have it, opening and closing windows and curtains and adjusting clothing, activity and diet remain relevant techniques.

As these observations suggest, indoor-living-systems are anything but static. Different components are in constant, dynamic interaction both on a daily basis, over the course of a year, and over generations. Fifty years ago a man's suit included a waistcoat as a matter of course. This is no longer so and in the UK (in relation to warmth) significant energy consumption is now required to make up for the insulation no longer worn as normal.[1] At first sight different configurations constitute what we might think of as alternative ways of achieving 'the same' effect, but this is a bit misleading. Critically, the details and relative importance of different parts of the system, its character and its composition are themselves significant for the 'meaning' of comfort – and as a result, this meaning is itself diverse and dynamic. As people become used to delegating to technology, so they become 'addicted' to standardised conditions, and even to conditions that might have been intolerably cold or hot to previous generations. For example, in Australia, a survey of 500 households in and around Sydney in 2008 found that 87% of respondents were are cooling their homes to below 23 degrees C in summer and that 82% were heating them to above 21 degrees C in winter, effectively ignoring 'recommended' ranges of 23 to 26 in summer and 18 to 21 in winter (Energy Australia 2008). As this example suggests, we are dealing with a truly sociotechnical system in seemingly permanent transition.

Cooling, urban energy consumption and climate change

Some configurations of comfort are more energy and resource intensive than others. For instance, insulation in the form of clothing is relatively cheap and easy to manage, and is more easily taken on and off, adapted and personally adjusted than when it is stuffed away in the walls of a building. Insulation of body and of building mediates the indoor-outdoor relation in ways that reduce the 'need' for extra energy, as do adaptive patterns like those of going to sleep in the hot part of the day. In short, the relative significance of different components (clothing, activity, building insulation, mechanical cooling) translates, pretty directly into energy demand.

It is therefore relevant to notice that one of the most significant innovations in indoor climate management is the relatively recent (100 or so years) concern and capacity to condition and manage 'space' – to cool entire rooms, buildings and even cities – rather than to modify microclimates closer to the body (Wilhite 1996).This almost inevitably places the burden of climate management on one part of the system.

This configuration, in effect, a *refrigerated regime*, represents a quite specific (cultural, historical, technological) arrangement of human and non-human actors, and results in a set of relationships in which energy substitutes for various kinds of busyness and in

[1] Similarly office air conditioning is often used to counteract the effects of wearing a suit and tie (the tie typically increases the thermal performance of the whole outfit by 2 degrees C) in hot weather.

which diurnal and seasonal variation is over-written. It is also a *standardising* configuration in that it irons out wrinkles in the pattern of the day (no need for the siesta), and in what people do, and wear; it is standardising too in creating similar conditions indoors whatever the weather; and in building energy demand into the core of daily life.

In 2001 air conditioning overtook space heating as a proportion of US domestic electricity consumption – 16% compared to 10%. This arrangement is sustained by an organized and mature 'air conditioning industry' complete with lobbying groups and societies (such as the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) and the Air Conditioning Contractors of America (ACCA)) capable of organising events like National Indoor Comfort Week (in 2009 from April 19th -25th) to '*celebrate the indoor environmental systems on which we all rely, and honor the men and women who keep those systems running efficiently and safely*' (http://www.comfortweek.com/).

In Europe the extent of air conditioning is currently much lower than in the US, but evidence of its growth is revealed in changing seasonal patterns of electricity consumption. An analysis undertaken by Hekkenberg et al (2009) for the Netherlands, tracks the temperature dependence of electricity demand over the period 1970 to 2007. This shows that in early and late summer months (May, June, September, October) the relationship between temperature and electricity demand shifted from negative to positive, meaning that a higher outdoor temperature now leads to an increased electricity demand, compared to a *decrease* with temperature as seen in the earlier historical record. This is a pattern already set in Southern Europe where summer peaks in electricity demand are higher than winter (for Greece, Italy and Spain), but newly observed in higher latitude countries such as the Netherlands.

Sivak's (2009) estimates of the energy required to cool the 50 largest metropolitan areas of the world to levels comparable to those now normal in the US are impressive. Using heating and cooling degree day data he shows that potential cooling demands are greater than heating demands in most of the metropolitan areas of the world, 38 out of 50 of which are in developing countries. Taking metropolitan Mumbai as an example he estimates that the *potential* demand for cooling (estimated in terms of person-cooling-degree-days) is 24% of the current demand for the *entire* US. Sivak attributes increasing air conditioning in developing countries to rising income, a narrow approach that overlooks the complex and subtle processes involved in multi-national cool transitions, but an approach that nonetheless gives a sense of scale (see also Isaac and van Vuren 2009)

To this we should add the potential impact of global warming (Wu and Pett 2006). Air conditioning is likely to be added to sites and situations in response to or in anticipation of higher temperatures. For example, the number of days on which the temperature exceeds 35 C in Melbourne, Australia, is expected to rise from an average of 9 to 12-26 in the next sixty years, and more erratic and unstable weather patterns are preditcted.[2] As concern grows over the mortality and health impacts of heatwaves (periods in which

[2] http://www.yarracity.vic.gov.au/Community/Community%20health/pdf/BeatTheHeatReport.pdf.

temperatures are much higher than usual for the places involved) installing air conditioning is being seen as a positively protective response particularly for the most vulnerable elderly populations. Urban areas are particularly at risk. Being already hotter than surrounding areas due to heat island effects, the impacts of heatwaves are exacerbated not only by elevated temperatures but also by various social and cultural processes and interactions with built infrastructure which produce heightened vulnerabilities to heat particularly amongst urban elderly populations (Klinenberg 2002; Brown and Walker 2008). Accordingly the analysis of the dynamics and differentiations of mortality peaks during heatwaves has often focused on large cities such as Madrid (Diaz et al, 2002), Rome (Michelozzi et al, 2004), Barcelona (Borrell et al 2006) and Chicago (Klinenberg 2002). Future expectations are of more such major urban events under climate change scenarios (Meehl et al 2004).

In combination these observations point to a global trend toward mechanically cooled indoor environments. It is, however, important to recognise that the extent to which this form of climate management has become commonplace and the conditions under which it has done so are socially and spatially differentiated.

Air conditioning as normal

We are not as yet in the globally refrigerated future imagined by Sivak, nor are we yet subject to many of the predicted impacts of climate change. On closer inspection there are really significant variations in how, where and to what extent air conditioning has been embraced across urban spaces, and in how traditions of cooling '*b ac*' (that is before air conditioning) persist and disappear. As with other systemic transformations there are multiple dynamics at work (or not at work). By implication, the processes involved and the conditions under which configurations of cooling practices evolve are spatially and culturally embedded and distinct.

The experience of the US, where electrical air conditioning first developed, is relatively well documented (Cooper 1998; Ackermann 2002). The earliest air conditioning technologies were used control temperature and humidity in printing and textile manufacturing processes in the early 1900s, and later to improve productivity in industrial, commercial and office buildings. Cooper (1998) shows how engineering expertise and visions of the mechanically controlled indoor climate emerged, along with the conclusion that 'buildings - and consequently peoples' activities - be organised around technical requirements' (pg 3). She also shows how air conditioning and building design co-evolved: mechanical cooling enabling the construction of 'deep plan' offices and of very tall structures difficult to cool through natural ventilation alone because of the high wind speeds involved. Urban spaces such as New York and Chicago had air conditioning inscripted into their form, functioning and iconography – and into the cultural imagination of what the successful future city would be like.

Partly because of these and other kinds of 'locking in', by 2003 88% of the estimated 64 million square feet of commercial floorspace in the US (excluding malls), was mechanically cooled. These figures disguise persistent variation within the building

stock. For example, the proportion of cooled floorspace varies in respect of the age of building (more floorspace being cooled in newer buildings), number of employees (smaller companies having less cooling) and number of floors (higher buildings having more cooled floorspace) (all figures from http://www.eia.doe.gov/emeu).

Cooling has therefore become pervasive but not equally so for all forms of buildings or types of commercial unit. There are still some spaces in which 'b-ac' (before air conditioning) systems of climate management remain in place.

In the US residential sector the first mass produced air conditioning units became available in the 1940s as window mounted units. These rapidly penetrated the domestic market followed by central air-conditioning units built into the fabric of the house (Biddle, 2008). As Cooper explains, "the postwar building boom created the perfect opportunity for the growth of central air conditioning systems" (1998: 152) and for establishing air conditioning as a normal expectation in new and refurbished homes. Table 1 shows the steady increase over time in the proportion of US households with air conditioning and the increasing proportion of these that have in-built central systems.

Table 1 Percent of households in the US with air conditioning

	Air conditioning	Central Air Conditioining	Window/wall Air Conditioning
1978	54%	23%	33%
1997	72%	47%	25%
2005	84%	59%	26%

Source: all figures from http://www.eia.doe.gov/emeu

The 84% of households that have air conditioning in 2005 are differentiated by region – with higher proportions in the Southern states – by age of house and by income, race and householders age. Again the availability of air conditioning has become increasingly pervasive across the domestic sector, but not entirely so. Domestic spaces in which methods of cooling are differently configured remain in place.

The US experience is instructive and, in terms of climate and sustainability concerns, a demonstrable threat if reproduced on a global scale. It is also the outcome of a unique history the contours of which are not simply replicated elsewhere. If, therefore, we are to explain, understand and potentially stem rapidly increasing reliance on mechanical cooling we need to figure out how systems of indoor-outdoor climate are changing in urban spaces around the world. This means thinking about how new relations between body, building and clothing emerge in different societies and social groups, and about the adoption not only of air conditioning but also of alternative means of responding to daily and seasonal variation. This far we have commented on the 'diffusion' of air conditioning as if it was a bounded technological solution. However we have already noticed that mechanical heating and cooling exists not in isolation but in association with other strategies and technologies, and in concert with an immense variety of building types, standards and ways of life.

Diversity and transition

As we have seen air conditioning took hold in the USA moving from commercial to domestic markets in the immediate post war period. This experience is not the same as in Japan, a country in which air conditioning 'arrived' as an already mature technology and as one that was, from the start, culturally associated with the 'West'. According to Wilhite, air conditioning made 'a rapid advance into Japanese commercial buildings and homes in a 30 year period from 1960 to 1990" (Wilhite 2008: 126). Meanwhile, in Kerala (Southern India) there was "very little air conditioning in any kind of building until the mid-1990s." (Wilhite 2008: 127). Australia has had its own distinctive pattern of rapid and relatively recent development, apparently experiencing a 50% growth in air conditioning in the five years up to 2003.[3] These details of timing are important, for example for whether air conditioning is primarily a matter of retrofit, or something that is embedded in new building. In addition, in each of the countries mentioned above, air conditioning enters existing regimes of cooling the details of which have quite specific cultural, political and economic histories. In order to understand these processes, we need a method of conceptualizing patterns of diversity and of chronological development in the same frame.

The transitions literature has much to say about the dynamics of change but for the most part the central focus is on movement from one dominant state to another, usually analysed in terms of innovation and the supply-side dynamics of technological and infrastructural systems. In this respect transitions talk has a homogenizing and generalizing tendency with examples implicitly conceptualized at societal or national scale. This far, less attention has been paid to transitions in demand, consumption and ways of life or to how these are situated in diverse social, economic and cultural contexts across multiple scales. In the following paragraphs we explore the possibilities and limitations of representing multiple co-existing instances of systemic transition.

Frank Geels has been writing about sociotechnical transitions for some years now, starting with a basic version of what has become known as the 'multi-level' model of innovation (based on Rip and Kemp 1998). In essence this suggests that potential innovations survive or fail in 'selection environments' created by incumbent sociotechnical configurations arranged in hierarchical order. Regimes consequently define the conditions in which niche level novelties do or do not take hold, just as 'landscapes' constitute the selection environments in which regimes do or do not flourish. The result is a neat and frequently useful model that can be used to make sense of mutually interdependent and also dynamic relations within a 'system'. This scheme has been used extensively as a means of plotting and accounting for developments, often in provision and supply, or in specific sectors of agriculture or energy management (Elzen et. al. 2008, Voss et al 2008).

Does it also help in understanding what we have referred to above as transitions in cooling?. Up to a point the answer is 'yes'. Geels' (2002) figure seeks to characterise

[3] http://home.vicnet.net.au/~eag1/Intervalmeters.htm

changes in the 'geometry' of the regime – that is in the specific relation between industrial regimes, cultural and symbolic meaning, infrastructure, technology, markets and user practices – such as those occasioned by the arrival and embedding of air conditioning.

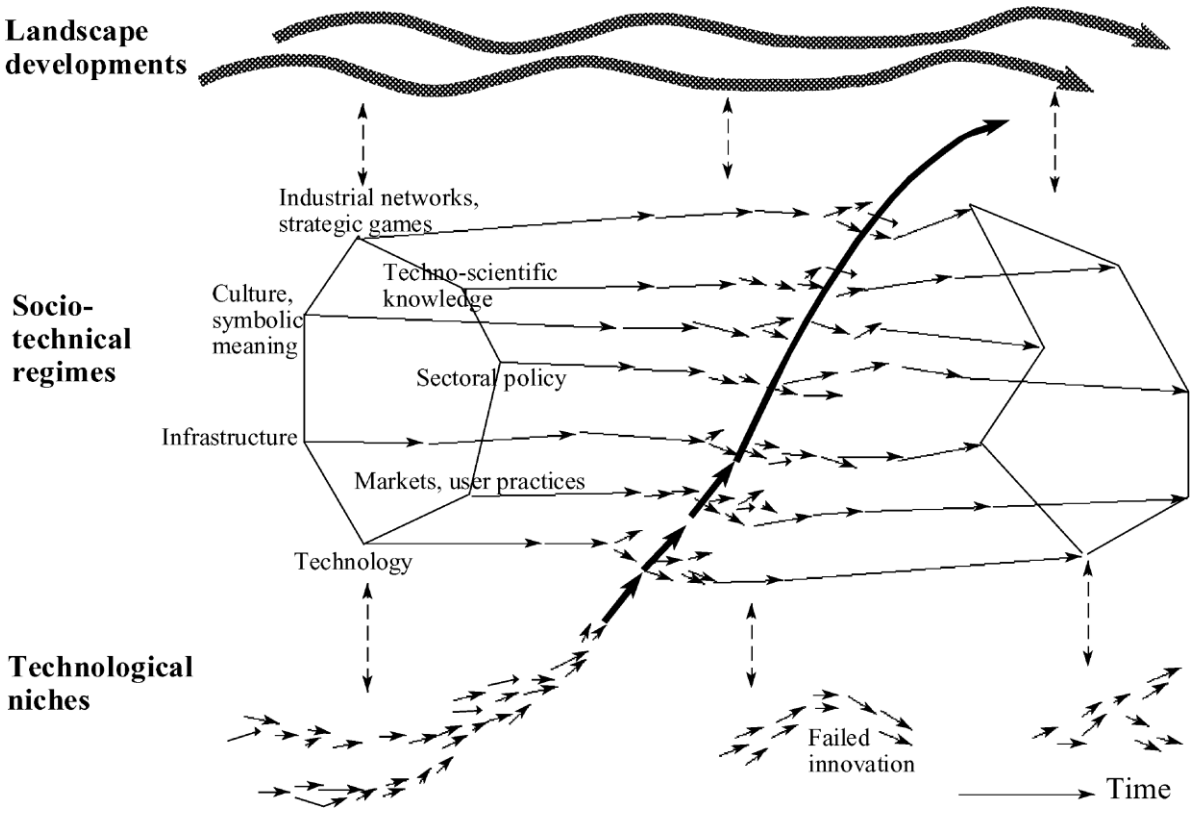

Figure 1. Source: Geels 2002.

While this representation makes sense, it does so only when we have some historical and (implicitly) geographically boundaries in mind. The figure might therefore work well in describing the air conditioning of US housing in the post war period. But can we use it to characterize the embedding of mechanical space cooling over the last century and at different rates and moments in different countries, cities, regions and types of building? Is there, in that sense, an 'air conditioned' landscape sustained by all these spatially diverse regimes, or is that to stretch the model too far? Alternatively, would it be better to disregard local differences, aggregate air conditioning sales and follow a 'diffusion curve' as if we are following the same entity over time?

Within this model there are questions to be asked about how established regimes (like air conditioning in the USA domestic sector) relate to not yet established regimes in other

countries, and about how the distinctive regime level geometries of mechanical cooling 'add up' not only over time, but also 'horizontally', from one city, country or setting to the next. Strongly horizontal geometries may, for example, been seen within specific applications and building forms such as elite hotels and multinational company offices where expectations of air conditioned refrigeration have become firmly embedded across the world. For this case it may well be that following the circulation of people, knowledge, expectations and designs transnationally across globalised networks is the necessary orientation - rather than one bounded in the discrete geographic units of cities or nations. In addition, and taking these implications further, although the notion of a total mechanical cooling 'refrigerated regime' is plausible (this being one in which people dress, and live and work etc. in ways that assume mechanical cooling), this is to suppose that such expectations are born of cool experiences in the significantly different domains of home, work, hotels, cars, etc. Should we treat each of these locations as a separate and distinctive 'niche' or should we view them as sites progressively 'colonised' by the incoming innovation (air conditioning)? If we went for the latter option we might imagine a variant of Geels' figure that brings multiple niches and regimes across multiple cities and cultures together such that all support and lend their different weight to the emergence of a truly 'global' landscape of mechanical cooling.

Landscape	Air conditioning as normal and ways of life associated with it							
Regime(s)	USA 60 years ago				Australia today, etc.			
Niche(s)	home	office	car	cinema etc.	home	office	car	cinema etc.

Figure 2: Multiple niches and regimes

One problem with this strategy is that it implies a seemingly even process of convergence and homogenization. While there is evidence of an overall tendency, that should not overwhelm the also vital observation that the 'geometries' of cooling are persistently and consistently diverse (between and within cities, regions etc.). To some extent, theories of transition draw attention to processes that arguably apply at many scales. Accordingly, it is up to the analyst to define the focus of attention, to select a trajectory to follow and to determine the borders of the analysis. Even so, our observations about multiple co-existing sites and scales leave us with a slightly uneasy feeling: surely there must be some way of characterizing processes of spatial aggregation within transition theory? Similarly, there must be more to say within and in the terms of transition theory, about the distribution and character of 'local' failures to fall in line with seemingly generic trends. On both counts we suggest that further work is required to address the spatial as well as temporal dimension of sociotechnical transition.

Given the resources entailed, the prospect of reproducing air conditioning as *the* 'normal' cooling configuration and of doing so around the world is evidently unsustainable. While mechanical cooling is becoming increasingly pervasive, it is possible and perhaps necessary to conceptualise alternative trajectories. These might involve the 'rediscovery' of cooling strategies (cooling regimes/geometries) from eras before air conditioning. In which case, traditional but currently displaced arrangements might constitute the 'novelties' of the future, edging the 20th century innovation (air conditioning) out of the

frame. With these ideas in mind we conclude by commenting on the relevance of 'transition' concepts for understanding and analyzing the waning of mechanical cooling and the (re)invention of alternative configurations of comfort.

After air conditioning

In Geels' 2002 figure, the trajectory of the technological innovation rises from left to right and the narrative effectively comes to a halt at the top of the page. As such the figure represents but one moment in what is sure to be a longer term process. This might be a process in which air-conditioning represents a temporary 'blip' in the configuration of comfort, a moment from and out of which new (which might also be old) regimes are formed. Figure 3 illustrates this possibility.

	Time 1	Time 2
Landscape	Local cooling	Air conditioning
Regime(s)	Local cooling	Air conditioning
Niche(s)	Air conditioning	Local cooling?

Figure 3: Trajectories to and beyond air conditioning

Put another way, can we use the transition model to account for the possible demise of air-conditioning as a dominant design and the potential reinvention of elements of the regimes that went before?

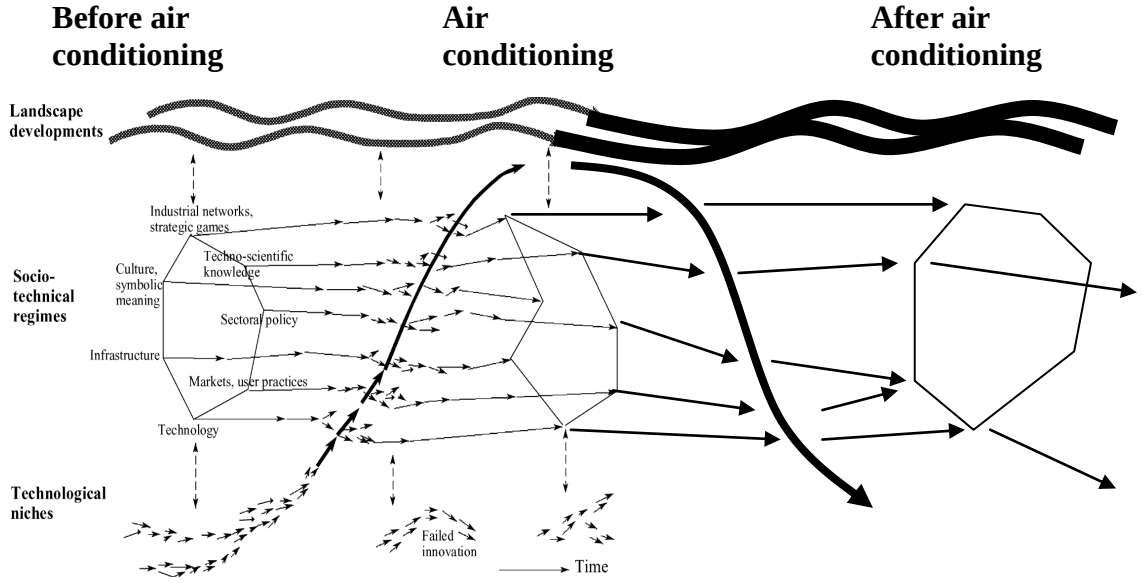

Figure 4: Reinventing previous regimes

The possibility of reinventing diverse 'local' regimes of cooling raises further questions about the uneven 'loss' of the once vital elements of a non air conditioned era. For example, where does local knowledge of how to adjust buildings to suit the changing climates of the day persist, where do those opportunities remain, and how does this play out in terms of social as well as national or climatic variation. For example, which societies sustain siestas and so keep alive the regimes associated with them? Which households are accustomed to 'sweating it out' and which are not? More abstractly, but also practically, how far has the air conditioned regime literally overwritten prior arrangements and led to their demise. To what extent is mechanical cooling wired into society along with the energy demand on which it depends, and how resilient is this arrangement in the longer run.

Although mechanical cooling is apparently becoming 'dominant' in certain sectors of certain societies this dependence goes hand in hand with specific vulnerabilities. What happens when peak demands force cuts in power, what new geographies of discomfort emerge, and how are capacities to adapt differentially distributed? To some extent the answer depends on the degree to which alternative configurations of continue to co-exist alongside air conditioning. On this point it is important to recall that even in the most dependent situations air conditioning is part of a more encompassing system that still includes bodies, sweat, clothing and the fabric of the building itself.

Looking ahead, and anticipating configurations of comfort better suited to a lower carbon society (Shove, Chappells, Lutzenhiser and Hackett 2008), we might imagine new relations emerging within, around and sometimes in place of broadly air conditioned regimes. This could involve the relocalisation of comfort related strategies and along with a much closer connection to the changing seasons. This implies some future transition in which the homogenizing grip of air conditioning is loosened and in which we see the emergence of not one but a proliferation of relatively discrete climate management regimes in different parts of the world.

Cities might differentiate between themselves in terms of how they manage 'cool'. As part of this, clothing could be deployed as a serious global environmental 'strategy'. This is not as strange as it might at first seem. In 2005, the Japanese government launched the cool biz initiative, setting thermostats in government offices to 28 degrees C in the summer and actively encouraging looser styles of clothing. The Prime Minster has got involved, and the Ministry of Environment has sponsored 'cool biz' fashion shows in which ministers and well known figures from industry model new style outfits with short sleeves and open necks, all designed to permit evaporative cooling. In the short term, there are noticeable energy savings and CO2 emissions reductions. In the longer run, it is possible that indoor climates will be designed in the expectation that clothing has a significant part to play in reproducing conditions of comfort. It is not yet clear whether Cool Biz represents the first step in a more systemic move towards body-centric rather than space-conditioning, but it may indeed be that clothing is the new cool.

Whether this is so or not, we suggest that our discussion of variously resource intensive methods of managing cooling and of keeping human animals indoors (Baker 2004) points to the need for an analysis of sociotechnical transitions capable of accommodating spatial diversity and of representing processes not only of innovation but also of disappearance and reinvention at different scales. In short we need to take account of the range of co-existing ways of life and of the complex, overlapping and sometimes parallel routes which these multiple forms emerge, change and intersect.

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