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The energy and monetary implications of the '24/7' 'always on' society ☆

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ABSTRACT

This paper reviews the trends in society, technology and energy demand of the past 30 years, together with the growth of the 'on-demand' culture. The '24/7' or 'always on' society can be defined as one where people demand—and generally receive—what they want 'now'. It has grown up in parallel with developments in information technology, which have produced the services needed to meet that demand. Larger numbers of appliances, resulting from greater affluence and disposable income, have increased energy use, despite energy efficiencies in other areas. While monetary factors suggest that changes brought about by the 24/7 society will generally be self-correcting at the macro-economic level, there will nevertheless be effects for individuals, such as potentially severe impacts on the fuel poor as electricity prices rise.

We conclude with a view of future directions. As the 24/7 culture continues to grow, there is scope for designers and for information technology to manage and reduce energy consumption. This includes buildings, their services systems, and the mix of new technologies that will be deployed over the next 20 years or so, including the possibilities for data exchange and control at the interface between energy suppliers and consumers, coupled with greater understanding of the behaviour of the consumers themselves.

1. Introduction

In 2003 a survey carried out by Yellow Pages (2003) attempted to identify changing attitudes to modern lifestyles. People aged 22–44 were asked what 24/7 (24 h per day, 7 days per week) goods and services they would most like to see available in their area. The most requested round-the-clock service was healthcare, with just under two-thirds of people wanting to be able to contact their doctor, dentist or local pharmacy at any time day or night.

Interestingly, in this survey entertainment is not mentioned. But if asked to provide a definition of a 24/7 society many of us would provide examples related to leisure and convenience, perhaps television and radio programming, satellite television services such as 'on-demand' TV, computer access to the internet and email, call-centre services for banking, mail-order shopping and 24-h shopping at supermarkets. These are the services that affect the everyday lives of people in the UK and other Western societies, and this review will focus on their likely energy and monetary implications. This example might suggest that the real issue is not a 24-h lifestyle—everybody needs to sleep—but a society that requires what it wants 'now'. If this definition is accepted, then it is necessary to examine the changes in our society which this approach involves, and the impact of these changes on energy use and hence carbon emissions.

Most energy consumption in the built environment occurs in the domestic sector. A smaller yet still significant amount of energy is consumed in office buildings, many of which will now be operating for far longer than the conventional '9–5' day. If it is also accepted that many longer working days will be spent 'at home', then, in order to understand the impacts of changes in our society's attitude to work and leisure, it is reasonable to focus on what is happening on the domestic scene. In this context Moll et al. (2005) identify households rather than individual consumers as the principal determinant of resource consumption. In addition, they identify the household as a social decision-making unit. They estimate that 70–80% of national energy use and greenhouse gas emissions may be related either to household activities directly or to activities required to deliver goods and services to households and to manage the waste flow they generate (Moll et al., 2005).

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To address these issues, this paper is structured as follows. First there is a short review of how society has changed over the last 30 years from the perspective of technology, energy demand, and the growth of the on-demand culture, together with the manner in which these inform our current situation. Monetary implications are then discussed, followed by a view of likely future developments in terms of the roles that design and information technology might play in shaping future energy demand.

2. What has changed?

In this section we look at changes in energy use, how society has changed and the technological changes that allow the on-demand society (Table 1).

Energy use for domestic space heating increased by 28% between 1970 and 2005. In the same period energy use for lighting and appliances increased by 148% (DTI, 2006).

The increase in energy use for space heating can be attributed to increased average household temperatures, 12 °C in 1970 and 18 °C in 2002 (Utley and Shorrock, 2006). According to the Energy Saving Trust (2006a), 22% of people in the UK turn up the thermostat instead of putting on extra clothing.

Increases in energy use can also be attributed to the number of households, which has risen significantly over the last 30 years while the population has remained relatively stable (Fig. 1).

2.1. Social change

2.1.1. Demographics

Demographic changes have influenced appliance and residential energy consumption (Environmental Change Institute, 2005; Moll et al., 2005; Van der Wal and Noorman, 1998; Van Diepen, 1998). The divergence between the growth of the population and the number of households indicates that the average size of the household decreased from 3.0 in 1961 to 2.4 in 2004 and is currently 2.3 (Jefferies, 2005). Only 7% of households in the UK contained more than four people in 2002 compared to 14% in 1971, and the proportion of single-occupancy dwellings rose from 12% to 29% over the period 1961 to 2004 (Environmental Change Institute, 2005).

There are also more single-generation households. Young people leave their parental home sooner and the elderly live by themselves and not in extended families. Divorces also add to this number (Sanne, 2002). According to Van Diepen (1998), the UK is rather unusual in that the number of households has increased much more rapidly than the population.

The trend in household numbers and size is a key factor of energy consumption. This is because each household requires its own set of appliances and lights (Environmental Change Institute, 2005), and within the household each member expects a TV set, computer or telephone (Van Diepen, 1998).

2.2. The 24/7 society

There is some evidence that householders now stay up later to use 24-h services: 7 million people (one-seventh of the UK adult

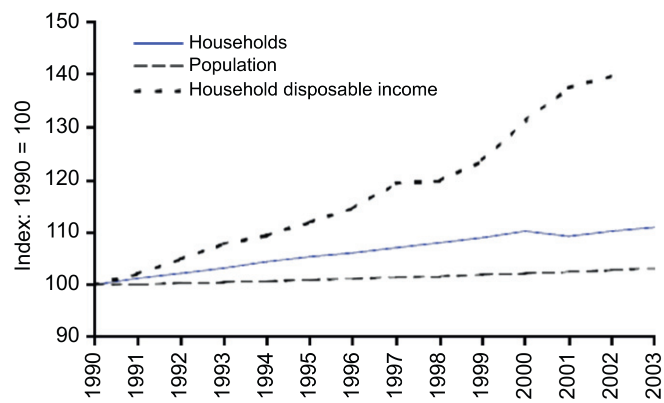

Fig. 1. Population, households and disposable income changes (*source*: DTI, ONS in BERR, 2007a).

Table 1
Direct energy demand including heat and electricity since the 1970s

	Space heating	Water heating	Appliances and lights	Data source
Energy carriers	Coal, oil, coal gas Natural gas 1950, 90% of UK's total primary energy was supplied by coal 2003, 80% of homes used natural gas as heating fuel			Van der Wal and Noorman (1998) DTI (2004) in Environmental Change Institute (2005)
Percentage of residential delivered energy consumption (electricity and gas)	77%		23%	Environmental Change Institute (2005)
	60%	20%	20%	Design Council (2005)
	59%	24%	17%	DTI (2002) in: Energy Saving Trust (2006b)
Change in demand	Total	Increased 36% (1970–2001)	Increased 70% (1970–2001) Increased 123% (1970–2003)	Data of 1970–2001 Environmental Change Institute (2005)
	Per house-hold	Remained stable (1970–2001)		Data of 1970–2003 Environmental Change Institute data in: DTI (2003)
Determinate of change		Increasing no. of households Low energy prices Availability of central heating systems Insulation installed in dwellings Higher indoor temperature	Increasing income Low electricity prices Availability and purchase of domestic appliances Energy use per appliance Use patterns	Van der Wal and Noorman (1998) Environmental Change Unit (1997)

Table 2
Domestic energy and electricity usage broken down by sector (Environmental Change Institute data in: DTI, 2003; Energy Saving Trust, 2006b, pp. 13–17)

Sector	Per cent energy usage (%)	Per cent electricity usage (%)	Appliance	Penetration
Space heating	59			
Water heating	24			
Cold	3	18	Fridge-freezer	64%
			Refrigerator*	43%
			Upright freezer	27%
			Chest freezer	17%
Wet	2	14	Washing machine*	79%
			Tumble dryer	40%
			Electric shower	35%
			Dishwasher	25%
			Washer dryer	15%
Cooking	3	17	Kettle*	97%
			Microwave	83%
			Oven*	80%
			Electric oven*	59%
			Electric hob*	46%
			Deep fat fryer	34%
			Sandwich toaster*	33%
			Slow cooker	20%
			Cooker hood	18%
Lighting	3	20		
Consumer electronics	4	21	TV*	98%
			Cassette player/radio*	95%
			Hi-fis*	94
			VCR	87%
Miscellaneous	2	10	Personal care product*	94% (hair care)
			Mobile phones	81%
			Heater	80%
			DIY equipment	59%
			Computer	45%
			Monitor	45%
			Printer	32%
			Fax/scanner	11% (fax)
			Vacuum cleaner*	
			Home security system	
			Telephone/answer machine	

population) undertake economic activity between 6 pm and 9 am (i.e. earning or spending), and 15% of shopping occurs between these hours as does 44% of household management (including banking). There is also a small proportion of household management that occurs between 4 am and 9 am, with call centres experiencing high volumes of calls in the early morning (Hicks, 2006).

Sleep time has reduced from 508 min in 2000 to 491 min in 2005 (Office for National Statistics in BERR, 2007a). Night-time is no longer ring-fenced for sleep. It has become the new daytime, offering us the chance to catch up on everything we did not manage to cram in during what used to be our waking hours. Now, instead of sleeping, we can check our bank balances by phone, buy groceries, surf the net for cheap flights or swap our slippers for training shoes and go to the gym.

Research carried out by the Future Foundation (2003, in Hicks, 2006) argues that the increase in 24/7 culture is being driven by the rising affluence and disposable income of those in higher earnings brackets who want to enjoy the fruits of their labour. The Future Foundation study found that two-thirds (67%) of people think that supermarkets opening 24 h a day is a positive trend—indeed, the study suggests that 15% of shopping takes place between 6 pm and 9 am.

Research by Shell estimates that in the UK, up to 17 million people regularly shop at night, and Nielsen Homescan found that 58% of young people with no dependents would shop at night if amenities were readily available (both quoted in Kreitzman, 1999, in Geiger, 2007).

2.3. Technological change

Since 1970, homes and products have become more energy efficient. But the increasing numbers of products and the advanced technological innovation they contain have brought a sharp rise in domestic energy consumption. According to the data from the Environmental Change Institute, UK residential electricity demand doubled from 44 to 89 TWh between 1972 and 2002 (Energy Saving Trust, 2006b). Table 2 provides a breakdown of electrical use in dwellings. The items marked by an asterisk are those that would have been common in the 1970s.

Ownership of home computers has increased from 0% in 1981 to 67% in 2005 (Market Transformation Programme, 2006). Daily use of the TV increased by 13% between 1995 and 2005 (Boyny, 2006). It is estimated that standby energy consumption accounts for about 1% of domestic energy use in the UK, equivalent to 6% of domestic electricity consumption.

2.4. Energy use

At the household level, the efficiency of buildings, heating systems and household appliances use has improved by around

Table 3
Estimated standby consumption by domestic appliances, 2006 (Market Transformation Programme, 2007)

Appliance category	Standby power (watts) mean	Stock (million units)	Standby time (hours/day)	Energy use (GWh)	Cost (£ million)
Desktops	3.4	23	13.7	392	39
Laptops	1.3	4	14.3	32	3
PC monitors					
CRT	2.1	8	13.7	91	9
LCD	1.1	15	13.7	90	9
Plasma	4.0	0.1	13.7	3	0.3
Multifunctional Devices (MFD)					
MFD Inkjet	4.1	4	18.0	106	11
MFD Laser	10.0	0.1	18.0	6	1
Printers:					
Ink	1.5	9	19.1	102	10
Laser	14.2	2	13.1	161	16
Photo	1.9	2	11.6	16	2
Televisions					
CRT primary	2.6	21	10.5	320	32
CRT secondary	2.6	32	12.9	583	58
LCD primary	2.7	2	10.5	24	5–2
LCD secondary	1.8	4	12.9	32	3
Plasma primary	4.0	3	10.5	46	5
Projection primary	1.8	2	10.5	10	1
DVD player	1.9	23	9.1	491	49
DVD recorder	9.4	2	9.1	78	8
VCR	4.0	19	9.1	324	32
Digital TV recorder (DTR)	6.2	0.1	9.1	2	0.2
Mobile phone charger					
3.5 W	3.5	10	10.0	123	12
1 W	1.0	60	10.0	220	22
Set-top boxes					
Cable	15.2	2	7.0	124	12
Satellite	15.0	8	7.0	412	41
Terrestrial	6.4	8	7.2	194	19

2% year on year since 1970 (Energy Saving Trust, 2006b). But the increased use of appliances (Table 2) and a liking for warmer houses has swallowed up these hard-won energy gains. The energy supply requirement of the residential sector has increased by 32%. Electricity consumed by household domestic appliances and lights has increased by 70% (Environmental Change Institute, 2005) and is anticipated to rise by a further 12% by 2010 (Energy Saving Trust, 2006b).

There is little official historical information available on energy use by different types of consumer at specific times of the day. Between 2001 and 2007 electricity use between midnight and 5 am increased by 10.9% in the summer and 14.5% in winter (National Grid, 2002, 2007). However, at the same time, daytime (8 am–6 pm) electricity use increased by 14% in the summer and 11% in the winter (National Grid, 2002, 2007).

Internet businesses claim to be more energy efficient than conventional ones. Amazon.com, for example, uses only 6% as much energy per square foot to sell a book as a regular store (Abukhader and Jonson, 2003). However, estimates of the electricity used to operate internet routers, switches and computers range from 1% of total US energy use to 8% (Abukhader and Jonson, 2003).

Reijnders and Hoogeveen (2001) found that internet businesses may use less energy than other organisations to distribute goods, but that the electricity used in the computers of people buying on the internet may far outweigh these gains. In general, among several pilot studies and reports, we find a common view that there is no conclusive evidence that e-business and internet use have either increased or decreased environmental impacts, as there are examples of both positive and negative effects (Fichter, 2001).

3. Monetary implications

The most obvious result of these changes is that people will be spending more money on electricity. Domestic consumers bought 116 TWh of electricity in 2006, at a cost of £11.8 billion (BERR, 2007b, Tables 1.7 and 5.3). The standby consumption depicted in Table 3 comes to just under 4 TWh per year, with an estimated cost of almost £400 million per year. The total spending depends on both price and quantity, of course, for spending in 2005 was only £8.8 billion. Domestic electricity prices were 22% higher in 2006 than in 2005 on average, and this price rise contributed to a small fall in the volume of electricity consumed.

We might ask whether electricity consumption, and particularly increasing electricity consumption, will be affordable. Total consumer expenditure in 2006 was £794 billion, and the spending on electricity came to only 1.5% of this. For the average household, there is clearly scope for the amount spent on electricity to continue to rise. A substantial minority of households is fuel poor, however—the official definition is that they are spending more than 10% of their disposable income on heat and light. In 2005, 2.5 million households were fuel poor, and 2 million of those were vulnerable, that is, they contained children, or people who were elderly, sick or disabled. Fuel-poor households may be relatively less likely to own the modern appliances contributing to increasing electricity consumption. But any price consequences of that increasing consumption will have particularly severe impacts on the fuel poor.

We should ask why increasing electricity consumption might affect electricity prices. The good news is that if the existing networks are able to effectively distribute increasing volumes of power, their fixed costs can be spread over a larger output, reducing the cost per unit distributed, and tending to lower prices. Of course, if the networks are not able to cope with increasing loads, more investment will be needed, with associated costs. The bad news is that, for a given stock of power stations, higher electricity demands will mean higher prices in the wholesale markets, and these will be passed on to consumers. In the longer term, rising demand would give generators the incentive to add more capacity, muting the impact on prices. But if the only way of accommodating the extra capacity is to use less suitable sites, costs will be higher, and the market will only regain its equilibrium at a higher price level. This could be a particular issue for renewable generators, where site-specific factors have a very significant impact on output, and hence on costs per unit generated. Consumers will pay more, and the existing generators will make more money. Finally, if there is a fixed carbon budget, an increase in electricity output is only possible if the carbon intensity per megawatt hour falls, requiring more use of low-carbon generators. This must involve higher costs, since if the low-carbon generators were cheaper than high-carbon alternatives, they would be used, whether or not carbon emissions were important.

This leads us to consider effects on the wider economy. The extension of Sunday trading hours provides a natural analogy to the 'always on' society. A study commissioned by the Department of Trade and Industry in 2006, when an extension was being considered, provides an estimate of the impact (Indepen, 2006). Large retailers' unit costs would fall by 0.6%, if longer opening hours gave them higher sales for the same amount of non-staff costs. In a competitive market, most of the benefits from a cost reduction of this kind would be passed on to consumers. Consumers would also gain from a greater ability to coordinate their trips (passing an open store while making another journey) and shop at less congested times, but might lose out if convenience stores lost sales and were forced to close. Indepen valued these effects at around £1.5 billion a year.

We might see similar effects as the 24/7 society becomes more intense. Consumers can spread their shopping over more hours, and those shops that gain sales will see a reduction in unit costs. If the increase in sales per shop means that fewer new shops are opened, there will be a saving in the total cost of shops, and the money saved can be spent on other things. If the increase in the shops that have extended their hours comes at the expense of others, then their unit costs will rise, reducing the total savings.

Online retailers' lower direct costs mean that the ratio between retail and wholesale prices will fall as the proportion of online sales increases. This implies that a given amount of consumer spending will buy a larger volume of products. To the extent that the UK is a net importer of consumer goods (as it is for all manufactured goods), this might worsen the balance of trade. However, changes in the balance of trade would have an impact on the exchange rate, which would itself feed back to exports and imports, and thus have a long-run tendency to be self-correcting. In fact, many of the changes from the 24/7 society will be self-correcting at a macroeconomic level. People do not gain more money to spend simply because they can spread that spending over a longer proportion of the day. There will be individual effects, but the macroeconomic effects will tend to be muted by this basic fact.

4. Future directions

4.1. Design

The non-stop society forces consumers to adopt lifestyles which are unsustainable (Reisch, 2001, in Shove 2003). Individual behaviours are deeply guided by what others around us say and do. 'We do so because that's what everyone else does' (Sustainable Consumption Roundtable, 2006). The internet is not expected to become the default shopping medium in the UK, because the social aspects of shopping are simply too powerful. Nevertheless, its impact continues to grow. Internet sales rose by 54% in the UK during 2007, while retail sales grew by 4.5% over the same period (IMRG, 2008).

It is predicted that by 2020, 25% of the UK population (over 13 million people) will be operating in the 24/7 culture. The increase is due to an increase in the disposable income of those in the higher earning brackets (Future Foundation, 2004). A total of 35% of households earning more than £46,000 and 20% of households earning £10,430 or less will take part in out-of-hours activities (Hicks, 2006). By 2020, 46% of the population will be over 45 years of age, and 39% of people will be aged between 25 and 45 years (Hicks, 2006).

Although behavioural patterns appear to be resistant to change, there is considerable evidence of radical technological and behavioural change in the uptake of products such as mobile phones, plasma TVs, power showers, standby modes in electronic appliances and air conditioning in cars (Jackson, 2005, p. 105). This highlights the potential for designers to intervene more creatively to unlock 'bad habits' and to establish new opportunities for sustainable living. At the same time, increasing European directives (such as EuE) are focusing on the reduction of energy use in products and setting minimum energy performance standards. There is potential to lead to large reductions in household energy requirements as designers begin to consider these issues.

4.2. Energy management

Among the new opportunities afforded by information technology is the ability to monitor and control the operation and hence the energy performance of systems, buildings in particular. Termed 'building management systems' (BMS), or 'energy management systems' (EMS), they allow the status of the building and its energy-consuming systems to be observed via a range of sensors, and action to be taken to change their operation. Control is frequently effected via control algorithms. They vary in complexity from digital versions of simple on/off, PID (proportional—integral—derivative), or optimum start/stop controls to advanced model-based control formats such as adaptive or predictive methodologies (see, for example, Liao et al., 2005). To date, such condition monitoring and control systems are usually restricted to commercial buildings, and there remains scope for their introduction into the domestic sector. More intelligent control of buildings and their systems might save in the region of 20% of energy consumption (Murakami et al., 2007). It is likely that the future will see an increase in the use of these technologies with the adoption of more advanced model-based strategies (EMS are capable of implementing such digital control algorithms). Systems could take automatic account of occupants' needs 'learned' from their behaviour or detected by sensors (see, for example, Fisk and De Almeida, 1998; Liang and Du, 2007). This is a key area where the technology that has helped create the 24/7 'on-demand' society can also be used to manage and reduce its energy consumption.

Fig. 2. Flower Lamp (Interactive Institute, 2005).

The concept of providing the user with more information about their energy usage, to allow them the opportunity to change their behaviour, is also gaining ground. This is termed 'smart metering' (Bertoldi and Huld, 2006; Houseman, 2005; Kinver, 2006). An example of how design has begun to tackle this can be seen with the Flower Lamp from Sweden (Fig. 2). It is not just the light of the lamp but its form that reflects energy used. The lamp 'blooms'—changing its shape and thus lit expression—when energy consumption in a household has been low for some time. In order to make the lamp more beautiful, a change in behaviour is needed.

4.3. Technology

In general buildings are responsible for over 40% of the UK's carbon emissions, with transport giving rise to about 35% (Energy White Paper, 2003). It is estimated that energy-efficiency measures have the potential to reduce primary energy consumption in Europe by over 20%, with the largest cost-effective savings potential being in households (27% savings) and commercial buildings (30% savings) (European Commission, 2006, 2007). Furthermore, there are commitments for a 20% reduction in energy consumption in Europe by 2020 (European Commission, 2004), as well as enhancement to the UK's targets for carbon reduction (UK Budget, 2008).

In line with these aims, the future is certain to see the increasing adoption of energy-saving measures, together with the likely integration of a mix of new and renewable energy technologies for space heating, water heating and power generation, as a means for the UK to make significant progress towards achieving its targets for carbon reduction. Technologies brought into use for the first time, or developed beyond their present scope, could include heat pumps, combined heat and power, photovoltaic and solar thermal collection and fuel cells. A review of low-carbon technologies for the built environment is given by the BRE Trust in partnership with the NHBC Foundation (Fisher et al., 2008). Alongside the deployment of the new technologies, it will be essential to provide the necessary infrastructure to support their use. This will involve their manufacture, installation and maintenance, education and awareness of them, and their eventual recycling. Interactions with users and wider society will need to be fully explored and accommodated. The role of hydrogen as the fuel of a future low-carbon economy is reviewed by McDowell and Eames (2006), including the factors that affect its rate of emergence.

Information technology offers an important means to reduce carbon emissions by complementing these technologies and by providing data to interface with user behaviour, as outlined in the previous section. This may take the form of remote system monitoring and control by energy utilities, perhaps linked to localised energy storage that helps the management of demand and assists in balancing the main grid infrastructure. Such storage techniques will also interface with the daily living patterns of the users. There will probably be increasing use of localised grids for power distribution as distributed generation increases. While information technology may well have helped to bring about the on-demand culture, it can also be used to help curb and control energy demand.

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