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Beyond Energy- efficient Built Environment – Examining the Relationship between the Users’ Cultural Values and Energy Consumption.

B K Satish

School of Art, Design and Architecture, University of Plymouth, UK.

Abstract. Recent developments at the global level have forced responsible countries to take decisive actions to mitigate climate change. In the race to reduce energy consumption in the Built Environment, resource efficiency has been underpinned by low embodied energy (low carbon building) and consumption pattern. Recent expectations of energy reduction and energy efficiency have redefined the way buildings are insulated and spaces are utilised. This is particularly critical in the case of Passivhaus design, smart buildings etc, where the users are expected to align themselves to the building specification than the conventional practice of designing and building for the users’ requirements. There is a direct correlation between culture informed behaviour and sustainable built environment. Though there is considerable progress in energy efficiency in the built environment, further research is required to understand the individual perception and its implication on energy consumption pattern. Further, research relating ethnic background and their behaviour to energy consumption are scant. In this context, this paper reviews the prevailing research in the three broad areas of Thermal comfort, Ethnicity and Cultural Behaviour and its impact on Energy behaviour. Due to time and scope, this paper will not dwell deep into these topics, rather on the overlapping, interrelated aspects. In the process, it proposes a framework to analyse user energy behaviour while addressing the built environmental issues related to climate change. These topics present many opportunities for productive future research.

Key words: Thermal comfort, Energy Behaviour, Cultural Behaviour

1. Introduction

Climate change and its immediate impacts have had a major consequence in the way we use energy. Meanwhile, technological advancements are leading us to be hypersensitive to the urge to be comfortable is forcing us to attain a higher degree of comfort. P.O. Fanger championed the heat balance calculation of the indoor climate and the users in the 1960s and 70s. His proposed studies, Predicted Mean Vote and Predicted Percentage Dissatisfied (PMV-PPD) indices and PMV model, is still being used as a thermal comfort evaluation tool by international standard organisations such as ISI and ASHRAE Standard 55 [1]. The key shortfall of the heat balance models is that it views occupants as passive recipients of thermal sensation irrespective of different building types and climate zones. On the contrary, later developed adoptive model emphasises more on the occupants and their thermal comfort through the psychological, physiological and behavioural process.

There are considerable innovations while understanding and responding to thermal comfort in buildings and it is the oil crisis in the 1970s, which encouraged the energy-efficient approaches in thermal comfort [2]. The recent developments have shifted the focus of thermal comfort from energy-



intensive central systems to locally controllable adoptive comfort [2]. Recently, researchers have highlighted the negative impact of the spaces designed for neutral, uniform and static condition as it is extremely energy intensive to maintain thermal neutral condition [3]. Researchers have argued for the need for a paradigm shift in the notion of comfort, reflecting individuals' preferences and internal ambience, which energises building inhabitants and brings pleasure while saving energy in the process. While introspecting the performance of the occupant, researchers have found out that no best temperature for productivity exists rather it occurs within a wide range of air temperature [3]. One of the crucial limitations of the prevailing studies is that the internal environment is mostly controlled and expressed by air temperature and humidity and building performance are directly related to thermal comfort [3].

While understanding the perception of thermal comfort, one has to acknowledge the distinction between sensation and perception. While sensation detects the stimulus in the ambience, perception refers to the interpretation process of the information [4]. It is this perception which interprets the quality of or changes in the environment to the user [2]. Delzende et al in their review paper have identified that hardly 10 % of the research papers related to user behaviour in the 100 papers they have reviewed relating to both social and personal factors [5]. One of the key components of the established Franger's PMV model is the limitation of being descriptive of thermal environmental parameters. For instance, zero on the seven-point ASHRAE scale meant that the environment evokes a neutral, neither warm nor cool, response. However, it does not reflect the perception of the occupants and hence whether they like it or not as the descriptive model assess the acceptability of the environment [2]. Introspecting and changing human behaviour is one of the key paths while addressing the climate change challenge and to reduce energy consumption [6]. Understanding the user behaviour is very important and there is very limited research in this area. This paper focuses on Alliesthesia and elaborates the perception of users beyond thermal neutral conditions. A key driver of the perception and energy behaviour, culture, is explored in the next section. Finally, a cross section of the users, expatriates in the UK, and their energy behaviour is examined.

2. Alliesthesia

Neutral thermal comfort has been the norm of thermal comfort studies for a while and it is only recently researchers have started challenging the notion of thermal neutrality. For instance, Shahzad et al. have in their study of Norwegian and British offices, questioned the reliability of any study that solely relies on neutral thermal sensation [7]. The human brain and physiology are inbuilt to appreciate and adapt to the seasonal variations. People are tempted to go to different climate conditions for holiday and vacations and in the process entice their sensory feelings. In all these cases, they are not necessarily trying to enjoy the extreme climate rather find the variation more stimulating and pleasurable. It is in this context we have to review the current notion of establishing a neutral condition.

To mitigate the climate challenge, we have to find means to reduce energy consumption and in the present climate of the energy-intensive world, we have to be cautious of investing an enormous amount of equipment and energy to produce neutral thermal condition when actually human are by nature are (designed) born to adapt to seasonal climatic variations, which is more pleasurable. Zhang et al have underlined the limitation of the literature pertaining to comfort at segment, body part level and argued that there is limited literature on the sub-segment level of comfort [8]. Ioannou et al have concluded that neutral sensation is not comfortable and variation in the thermal sensation levels could be out of habits and the variation is attributed to alliesthesia [9].

Lichtenbelt et al have demonstrated that the human body will be positively affected by exposure to cardiovascular parameters and challenged the seminal knowledge of comfort zone [10]. It is established that minimal heat is produced while maintaining body temperature and human energy balance is influenced by microclimate [10]. However, it is also proven that mild cold or warm can increase energy metabolism without discomfort. In fact, low or high temperatures in a dynamic thermal environment may be perceived as even pleasant, evoking thermal alliesthesia. These researches underpin the significance of alliesthesia while designing healthy, comfortable and energy-friendly indoor

environments [10]. In a Psychology study, Sailer et al have explored the difference between olfactory alliesthesia and olfactory sensory-specific satiety [11]. According to olfactory sensory-specific satiety, there will be a decrease in the pleasantness of an odour as it is smelled and it is the external factor which defines the perception of an individual. However, alliesthesia is defined as “the change in pleasantness that results from a change in the internal state of the subject” [12]. For example, internal state changes due to glucose after eating food results in a decline of the pleasantness of a food stimulus [11].

The Human body responds to the changes through sensors received from the external environment. These sensations are descriptive and hence displeasure or pleasure of a sensation depends on internal signals [4]. These signals from within the body define the external stimulus as pleasant or unpleasant. The early advocate of the concept, Cabanac, coined the term Alliesthesia. Alliesthesia can be defined as the phenomenon whereby ‘a given stimulus can be perceived as pleasant or unpleasant according to the inner state of the subject’ [4]. The concept of alliesthesia enables us to differentiate thermal pleasure from the established thermal neutrality [2]. Cabanac, in his original study, had focused on thermal, gustatory, and olfactory senses and argued that alliesthesia also exists in bringing signals to the individual’s attention [4]. Further, ‘a stimulus can feel pleasant or unpleasant depending upon its usefulness as determined by internal signals’ Michel Cabanac [4].

Son and Chun have studied the correlation between psychological and physiological measures [13]. Alliesthesia is a compound word; ‘Aesthesia’ means ‘sensation’ and ‘allios’ means ‘changed’. Some stimuli may leave either pleasantness or unpleasantness depending on perception. Alliesthesia studies tend to combine physiological (objective) and psychological (subjective) measures. Son and Chun have demonstrated that EEG as a psychological and physiological measurement tool can be used while evaluating individuals’ thermal pleasure in thermal alliesthesia [13]. In the case of air movement within an enclosed space, people who feel warm would prefer more air movement and people who feel cold would generally prefer less air movement [14]. Parkinson and Dear have established that contrasting relationships between local and global skin temperatures trends enables positive thermal pleasure [14]. Brager et al have examined the quality of indoor air movement to advance the understanding and use of Alliesthesia [3].

In the race to reduce carbon emission, care has to be taken that there are no adverse effects and negative impact on the comfort of the inhabitants [6]. Traylor et al have demonstrated that one can experience pleasure through change by modulating setpoints [6]. This study suggests a savings of 5-10C by modulating the indoor temperature in cooling applications, whereas in heating applications the variable temperature consumed more energy than the constant set point. It is established that modulating temperature could lead to greater thermal pleasure. Way ahead is to achieve both increased human comfort levels and energy savings. Recent studies demonstrate the significance of users behaviour in energy use [6]. For instance, Hong and Lin have identified a reduction of 50% energy use or increase by 89% due to the behaviour of users compared with the average person [15].

Personal experience and improving comfort condition are paramount while reducing energy reduction. In the thermal sensation vote (TSV) model of seven-points developed by Fanger [16], earlier understanding advocated for maintaining Zero (neutral) to achieve optimum thermal comfort and a PPD below 10% and PMV of between 0.5 and -0.5 [16, 17]. Whereas, research suggests that people tend to prefer a value of 1 as a desired thermal sensation in a cool climate area [18]. Michel Cabanac has established the relation between pleasure and thermal comfort [4] and demonstrated that constant thermal comfort will only avoid thermal discomfort. Building on this, De Dear (2011) has challenged the validity of maintaining the constant indoor temperature. Traylor et al have argued that building energy consumption by changing the human behaviour [6]. Delzendeh et al, through psychological cognitive behavioural methods, have identified the need for understanding socio-personal parameters while analysing the user’s behaviour and resultant energy consumption. In their review paper, they have highlighted the lack of impact of occupants’ behaviour in building energy performance analysis. One of the key shortfalls is that the impact of occupants is only considered through means of scheduled and fixed patterns of behaviour [5].

3. Culture informed Energy behaviour

It is established that energy use is influenced by homeowner behaviour and this behaviour varies across the population. The homes of similar build and from the same climate zone can still consume a varying level of energy due to homeowners' behaviour [19]. Human behaviour is quite a complex subject to understand with cognitive biases and behavioural anomalies which have a direct bearing on predicting and changing the behaviour of households. The household's behaviour could be analysed by modelling the formation of behaviours. The individualistic model of behaviour looks at the process of rational decision making focusing on the particular actor. The socially orientated model focuses on action or practices of society. Ofgem and Chatterton have looked at four types of theories to interpret user's energy behaviour [20]; Economic Theories, Psychological Theories, Sociological Theories, and Educational Theories: [20]. When it comes to policy implementation, behaviour plays a crucial role. Frederiks et al. have highlighted the difference between what households admit to what they actually do [21]. For instance, there is an attitude-action gap, a value-action gap, a knowledge-action gap and an intention-action gap. Also, it is likely that households would be aware of the values and hold a positive attitude in a socially desirable way. However, they not necessarily translate into actual behaviour [21]. For instance, people acknowledge that they understand the significance of climate change and the relevance of saving energy. However, research suggests that there is no direct correlation and these concerns not necessarily translate into actions in terms of practical actions to reduce household energy consumption [21].

From the research in behavioural economics and psychology, key suggestions by Frederiks et al. include, Status quo bias and defaults, Satisficing, Loss aversion, Sunk costs, Risk aversion, Normative social influence, Intrinsic and extrinsic rewards, Temporal and spatial discounting, Free-riding and social loafing, Perceived trust, and Availability heuristics. While reviewing the energy conservation behaviour, Delmas et al. have concluded that the energy saving tips and information strategies, the feedback strategies and providing additional pricing information not necessarily lead to additional energy savings [22]. Further, they have argued that providing financial incentives could sometimes be counterproductive. Alcott, in his study of 600,000 households across the United States has demonstrated that non-price interventions can affect consumer behaviour [23].

The underlying determinants of energy-related behaviours and resultant energy use have hardly been examined. This work reiterates the fact that knowledge and attitude are mostly positively related to energy savings. Abrahamse et al. in their review of behaviour studies of the households have concluded that rewards to the households seems to have a positive effect on energy savings and identified the shortfall of relatively little known long-term effects of interventions [24]. Similarly, behaviourally based changes can have a very quick impact on emission reduction, they are highly cost-effective and provides benefits to households directly [25]. The UK government has recognised the significance of behavioural insights to public policy to promote energy-efficient products. They have also demonstrated that carbon emissions could be reduced by awareness of the neighbour's energy use to manage their own emissions [25].

There are many studies reviewing different housing practices for different stakeholders. Chen et al has identified behavioural patterns and their impacts on residential energy use among the low-income population. Further, there is a positive correlation between household size and income to the level of energy use [26]. Based on energy consumption, Barthelmes et al. have classified the occupant behaviour into three lifestyles: low consumer, standard consumer, and high consumer [27]. The occupant's energy behaviour is also underpinned by the values and identity. For instance, people's willingness to be part of the social norm or to see themselves as different from others would be crucial to how they act and respond to societal requirements. There is a correlation between the users' values and behaviour, and occupant's behaviour could be positively influenced by developing new strategies from socially-oriented approaches. Whereas, Individualist approaches to behaviour have its own limitation due to inclusivity, scalability and ethics of an individual's private space [20].

3.1. User cultural values

Cultural (cul-ture (klchr) n) values are explained by Webster's Dictionary as "The totality of socially transmitted behaviour patterns, arts, beliefs, institutions, and all other products of human work and thought". These patterns, traits, and products considered as the expression of a particular community, period, class, or population: Edwardian culture; Japanese culture; the culture of poverty" [28]. Over the years, scholars have articulated the concept of culture in different facets. For instance, Rice has defined culture as "the values, attitudes, beliefs, artefacts and other meaningful symbols that help people interpret, evaluate and communicate as members of society" [29]. In this context, Hofstede argues that it is an important manifestation of culture [30]. Values (system) evolves over a period of time and hence stable and can be defined through research techniques. Hence, the concept of users' culture comparable and measurable.

The terms 'customs', 'culture,' and 'values' are distinctive pieces of a bigger picture, though it is used interchangeably. A 'custom' is an outward sign of the group's cultural values. Whereas, in contrast, a group's values run deep and not always visible. It is the cultural values in the form of customs, people pass down for generations. Tylor's definition of culture is "that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society". In contrast to Arnold's view, "all folks "have" culture, which they acquire by virtue of membership in some social group – society" [31]. Further, Cultural values are articulated as the predominating attitudes and behaviour that characterize the functioning of a group or organisation.

Culture has various taxonomies and different scholars have explored different facets. Hofstede has reviewed culture as a concept and identified the characteristics of specific societies mapping the data from 50 countries worldwide as Long-term vs. short-term orientation, Power distance, Uncertainty avoidance, Individualism vs. collectivism, and Masculinity vs. femininity [30]. The role of individualism and collectivism plays a key role in the Sustainable Built Environment. Individualism promotes one to take care of self and their immediate family and advocates for a society with loose ties between individuals [30]. On the contrary, Collectivism represents an emphasis on community over the individual and priority for the family requirement than for that of individuals. The key difference is in terms of these community's emphasis on individual values and community values, for instance, Individualism promotes 'I' right from the childhood and Collectivism advocates for 'We'. This will have a significant impact on the built environment as it informs the way people make choices about individual requirement/ spaces. Hofstede's models of understanding culture through the lenses of Power Distance, Individualism, Masculinity and Uncertainty Avoidance, has relevance while understanding the homeowner's behaviours towards the development of Sustainable Built Environment [30].

Significance of culture and its impact is acknowledged in workplaces and resultant business and economic implications. For instance, John et al. have adopted the Hofstede (2001) taxonomies to account for the observed variance of cultural differences in employee commitment [32]. A key challenge of mapping culture to behavioural pattern and sustainable built environment is that the unique aspects of cultures have to be described using a finite set of dimensions. Further with globalisation and movement, it is challenging to compare countries reflecting their relative standing on a set of dimensions [32]. Further, countries are not egalitarian and homogeneous societies and it would be too simplistic to assign one tone for the whole country. Further, consumer-oriented societies have blurred the differences and the culture-based value system is now more driven by affordability and consumption.

4. Expatriates and energy behaviour

A clear and strong relationship has been established between thermal comfort and households. User's cultural background plays a crucial role. Now with more than 15% of people move around for work and settle, the way expatriates adopt themselves to the new place is important [33]. It is even more central to the discussion in the way the expatriates adopt, internalise the prevailing housing typology. Adjusting to the local housing is a complex phenomenon as it had to meet the climatic condition, cultural and social conditions and bridge the gap between two typologies and alleviate the homesickness of the expatriates.

There are about 60 million expatriates globally and the annual growth rate is growing exponentially [33]. The size of the expatriates is nearly equal to the population size of the UK. The behaviour pattern of the Expats is complex and constantly prodded by culture, ethnicity they belong to and the place and culture they have moved. According to UN statistics, Expatriates can be ranked as the fifth most populous nation on the planet with more than 235 million [34]. Nearly 15% of the UK population is expats [34]. With the reconfigured political system, more EU Expatriates from Bulgaria, Latvia, Romania, Poland and Lithuania have entered the UK in the last decade [34]. Review of literature suggests that immigrants' demonstrate similar or at times, even stronger concern for the environment compared to that of native-born individuals [35]. However, researchers have identified a lack of concern and lower levels of environmental awareness among immigrants compared to native-born individuals [36]. These studies have examined the concerns and attitude of ethnic individuals, however, there is limited research to prove how these attitudes translate into pro-environmental behaviour [35]. On the contrary, researchers have demonstrated that environmental concern not necessarily reflects environmentally responsible behaviour, known as the attitude-behaviour gap [35].

Values act as a guiding principle and enable people to develop their beliefs and attitudes about their physical environment [37]. According to the cultural cognition thesis, cultural values operate as a type of heuristic in the rational processing of information related to public policy issues. At the centre of the cultural cognition thesis, Douglas has articulated framework for classifying cultural values, which defines cultures based on their characteristics; hierarchy-egalitarianism and individualism-communitarianism [38]. The cultural cognition thesis asserts that people tend to form perceptions of societal risks based on the values characteristic of the groups with which they identify [39].

The hierarchical worldview advocates a hierarchy in the system and believes in distributing the rights, duties and goods based on the established social characteristics such as wealth, gender or ethnicity. Contrarily, equal distribution of the rights, duties and goods equally in the society is the egalitarian worldview. Further, individualistic worldview advocates that individuals should secure their own well-being and succeed without any collective assistance or interference. Whereas, societal interests are considered before individuals by the 'communitarian' or collectivistic worldview and consider society as responsible for securing the conditions necessary for individuals to thrive [35]. Environmental values: Pro-environmental perceptions (environmentalism) characterise people who show environmental responsibility.

Environmentalism can be viewed as a more specific, context-oriented value that is key to pro-environmental behaviour and includes a set of perceptions about the relationship between human beings and their environment [35].

5. Conclusions

To mitigate the climate challenge, we have to find means to reduce energy consumption and in the present climate of the energy-intensive world, we have to be cautious of investing an enormous amount of equipment and energy to produce neutral thermal condition when actually human are by nature are (designed) born to adapt to seasonal climatic variations, which is more pleasurable.

The user's cultural values and energy behaviour are explored in depth and debated. However, further work is required as to how homeowner action has either contributed to the growth of household energy use over time or offset it. Further, catalogue the changes in homeowner's behaviour over time and examine whether such changes would lead to more or less energy consumption.

The relation between the environmental concern and behaviour is well researched and the relationship between environmental concerns and pro-environmental intentions and behaviour is debated both for and against. A key concern of the individual's behaviour and values is that despite individual's high concern for the environment, there is a tendency to depend on the government and big business. Further, the cost of complying with environmental restrictions would influence the energy behaviour along with the price, quality, and convenience of the product.

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