Anglia Ruskin University

Research Project

How human behavior influences on the energy consumption of a PassivHaus

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2014

ABSTRACT

This research project, developed in a short period of six weeks, aims to perform an analysis based on literature review about how user behavior may interfere on energy consumption of PassivHaus dwellings. By the understanding of how these high standard houses work and how external factors, such as technology improvement, can impact directly on behavioral aspects, it could be seen that there is a gap between the predict energy performance of many PassivHaus and their actual energy consumption. This is a result of several and different particularities, for instance the lack of considering occupant's behavior on the simulation of residential energy consumption and/or the little preparation of residents on knowing how to operate correctly a Passivhaus and its technologies.

Keywords: Domestic energy consumption, energy practices, user behavior, PassivHaus

INTRODUCTION

Global warming and severe climate changes are some of the concerns of the contemporary world. Those changes are a result of human behavior in relation to what the Earth has to offer and how it is managed. The use of fossil fuels, for example, which are produced a finite source of carbon, are regularly used to produce energy, but do not renew themselves and their use increases the production of carbon dioxide and other Green House Gas (GHG), that contribute to Global warming. As Chen, Cook and Crandall (2012, p. 01) state "Society is becoming increasingly aware of the impact that our lifestyle choices make on energy usage and the environment", and as a result, alternatives have already been found in order to not only decrease the environmental impact but also to produce energy from renewable sources, which can be defined as energy that comes from resources that are naturally replenished such as sunlight, wind or rain.

The development of low-carbon technologies are a crucial investment to be inserted on the worldwide residential sector. According to Kelly (2013, p.03), in the UK, for instance, the improvement of energy efficiency on the building stock is vital to reduce GHG emissions because "at least 30% of all end use Green House Gas emissions are from the UK residential sector". The PassivHaus concept appeared in Germany, in the early 1990s, and fits this idea once it refers to a passive house or building in relation to energy performance and low-carbon emissions. Designed with all-around insulation, airtight design and to collect and maintain solar gain, this kind of house is healthier, comfortable and it is supposed to use vastly less energy than a standard one. "Although research and development projects in Germany (and elsewhere) have … demonstrated [for example] that it is not difficult to reduce space heating demands by 90%, only 12 000 PassivHaus Standard dwellings exist in Europe, most in Austria, Germany, and Scandinavia" (Vale and Vale, 2010, p. 580). This small amount is a start, but it is not sufficient to obtain a considerable reduction of GHG emissions. To make it happen, not only all new builds around the world have to be in the Passivhaus Standard or on a similar low-energy design, but also the large stock of existing buildings have to pass to a retrofit, which means that they must adapt to ultra-low-energy standards.

Cotterel and Dadeby (2012, p. 31) explain that to build a PassivHaus it is not necessary lots of 'advanced' technology; rather, it is about changing the way the construction sector works. In fact, the system used in PassivHaus and its high-standard are "achieved by careful design informed by building physics and, crucially, by thoughtful and careful construction by a properly skilled and motivated team" (Cotterel and Dadeby, 2012, p. 17). This is what ensures that the fabrics will be well insulated to avoid thermal bridges, that the solar gain and shadings will keep the building warm in winter and not overheat in summer, and that the airtightness and indoor air quality will be comfortable and in a good quality by the use of mechanical ventilation with heat recovery. It may appear that building a PassivHaus will cost a lot more than a standard house, but actually "the additional cost of building a Passivhaus has been estimated by the Passivhaus Institut at between 3 and 8 per cent, and by the Passive-On Project (having examined costs across a number of European countries) at between 3 and 10 per cent. This is because: building codes are setting tougher energy performance standards; knowledge and experience of successfully building Passivhaus is expanding; [and] products associated with Passivhaus are becoming more mainstream." (Cotterel and Dadeby, 2012, p. 39). Moreover, when thinking about the whole lifetime costs and the long-term return on investments by energy saving, the PassivHaus is cheaper, at least in theory.

In practice, some analysis of energy consumptions on PassivHaus demonstrated that there is a gap between the predict energy consumption and the actual one. Furthermore, some researchers observed that a paradigm exists with high-efficient homes consuming more energy than lower-efficient builds. This research is divided, firstly, by analyzing how the measurement of energy consumption is done in order to identify the possible causes for the consumption gap. Then, why the paradigm occurs will be discussed and finally, it will be seen the relation of PassivHaus and its occupants.

METHODS

This research utilized a simple methodology of reviewing literature about the themes of PassivHaus, Energy Consumption and User Behavior; and, by observing how these three aspects relate with each other, a summary of the investigations was made. As it was a six weeks project, the time of work was divided in four weeks for researching and reading books, articles, journals and internet sites, while the last two weeks were destined to organize the material collected and to write about it. The only limitation found was time, because six weeks is a short period to work and as there are many texts about the subject, it was not possible to read as much as it would be possible in a longer period. Finally, it would be interesting for the research if a PassivHaus could have been visited and seen in a real situation with its owners.

FINDINGS AND DISCUSSION

The analyses of the performance of domestic and non-domestic buildings is done by the measurement of the energy consumption and for a questionnaire of post occupancy evaluation (POE), which is used to obtain occupants' feedback to see if the builds are working as predicted, and ask questions, for example, about temperature, noise and lighting levels and indoor air quality. But why is there a gap between the predicted energy consumption and the real one, since the 1990s in the UK according to Tofield (2012, p. IV), where in many times buildings perform worse than the expected? Kelly (2013) stated that many other aspects interfere on energy consumption such as income, age group, lifestyle and behavior of occupants that are as important as the physical characteristics of builds, their location and the mechanisms and technologies installed; and only the understanding of the interactions of all these factors will make it possible to maximize the potential for carbon mitigation and reduction of energy consumption for each dwelling. Thus, the POE is incomplete, since it did not consider all these characteristics, especially user behavior, creating the need of a more complex way of evaluation to predict buildings' performance in a more realistic perspective. This can be confirm by the fact that "even if the amount of energy consumed by the building for heating and cooling space is low, occupants will still be free to use as much energy as they like for appliances and hot water systems" (Stevenson and Leaman, 2010, p. 340), which may create a huge variation in energy consumption, for example, on similar builds. However, developing this new and more complete POE is still an emerging area as Stevenson and Leaman (2010) argue that accessing people's homes and observing their lifestyle, which are private aspects, can be a barrier, creating difficulty to obtain a realistic measurement.

The gap in performance is highly related with a paradigm observed by some researchers, such as Karresand (2012) and Sunikka-Blank and Galvin (2012), where high-efficiency dwellings are consuming more energy than low-efficient ones. The former observed that the buildings that have better energy performances are not reaching the overall targets of reduced energy consumption. Evidence demonstrated that reducing energy consumption is usually not a priority for the occupants and they tend to not make good energy choices. In passive houses, for example, "[one] reason that could explain why household electricity use … is not lower than that in regular houses is the increasing number of appliances in the home, particularly appliances used for entertainment and information (Swedish Energy Agency, 2011) … [a] more intriguing reason is that, when designing the houses, the builders did not realize that the energy concept itself does not encourage energy efficient behavior and that the people living in the houses do not know how their own activities affect the indoor climate. In other words, people do as they have always done, and the passive house energy concept provides only a better building envelope." (Karresand, 2012, p. 10). Sunnika-Blank and Galvin (2012) call this paradigm the 'prebound' and 'rebound' effects, where one is the opposite of the other, so while the first refers to dwellings which are expected to consume lots of energy, but actually consume less, the second refers to low-energy dwellings where occupants consume more than the rating. Besides the idea and the concept itself of high-efficiency buildings and passive houses guide for a future with lower GHG emissions, the fact that it is not the building that consumes the energy, but, in fact, people do it, is forgotten. Thus, as passive houses and high-efficiency buildings do not control their own energy consumption, it is necessary for the occupants to learn how to operate their systems instead of acting like they are living in standard homes. Otherwise, the rebound effect will happen. Cotterel and Dadeby (2012) observed the adaptations of some families that started living in passive houses, and they found out that although PassivHaus buildings do require a few small changes in how to "operate" the homes, they do not demand a complete lifestyle change, just some adjustments that, with explanation, intuitive learning and a small period of adaptations, which can be easily accommodated to the families' routines, especially when it comes to the awareness of overheating and adjustment of blinds or other shading devices accordingly. However, if the energy savings start to be utilized with the installation of other appliances, the whole idea of living in a high-efficiency house will be in vain, and not only the electricity bills will remain the same or increase, but also the GHG emissions will not be reduced. “When it comes to energy use in households in the UK and elsewhere, introducing energy-efficient technology is removing a constraint to allow growth in energy consumption in other areas, such as the proliferation of lights and appliances. What is essential now is to concentrate on household behavior, not just the building.” (Vale and Vale, 2010, p. 586). In other words, it is necessary to have more than efficient builds, as they have proven not to be enough, but efficient occupants, conscious of their choices and of what they may imply.

CONCLUSIONS

To sum up, it is common knowledge that the world’s climate is changing due to human behavior and the lack of mitigation in relation to how this parasitism relationship, where humanity takes advantage on what the Earth has to offer while damaging it, is leading to a future of shortages of supplies and high level of pollution. However, alternatives have already been found in other to decrease energy consumption and GHG emissions, in particular in the residential sector, which, as been proven, it is responsible for a large part of the high consumption of energy and emissions of Green House Gasses. The PassivHaus concept appeared as a solution for the development of low-energy builds with high potential for carbon mitigation and, although its construction is more expensive than the one of a standard build, the whole lifetime costs and the long-term return on investments by energy saving, make it cheaper at the end. However, as Janda (2011, p.15) stated “reducing energy consumption is affected by not just how buildings are designed, but also how they are built, commissioned and used.” Thus, two factors need to be carried out in order to the PassivHaus concept, in fact, make a difference and to end the paradigm and the gap on energy consumption: first, not only all new builds have to utilize the concept, but all the existent build stock need to pass to a retrofit in order to reach a high-efficiency standard; and, secondly, people have to become high-efficient as well by the understanding of how this new builds work, in order to extract the best of them, and of how their attitudes, routines and lifestyle choices have a huge role in determining whether the energy consumption and GHG emissions will be reduced or not. Finally, it is necessary to continue investing on high-efficient technologies, to make them available for all, and to make people conscious of the impacts their behaviors have, because now is the time to try to solve or at least decrease the impacts that humanity had caused on the Earth’s many environments, as a result of hundreds of years of massive production with no preoccupations with what could happen by the cause of it.

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