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Reducing energy consumption in a tertiary building by using Nudges

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1. Introduction

In France, residential and tertiary buildings consume 46% of the total final energy (2017) and are responsible for 30% of all energy related carbon dioxide emissions (2016) [1]. It is then an important field where significant energy consumption reduction can be brought. However, this potential is not totally exploited and the building sector remains a silent consumer. With the development of Internet of Things and the integration of Big Data and sensors in many fields of daily life, the idea of using technologies in managing energy consumption in buildings is an interesting field for investigation. In fact, there is a significant need to develop intelligent approaches in order to develop sustainable environments where less energy is consumed while responding to comfort needs. More and more importance is nowadays given to the industrial and academic issue of using the potential of digital solutions in order to make buildings more energy efficient. However, technology alone is not able to bring up changes in buildings energy consumptions. Indeed, excluding the human factor from the decision making processes may lead to less comfort and more waste of energy [2]. By developing and using simulation tools, designers aimed to predict the energy consumption and performance of buildings. However, literature has shown through different experiences a considerable gap between predicted and real consumptions of energy in buildings, and occupant behaviour is now essentially recognized as the main responsible of this disparity [3]. It is thus important to develop tools to understand and model more accurately the behaviour of building occupant in order to identify its impact on energy consumption. This will help identifying the adequate energy saving recommendations and turn occupants from consumers to active users of energy

in buildings. For these reasons, an approach combining both behaviour insights and technology seems to be the right solution towards a better management of energy in buildings taking into consideration all factors.

2. Background and Methodology

Buildings don't use energy, people do [4]. Literature shows that the real energy consumption of a building can be five times higher than predicted [5]. [6] identified an energy gap of 34% between predictions and reality based on 62 case study buildings. The interaction between users and buildings, the presence of occupants and the adaptive actions they may have to maintain their comfort are the reasons behind these disparities. Despite the integration of solutions of energy efficiency in order to make buildings consume less, consumptions are different from those predicted once the building is occupied. In fact, the impact of occupant behaviour on this prediction gap is estimated between 10-80% [6]. Hence, occupant behaviour is an important factor that may cause higher energy consumptions. For example, [7] showed that some actions like opening windows in hot days can easily nullify the thermal benefits of a good insulation. That's the reason why changing occupants' behaviour towards a virtuous one can bring important energy reduction.

In this context, the aim of our work is to deploy both technological and behavioural solutions in order to raise energy efficiency in buildings, and our approach consists of simulations and experimental studies to show the impact of changing occupant behaviour on energy savings. For this, we use insights from behaviour economics especially different types of nudges and compare their multiple effects.

To reduce the gap between predictions and real energy consumptions in buildings, literature presents different stochastic behaviour models that can be integrated to simulation tools in order to bring more accuracy in results and simulate real occupant behaviours [8] [4] [9]. Another solution is to educate occupants by changing their behaviour without restricting their choice and by maintaining at the same time their comfort [3]. This is an interesting side to investigate through showing by using simulation and experimental data the impact of using nudges in reducing energy consumption in buildings. "Nudge" is an interesting way of transforming incentives to actions by making individuals choose the wished decision through changing the environment architecture [10]. Our ongoing methodology consists of using both simulation tools and filed experiment to evaluate the impact of using Nudges in reducing energy consumption in a tertiary building.

3. Results and Findings

The simulation part is based on a co-simulation of a case study building by using an energy simulation tool and models from literature (presence, use of openings, shading, lighting, and management of heating and cooling set points). The studied building is an office building situated in Nice, in France. It is interesting to study such a tertiary building because occupants

don't pay electricity bills and so don't have financial reasons to adopt virtuous attitudes towards energy use. The building is simulated taking into consideration its envelope, architecture, location and its HVAC (heating, ventilation and air-conditioning) systems in order to calculate its energy consumptions. In parallel, a survey will be conducted in order to define occupants' profiles depending on their age, gender, job position, background, energy consciousness, ability to use technology. This survey will also help confirming data that must be collected for the experimental study, but also defining the behaviours that need to be changed and on which we have to focus in order to avoid useless energy consumptions. On the other hand, since more and more smart meters and sensors are incorporated in buildings, these developed tools can play an important role in studying the interaction between occupants and buildings which is an important step towards behaviour change. They give access to a considerable amount of data concerning indoor and outdoor parameters, occupants' presence, use of openings and electrical equipment. The analysis of this data will enable understanding the use of energy in the building and define the factors behind excessive consumptions. Then, change towards a virtuous behaviour can be brought through concepts from behavioural economics. In this regard, we will use sensors and collecting data in our experimental study will be conducted in the same simulated building. Data will be collected from different installed sensors about physical parameters of the building including temperatures, humidity and luminosity, but also parameters representing occupant's activities such as: the use of openings, shading, heating and cooling set points, and different energy consumptions. The objective is to investigate the impact of using four types of Nudges in the studied building by dividing occupants into groups. The proposed nudges are: (1) Peer to peer comparison, appealing to one's inclination to adopt the same behaviour of one's peers. It will consist of benchmarking energy consumptions and eco-friendly behaviours of other occupants. (2) Feedback and tailored messaging, appealing to one's desire to build an eco-friendly self-image. (3) Moral Appeal, appealing to one's culpability towards behaviours that lead to global warm. (4) Social reviews, appealing to one's desire of being part of the majority adopting the right behaviours. The collected data from field study will be exploited in order to highlight the impact of these nudges on changing behaviours and so on reducing energy consumptions. Based on the previous results of occupants behaviour modelling and the impact of some activities on energy consumptions, we can choose, develop and test the adequate "Nudge" to implement in the studied building. To have more effective results, we may need to combine different type of Nudges depending on the particular characteristics of the building and the estimated impact the tested incentives had on consumptions reduction [11].

4. Discussions and Conclusions

The aim of our work was based on the consciousness that a multidisciplinary approach (technical and social) is required in order to understand energy use in buildings and reach energy efficiency by changing occupants' behaviour [12] [13]. Through the prediction of occupants' activities and comfort needs, a more effective nudging towards changing energy

use can be achieved. In future work, the objective will consist of an automatization of the process of generating “nudges” for the studied building based on the previous study of occupants’ influence on energy consumptions.

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