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Insights on pro-environmental behavior towards post-carbon society

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Abstract

The increasing phenomena related to urbanization and human impact on landscape leads to re-think the future of the cities. As well as in buildings, a careful design, the use of renewable sources and the use of advanced technical solutions, to achieve a significant energy savings, are strategies not sufficient to define a "Post-Carbon city" or a "Post-Carbon building". It is necessary that the citizen/occupant become a "Post-Carbon society", i.e. they pursue conscious lifestyle marked on energy saving principles. This suggest that the occupant's behaviour plays a fundamental role. In fact, many studies have shown that the human behaviour influences, mainly, the energy performance, explaining, in this way, the discrepancy gap between predicted and real consumptions. Since human behaviour is, in large part, influenced by several factors, a behavioural change towards sustainable lifestyle is desirable and this is possible, for examples, by providing to users feedback and information on comfort condition and energy use. The main goal of this research is to identify the pro-environmental behaviour by a questionnaire survey. Specifically, the structure of the survey will be described in this paper and the main results presented.

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Keywords: Post-Carbon behaviour; Pro-environmental behaviour; Survey; Experimental campaign; Energy saving.

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1. Introduction

The city are responsible for 75% of energy consumption and for the 80% of carbon dioxide emissions that are globally produced every year [1]. This data are constantly increasing in relation to the population growth and the linked urbanization rate. An increase of about 1.2 billion people is expected in 2030, from current 7.3 billion to 8.5 billion [2]; moreover, the "urban mode" will be the geographical dominant context that will entirely absorb the population growth. In addition, every citizen aspires to achieve his/her comfort condition and this leads to an increase of both services demand, resources consumption (e.g. energy and soil) and air and noise pollution.
In this way, the city is a carrier of problems and thus new challenges to face because itself could be a victim of the climate change and, consequently, of "natural" disasters. Simultaneously, the city is the "place" in which people, goods and information concentration can lead to experiment new technologies not only in the field of production, management and use of energy, but also in other sectors such as mobility and transport, water and waste and in the building system. Then, on one hand, it is essential a correct and careful planning in which buildings and the whole cities are designed following precise rules (e.g. bioclimatic principles), where a physical infrastructure (physical capital) and an information and communication infrastructures (ICT capital) are present in order to create a connection between the technological and the sustainable city. Therefore, the city could be defined, referring to an IBM (International Business Machines Corporation) definition [3], "instrumented" (the city is digitised with the aim of gathering information) and "interconnected" (the various part of the city are connected to central system with the aim to broadcast the information) but, at the same time, must be defined "intelligent". In other words, the city must be able to create behavioural patterns in order to allow the users to perform informed actions. Therefore, the goal is not only to arrive to a digital or technologically advanced city, but to consider the collaboration of different stakeholders. In this framework, the social capital plays a key role; more the city is liveable, more the information is favoured and more citizen will be involved and participate, favouring, consequently, the development and the growth of the city.
The behavioural change could lead to an energy saving between 5% and 20% [4, 5] only if a sharing of simple, immediate and easy to be interpreted information is possible, highlighting the close relationship between technology and users in order to let everyone be aware of appropriate mechanisms to reduce consumption. The user becomes a key player, active and dynamic, that will make the right decision not only in the building itself but in connected buildings (i.e. in the Smart Grid). A correct interpretation of ICT data and insights on the human *psyche* would help to achieve the awareness of sustainable behaviour. According to the Theory of Planned Behaviour (TPB) [6], human behaviour is a function of several aspects: attitude (as the user stands in relation to other objects or people), moral or social norms (set of shared rules that do not have the force of law, remembering that man, unconsciously, let himself be influenced by the opinion of others) and the behavioural perception (the idea that some factors may facilitate or hinder the achievement of a specific behaviour).
The main goal of this paper is then to explore behaviours, attitudes and building characteristics (related to energy consumption) of a random group of people through the elaboration and the administration of an online questionnaire aiming at highlighting the factors leading to a pro-environmental behaviour.

2. The pro-environmental behaviour

Some important issues as global warming, urban air pollution, water scarcity, environmental noise or loss of biodiversity are emerged in recent years, as a result of human activities. Although the man has changed the environment in which he lives, this does not necessarily mean that his actions were and are facing a conscious and intentional of ecosystem destruction, but rather to a research of comfort, safety and fun. Therefore, it is necessary to investigate what are the most common behaviours related to energy saving/consumption.
The occupant behaviour is not based on objective and unambiguous principles, but it is unpredictable. For this reason, this issue is still a subject of several studies with the purpose of understanding, as much as possible, the actions and reactions between man and other objects, organisms or environment, reminding that the behaviour is a manifestation of the interaction between a number of factors, which lead the individual towards different ecological, economic and social choices. Specifically, the environmental behaviour is the relationship between individuals, their

choices and the consequent impact that these will have on the ecosystem. Moreover, it investigates the individuals behaviour identifying the behavioural change possibilities in order to reduce environmental problems and, at the same time, to allow high welfare and high life quality.
The environmental behaviour is defined by Stern [7] as "the behaviour that changes availability of materials or energy from environment or alter the structure and dynamics of ecosystems or the biosphere itself". This is a general definition where the nature of behaviours is not mentioned; the man, seeking to satisfy his own desires for comfort, mobility, entertainment and personal safety, performs actions that will have a positive or negative environmental impact generating direct or indirect changes. Moreover, the behaviour can be classified considering the impact on the environment or the intent with which a person performs a behaviour. The impact of the human choices on indoor environmental quality and his/her behaviour (a number of actions or practices that can be described as "good" or "bad"), contributes to increase/decrease the environmental changes. According to the TPB [6], the intention affects the environment; in this case it is necessary to evaluate how much a person, who performs a certain behaviour, is aware of the consequences of his/her action. In fact, many actions are not coherent to the purposes for which they were born, e.g. the real intention of a person who decides to ride a bicycle to get to work, instead a private car, could be save money or do exercise instead being sensitive to environmental issues.
In literature, several authors [7, 8, 9] have studied the relationship between behaviour and environment with different perspectives (i.e. pro-environmental behaviours, behaviours related to the environment, "friendly" behaviour toward the environment, "environmentally responsible" behaviour, "environmentally relevant" or "environmentally significant" behaviour), highlighting how in the same field of interest there are different points of view. Specifically, in this research, the pro-environmental behaviour, or the "behaviour that consciously seeks to minimize the negative impact of one's actions on the natural and built world" [10] or "actions that contribute to the preservation and/or conservation of the environment" [11] has been considered.
Pro-environmental behaviour is generally studied through the Campbell Paradigm [12, 13, 14]. This paradigm represent "the probability that a person has to engage in a pro-environmental behaviour and it depends on the pro-environmental attitudes of a person and on the difficulty of a behaviour" [15]. Therefore, a specific purpose may not be achieved in the same way by different people since two components (the personal effort and the behavioural price) are involved. The personal effort represents the ability of each person and it refers to the personal disposition determined by the level of environmental skill of a certain individual. The behavioural price are the physical, intellectual, cultural, economic, etc. "costs" or difficulties that a person carries out or overcomes when a behaviour is performed. Considering that the achievement of a goal is the sum of different actions, the Campbell Paradigm is based on a simple concept; big obstacles (difficulties) will be overcome in presence of a great effort, while in presence of a low devotion or personal interest, just small difficulties will be overcome. Consequently, the most difficult actions require a high personal effort; a person who performs a behaviour, that in a certain context is difficult to be taken, can be evaluated as inclined to make ecological behaviour respect a person who performs, in the same context, only easy actions. In fact, more obstacles a person overcomes, the effort, that was spent to achieve its purpose, is greater and the engagement towards that goal is stronger. On the other hand, when also only little difficulties are sufficient to prevent that a person performs behavioural measures beyond the simplest ones, probably the engagement is minimal. Then, this paradigm explains why people behave in different way, determining common and uncommon actions. In this way, several behaviours could be ordered in a ranking, from common actions (whose difficulty is tiny) to uncommon actions (whose difficulty is high). In the next section, a questionnaire for gathering data on an Italian sample will be described.

3. Method

This section describes the online survey that was administered to a random users' sample. The survey is a tool that allows to describe, to compare and to explain the adopted behaviours, the inner attitudes, the expressed opinions and the beliefs of a selected sample, facilitating the interaction between the researcher and the interviewees in order to collect both quantitative and qualitative information on the object of analysis. The advantages of this tool are affordability, simplicity and speed even if it sin in rigidity and insensitivity. In addition, the online survey can reach

a large sample although the interviewees belong to a specific class, those who own a PC/tablet and an internet connection.
The purpose of investigation is to determine the probability that an individual has to change his behaviour towards sustainable and conscious lifestyle, considering the impact of some socio-economic variables. The drawn up survey consists of 31 closed questions both dichotomous and politomous to ensure homogeneity in the answers. The survey is divided into four main sections with the aim to investigate different aspects. The first two sections explore the socio-economic properties of the sample, investigating respondent's characteristics, like personal, social and economic data, buildings' characteristics, like building age and characteristics of the heating system features. The next two sections explore the respondents' habits, as actions and events empirically observable and potentially controllable related to energy consumption in buildings, and respondents' attitudes, where values, motivations, guidelines and opinions on the topic of behavioural change are studied.
The first questions are aimed at studying what factors and their weight have an impact on determining behaviour and behavioural change. In reference to this, studies about the theory of occupant behaviour [16, 17], or about the definition of "travellers' profiles using a statistical multivariate analysis of attitudinal variables" [18] or about "the role of urban form and socio-economic variables for estimating the building energy savings potential at the urban scale" [19] are discussed. The common factors in these studies have identified the 12 influential variables (age, gender, education, employment, income, residential city, family composition, number of habits change, period of construction of the building, property, type of heating and heating cost). For the remaining questions related to the behaviour and attitude, the studies regarding the Campbell Paradigm [12, 13, 14] (and consequently its mathematical resolution, i.e. Rash model [20]) are taken as reference. The Campbell Paradigm is used in several fields: school tests (e.g. INVALSI tests or admission test to university), medical studies on the physical well-being or environmental behaviour. Specifically, the basis of this research are found in the environmental psychology literature, mainly considering the studies on pro-environmental behaviour. Existing surveys on this topic are proposed by Kaiser [12, 14] and they concern six domains related to energy saving behaviours: consumerism, energy conservation, mobility and transport, waste avoidance, recycling and social behaviours toward conservation. Since this research focuses primarily on energy consumption in buildings, the question related to energy saving were taken into account for the survey processing. In addition, a control questions have been added in order to investigate the difference between behaviour and attitude.
In conclusion, the responses obtained in a period of a week in winter time were gathered. The answers to politomous questions (i.e. requiring multiple choices; i.e. "never, seldom, occasionally, often and always") were transformed into dichotomous, assigning the 0 or 1 values. The value 0 represents a "not-environmental" behaviour and the value 1 describes a "pro-environmental behaviour" intended as explained in the previous section.

4. Results

The survey was completed by 298 random people and although the sample is not huge, it is characterized by elements of community heterogeneity and variety. The most significant graphs of the obtained responses will be shown in this section.

4.1. Questionnaire section 1: respondents' characteristic.

The prevalence of a certain characteristic is determined by the nature of the diffusion of the survey. Since this questionnaire was a part of a master thesis project, the highest percentage of respondents are students (54%) between 20 and 30 years (67%), the biggest users of internet and social networks. For this reason, workers (teachers, freelancers, labourers, etc.) represents only the 37% of employed respondents, while unemployed or retired people are a minor part (9%). These values are generally associated with the income data; in fact, about 36% of the sample refers to those who do not have an income (students and retired). The average salary is about 1000 € for the remaining part of the sample. Furthermore, the sample is mainly represented by female (68%). The most part of respondents lives in northern Italy (78%), specifically they come from the province of Turin (56%). In Figure 1, the distribution of answers in the section 1 related to the age, job and income, is shown.

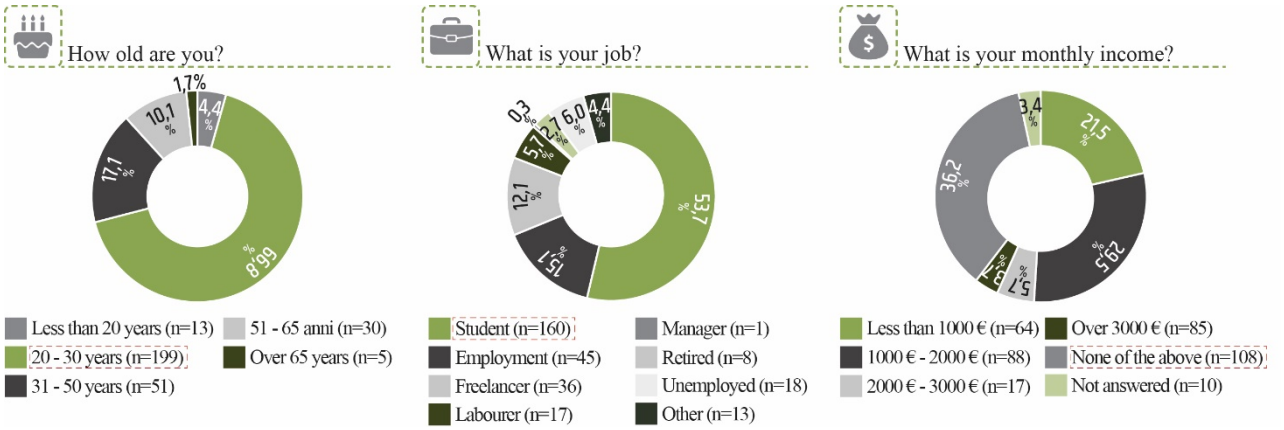

Fig. 1. An example about the answer distribution to some question of the first section.

4.2. Questionnaire section 2: building's characteristics.

The most part of respondents live in a property building (69,5%) while the remaining part are a building tenant (30,5%). The building age is various and there is not one that predominates over the other and the typical household consist of three components. The most common heating system is autonomous (64%), followed by a centralized system (29%) and, finally, by district heating (7%) (Figure 2). The average amount of energy costs for heating is between 500 € and 1000 €, as a function of square meters of the building.

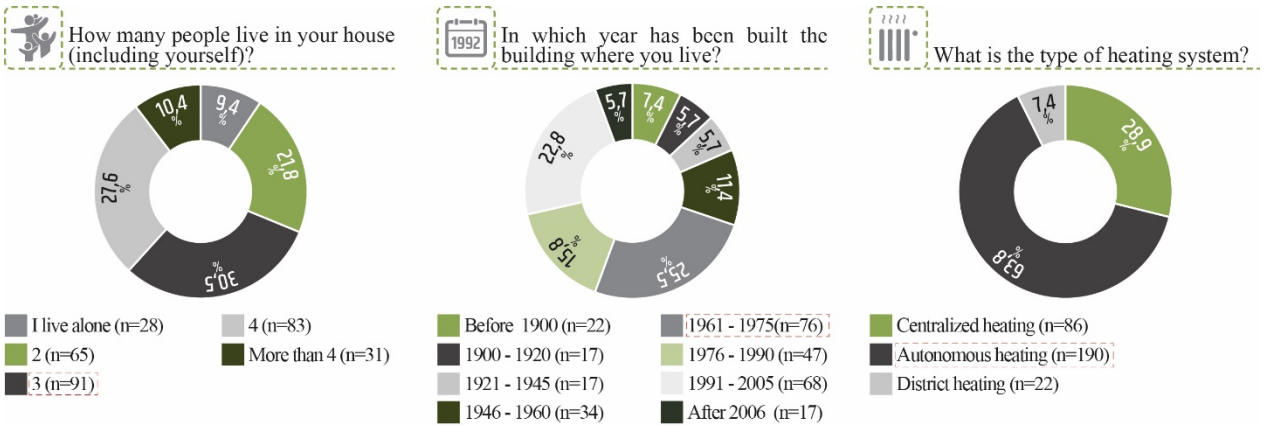

Fig. 2. An example about the answer distribution to some question of the second section.

4.3. Questionnaire section 3: behaviour related to energy consumption.

Generally, from a first analysis of the responses, only half of the proposed behaviour are performed in a pro-environmental way. This is explained from answers of each respondents analysis; about 150 people pursue a non-environmental behavior, while the remaining half people are more sensitive to pro-environmental values.
Renewable energy systems are generally not installed by 84% of respondents at home or at work; in fact, photovoltaic and/or solar panel for the production of electricity or domestic hot water is available only in the 16% of interviewees (Table 1). Anyway, the willingness of installing solar panels (to reduce energy spending and the burden on the environment) has received a favorable response from almost the entire sample of interviewees (96%) (Table 1). In addition, 176 respondents (59%) said that they had examined the pros and cons of owning a system for energy production by renewable sources.
Some usual practices, such as choosing to wear (in winter) warm clothes instead raising the set point temperature (Table 1) or keeping the window open for long period (in winter) (Table 2) are a common behaviours.
Moreover, leaving appliances in stand-by or using frequently the washing machine are common behaviours, actually they count respectively for the 60% and for 82% (Table 2).

Table 1. List of dichotomous answers and questions. The percentages whit asterisk indicate the pro-environmental behviour.

Questions	Yes	No
Have you got some energy efficient household devices?	78,19%*	21,81%
When you stay in hotel, do you ask to change the towels every day?	28,19%	71,81%*
At home and/or at work, have you installed solar panels to produce energy?	10,07%*	89,93%
At home or at work, do you use renewable energy sources (e.g. solar energy for solar thermal or photovoltaic, wind energy, biomass energy, geothermal energy, etc.)?	15,77%*	84,23%
In winter, do you prefer turn the heating on instead wear a sweater?	34,90%	65,10%*
In your opinion, is a good idea install solar panels for producing energy to reduce your energy costs and to respect the environment?	96,31%*	3,69%
Have you ever looked into the pros and cons of having private sources of renewable energy (such as photovoltaic panels, panels for thermal etc.)?	59,06%*	40,94%
We suppose that wash the laundry with washing machine costs, on average, 2 €. Are you willing to use it less to save money and energy?	74,16%*	25,84%
Are you willing to change your habits turning off completely households and devices (after use) in order to reduce energy consumption?	95,64%*	4,36%
Knowing that replacing your windows with newer increase the need to open the windows more regular and with short intervals; are you willing to change your habits to guarantee a healthy indoor air?	8,59%*	11,41%

4.4. Questionnaire section 4: willingness to behavioural change.

The totality of questions about the willingness to a behavioural change has received a positive feedback, with percentage of “yes” responses over the 70%. For example the question relating to an engagement towards a switching off of an appliance after their use was not shared by only 4,4% of respondents.

Table 2. List of politomous answers and questions. The percentages whit asterisk indicate the pro-environmental behviour.

Questions	Always	Often	Occasionally	Seldom	Never
Do you wait to have a full load before using your washing machine and/or your dishwasher?	46,64%*	44,97%*	5,37%	2,35%	0,67%
How often do you use the washing machine?	20,47%	61,74%	14,77%*	2,35%*	0,67%*
In winter, how often do you leave the windows open for long periods to let in the fresh air?	4,36%	27,85%	35,57%*	26,51%*	5,70%*
In winter, how often do you turn down the heat when you leave your apartment for more than four hours?	34,90%*	24,50%*	8,72%	14,09%	17,79%
How often do you prefer take a shower than a bath?	78,19%*	14,09%*	3,69%	2,35%	1,68%
How often do you leave households (such as TV, PC, subwoofer, microwave etc.) in standby?	14,43%	28,52%	16,78%	22,82%*	17,45%*
How often do you talk with friends/family about problems related to the environment (specifically global warming, greenhouse emissions, etc.)?	3,36%*	21,81%*	42,95%	23,83%	8,05%
How often do you read papers/books/internet sites about environmental issues?	4,36%*	24,83%*	39,26%	23,15%	8,39%
How often do you point out (for example to your friends or family) a behaviour that can generate an energy waste?	13,76%*	39,60%*	31,54%	11,41%	3,69%

5. Discussion

From the questionnaire results, the most difficult behaviour to achieve is the installation, in own home, of solar panels for the production of energy. This finding is in line with data presented in literature [12, 14]. This represents, in fact, a behaviour that, in order to be implemented, require the overcoming of an economic price and depends on several building and site opportunities. Instead, it is interesting to observe how the belief on installing solar panels is a major concern for people answering the questionnaire, identifying this action as appropriate for the environmental issues and for the reduction of economic costs. Anyway, respondents highlight that there is a gap (predominantly an economic gap) to put it into practice. Still, pros and cons of owning a power-generating plant of energy from renewable sources is a mid-step behaviour, lying among the difficulty of owing a renewable energy system and easy of having an opinion, showing the sequence of actions: opinion, do, act. Similarly, it should be noted as the willingness to change is an action that almost everyone is likely to be implemented.
In addition, it can be seen that the washing machine is an appliance used frequently even if it is used with a full load; the use of certain appliances is rightly forcefully entered a part of everyday life. Finally, it could be observed that the occupant, with his actions, strongly determines the energy consumption: a habit to leave the windows open for long periods in the winter, leave appliances on standby or even turn on the heat for not wearing more clothes are still well entrenched behaviours; these show how the user needs to be educated.

6. Conclusion

The research aims to investigate the occupants' habits related to energy consumption in residential buildings. Understanding and studying the nature of human behaviour offers a potential improvement in determining the real building consumption and, consequently, a performance improvement. The analysis of the results shows that a specific goal is not achieved in the same way by different people, since several factors are involved; the personal disposition to issues of environmental and energy consumption and the physical, intellectual, cultural and economic

"costs" that a person overcome. In fact, this explains how each behaviour has received different answers, where easier behaviours (answers with a high approval rating) and more difficult behaviours (answers with a low approval rating) are identified. In addition, the analysis shows that there is a strong occupant willpower to change their habits towards aware behaviour. To make possible this change it is necessary a citizen education toward energy conservation values; in this way the use of new technologies can help the user to understand the feedback on the actions that are taking place, and, consequently, he/she pursue a pro-environmental behaviour.

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