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An Exploration Of Parameters Affecting Employee Energy Conversation Behaviour At The Workplace, Towards IOT-Enabled Behavioural Interventions

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AN EXPLORATION OF PARAMETERS AFFECTING EMPLOYEE ENERGY CONSERVATION BEHAVIOUR AT THE WORKPLACE, TOWARDS IOT-ENABLED BEHAVIOURAL INTERVENTIONS

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Abstract

Energy conservation is one of the widely recognised important means towards addressing CO_2 emissions and the resulting global issue of climate change. Furthermore, public buildings have been recognised as contributing significantly to the consumption of energy worldwide. More importantly, occupant behaviour, a factor that needs to be studied further, can have a high impact on the energy consumed within public buildings. Through our study, we have conducted an exploratory study on the parameters affecting employee energy conservation behaviour in public buildings, towards constructing a behavioural model that can be employed in IoT-enabled personalised energy disaggregation initiatives. We propose an extension to an existing model of employee energy behaviour based on Values Beliefs Norms (VBN) theory, with the addition of five parameters – comfort levels, burnout, locus of control, personal disadvantages and energy awareness. In addition, we discriminate between two groups of inter-related energy conservation behaviours at work – popular and unpopular energy conservation behaviours – and explain our resulting behavioural models' utility towards IoT-enabled energy conservation, within workplaces. We find that promoting employees' energy awareness levels, as well as positively affecting their environmental worldviews and personal norms are important factors that should be considered in behavioural interventions toward energy conservation at the workplace.

Keywords: Employee, Energy, Conservation, Behaviour, Workplace.

1 Introduction

The importance of energy conservation in public buildings stems from a number of facts. Starting from the big picture, climate change is an issue that has been recognised worldwide for decades, through international actions, authorities and treaties. More specifically, the need to intensify our efforts towards reducing CO_2 emissions and protecting the environment has been stressed by the United Nations Framework Convention on Climate Change (UNFCCC, 2014);(UNFCCC, 2016), as well as illustrated through the worldwide participation in the Paris Agreement on climate change (UN News Centre, 2016), which is at its heart an agreement about energy and transformative change in the energy sector – the source of at least two-thirds of greenhouse-gas emissions (International Energy Agency, 2016). In addition, commercial and industrial sources in the US produced three times the CO2 emissions of residential sources in 2010 (Lülfs & Hahn, 2013), while the buildings sector also consumes 20% of the total delivered energy worldwide (Conti et al., 2016) and the commercial sector features the fastest-growing energy demand – with consumption projected to grow by an average of 1.6% per year until 2040 (Conti et al., 2016). Based on all of the above, increasing our efforts towards energy conservation in public buildings and workplaces is an important measure towards addressing the worldwide recognised issue of climate change.

Occupant behaviour is an important factor towards energy conservation in buildings, as it can lead to an increase, or decrease on designed energy performance by one-third (Nguyen & Aiello, 2013). Additionally, despite the forementioned effect of public buildings on energy consumption, only a limited body of research focuses on employees' energy consumption behaviour – one of the most important factors that could limit it. As part of our research, within the course of an EU project we are participating in, we will design and deploy a mobile application that receives input from an IoT-enabled ecosystem and provides personalized real-time recommendations to employees, motivating and educating them to adopt a more energy efficient behavior. The forementioned ecosystem leverages IoT enabled, low-cost devices (NFC or Bluetooth Beacons) to improve energy disaggregation mechanisms that provide energy use and (consequently) wastages at the device, area and end-user level – a more detailed description can be found in (Papaioannou et al., 2017). These wastages are consequently targeted by a mobile app that feeds personalized real-time recommendations to its end users on a consumption event-driven basis. To identify and assess the different parameters involved in our targeted behaviour, we performed a review of the relevant literature and conducted unstructured interviews in three different workplaces, situated in three different EU countries – as analysed in (Kotsopoulos et al., 2017).We consequently deployed a survey within the same three workplaces, aiming to verify findings presented in the literature so far, as well as cover existing gaps by expanding on our observations through the unstructured interviews. Based on the gathered insight from the collected answers, we identified important parameters, explored the relationships between them and suggest a behavioural model, which we aim to validate through our ongoing experiments.

We consider five important parameters that are connected to energy consumption behaviour at the workplace: Employees' perceived comfort levels within their workplace, work-related burnout levels, internal or external locus of control with regards to energy conservation at the workplace, perceived personal disadvantages and awareness of energy saving actions that are available within the workspace environment. To assess the impact of these five parameters on employees' level of motivation towards energy conservation at the workplace, we examine them in relation to an existing model for employee energy behaviour (Scherbaum, Popovich, & Finlinson, 2008) – based on the Values-Beliefs-Norms theory of environmentalism. In the next sections, we begin by reviewing related work presented in the literature, discuss our research methodology, analyse and discuss our findings, as well as propose and explain the resulting behavioural model. Our aim is to validate this model through our ongoing experiments in the context of an EU-funded Horizon 2020 project on employee energy efficiency.

2 Background

2.1 IoT and Human Interaction towards Energy Conservation

The Internet of Things (IoT) refers to the emerging trend of augmenting physical objects and devices with sensing, computing, and communication capabilities, connecting them to form a network and making use of the resulting collectiveness of the networked objects (Guo, Zhang, Wang, Yu, & Zhou, 2013). In addition, the fundamental of IoT implies that objects in an IoT can be identified uniquely in their virtual representations, are able to exchange and, if needed, process data according to predefined schemes (Li, Xu, & Zhao, 2015). More importantly, various IoT devices (equipped with sensing and short-range communication capabilities) are already weaved deeply into the fabric of everyday life while, under the vision of IoT, the next-generation Internet is expected to promote the harmonious interaction between human, societies, and smart things (Guo et al., 2013). Consequently, the diverse features of IoT devices present unprecedented opportunities to understand the aspects of interaction between humans and real-world entities (human-object, human-environment, and human-human interactions), while three main sensing capabilities emerge as a result (Guo et al., 2013): (i) user awareness – the ability to understand personal contexts and behavioral patterns, such as human activity, popularity and preferences, (ii) ambient awareness – status info on a particular space, such as traffic dynamics or jams, and (iii) social awareness – revealing the patterns of social interaction, human mobility, etc.

With increasing awareness about the energy crisis, the development of intelligent energy-saving systems has become a new trend (Cho, Lai, Lai, & Huang, 2013). More importantly, it has been recognised as a new challenge in the range of upcoming IoT applications, while appliance and activity recognition mechanisms have already been integrated in the past towards IoT energy management systems (Lai, Lai, Yang, & Chao, 2012). Improving the usage behaviour of appliances by utilising an IoT-enabled reminder system has furthermore been proven efficient in electricity conservation within household environments (Cho et al., 2013).

2.2 Energy Conservation through Behavioural Change

Overall, the role of the human factor has been largely overlooked in energy consumption analysis, especially at the workplace, despite the fact that employee behaviour can also significantly affect the successfulness of technology-based efficiency improvements (Lo, Peters, van Breukelen, & Kok, 2014). It is important to note that the relative strengths of attitude and context, in specific, may depend on the complexity, difficulty, and cost of the behaviour in question (Lutzenhiser, 1993). Hence, energy conservation through behavioural change should be considered alongside efforts to reduce energy consumption through technological improvements (Delmas, Fischlein, & Asensio, 2013). Studies in energy consumption behaviours emerged with the oil crisis of the 1970s, from a wide range of disciplinary perspectives (Stephenson et al., 2010). Space heating and cooling systems, lights, refrigerators, computers, and other equipment are typically the largest energy consumption sources within public buildings both in the EU and the US (Nguyen & Aiello, 2013). Additionally, despite the already mentioned importance of occupant behaviour in the consumption of energy in buildings, as it can add, or save one-third to a building's designed energy performance (Nguyen & Aiello, 2013), unlike private households, users at workplaces generally lack direct financial incentives to conserve energy within the confines of their office and hence different dominant motivations, as well as incentive structures are dominant for users in organizational settings. More altruistic motives, such as supporting the organization in energy and monetary savings, contributing to environmental protection and complying with peer expectations, can be leveraged to increase employee motivation for energy saving at the workplace (Matthies, Kastner, Klesse, & Wagner, 2011).

A limited number of studies exist regarding energy conservation in a work environment, compared to household contexts, while very few investigated employee energy-related behaviours in organisations at the individual, behavioural level of analysis, none involving inter-organisational comparisons (Lo, Peters, & Kok, 2012). However, a large number of information-based energy conservation experiments have been conducted to explore building occupants' behaviour in various settings. Interestingly, in a meta-analysis of 156 such published studies, non-monetary information-based strategies led to an average reduction in electricity consumption of 7.4% – while monetary incentives led to a relative increase in energy usage instead of conservation (Delmas et al., 2013). Additionally, promising means for employee energy behaviour change include training on energy conservation at work, modifying organisational procedures and norms, and increasing awareness levels by providing feedback on the employees' own behaviour, as well as its consequences (Lo et al., 2012). The recorded effectiveness of feedback towards that end has varied, with savings from behavioural interventions in the region of 5-15% for direct and 0-10% for indirect feedback (Darby, 2006), and tailored information proven to be more effective towards energy behaviour change (Matthies et al., 2011).

2.3 Behavioural Factors towards Energy Conservation

It is important to recognize that structure-focused and employee-focused approaches are not by definition distinct strategies towards decreasing energy use, but complementary. Changes in employee behaviors are therefore necessary to support structural or operational changes, albeit often overlooked in organizations (Scherbaum et al., 2008). Various motivational theories have been recruited, to explain pro-environmental, as well as energy conservation behaviours, in various environments. Values - Beliefs - Norms (VBN) theory links value theory, norm-activation theory, and the New Environmental Paradigm (NEP) perspective, through a causal chain of five variables leading to behaviour: personal values (especially altruistic values) as recorded by NEP, Awareness of Consequences (AC) and Ascription of Responsibility (AR), beliefs about general conditions in the biophysical environment, as well as personal norms for pro-environmental action (Stern, 2000). Furthermore, Scherbaum et al. have examined individual-level factors related to employee energy-conservation behaviours at work, based on the VBN theory. According to their conclusions, environmental personal norms and environmental worldviews are factors that can be leveraged in organizational interventions concerning employee energy use (Scherbaum et al., 2008).

Focusing on people's beliefs and motives regarding energy conservation behaviour, is necessary in order to understand and change targeted pro-environmental behaviours. Furthermore, as pro-environmental intent may fail to result in environmental impact, this raises important research questions about the nature and determinants of people's beliefs about the environmental significance of behaviours (Stern, 2000). Interestingly, in a research conducted with employees in a UK retail store environment, that combined VBN theory with additional factors, the wider organisational and structural context was found to be more relevant to behavioural outcomes than personal environmental attitudes, while energy management was found to be prone to multiple-goal conflicts, with a related negative impact on task performance (Christina, Dainty, Daniels, & Waterson, 2014). Additionally, the importance of norms towards energy conservation behaviour at the workplace has also been explored through an intervention based on Norm Activation Theory in China. Results showed that personal norm positively influences employee electricity saving behaviour, while awareness of consequences and ascription of responsibility also positively influence personal norm (Zhang, Wang, & Zhou, 2013).

Understanding the multi-dimensional problem of energy sustainability and knowledge on how to conserve energy generally enable more sustainable energy-consumption behaviors. However, actually saving energy is most often influenced by other internal and situational factors. The absence of a direct link between knowledge and action is often referred to as "knowledge-action gap" (Stern, 2000). However, awareness of the intricacies of energy conservation is important towards achieving it. Habits are part of the ability factor in the MOA-model (Olander & Thogersen, 1995) and the Fogg behaviour model (Fogg, 2009). Furthermore, as they strongly determine the behaviour of people, interventions aimed at changing behaviour, will have to address habitual behaviour as well as intentional behaviour. Therefore, it is important to record habits, by assessing the current energy consumption behaviour of prospective participants before any intervention.

Locus of control (Rotter, 1966) reflects a person's perception of whether they have the capability to enact change and/or control events that impact them. Individuals with a strong internal locus of control believe that they can exercise personal control over their own decisions, life circumstances and outcomes (i.e., belief that events arise primarily from internal factors, such as one's own motivation and actions), whereas those with a strong external locus of control believe that decisions, life circumstances and outcomes are controlled by environmental factors outside their influence (i.e., belief that events arise primarily from external factors, such as other people, the government, socio-economic influences, etc.). Therefore – with regards to energy conservation – employees with a strong internal locus of control are expected to also believe that they can conserve energy at the workplace through their own personal actions.

The perceived loss of comfort or perceived threat to lifestyle quality may reduce the likelihood of engaging in conservation behaviour due to loss aversion (Kahneman, & Smith, 2002). According to (Frederiks, Stenner, & Hobman, 2015), people are often motivated by self-interest and try to select alternatives that yield the highest benefit for the lowest cost. Both economic and behavioral cost-benefit tradeoffs may influence pro-environmental behavior such as energy consumption and conservation. Several categories of perceived advantages and disadvantages may also be taken into account: (i) Personal disadvantages (e.g., beliefs regarding loss of comfort or coldness, behavioural constraints, etc. imposed by an energy-saving lifestyle), (ii) societal advantages (e.g., beliefs regarding less environmental pollution, more energy for future generations, world energy supplies, etc.), (iii) personal responsibility (e.g. beliefs regarding a sense of duty/responsibility). In daily life, there are countless situations where people procrastinate, postpone decisions, or delay actions because they are viewed as costly in the short-term, despite offering long-term benefits (Kahneman, & Smith, 2002).

Existing stressful conditions at work or high workload for employees (Maslach et al., 1996; Maslach & Jackson, 1981) may create a context in which individual considerations for energy conservation are assigned a lower priority. In the overall motivation-opportunity-ability (MOA) decision-making behavioural model, work burnout would mostly negatively affect the opportunity dimension. Time scarcity is an important factor that is considered in the perceived cost/benefit of employees. Therefore the IoT app designer needs to understand the work conditions in terms of work pressure, in order to properly arrange the time that should be dedicated by the employees to the app, the structure of the incentives, the frequency of tips/feedback, etc., and make it easier for employees to exert energy-conserving behaviour despite their potentially-demanding work conditions. Better understanding this contextual factor is important for another reason as well: it can serve as a weight or normalization factor to summarize the effectiveness of a behavioural intervention across multiple sites. A lower performance in terms of energy-consumption reduction at a particular site with very stressful work conditions may be perceivable as equally or even more important than a higher performance in terms of energy consumption at a more easy-going work environment.

Finally, it is important to note that demographic factors should also be taken into account when designing behavioural interventions, as they have been correlated to energy behaviour. Engagement towards pro-environmental behaviour tends to increase with age, while women tend to have stronger environmental attitudes, concern and behaviours than men across age (Gifford & Nilsson, 2014). Additionally, higher levels of motivation to conserve energy have been reported by residential users with children (McMakin, Malone, & Lundgren, 2002), suggesting that this may also be true for employees.

3 Questionnaire Design

Based on the insight gained from the literature, we performed an online survey of employees at 3 pilot sites (office buildings in Greece and Spain, and a museum in Luxemburg) aiming to assess and capture the behavioural characteristics of the prospective participants of an IoT-enabled application towards energy conservation at the workplace. The ultimate goal was to provide an effective tool towards designing such a behavioural intervention, so that its attractiveness to the users, as well as its effectiveness in energy consumption reduction would be optimized. By designing behavioural intervention apps while taking into account the personal profiles of the prospective participants, we can increase the chances that they include it in their daily work routine. Thus, having reviewed the relative literature, in order to assess our participants' behavioural patterns towards energy consumption and conservation at the workplace, we compiled a composite questionnaire instrument, consisting of 37 questions divided into 10 sections (see Table 1). All items on the questionnaire were rated on a 7-point likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Higher scores indicate higher agreement in the statements and hence also higher levels of the investigated variables.

The aim of the first part of the questionnaire was to assess the participants' adherence to a number of different daily energy-offending behaviours at the workplace – so that we can delineate the current situation in the different sites, with regards to energy consumption – as well as to identify the environmental worldviews, norms, and behavioural intentions towards energy conservation currently instilled in the employees. We also wanted to identify the most prominent factors at each workspace, so that they could be addressed in a behavioural intervention towards decreasing energy consumption in the future. Since concern for the environment does not automatically translate to pro-environmental behaviour, in the 'value/action gap' phenomenon (Christina et al., 2014), it is also important to evaluate the actual energy conservation behaviours, apart from the energy saving values and intentions instilled in employees, as they may not always lead to actual actions. More specifically, in the first part of the questionnaire, the participants' individual energy consumption profile is assessed, based on an existing questionnaire instrument suggested in the literature, towards studying energy consumption behaviour at the workplace in line with VBN theory (Scherbaum et al., 2008): (i) the self-rated adherence of individuals in specific energy saving behaviours at their workplace are rated through the self-reported behaviours questions, (ii) the environmental personal norms items measure the participants' normative beliefs towards conserving energy, (iii) the environmental worldview items measure the degree to which the participant believes that energy conservation is an issue of concern, (iv) the behavioral intentions items assess individuals' intentions to engage in energy-conservation. We modified some of the questions originally proposed in the literature, in order to reflect the difference in our study context. Namely, some of the energy consumption behaviours assessed by the original questionnaire instrument – such as "turning off desk fans" – were not relevant in our case, as the respective equipment did not exist within the workplaces we surveyed. Furthermore, some of the questions were rephrased due to the fact that the original questionnaire contained phrasing referring to a University environment. Thus, the word "university" was substituted for "workplace" as needed. Finally, as the original questionnaire was distributed in the US, we also changed any references to the participants' country from "the US", to "my country".

In the second part of the questionnaire, we assessed the participants' profile, regarding a number of additional factors that may influence their energy behaviour at work. First of all, we assessed their work Burnout levels by deploying three questions from the burnout section of the Maslach Burnout Inventory (MBI) (Maslach & Jackson, 1981) – instead of the complete MBI – in order to limit the overall length of the questionnaire instrument. Secondly, we survey personal disadvantages the employees may experience regarding the perception of heat, or cold, within the workplace. Thirdly, the participants' perceived level of comfort at their workplace. The direction of their locus of control in conserving energy at the workplace was assessed next. The questions we deployed are in the spirit of the general Locus of Control questionnaire by (Rotter, 1966), but focused on energy. Internal locus meaning that the participants perceive their actions as important towards inducing energy conservation, while external meaning that the organisations' / other's actions can induce energy conservation. In addition, we assessed their perceived level of awareness of energy saving costs and actions at the workplace. Finally, we recorded our samples' demographic characteristics – their age, gender, position in the organisation, as well as if they had children or not.

4 Methodology

The IoT-enabled application we are designing shall be deployed in three pilot sites equipped with the necessary IoT infrastructure to facilitate the experiments we shall be running: (i) a municipal IT-support office situated in Greece, (ii) an electricity regulation authority in Spain, and (iii) an art museum in Luxembourg. The prospective survey participants on all three sites were contacted by e-mail and invited to participate, with two additional rounds of reminder e-mails sent. Selected employees at each of the three sites also regularly reminded their colleagues to take part in the survey. After two weeks, the collection process was deemed complete and the submitted answers were collected for analysis. The questionnaire was administered to employees of various roles in their organizations through an online platform, while a total of 119 completed questionnaires were collected. The participants were in their majority aged between 18 and 45 years old (66,1%), while only 33,9% were older than 45 years old. Regarding their gender, male outnumbered female participants (55.7% vs 44.3%), while employees with outnumbered those without children (55.7% vs 44.3%).

Following the collection of results, we performed four kinds of analyses: (i) *Reliability analysis:* An analysis on all the sub-sections of the questionnaire, except the demographics section, to determine the reliability of the scales proposed for the nine respective constructs. (ii) *Factor analysis:* An analysis of the factors included within our constructs, to ensure that they indeed form a construct and, if not, to determine the specific factors included within our proposed constructs. Newly formed constructs that were derived through this process, were also re-analysed as per their reliability. (iii) *Descriptive Statistics*: We performed a descriptive statistical analysis of our resulting factors and constructs, to gain insight on the general trend of our samples' characteristics in all the factors surveyed through the questionnaire. (iv) *Analysis of correlations:* As our study was exploratory in its nature, we performed bivariate correlation analysis, to explore the relationships between our variables. Correlation analysis is used to describe the strength and direction of the linear relationship between variables, while correlation values are interpreted as small (r=.10 to .29), medium (r=.30 to .49), or large (r=.50 to 1.0) (Pallant, 2010). All statistical analyses on our collected results were performed using IBM SPSS Statistics v.23. Prior to conducting a correlation analysis, we calculated composite scores for all the constructs mentioned in Table 1, by summing responses to the respective construct items and dividing by the number of items as needed. Composite scores were used in the subsequent correlation analyses. The Pearson product-moment correlation coefficient (r) is presented for all correlations reported as part of our analysis, along with the level of statistical significance, indicating the confidence levels of correlations calculated.

To assess the scale internal consistency, where needed, we have calculated and reported Cronbach's alpha coefficient, which should ideally be above .70. However, the reliability of a scale can vary depending on the sample, as well as number of questions in a scale. As it is frequently difficult to achieve acceptable Cronbach a values on scales with a small number of items (less than 10), reporting the mean inter-item correlation value is suggested instead, while optimal mean inter-item correlation values range from .20 to .40, suggesting that while the items are reasonably homogenous, they do contain sufficiently unique variance so as to not be isomorphic with each other (Pallant, 2010; Michalos, 2014). Cronbach alpha values are quite sensitive to the number of items in the scale, while with short scales (e.g. scales with fewer than ten items) it is common to find quite low Cronbach values (e.g. .5), in which case it may be more appropriate to report the mean inter-item correlation for the items (Pallant, 2010). Furthermore, inter-item correlations are an essential element in conducting an item analysis of a set of test questions, as they examine the extent to which scores on one item are related to scores on all other items in a scale while, when values are lower than .20, then the items may not be representative of the same content domain and when they are higher than .40, the items may be only capturing a small bandwidth of the construct (Michalos, 2014). Finally, inter-item correlations address issues relating to a scale's fidelity of measurement, how well the instrument is measuring some construct (e.g., its internal consistency) (Michalos, 2014).

5 Results

5.1 Descriptive Statistics

The complete questionnaire instrument we deployed in our survey, as well as some descriptive statistics on the answers we collected, can be found in Table 1. The structure of the sections was corroborated through factor analysis and the crossed out questions represent the ones that we did not utilise in our analysis, towards increasing the reliability of the respective scales. More details regarding scale reliability and structure can be found in the following sections. Notably, the mean levels of our samples' personal norms and behavioural intentions were higher than their mean environmental worldviews. Furthermore, moderate mean levels of burnout were recorded at the surveyed workplaces, as did personal disadvantages and perceived comfort levels. Finally, the direction of the participants' mean locus of control towards energy conservation at work was recorded as moderately external.

QUESTIONNAIRE SECTIONS	**Mean**	**S.D.**
A. Self Reported Behaviours **(N=119)**	-	-
Popular Self Reported Behaviours	*6.56*	*0.82*
1. When I am finished using my computer for the day, I turn it off.	6.56	1.02
2. When I leave a room that is unoccupied, I turn off the lights.	6.56	0.86
Unpopular Self Reported Behaviours	*4.61*	*1.64*
3. When I am not using my computer, I turn off the monitor.	4.89	2.03
4. When I leave my work area, I turn off the Air Conditioner(s).	4.65	2.31
5. When I leave my work area, I turn off the printer(s).	3.86	2.22
8. When I am the last to take coffee in the afternoon at work, I turn the coffee machine off.	5.06	2.01
Partially Unavailable Self Reported Behaviours	*5.84*	*1.23*
6. When I leave a bathroom that is unoccupied, I turn off the lights.	6.25	1.37
7. I often leave the windows open while the Air Conditioner is on. (Reversed)	5.44	1.83
B. Behavioural Intentions **(N=119)**	*6.16*	*0.94*
9. I would help the organization I work for conserve energy.	6.40	0.80
10. I would change my daily routine to conserve energy.	5.91	1.39
C. Environmental Worldviews **(N=119)**	*5.57*	*1.14*
11. My country is in the middle of an energy crisis.	4.77	1.65
~~12. News reports about an energy crisis are blown out of proportion. (Reversed)~~	~~4.67~~	~~1.46~~
13. Energy conservation is something to be concerned about.	6.36	1.09
~~14. It is my right to use as much energy as I want (Reversed).~~	~~5.24~~	~~1.81~~
D. Environmental Personal Norms **(N=115)**	*6.14*	*0.95*
15. Conserving energy and natural resources is important to me.	6.27	1.07
16. Conserving energy is not my problem. (Reversed)	6.10	1.50
17. I have a responsibility to conserve energy and resources.	5.99	1.47
18. The organization I work for should conserve energy.	6.25	1.11
19. I should help the organization I work for conserve energy.	6.12	1.14
E. (Energy) Awareness **(N=119)**	*5.85*	*1.07*
20. I am aware of energy costs and possible sources of energy wastage.	5.88	1.20
21. I am aware of ways to save energy at work.	5.82	1.22
F. Locus of Control **(N=119)**	*4.10*	*1.65*
22. Saving energy is a collective effort. Doing it individually has no impact at all.	4.10	2.20
23. I would change my energy-consumption behaviour at work, if others do so.	4.09	1.97
G. Comfort Levels **(N=118)**	*3.28*	*1.26*
24. The quality of air at work is satisfactory.	3.53	1.81
25. Climate conditions at work are comfortable.	3.92	1.73
26. My personal comfort at work is of crucial importance.	5.62	1.34
H. Personal Disadvantages **(N=117)**	*3.42*	*1.56*
27. Bad weather or climate conditions make me sick.	3.68	1.95
28. I often feel colder than people around me at work.	3.19	1.86
~~29. I often feel warmer than people around me at work~~	~~3.34~~	~~1.94~~

I. Burnout **(N=116)**			*2.24*	*1.51*
29. Working with people all day long requires a great deal of effort.			3.08	2.15
30. I feel I work too hard at my job.			2.49	2.08
31. It stresses me too much to work in direct contact with people.			1.09	1.57
J. Demographics **(N=115)**	***Group***	***Count***	***%***	
32. Age	18 - 35	23	20.0 %	
	35 - 45	53	46.1%	
	45 - 65	39	33.9%	
33. Gender	Male	63	54.8%	
	Female	52	45.2%	
34. Do you have children?	Yes	64	55.7%	
	No	51	44.3%	

Table 1. The Questionnaire Instrument deployed in our study, as well as descriptive statistics, means, standard deviations and sample characteristics. Sections A, B, C, D Adapted from (Scherbaum et al., 2008) and section I from (Maslach & Jackson, 1981).

5.2 Scale Reliability – Internal Consistency

The reliability reported by Scherbaum et al. for the scale on which we based our own self-reported behaviours scale was sufficiently high, with an internal consistency (a= .71), while one factor was revealed for all the items (Scherbaum et al., 2008). In our study, we found that – if examined as one scale – the eight energy saving behaviours we surveyed featured lower internal consistency (a= .646), with a number of low (even below .150) inter-item correlations in some cases. We hence performed an exploratory factor analysis to explore if the items in the scale indeed reflected a unique construct. More specifically, a Principal Components Analysis (PCA) was followed after the suitability of our data for factor analysis was assessed. Indeed, an inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Kaiser- Meyer-Olkin value was .643, exceeding the recommended value of .6 and Bartlett's Test of Sphericity reached statistical significance ($p<.001$), supporting the factorability of the correlation matrix. The results from the PCA revealed the presence of three components with eigenvalues exceeding 1, explaining 31.2%, 20.9% and 13.7% of the variance respectively. Additionally, the three-component solution explained a total of 65.8% of the variance. Therefore, the results of this analysis supported the division of the items into three separate sub-scales, as reported on table 1. Towards exploring the inter-relationship between the items in the newly-formed three sub-scales, we also explored their descriptive statistics. What we realised, was that the behaviours surveyed through the first sub-scale {(i) When I am finished using my computer for the day, I turn it off, and (ii) When I leave a room that is unoccupied, I turn off the lights}, also exhibited high mean values (both 6.56 / 7), with a standard deviation of around 1. Therefore they are both behaviours that are in general adhered-to by the majority of our sample to a high degree. More specifically, their mean value suggests that the participants (as a general trend) admitted to almost completely agreeing that they perform these two behaviours at the workplace consistently. If we take into account that these behaviours (turning off the PC, as well as the lights), are also behaviours that can be performed at home, there might be room to also investigate if there is some spill-over effect at play in this specific case. In any case though, their high level of adherence led us to name this sub-scale *"popular self-reported behaviours"*. The reliability of this scale (a=.660) was deemed acceptable – although below the .700 threshold regularly reported for scale reliability in the literature – also taking into account that it is a two-item scale, with acceptable levels of inter-item correlation (.499) (as delineated in the methodology section earlier).

With regards to the items in the second sub-scale {(i) When I am not using my computer, I turn off the monitor, (ii) When I leave my work area, I turn off the Air Conditioner(s), (iii) When I leave my work area, I turn off the printer(s), (iv) When I am the last to take coffee in the afternoon at work, I turn the coffee machine off}, their mean values were significantly smaller than the ones reported for the "popular self-reported behaviours". More specifically, they ranged between 3.86 and 5.06, with a standard deviation over 2. Thus, these behaviours seem to be performed a lot less consistently by the users, thus making them less popular in our sample. Hence, we named the resulting sub-scale *"un-popular self-reported behaviours"*. The reliability of this scale was good (a=.763).

As for the items in the derived third sub-scale, {(i) When I leave a bathroom that is unoccupied, I turn off the lights, (ii) I often leave the windows open while the Air Conditioner is on. (Reversed)}, a more careful examination of the context within which we deployed the questionnaire revealed that they were not uniformly available across our sample. In some workplaces the windows could not be opened, while in some cases the bathroom lights were automated through motion sensors. This construct had low reliability (a=.263), as expected and the two items were grouped into the category *"partially un-available self-reported behaviours"*. Based on our findings, we decided to omit this construct from any further analysis within this research paper.

The reliability reported by Scherbaum et al. for the two-item *behavioural intentions* scale was modest, with an internal consistency (a= .68) (Scherbaum et al., 2008). In our study context, it also featured even more modest internal consistency (a=.55). However, the inter-item correlation between the two items in the scale was well within the acceptable range (.440), in support of the scales' reliability. Hence the overall reliability of the scale was considered as acceptable. Similarly, the internal consistency of the four-item *environmental worldviews* scale was reported by Scherbaum et al. as modest (a=.69) (Scherbaum et al., 2008). In our case, the reliability of this scale was considerably lower (a=.48) while, at the same time, two of the items showed inter-item correlations outside the acceptable range. Hence, we revised the scale by excluding two of the items, as indicated by our results. The resulting two-item scale featured only slightly elevated reliability (a=.49) but, based on the fact that the items showed inter-item correlation within the acceptable range (.351), the resulting scale was considered as acceptable. The next scale we examined towards reliability was the *personal norms* scale. The results by (Scherbaum et al., 2008) indicated high levels of internal consistency (a= .92) in the literature. In our case the consistency was lower (a=.719), but within the acceptable range, while all items feature inter-item correlation scores well within the desirable range. Thus, this scale was also deemed reliable.

The *energy awareness* scale also consisted of two items. Its internal consistency however was well within the acceptable range (a=.720), while an acceptable inter-item correlation of (.563) was also recorded. Therefore the scale was considered reliable. *Locus of control* was also assessed by a two-item scale, while its recorded internal consistency was lower than the rest of the scales (a=.394). However, since the inter item correlation between the two questions was within the acceptable range (.247), we decided to accept the construct as uniform, with the note that additional items should be added in the future, to boost its reliability. The *comfort levels* of the participants were assessed by a three-item construct, which exhibited modest internal consistency (a=.645). However, since it is a three-item scale and the inter-item correlations were good, we deemed the scale reliable for the purpose of this study. As per the *personal disadvantages* scale, the three item scale exhibited relatively low internal consistency (a=.444), while based on low inter-item correlation with the other two items, we decided to revise the scale by excluding the third item. The resulting two-item scale features moderate internal consistency (a=.502) but, since the inter-item correlation between the two items is within the acceptable range (.336), it is considered a reliable measure. Finally, as per the burnout scale administered, the three-item version featured moderately good reliability (a=.670), which, taking into account the very good inter-item correlation scores, combined with the small number of items in the scale, indicates that it is a reliable measure.

5.3 Identified Correlations

Having performed bivariate correlations between all of the variables we measured through our composite questionnaire instrument, we observed that, first of all, few correlations arose with the demographic items. More specifically, female participants were found to be positively (weakly) correlated with positive environmental worldviews (r=.277**, p=.003), as well as personal norms (r=.206*, p=.030) and behavioural intentions (r=.239*, p=.010). Male participants, in contrast, were weakly correlated with an external locus of control towards energy conservation (r=.204*, p=.029), as well as higher levels of perceived comfort (r=.194*, p=.039) at their workplace. The correlations we identified between all the other constructs we employed can be found on Table 2.

	1.Environm. Worldviews	2	3	4	5	6	7	8	9
2.Environmental Personal Norms	**.605****								
3.Behavioural Intentions	**.400****	**.486****							
4.Popular Energy Saving Behaviours	.174	**.306****	**.198***						
5.Unpopular Energy Saving Behav.	.044	-.091	.058	.046					
6.Awareness of Energy	**.417****	**.511****	**.232***	.141	-.020				
7.Locus of Control	.061	-.025	.053	.013	**.202***	-.138			
8.Comfort Levels	**-.266****	-.123	-.038	-.040	**.203***	-.114	.020		
9.Personal Disadvantages	-.064	-.175	-.054	-.101	.109	-.164	.067	**-.186***	
10.Burnout	.115	-.119	-.095	**-.199***	.107	-.066	**.241****	**-.257****	.171

Table2. Correlations between the questionnaire constructs employed. Significant correlations flagged:
***. Correlation is significant at the 0.01 level (2-tailed).*
**. Correlation is significant at the 0.05 level (2-tailed).*

6 Discussion

Having conducted the exploratory statistical analysis delineated above, we discovered that, first of all, the relationships presented in previous studies employing VBN theory towards energy conservation at the workplace (Scherbaum et al., 2008) were verified in our case. Scherbaum et al. found that environmental personal norms were a statistically significant predictor of self-reported conservation behaviors at work, as well as behavioral intentions, while environmental worldviews were a statistically significant predictor of environmental personal norms, and environmental personal norms mediated the relationship between environmental worldviews and reported conservation behaviors and behavioral intentions. Compared to their findings, in our study context environmental worldviews were strongly correlated with environmental personal norms and moderately correlated with behavioural intentions, while environmental personal norms were moderately correlated with behavioural intentions. However, since we employed two different constructs regarding energy behaviours in specific, the correlations discovered in this case were different. Environmental personal norms featured a medium correlation with popular energy saving behaviours, while behavioural intentions were mildly correlated with popular energy saving behaviours, in contrary to the model from Scherbaum et al, where no correlation was discovered between intention and actual behaviour. In addition, we believe that we have complemented the applicability of the existing model proposed by (Scherbaum et al., 2008), by employing it in a different context. More specifically, whereas the sample investigated in previous studies comprised of N=154 university personnel in the US, we have conducted our study in three different workspace environments with N=119, situated in three different EU countries, verified some of the existing relationships already explored in the bibliography, as well as discovered new ones, and proposed an extension of the model in various directions.

As already mentioned, female participants were found to bear more positive environmental worldviews, as well as personal norms and behavioural intentions, while male participants, in contrast, were weakly correlated with an external locus of control towards energy conservation, as well as higher levels of perceived comfort at their workplace. With regards to the additional factors considered in this paper, energy awareness strongly correlated with environmental personal norms, moderately with environmental worldviews, as well as weakly with behavioural intentions. Furthermore, burnout was mildly correlated with external locus of control and (negatively) with comfort levels at work, while personal disadvantages were also mildly negatively correlated with comfort levels at work. Additionally, burnout was also mildly negatively correlated with popular energy saving behaviours, while an internal locus of control was mildly correlated with unpopular energy saving behaviours. Comfort levels were also mildly negatively correlated with environmental worldviews and positively with unpopular energy saving behaviours. The significant correlations discovered through the exploratory statistical analysis performed can be found in Figure 1. Having delineated the results from the statistical analysis, we propose that the factors included in our model are divided into three groups: (1) personal characteristics, (2) VBN-based model (Scherbaum et al., 2008), (3) energy saving behaviours.

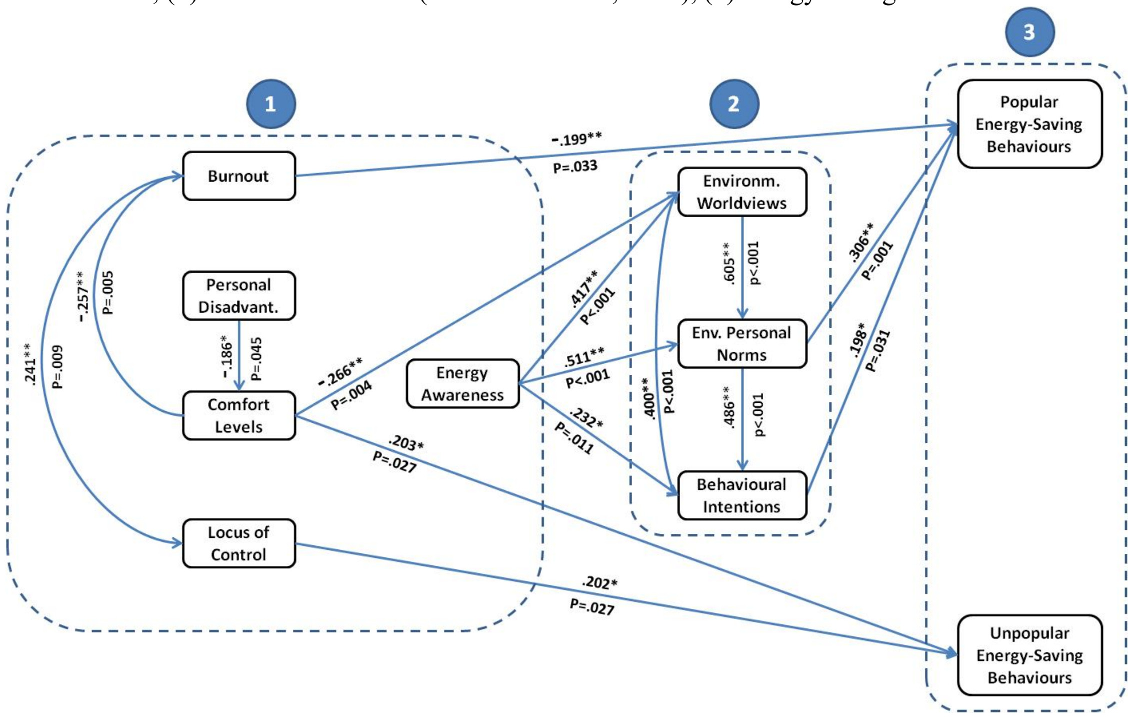

Figure 1. Behavioural model for energy conservation at the workplace – Significant relationships discovered and/or verified. The groups of constructs represented are: (1) personal characteristics, (2) VBN-based model (Scherbaum et al., 2008), (3) energy saving behaviours

7 Conclusion

Energy conservation at the workplace through behavioural change, is a potentially effective, but under-researched issue. Through our research, we have explored a number of parameters that can be handled within organisational settings to affect such behaviours. Furthermore, we have conducted a survey with N=119 employees in three different workplaces, to record employees' behaviour based on these parameters. Having statistically analysed the collected responses, we presented the correlations between all constructs employed and derived a behavioural model through which we present our main findings. We have grouped the constructs employed into three categories, so that the model can be interpreted more easily: (i) the employees' personal characteristics that consist of burnout level, personal disadvantages, comfort levels, locus of control and energy awareness (ii) the parameters that stem from the existing model by (Scherbaum et al, 2008) – environmental worldviews, personal norms and behavioural intentions and, finally, (iii) two different categories of energy behaviours at the workplace, namely popular and unpopular behaviours. We have presented significant correlations between all the models already mentioned and analysed them in the discussion of this paper, so that they may guide future research in the same direction.

More importantly, the resulting behavioural model can provide guidance towards applying IoT-enabled energy conservation initiatives at the workplace, by manipulating the corresponding variables identified, as needed, while also taking into account the employees' personal and behavioural characteristics. We stress that towards enabling energy conservation at the workplace, initiatives that promote raising the employees' energy awareness, as well as positively affecting their environmental worldviews and personal norms may be most effective. Additional ways of increasing engagement towards the same behaviour identified through our research involve more difficult interventions at the workplace: alleviating the employees' burnout levels and amending their sense of personal comfort, while respecting their personal disadvantages and perceived ambient temperature differences.

Notably, a general framework towards utilising the potential of environmental psychology for understanding and promoting pro-environmental behaviour comprises of: (1) identification of the behaviour to be changed, (2) examination of the main factors underlying this behaviour, (3) design and application of interventions to change behaviour to reduce environmental impact, and (4) evaluation of the effects of interventions (Steg & Vlek, 2009). Having identified energy conservation by employees at the workplace as our targeted behaviour, we have contributed towards the second step of examining and indentifying the main factors underlying energy conservation through behavioural change. We aim to also perform the remaining two steps of designing and evaluating our interventions through our research in the future.

As all research, our work comes with its limitations. First of all, we have relied only in self-reported measures, thereby introducing the factor of potential personal bias to our results. In addition, our survey results have been based on a limited number of answers (119), while a larger sample of participants would have provided an even more firm basis for drawing safe conclusions. More importantly, some of the constructs we have employed in our survey consisted of a low number of items each, thereby weakening their consistency in some cases, as well as potentially their generalisability. Finally, we have yet to test our model in a real-life experiment that would record longitudinal data, towards proving its utility, as well as fortifying, or extending its connections. Towards that end, we aim to complement our research in the future, by putting our theoretical findings to practice through experimentation at actual workplaces. We are already designing such an approach and plan to implement an IoT-enabled behavioural intervention, through which we may corroborate our findings and extend the validity of our findings.

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