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Research article

How to motivate employees towards organizational energy conservation: Insights based on employees perceptions and an IoT-enabled gamified IS intervention

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ABSTRACT

Employees can help organizations attain Corporate Environmental Performance (CEP) goals and save on energy bills, by conserving electricity. However, they lack the motivation. Information Systems (IS)-enabled energy-related feedback interventions featuring gamification (utilizing game-design elements), have been suggested to increase organizational energy conservation. To identify the behavioral factors that should be considered when designing such interventions towards optimizing their results, this paper focuses on unravelling the intricacies of employee energy consumption behavior and providing answers to the research question: "What drives employees to save energy at work?". Our research is conducted in three workplaces across Europe. First, we analyze employees' energy-saving motivation and behavior at an individual level of analysis to identify defining behavioral factors behind it. Then, considering these drivers of employees' energy consumption behavior, we focus on answering the question: "How a gamified IS that provides real-time energy usage feedback affects employees' motivation to conserve energy at work, and in turn the actual energy savings in organizations". Our findings suggest that employees' level of self-determination to conserve energy, energy-saving personal norms, and personal and organizational profile, significantly explain both their energy-saving behavior and the energy behavior change attained through a gamified IS intervention. Moreover, the provision of feedback to employees, via an Internet-Of-Things (IoT)-enabled gamified IS, is proven an effective strategy for accomplishing actual energy conservation at work. The acquired insight on what drives employees' energy usage behavior supports the design of gamified IS interventions that have higher motivational capacity and, thus, can change employees' energy behavior. When designing behavioral interventions aimed at energy conservation at work, we should primarily focus on monitoring (to decide whether a behavioral intervention would be worth organizing) and ultimately positively affecting employees' energy-saving habits and intention. Our findings can be transformed to specific practical suggestions for firms to encourage employees' energy saving behavior when aspiring to attain CEP goals. They include satisfying their basic psychological needs for autonomy, competence, and relatedness, activating their personal norms in the context of energy-saving at work, and educating and encouraging them towards specific energy-saving behaviors by utilizing gamified IoT-enabled IS that keep their energy-saving "in shape".

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1. Introduction

Climate change, and the worldwide acknowledged need to intensify our efforts to reduce CO2 emissions and protect the environment, are directly connected to energy conservation [1,2]. Accordingly, three out of the seventeen United Nations' "Envision2030" Sustainable Development Goals (UNSDGs) – #7, #12, and #13 – are connected to energy conservation [3]. At the same time, companies are increasingly held accountable for the social consequences of their activities by governments, society, and the media, and ranked based on their Corporate Social Responsibility (CSR) – that is in turn directly linked to sustainable competitive advantage [4].

Corporate Environmental Performance (CEP) is an important aspect of CSR that was first conceptualized in 1998 as "organization-wide commitment to environmental excellence relative to the rest of the industry in a variety of areas" [5]. Nowadays, CEP is defined as "the results of an organisation's management of its environmental aspects" (both within ISO 14000 standards and EU legislation). Further to its effect on the environment, CEP also seems to have a direct positive effect on firms' economic performance, justifying the notion that "it pays to be green" [6]. Moreover, a proactive environmental strategy can strengthen the competitive advantage of organizations [7]. The focus on CEP has recently gained more attention in the context of climate change that is directly connected to energy consumption. Interestingly, 40% of EU energy consumption (and 36% of CO2 emissions) is performed in buildings (one third of which in non-residential buildings), where a gap of up to 300% between predicted and actual energy consumption has been identified [8,9], and at the same time the fastest yearly increase (1.6%) in energy demand is projected until 2040 [10,11].

Based on the above, energy conservation in workplaces can help towards attaining corporate CEP goals. However, although the occupants' role has been identified as a major determinant of energy use (and conservation) in buildings, with a comparable impact to – and significant effect on the successfulness of – technological solutions, it has so far been largely overlooked [12–14]. Therefore, there is a significant identified lack of knowledge about the internal factors that influence occupant energy consumption behaviors in buildings [15].

Relevant studies on energy consumption in non-residential buildings claim that effecting positive employee energy behavior change can lead to significant savings, as the average employee consumes >5.600 kWh of energy yearly at work in the EU [16,17]. At the same time the behavior of buildings' occupants can increase or decrease its designed energy performance by as much as 33% [18]. However, energy behavior research has mainly focused on the residential sector [14,19], despite the fact that the factors that guide energy consumption by employees at work are not the same as at home [20]. Furthermore, research on employees' energy conservation behavior, as well as the socio-psychological influences of the organizational context on their energy consumption actions is generally limited [19,21–23]. Thus, the need to further research the relationships between individual – behavioral, social, and work-context related – factors, and energy use at work has been acknowledged [9,19,21–26].

A sophisticated understanding of the causal variables in the context of employee energy-saving at work, and their connection to the target behavior from the actor's viewpoint, is essential for designing successful energy behavior change interventions in non-residential buildings [27,28]. In particular, behavioral interventions where feedback has been provided to users on their energy behavior through information systems (IS), have been successful for promoting energy conservation behavior [29]. However, the existence of a limited number of studies that have assessed the effect of providing energy feedback to employees at their offices, has led researchers to call for more research on IS-enabled interventions at work, and on how they affect energy consumption behavior in specific [30–33].

Drawing from all the above – and acknowledging that energy-saving by employees can help organizations reach their goals for sustainability as well as save on corporate energy bills – this paper delves deeper into employee energy consumption behavior, with the purpose of exploring factors that may affect it and should be considered when designing IS-enabled energy feedback interventions. More specifically, we address the following research question: *"What drives employees to save energy at work?"*. We designed our research accordingly to investigate employees' energy-saving behavior, and especially, motivation at an individual behavior level of analysis. Moreover, considering these theory-rooted drivers of employees' energy consumption behavior, we also focus on an additional, more specific, research question: *"How a gamified IS that provides real-time energy usage feedback affects employees' motivation to conserve energy at work, and in turn the actual energy savings in organizations"*.

Our study was conducted with employees in three workplaces situated in different EU countries. First, we performed a survey to explore their motivation to conserve energy at work, and ascertain if it is affected by their self-determination, or their personal norms, or if it is a planned behavior. These viewpoints are rooted in three established behavioral theories, i.e. self-determination theory of motivation (SDT) [34,35], the theory of planned behavior (TPB) [36] and values-beliefs norms theory of environmentalism (VBN) [20]. We also considered additional factors that may affect energy behavior at work, such as work engagement, gender, age, and having children. Then, taking into account that participatory behavioral interventions are recognized as an effective means towards enhancing organizational energy-saving behavior [17,33], we utilized an IoT-enabled, gamified IS that encouraged the employees to conserve energy during their daily work routine. The employees' actual energy saving was recorded throughout the IoT-enabled intervention, to allow for a comparison with their self-assessed behavioral change towards reaching further conclusions. We emphasize that our research design does not rely only on subjective means (i.e., the employees' perceptions of energy conservation based on the survey), which is the conventional research approach when examining human behavior. Instead, we have also collected objective evidence (i.e. IoT-enabled records of the employees' actual energy conservation) to reinforce our findings.

To the best of our knowledge, this is the first study exploring energy-saving utilizing three behavioral theories concurrently (as a self-determined behavior, planned behavior, and personal norms activation), especially in workplaces. Although recent studies have in some cases examined extended models of TPB that have included personal norms or self-determination in the context of PEB (e.g. Refs. [15,37–41]), to our knowledge there is a lack of a study that assesses these three theories together towards explaining energy conservation, and especially in the context of the workplace. However, the motivation behind this study was not just theoretical; we also aimed to realize more about the employees' behavioral and motivational drivers to better interpret the effect of gamified feedback interventions on employees' motivation and energy usage behavior. The more we understand about the behavioral and motivational profile of employees/users, the higher the potential to design gamified feedback interventions with improved motivational capabilities that will foster employees' energy consumption behavior change.

Our analysis of the survey results, as well as the objective energy usage records, reveals that all three theoretical viewpoints we examine present merits as per their utility in explaining employees' energy-saving motivation and behavior at work. From a practical point of view, we find evidence that, when designing and applying behavioral interventions, the level of employees' self-determination may be more salient in explaining their energy-saving behavior at work compared to personal norms or planned behavior. Moreover, we find that the IS-enabled behavioral intervention led to actual energy savings, as well as employees' (self-reported) behavior change, primarily in terms of the formation of energy-saving habit at work, and secondly in terms of behavioral intention to conserve energy. Our findings can assist future researchers and practitioners that explore the drivers of energy-saving behavior at work. In addition, they can be utilized, to design IS-enabled interventions that encourage energy-saving at work. Finally, inspired by our findings, we suggest specific actions and changes that organizations can adopt for cultivating employees' energy saving behavior and, thus, achieving their CEP goals.

Next, we briefly overview existing literature and formulate our hypotheses. Then, we present our research approach for validating them. Finally, we detail and discuss our findings, their theoretical, practical, and managerial implications, and provide our concluding remarks.

2. Background and hypothesis development

2.1. Organizational energy-saving behavior and its indicators

Occupants' behavior significantly affects non-domestic buildings' energy performance, even during non-operational hours [42,43]. Although the use of Energy-Efficient Technologies (EETs) like automated lights and programmable thermostats has contributed to long-term energy reductions worldwide, lack of knowledge of their existence, as well as lack of access and willingness to use them, can impede their adoption and overall successfulness [44]. At the same time, employees are not in any way passive, despite the reduced agency they may be allowed by extant automated systems in modern buildings: Instead, they constantly interact with their surroundings and influence energy consumption in their efforts to optimize their environment, and also tend to learn and accordingly adapt to automated energy-saving solutions, by experimenting and improvising in order to address practical issues they may face at work as part of their daily routine (e.g. to increase illumination they trick light sensors into turning on lights by covering them with post-it notes) [45,46]. Therefore, to achieve energy conservation, organizations are encouraged to establish a cohesive culture (through integrated efforts across organizational levels) that combines structural changes with employees' behavioral change [47].

Employees' organizational energy-saving behavior is characterized as a "Pro-Environmental Behavior" (PEB) [48], and an "Organizational Citizenship Behavior for the Environment" (OCBE) [49]. It is hence usually considered altruistic, with no personal benefits expected in return, and enacted out of concern for the environment along with the desire to help one's employing organization [50]. However, in order for the employees to adopt an energy-saving behavior, it should not decrease productivity [19]. Moreover, motivations further to energy reduction need to be harnessed, to convince employees to change their energy behavior at work [51]. Lack of an organizational energy-saving culture, monetary incentives, and/or feedback on individual energy usage [28] are among the barriers for energy-saving behavior. However, it is promoted by highly motivated employees that are determined to 'selling energy savings' at work [52], and those holding a strong belief on the importance of energy saving, that are more willing to conserve energy at work even when it influences their personal comfort [26].

Bearing in mind the abovementioned facts, we decided to focus on the motivation aspect of employees' energy saving behavior at work. Moreover, we took into account that the enactment of organizational PEB is determined by employees' intentions, habits, and context, that may interfere with each other [11]. Accordingly, we are examining energy conservation behavior change at work as it is reflected through three different *self-reported behavioral indicators of energy conservation at work*:

- ***Energy-Saving Behavioral Intention***: Behavioral intention can be defined as "a person's perceived likelihood or subjective probability that he or she will (or will not) engage in a given behavior" [53]. It is considered as a behavioral outcome indicator in numerous theories, including TPB [36]. Intention has also been suggested as the best predictor of PEB [38] and energy-saving behavior [15,54] in past studies. Mixed study models have also considered it in connection to self-determination [55] and personal norms [56] in the context of energy conservation at work [21]. However, according to a meta-analysis of 47 studies, intention is not necessarily an accurate indicator of actual behavior change [57]. Therefore, it may be beneficial to examine it alongside additional indicators.
- ***Self-Reported Energy-Saving Behavior*** has been extensively researched in existing literature. However, honest self-accounting of energy consumption behavior may be "fundamentally problematic because of the limits of human cognition" [58]. Self-assessment of energy is not an easy task. Energy is an invisible commodity, that even experts find intrinsically difficult to quantify and analyze, and hence it is usually not accurately assessed by its consumers [59,60]. Moreover, limited knowledge of technology also contributes to incorrectly assessing the impact of electrical devices on energy consumption, thus leading, for example, to the belief that lights (a "visible" end-use) bear a significantly large contribution to total consumption [12]. Consequently, self-reported behavior

has been criticized as a relatively weak indicator of actual energy consumption that on average – according to a meta-analysis – explains only 21% of the variance in objective consumption [61].

- ***Energy-Saving Habit:*** Interventions that aim to change everyday behaviors often target people's beliefs and intentions [62]. However, energy saving behaviors at work are not necessarily a product of employees' pro-environmental intentions, and may instead come as a result of habit or routine [63]. Habit has in turn accordingly been suggested as one of the best predictors of PEB [38]. The stressful modern work environment and "automatic nature" of energy-related behaviors promotes their habitual enactment and impedes changing them [28]. The saying "old habits die hard" stresses that individuals have a "status-quo bias" [28], electing to do nothing to change their current situation or behavior when called upon to do so ("out of convenience, habit or inertia, policy or custom, because of fear or innate conservatism, or through simple rationalization") [64]. As a result, changing conscious intentions can prove ineffective towards actual behavior change in the face of strong habits [65]. In fact, as strong habits tend to override conscious intentions, intention is a more salient predictor of behavior only when established habits are weak [66]. Moreover, where goals require repeated action, behavior change is a long-term process and the promotion of the formation of habits has been proposed in order to achieve behavior maintenance [67]. Finally, habit has been explored towards explaining employees' energy-saving behavior at work [68].

2.2. Personal factors affecting employees' energy-conservation at work

A variety of factors, anchored on different theoretical frameworks, have been suggested in existing literature and utilized in the past, towards analyzing and explaining employees' organizational energy conservation behavior. In the present study, we investigate employees' individual personal, behavioral, organizational, and social factors that may affect them with regards to the forementioned energy-saving behavioral indicators (habit, intention, self-reported behavior), and accordingly formulate our hypotheses as further explicated below.

2.2.1. Self-determination to conserve energy

Self-determination is the focus of the homonymous theory of motivation (SDT) that has found wide application in work contexts [69]. It has also been proposed as a "guide" to fostering pro-environmental motivation [70] and explaining self-reported household energy-saving behaviors (Lavergne et al., 2010; D. Webb et al., 2013). It examines types – rather than just amount – of self-determination, identifying autonomous motivation, controlled motivation, and amotivation as the predictors of behavioral outcomes, as well as the basic psychological needs for autonomy, competence, and relatedness as controlling factors of their strength [35, 73,74]. It also discriminates between intrinsic and extrinsic life goals towards performance, and defines a continuum across which human motivation extends, in different degrees of internalization from intrinsic motivation (inherent drive to enact behaviors) to extrinsic motivation (need for external rewards) and amotivation (lack of motivation) [35].

According to the organismic integration theory (OIT), four degrees of extrinsic motivation exist from the least to the most self-determined: external regulation (to gain rewards, or avoid punishment), introjected regulation (to obtain contingent self-worth, or avoid feeling guilty), identified regulation (because it is personally important), and integrated regulation (because it contributes to defining oneself) [75]. Moreover, according to the hierarchical model [76], intrinsic and extrinsic motivation, and amotivation, reside hierarchically within a person at the global, contextual, and situational levels. Accordingly, increased self-determination towards PEB has been related to its longitudinal preservation [77], while autonomous motivation is considered critical in fostering it [78]. Hence, in the context of this research, we examine employees' self-determination at the situational level, and focus on their intrinsic and extrinsic motivation and amotivation towards energy-saving at work in specific.

Based on the aforementioned theoretically-rooted causality between the various forms of situational (energy-saving at work) motivation and situational (energy-saving) behavioral outcomes, we formulate the following hypotheses: *The level of employees' motivation for energy-saving at work, as expressed through their self-determination, will – [intrinsic(i) - integrated(ii) - identified(iii) - introjected(iv) - and external(v) - motivation positively, and amotivation(vi) negatively] – affect the strength of their behavioral intention towards conserving energy* ***(H1a)****, self-reported energy-saving behavior* ***(H1b)****, and energy-saving habit at work* ***(H1c)****.*

2.2.2. Energy-saving as planned behavior

According to the Theory of Planned Behavior (TPB), human behavior is deliberately planned [36]. Moreover, intention is assumed to be an immediate antecedent of any behavior, and is guided by attitude, perceived social pressure (or subjective norm), and perceived behavioral control [79]. TPB is considered as a plausible model for explaining pro-environmental and energy use intentions and behavior [80–83]. Multiple studies on conservation behaviors have accordingly recently applied the TPB in both organizational and domestic settings [37]. In most studies, subjective norm has been found to be the parameter that mostly affects intention to act pro-environmentally [38,40] and to conserve energy [54] in the TPB model. However, in other studies subjective norm had no direct effect on pro-environmental behavioral intentions [41]. Attitude and perceived behavioral control has had a direct influence on pro-environmental behavioral intentions which encourage active engagement in pro-environmental behaviors [40,41]. Perceived behavioral control has also had a significant effect on energy conservation intentions of students with physical impairments but not a direct effect on their behaviors, while attitude had the lowest power to predict intentions to perform energy-saving behaviors [54].

TPB has also been employed to explain pro-environmental behavior at work [11,84–86] and, extended with perceived habit, it has also been utilized to explain energy-saving behaviors [54] and office energy-saving behaviors in specific [19]. Moreover, since behavioral control includes both the capacity and autonomy in performing a behavior, we deduce that, in the case of energy-saving at work – where a multitude of energy-consuming devices are shared (e.g. shared lights switches, printers, etc.), and therefore energy consumption is in many ways conducted as parts of groups – perceived behavioral control should reflect a persons' beliefs regarding both personal, as well as collective behavioral control regarding energy saving at work.

Based on the above, we formulate the following hypotheses with regards to the three self-reported energy behavior outcome indicators we employ in the present research: *The level of employees' subjective norms (i), attitude (ii), felt personal impact (iii), and felt collective impact (iv), with regards to energy-saving at work, will positively affect the strength of their behavioral intention towards conserving energy **(H2a)**, which will in turn positively affect the level of their self-reported energy-saving behavior **(H2b)**, and energy-saving habit **(H2c)** at work.*

2.2.3. Energy-saving personal norms

According to Values - Beliefs - Norms (VBN) theory of environmentalism [20], pro-environmental personal norms (PN) directly lead to enacting pro-environmental behaviors. More importantly, PN have been employed in the past to explain workplace PEB [87], as well as energy-saving in specific [88–90]. In our context, PN reflect the sense of obligation towards energy-saving at work that can be leveraged in organizational interventions, in order to affect both employees' intention, as well as actual energy-saving behavior [91], and can be activated by providing information and training [92].

Accordingly, we formulate the following hypotheses with regards to the three self-reported energy behavior outcome indicators we employ in the present research: *The level of strength of employees' personal norms towards conserving energy at work, will positively affect the strength of their behavioral intention towards conserving energy **(H3a)**, self-reported energy-saving behavior **(H3b)**, and energy-saving habit **(H3c)** at work.*

2.2.4. Additional personal factors affecting energy conservation at work

One of the three constituents of work engagement (along with dedication and absorption) is ***Vigor***, characterized by "high levels of energy and mental resilience while working, the willingness to invest effort in one's work, and persistence even in the face of difficulties" [93]. It has been correlated with increased organizational citizenship behaviors (OCBs) (such as energy conservation) and decreased deviance (such as energy wastage) [94]. ***Demographic characteristics*** have also been correlated to energy behavior in the past.

More specifically, PEB tends to increase with age and women tend to exhibit more positive environmental concern, attitudes, and behaviors than men across age [51,95–97], while having children has been found to be correlated with PEB [98,99] and higher levels of motivation to conserve energy have also been reported by residential users with children [100], suggesting that this may also be true for employees.

Some past studies have also suggested that education causes individuals to behave in a more environmentally friendly manner [101], and having a university degree has been positively correlated with pro-environmental behaviour [99]. However, in other studies the results with regards to the effect of education level on PEB have been conflicting [96]. The lack of a specific connection between education level and PEB is reflected in a recent review of studies that have been conducted in EU countries, where the prevalence of a larger group of people with tertiary education in the community was found to have no statistically significant association with PEB [102]. Moreover, recent studies on energy consumption have also shown that households belonging to higher education levels are not more likely to adopt energy-saving habits [97]. Therefore, we found no significant evidence to support a hypothesis that education level affects energy conservation behavior in any direction, and decided not to include this demographic variable in our studies.

Based on the above, we formulate the following hypotheses with regards to the three self-reported energy behavior outcome indicators we employ in the present research: *Employees' level of engagement as expressed by vigor (i), age (ii), female gender (iii), and having children (iv), will positively affect the level of their behavioral intention towards conserving energy **(H4a)**, self-reported energy-saving behavior **(H4b)**, and energy-saving habit **(H4c)** at work.*

2.3. Employing IS-enabled gamified feedback for energy conservation at work

Energy has in the past been described as invisible, abstract and intangible, thus resulting in a difficulty for the average building users to estimate the amount of energy that is expended during their daily routine, and the difference they could make by adjusting their behavior [60,103]. Providing real-time energy consumption feedback can therefore help address this issue by "making invisible energy visible", as well as acting as a reference point from which to evaluate and accordingly adjust one's energy behavior [103,104]. Direct feedback has led to 5–15% (and indirect to 0–10%) savings [60], while 7.4% reductions have been achieved on average in past experiments aimed at conserving energy [13]. However, a limited number of studies have explored the effect of energy feedback in offices, and findings from studies performed in domestic environments are not easily translatable to the workplace [103].

In the same spirit, as habitual behavior is often hard to change due to people's lack of ability to monitor their own behavior, digital technologies allow self-monitoring by accurately and timely facilitating the delivery of feedback on habitual behavior thus disrupting existing habits in an effective way [105]. Feedback has in fact been proven to be especially effective for promoting energy conservation behavior when provided by an IS and combined with incentivization [29]. It has been suggested that feedback interventions should also be designed to be engaging to their target audience [106] by, for example, utilizing gamification. This is especially important in organizational environments where socio-technical relationships that connect people, organizations, and energy exist, and where "a move beyond unidirectional forms of engagement" (such as the simple provision of feedback) to more socially interactive processes is suggested [107].

Gamification can be used to encourage behavior change; increase and sustain employee participation and compliance in specific goals, motivation, engagement, performance and productivity within an enterprise; break existing habits and create new ones, and lead to satisfaction and behavior change through positive emotional feedback and the continuous provision of appropriate stimuli [108–112]. The basic, most well-known and utilized game elements in gamification applications are points, badges and leaderboards [113]. Gamified systems have been employed towards increasing occupants' motivation, knowledge, behavior and attitude, towards energy conservation and promoting real-world energy-saving behaviors in the range of 3–6%, with more than 10% achievable [114–122], in various workplaces worldwide [122–125].

Various theories have been adopted to explore the motivational capabilities of gamification. Leveraging self-determination has been suggested to effectively design and analyze motivational and gamified experiences [126–130]. TPB [36], in turn, has been used to explain the behavioral effects of gamification in various contexts [131–133]. Moreover, personal norms [20] have been employed, to explain gamifications' effects on PEB and energy conservation behavior [133,134]. Finally, to understand the influence of an IS on PEB more thoroughly, the complex interdependencies between the individual, organizational, and societal level must be investigated [135].

Inspired by all of the above, *we utilize timely and personally relevant feedback distributed by an IoT-enabled, gamified IS, expecting that it will lead to: (i) an increase in employees' motivation to conserve energy at work* ***(H5)*** *– as expressed through their Self-Determination* ***(H5a)****, Planned Behavior* ***(H5b)*** *and Personal Norms* ***(H5c)*** *–, and in turn (ii) positive actual energy consumption behavior change* ***(H6)*** *– as expressed through the change in the participating employees' energy-saving intention* ***(H6a)****, self-reported behavior* ***(H6b)****, and habit* ***(H6c)*** *–, that will then lead to (iii) actual energy savings* ***(H7)*** *– calculated by comparing energy consumption during the intervention to baseline consumption before the intervention.*

3. Methodology

Considering the forementioned background, we see that behavioral theories have been studied to explain how the personal behavioral profile and especially motivation may affect energy-saving behavior. On the other hand, researchers have provided evidence in the past that providing energy usage feedback can make a difference and improve energy consumption behavior. They have also highlighted that feedback is more effective when offered by an information system, which should be designed with the purpose to maintain high users' engagement. For gamified IS, it is well known that they can be used for behavior change and there has been theory-driven investigation of gamification's motivational, as well as behavior change capabilities. Still, the available research focuses on either one or a combination of two behavioral theories when exploring energy usage decisions and behavior and gamified systems' effect on users' motivation and behavior; and these studies do not usually consider an organizational context, namely a workplace.

In the present research, we study behavioral factors rooted on three behavioral theories concurrently, aspiring to delve deeper into employees behavioral and motivational profile that may affect their energy consumption. We believe that this more holistic investigation will provide more insight on employees' behavior and motivation, which in turn can help in designing gamified interventions that serve and nurture the identified behavioral and motivational drivers behind energy conservation at the workplace and can thus be more effective. Hence, we developed our research model to reflect the fact that, when carefully designed, feedback provided to employees through gamified IS interventions has the power to affect employees' energy-saving behavior, that in turn leads to actual energy-savings in organizations. Our Research Model can be graphically reviewed in Fig. 1.

Through our findings we provide insight into how employees' individual behavioral, social, and organizational factors affect their energy-saving behavior, as well as how IoT-enabled gamified IS that provide feedback to users can affect their motivation to conserve energy, and lead to energy consumption behavior change and actual energy-savings.

3.1. Summary of hypotheses & supporting evidence

The hypotheses we examine in the present research, can be reviewed in Fig. 2.

A summary of the hypothesized relationships, in connection to extant supporting evidence drawn from the literature, can be found in Table 1.

3.2. Participants and procedure

The participants in our research were employees in workplaces across three different countries: (a) two university buildings in Spain, (b) an I.S. institute in Switzerland, and (c) a technology business incubator in Italy. Although the three organizations were different in their main activity, the areas where the participants worked within all three workplaces had similar characteristics. In essence all the participating employees worked in regular office spaces, performing desk jobs, on standard morning shifts.

To test and validate our research hypotheses, we first conducted a survey that assessed employees' self-reported energy-conservation motivations and behavior. Subsequently, an IoT-enabled, gamified energy-saving IS solution was utilized in the context of a behavioral intervention designed to motivate employees to reduce their energy use at work. The subset of employees that participated

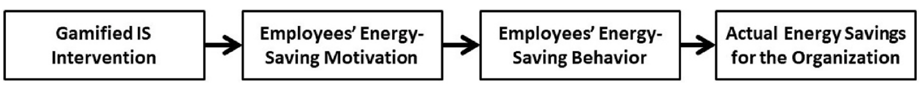

Fig. 1. Research model.

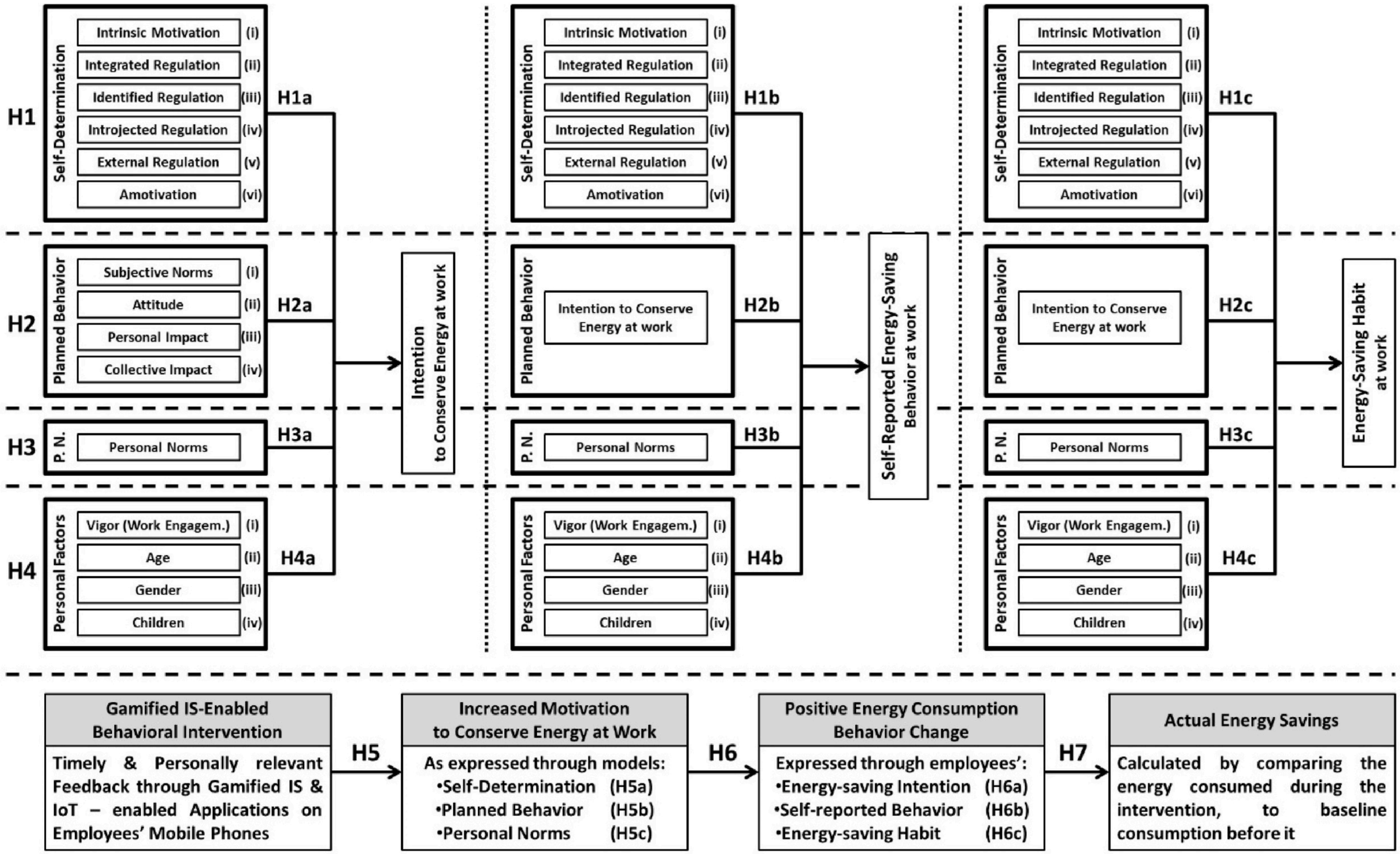

Fig. 2. Schematic representation of research hypotheses.

Table 1
Summary of research hypotheses.

		Description	Supporting Evidence from Existing Literature
Self-Determination	H1	The level of employees' motivation for energy-saving at work, as expressed through their self-determination, will affect the strength of their behavioral intention towards conserving energy (H1a), self-reported energy-saving behavior (H1b), and energy-saving habit at work (H1c).	• Higher levels of self-determination are related to long-term maintenance of PEBs [77] • Autonomous motivation is critical in fostering PEBs [78] • SDT should be used as a guide to fostering environmental motivation [70] • SDT has been used to explain self-reported household energy-saving behaviors [71, 72]
Planned Bahavior	H2	The level of employees' subjective norms (i), attitude (ii), felt personal impact (iii), and felt collective impact (iv), with regards to energy-saving at work, will positively affect the strength of their behavioral intention towards conserving energy (H2a), which will in turn positively affect the level of their self-reported energy-saving behavior (H2b), and energy-saving habit (H2c) at work.	• Planned Behavior (TPB) can explain energy use intentions and behavior [80,81] • Energy consumption behavior is positively influenced by consumers' attitude [155] • Planned Behavior (TPB) has been employed to explain PEB at work (Cordano & Freeze, 2000; Lülfs & Hahn, 2013, 2014; Martín-Peña et al., 2010) • Planned Behavior (TPB), extended with perceived habit, has been used to explain office energy-saving behaviors [19]
Personal Norms	H3	The level of strength of employees' personal norms towards conserving energy at work, will positively affect the strength of their behavioral intention towards conserving energy (H3a), self-reported energy-saving behavior (H3b), and energy-saving habit (H3c) at work.	• Personal PEB norms are connected to actual conservation behaviors [20] • Personal norms have been employed to explain workplace PEB [87] • Personal norms have been employed to explain energy-saving behavior (Fornara et al., 2016; Ibtissem, 2010; Steg et al., 2005) • Employees' personal energy-saving norms can be leveraged to affect their intention, and actual energy-saving behavior [91]
Personal Factors	H4	Employees' level of engagement as expressed by vigor (i), age (ii), female gender (iii), and having children (iv), will positively affect the level of their behavioral intention towards conserving energy (H4a), self-reported energy-saving behavior (H4b), and energy-saving habit (H4c) at work.	• Vigor is characterized by willingness to invest effort, and persistence, at work [93] • Vigor has been correlated with increased organizational citizenship behaviors (OCBs) and decreased deviance [94] • PEB tends to increase with age, and women tend to have stronger environmental attitudes, concern and behaviors than men across age (Gifford & Nilsson, 2014; Murtagh et al., 2013) • Residential users with children exhibit increased motivation to save energy [100]
Behavioral Intervention	H5	Timely & personally relevant feedback distributed by an IoT-enabled, gamified IS solution will lead to: an increase in employees' motivation to conserve energy at work – as expressed through the Self-Determination (H5a), Planned Behavior (H5b) and Personal Norms (H5c) models	• Utilizing feedback has been suggested towards engaging employees in energy saving behavior at work (Lo et al., 2012; Matthies et al., 2011) • Real-time consumption feedback can help make "invisible energy visible", and act as a reference point for the self-evaluation and adjustment of energy behavior (Boomsma et al., 2016; Burgess & Nye, 2008) • Employees' personal energy-saving norms can be activated by providing information and training [92] • SDT has been suggested towards effectively designing and analyzing gamified experiences (Aparicio et al., 2012; Hamari et al., 2014; Kappen & Nacke, 2014; Sailer et al., 2013) • TPB has been used to explain the behavioral effects of gamification in various contexts (Bittner & Shipper, 2014; Hamari & Koivisto, 2013, 2015) • VBN has been employed, in order to explain gamifications' effects on PEB and energy conservation behavior (Bittner & Shipper, 2014; Kotsopoulos et al., 2016)
	H6	The increase in employees' motivation to conserve energy will in turn lead to positive actual energy consumption behavior change – as expressed through the change in the participating	• Digital technologies facilitate self-monitoring of undesired behaviours by accurately and timely delivering

(continued on next page)

Table 1 (*continued*)

	Description	Supporting Evidence from Existing Literature
	employees' energy-saving intention (H6a), self-reported behaviour (H6b), and habit (H6c)	feedback, thus disrupting existing habits in an effective way [105] • Gamification can be used to encourage behavior change, increase and sustain employee participation and compliance in specific goals, motivation, engagement, performance and productivity within an enterprise, break existing habits, update them with new ones, and lead to behavior change (Blohm & Leimeister, 2013; Pickard, 2015; Robson et al., 2015; Seaborn & Fels, 2015; Webb, 2013)
H7	The increase in employees' energy-saving intention, self-reported behaviour, and habit will lead to actual energy savings (H7), compared to baseline consumption before the intervention	• Up to 15% energy savings [60], and 7.4% on average [13], have been reported from behavioral interventions employing feedback • When provided by an IS and combined with incentivization, feedback has been especially effective in promoting energy conservation behavior [29] • Gamification has been employed towards increasing motivation, knowledge, behavior and attitude towards energy conservation and promoting real-world energy saving behaviors in the range of 3–6%, with more than 10% achievable (Bourazeri & Pitt, 2013; Brewer et al., 2013; Fijnheer et al., 2016; Fijnheer & Van Oostendorp, 2016; Geelen et al., 2012; Grossberg et al., 2015; Knol & De Vries, 2011; Orland et al., 2014; Reeves et al., 2012) • Energy efficiency games, have successfully been deployed in workplace environments (Cool Choices, 2019; Energic, 2019; Grossberg et al., 2015; WeSpire, 2019)

in this intervention, also answered the same questionnaire afterwards. The steps we followed in the present research (our research design) can be outlined in Fig. 3.

We collected 110 complete answers before (Pre-) and 54 after (Post-) the behavioral intervention. Total attrition was therefore 49.1%. To examine the nature of attrition, a more thorough comparison was made between the samples. Overall, as evident in Table 2, we found no significant differences between the two samples, with regards to their socio-demographic characteristics ($\Delta_{min} = 0.4\%$ for gender and $\Delta_{max} = 4.4\%$ for having children), and their organizational profiles ($\Delta_{min} = 1.3\%$ for felt vigor at work and $\Delta_{max} = 7.5\%$ for role in the organisation).

The behavioral intervention was performed in offices equipped with IoT devices (i.e. sensors). The employees interacted with a gamified solution, during a series of two-week energy-saving "campaigns" that took place over a period of one year. Throughout the duration of the intervention period, actual energy use, as well as environmental parameters (interior & exterior temperature, luminosity, humidity), were monitored, recorded, and compared to historical and baseline values, through a specially designed and implemented IoT-enabled platform that was interconnected with the IoT devices. The platform also enabled the deployment of the behavioral intervention, the delivery of the content and the gamified incentives (e.g. points or badges) to the end-users, as well as the monitoring of energy consumption and calculation of savings achieved.

The participants downloaded and "played" with two gamified mobile applications on their smartphones, that provided them with contextually relevant real-time: (a) ***educational content*** –quizzes and tips on how to conserve energy – e.g. *"Before turning your air conditioning on, consider using a fan, or opening the windows instead."*, (b) ***notifications*** of when they could reduce energy use – e.g. *"The*

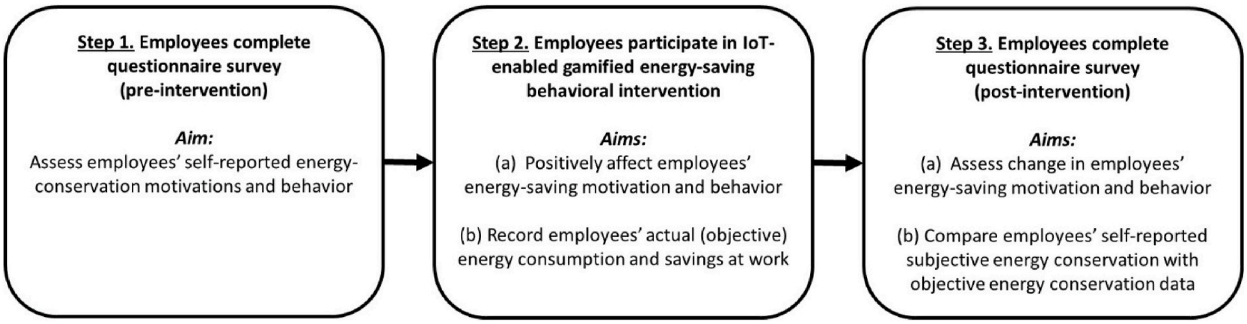

Fig. 3. Research Outline - Research Design Steps and their Aims.

Table 2
Comparison of Sample Characteristics (Pre-vs Post-questionnaire).

Control Variables		Pre-Questionnaire			Post-Questionnaire			Δ (abs.)	
		M	SD	A	M	SD	α	M	%
Vigor		3.79	1.29	.82	3.84	1.27	.77	0.05	1.3
Age		35.36	7.96	–	36.43	9.06	–	1.07	2.9
		N	%		N	%		Δ (N)	Δ (%)
Gender	Male	83	75.5		41	75.9		42	0.4
	Female	27	24.5		13	24.1		14	
Children	Yes	38	34.5		21	38.9		17	4.4
	No	72	65.5		33	61.1		39	
Role	Administrative	18	16.4		8	14.8		10	2.4
	Managerial	11	10.0		4	7.4		7	2.6
	Technical	63	57.3		35	64.8		28	7.5
	Other	18	16.4		7	13.0		11	3.4

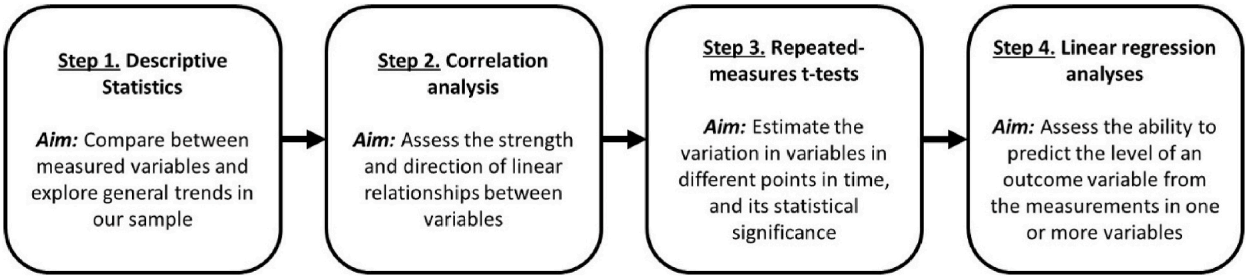

Fig. 4. Outline of statistical analysis process.

temperature in this room is quite high for wintertime. Please adjust the controls to lower the temperature and save energy" and (c) ***information*** on the actual energy consumption at their workplace – through corresponding *graphs, bar and pie charts* accessible to the participants.

Interaction with these two context-aware mobile apps – a mobile AR "treasure-hunt" serious game utilizing Augmented Reality Markers, and a mobile gamified personalized app – was rewarded with points (10 points for each action) and badges (such as the "illuminator badge" for systematically closing lights when prompted), in order to increase user engagement. Moreover, the users received content with specific relevance to them through the apps, triggered by IoT-driven context-aware rules (e.g. "*The temperature in this office is quite high for winter time. Please adjust the controls to lower the temperature and save energy"* to *users_in_room_X*, when *temperature* $> 25^{o}$ *C* and *Heating is ON*").

All statistical analyses on the collected results were performed using IBM SPSS Statistics v.23. We employed descriptive statistics – means and standard deviation (SD) – to perform comparisons between the measured variables and explore the general trend in our sample's characteristics. The reliability and consistency of multi-item scales was assessed by adopting the threshold of Cronbach's alpha >.70 [136]. Correlation analysis (Pearson's r) was employed, to assess the strength and direction of the linear relationship between variables, interpreting values ($r = 0.10$ to 0.29) as small, ($r = 0.30$ to 0.49) medium, and ($r = 0.50$ to 1.0) large [137,138]. Repeated-measures t-tests were conducted to estimate the variation in the measured variables in different points in time, and its statistical significance. Linear regression analyses were performed using the enter method, to assess the ability of the observed measurements in one or more (predictor) variables to predict the level of the measurements in another (outcome) variable. We followed existing prescriptions in the literature with regards to acceptable sample sizes, for linear regression in psychology (i.e., minimum sample size of "$N > 50 + 8$ m" – where m is the number of independent variables – for testing a multiple regression, and "$N > 104 + m$" for testing individual predictors in the regression, assuming a medium-sized relationship [139,140]). The statistical analysis process we followed in our research is outlined in Fig. 4.

Next, we detail the survey instrument, as well as our methodology for identifying the actual energy savings achieved during the gamified intervention.

3.3. Self-assessed energy-conservation motivation and behavior

All the items in the questionnaire were rated on a seven-point Likert scale, and individual scores were summed and averaged, to provide scale scores. All scales featured good internal consistency (α = .77–0.97) in both study samples. More information on the different constructs we employed can be found in Table 3.

Table 3
Self-Assessed Energy-Conservation Motivation and Behavior – Scales Employed in this study.

Scale *(Energy-Saving at work ….)*		Items	Sample item	Source
Behavioral Outcome Variables	Intention	1	"I intend to, always or in most instances, consume energy at my workplace responsibly and conserve as much as possible during the next 6 months."	Adapted from [147]
	Self-Reported Behavior	7	"When I leave a room that is unoccupied, I turn off the lights"	Based on [21]
	Habit	4	"Conserving energy at my workplace is …" "Something I do without thinking"	Self-Reported Behavioral Automaticity index (SRBAI) [149]
Self-Determination	Intrinsic Motivation	4	"I save energy at work because …" "Conserving energy at work is a sensible thing to do." (e.g. Identified Regulation)	Adapted from "Motivation Towards the Environment Scale" (MTES) [77]
	Integrated Regulation	4		
	Identified Regulation	4		
	Introjected Regulation	4		
	External Regulation	4		
	Amotivation	4		
Planned Behavior	Subjective Norms	1	"Co-workers who are important to me expect me to conserve energy at work"	Adapted from [147]
	Attitude	4	"Energy conservation at work is too much of a hassle"	Adapted from [150]
	Perceived Personal Impact	3	"My personal impact on energy consumption at my workplace is large"	Adapted from "Sense of personal impact" [151]
	Perceived Collective Impact	1	"By changing our behavior, employees like me can reduce energy use in our workplace"	Adapted from "Collective energy-conservation outcome expectancy" [152]
Personal Norms	Personal Norms	7	"I feel personally obliged to save as much energy as possible at work"	Adapted from [90,150]
Personal Parameters	Age	1	"What is your age?"	–
	Gender	1	"What is your gender?"	–
	Children	1	"Do you have children?"	–
	Vigor	3	"At my job, I feel strong and vigorous"	Subscale of the UWES-9 [93] work engagement survey

3.4. *Actual energy savings achieved*

Since energy "savings" cannot be measured directly (they actually come as a result of the absence of energy consumption), they are instead estimated by performing a comparison between measured consumption before and after an intervention, making suitable adjustments for changes in conditions, using the general equation: "Savings = (Baseline Period Energy – Reporting Period Energy) ± Adjustments" [141].

In our context, energy baseline was used as a tool that allowed the comparison of energy performance before and during the gamified energy-saving intervention. The baseline energy consumption model we utilized was based on the characteristics of each building, as represented in their Building Performance Certificates (all public buildings in the EU are required, under directive 2010/31/EU, to have BPCs). It enabled the platform to predict the expected energy use and calculate energy savings (or wastage) in real time. Additional factors that may affect energy consumption, such as weather conditions, were also considered.

4. Results

4.1. *Pre-intervention survey*

We conducted a series of multiple regression analyses to corroborate our hypotheses. A brief presentation of the obtained statistical

Table 4
Correlations between personal factors affecting energy-saving at work and energy behavior outcome variables.

	Variable at Work	Self-Reported Behavior	Habit	Behavioral Intention
Energy Saving	Habit	**.652****		
	Behavioral Intention	**.494****	**.518****	
Personal Factor	Vigor	**.500****	**.303****	**.319****
	Age	.144	.097	**.268****
	Gender	−.038	−.010	.186
	Children	**.229***	.165	**.214***

N = 110, *p < .05, **p < .01.

results is included in Table 7 in Appendix I. Our findings are described in more detail, on a per-behavioral category basis, in the following paragraphs.

Self-Determination: A series of three separate multiple regression analyses were performed, to assess the ability of employees' self-determination to predict their level of energy-related behavioral outcomes at work (H1a,b,c). We found that the six types of motivation in the self-determination continuum explained (i) 54.9% of the variance in their behavioral intention to conserve energy (identified regulation and external regulation significantly), (ii) 59.9% of the variance in employees' self-reported energy-saving behavior (identified regulation and intrinsic motivation significantly), and (iii) 58.5% of the variance in employees' strength of energy-saving habit (identified regulation, and integrated regulation significantly) at work.

Planned Behavior: A multiple regression analysis was performed, to assess the ability of the predecessors of behavioral intention in the planned behavior model to predict the level of employees' behavioral intention to conserve energy at work (H2a). Two additional analyses were performed, to assess the ability of behavioral intention to predict the variance in the employees' energy-saving habit (H2b) and self-reported behavior (H2c) at work. We found that the planned behavior model explained: (i) 49.5% of the variance in employees' behavioral intention to conserve energy (subjective norms, attitude, and perceived collective impact on energy saving at work significantly), (ii) 24.4% of the variance in employees' self-reported energy-saving behavior (behavioral intention significantly), and (iii) 26.9%, of the variance in employees' self-reported energy-saving behavior (behavioral intention significantly), at work.

Personal Norms: A series of three separate regression analyses were performed, to assess the ability of employee's personal norms towards energy-saving at work to predict their level of energy-related behavioral outcomes at work (H3a,b,c). We found that: (i) 49.4% of the variance in employees' behavioral intention to conserve energy, (ii) 40.4% of the variance in employees' self-reported behavior, and (iii) 46.8% of the variance in employees' energy-saving habit, was explained by the levels of their personal norms towards energy-saving at work.

Personal Parameters Affecting Energy Conservation at Work: A series of three separate regression analyses were performed, to assess the ability of employee's vigor, age, gender, and having children, to predict their level of energy-related behavioral outcomes at work (H4a,b,c). We found that the model explained: (i) 18.6% of the variance in employees' behavioral intention to conserve energy (vigor and gender significantly), (ii) 24.5% of the variance in employees' self-reported behavior (vigor significantly), and (iii) 7.2% of the variance in employees' energy-saving habit (vigor significantly), at work. As the forementioned personal factors did not belong to a theoretically unified model, a correlation analysis was also performed, to assess the ability of each of the individual forementioned personal factors, to predict employee's level of: (i) behavioral intention to conserve energy, (ii) self-reported energy-saving behavior at work, and (iii) energy-saving habit at work. A summary of the obtained results is included in Table 4.

We found that vigor was correlated with all three behavioral outcome variables – most highly with self-reported energy-saving at work, less with behavioral intention to conserve energy, and least with energy-saving habit at work. Furthermore, the participants' age was mildly correlated with behavioral intention. An even weaker relationship was recorded between having children and behavioral intention, as well as self-reported energy saving behavior. Finally, we also found that the three self-reported behavioral outcome variables were significantly intercorrelated.

4.2. Behavioral intervention

Paired samples t-tests were performed (between the collected responses in the pre- and post-intervention surveys), to estimate the impact of the behavioral intervention on: (i) employees' motivation to save energy ***(H5)***, focusing on the three different theoretical models employed – Self-Determination (H5a), Planned Behavior (H5b), Personal Norms (H5c) – and (ii) self-reported organizational energy-saving behavior change ***(H6)***, focusing on the three self-reported behavior change indicators we employ in this research – energy-saving intention (H6a), self-reported energy-saving (H6b), and energy-saving habit (H6c). Moreover, an assessment of the actual energy savings achieved was made ***(H7)***, by comparing the actual recorded energy consumption during the intervention, to baseline values. Descriptive statistics, as well as results from the t-tests are presented in Table 8 in Appendix I. Reviewing these results, we find that:

- With regards to the change recorded on the behavioral outcome variables, although there was a statistically significant increase in the participants' intention to conserve energy at work from pre-pilots to post-pilots, with a moderate effect size ($\eta^2 = 0.13$), as well as in their sense of energy-saving habit at work, with a large effect size ($\eta^2 = 0.26$), the positive average change recorded during the experiment in their self-reported energy-saving behavior was not statistically significant. Hence, the behavioral intervention seems to have had the largest positive effect on employees' energy-saving habit.
- The intervention also had a positive effect on the participants' behavior. A positive average change was recorded during the experiment in all the different types of self-determination (we note that, since amotivation signifies a lack of motivation, the negative average change observed in this variable was indeed an indication of positive behavior change). However, although this change was statistically significant and with a large effect size for intrinsic motivation ($\eta^2 = 0.37$), integrated ($\eta^2 = 0.36$), identified ($\eta^2 = 0.15$), and introjected regulation ($\eta^2 = 0.19$), it was non-significant for external regulation and amotivation. At the same time, with regards to the planned behavior model, although there was a positive average change in subjective energy-saving norms, attitude, personal and collective impact at work, it was not statistically significant. Finally, there was a positive average change recorded on employees' personal norms regarding energy-saving at work with a moderate effect size ($\eta^2 = 0.09$).
- A total of 6413 kWh of energy were conserved during the intervention, which corresponds to 12.99% compared to baseline energy consumption before the intervention. By cross-referencing with the three energy-behavior outcome variables, we find that the % energy saved (12.99%) is more comparable to the average change in energy saving habit (13.50%), followed by the increase in

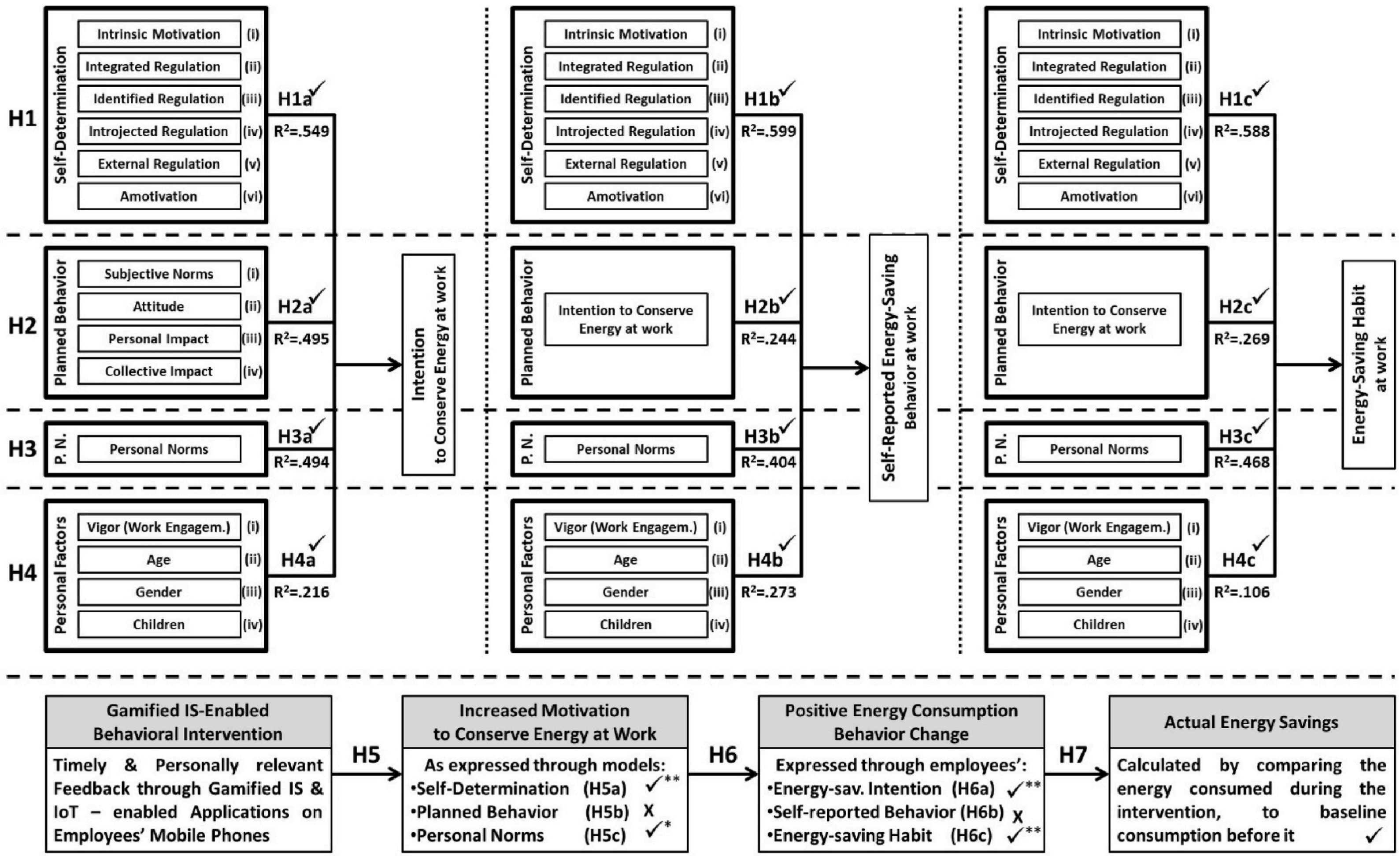

Fig. 5. Summary of main research findings.

intention to conserve energy at work (11.35%), and least of all with the (statistically non-significant) average change in participants' self-reported behavior (4.66%).

5. Discussion

Our research findings satisfy our original interest in theory-driven factors that may affect employee energy consumption behavior and, thus, could be considered when we want to design effective IS-enabled energy feedback interventions in the workplace. Considering our research questions, the contribution of our research results is two-fold. First, we provide insights into employees' individual behavioral, social, and organizational drivers (especially motivation) that affect their energy-saving behavior. Secondly, we realize how gamified IoT-enabled real-time feedback systems/interventions can affect the employees' motivation to conserve energy and drive actual energy-savings.

We advance the related literature that has called for more research in employees' energy-saving behavior at an individual behavior level of analysis, and in inter-organisational contexts [9,19,21–26]; and has highlighted that the application of ICT, IoT, real-time data & tailored persuasion techniques, results in increasing employees' motivation for and actual energy consumption behavior at work [30–33]. Our main difference from the current literature is that our research combines the two highlighted research interests, as we wanted to understand the behavioral and motivational profile of employees' energy consumption and conservation behavior in order to acquire a deeper, broader view of the effect of gamified IS feedback interventions on the employees' motivation and actual energy saving actions. The acquired theory-driven knowledge of what drives employees' energy usage behavior can – as indicated through our practical application results – be put in practice and result in gamified IS interventions that have higher motivational capacity and can change employees energy behavior.

5.1. Main research takeaways

Reviewing our results, the hypotheses we formulated regarding the theory-driven factors (self-determination, planned behavior, and personal norms) that drive energy-saving at work were verified. We also discovered that employees' vigor (a constituent of engagement) at work is a personal parameter that may significantly directly affect energy-saving behavior at work. Through the results of the IS behavioral intervention, we found that self-determination may provide a better fit for understanding employees' motivation for energy conservation at work when they interact with interventions aiming to effect positive energy behavior change at the workplace. We also realized that focusing on two additional behavioral factors, namely personal energy-saving norms and vigor, can also significantly help towards that direction. At the same time, self-reported energy-saving behavior was found to be a less significant indicator of energy behavior change, compared to both energy-saving intention and habit. Furthermore, the behavioral intervention with real-time energy consumption monitoring capabilities seems to also have had the largest effect on the participants' self-reported energy-saving habit confirming that digital interventions that allow self-monitoring can disrupt habits in an effective manner [105]. Moreover, the improvement in the participating employees' energy-saving habits more closely reflects the actual energy savings achieved during the intervention, followed by behavioral intention, and least of all self-reported energy-saving behavior. Our main findings in connection to our stated hypotheses can be summarized in Fig. 5.

Further to the above, we also discovered significant inter-correlations between the three self-reported energy-saving indicators (intention, habit, self-reported energy-saving behavior). The inter-correlated relationship of this "trifecta" of self-reported energy-saving behavior indicators at work is graphically depicted in Fig. 6. Exploring this relationship, several deductions can be made accordingly. For example, that employees with a strong intention to conserve energy at work seem to also have acquired the habit to do

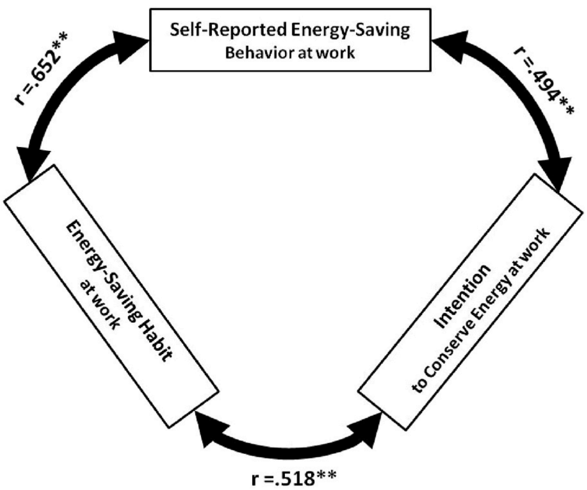

Fig. 6. Correlations between the "trifecta" of self-reported energy conservation at work behavior indicators.

Table 5
Validation of hypotheses – supporting evidence from the present research.

Model	ID		Description	Validation Based on Findings in this study
Self-Determination	H1		The level of employees' motivation for energy-saving at work, as expressed through the SDT theory continuum, will affect the strength of their:	
		H1a	behavioral intention towards conserving energy	54.9% of the variance in employees' behavioral intention to conserve energy at work was predicted by the levels of identified regulation and external regulation.
		H1b	self-reported energy-saving behavior	59.9% of the variance in employees' self-reported energy-saving behavior at work was predicted by the levels of identified regulation and intrinsic motivation.
		H1c	energy-saving habit	58.5% of the variance in employees' strength of energy-saving habit at work was predicted by identified regulation, and integrated regulation.
Planned Behavior	**H2**		**The level of employees':**	
		H2a	subjective norms, attitude, felt personal impact, and felt collective impact, with regards to energy-saving at work, will positively affect the strength of their behavioral intention towards conserving energy at work	49.5% of the variance in employees' behavioral intention to conserve energy at work was predicted by the levels of subjective norms, attitude, and perceived collective impact on energy saving at work.
		H2b	intention towards energy-saving will positively affect their self-reported energy-saving behaviour at work	24.4% of the variance in employees' self-reported energy-saving behavior at work was predicted by the levels of behavioral intention.
		H2c	intention towards energy-saving will positively affect the strength of their energy-saving habit at work	26.9%, of the variance in employees' self-reported energy-saving behavior was predicted by the levels of behavioral intention.
Personal Norms	**H3**		**The level of strength of employees' personal norms (VBN theory) towards conserving energy at work, will positively affect the strength of their:**	
		H3a	behavioral intention towards conserving energy	49.4% of the variance in employees' behavioral intention to conserve energy was explained by the levels of their personal norms towards energy-saving at work.
		H3b	self-reported energy-saving behavior	40.4% of the variance in employees' self-reported behavior was explained by the levels of their personal norms towards energy-saving at work.
		H3c	energy-saving habit	46.8% of the variance in employees' energy-saving habit was explained by the levels of their personal norms towards energy-saving at work.
Personal Factors	**H4**		**Employees' personal profile, as expressed through vigor (work engagement), age, female gender, and having children, will positively affect their:**	
		H4a	behavioral intention towards conserving energy	18.6% of the variance in employees' behavioral intention to conserve energy was predicted by the levels of their vigor at work and their gender.
		H4b	self-reported energy-saving behavior	24.5% of the variance in employees' self-reported behaviour was predicted by the levels of their vigor at work.
		H4c	energy-saving habit	7.2% of the variance in employees' energy-saving habit, was explained by the levels of their vigor at work.
Behavioral Intervention	**H5**		**Timely & personally relevant feedback distributed by an IoT-enabled, gamified IS solution will lead to: an increase in employees' motivation to conserve energy at work – as expressed through:**	
		H5a	Self-Determination	Positive statistically significant change, with large effect size in intrinsic motivation (η2 = .37), integrated (η2 = .36), identified (η2 = .15), and introjected regulation (η2 = .19).
		H5b	Planned Behavior	Although there was a positive average change recorded in subjective energy-saving norms, attitude, personal and collective impact at work, it was not statistically significant
		H5c	Personal Norms	There was a positive average change recorded in the participants' personal norms regarding energy-saving at work with a moderate effect size ($\eta^2 = .09$)
	H6		**The increase in employees' motivation to conserve energy will in turn lead to positive actual energy consumption behavior change – as expressed through the change in the participating employees':**	
		H6a	Behavioral Intention towards conserving energy	There was a statistically significant increase in the participants' intention to conserve energy at work during the intervrention, with a moderate effect size ($\eta^2 = .13$).
		H6b	Self-Reported energy-saving Behavior	The positive average change recorded during the experiment in their self-reported energy-saving behavior was not statistically significant.
		H6c	energy-saving Habit	There was a statistically significant increase in the participants' sense of energy-saving habit at work during the intervention, with a large effect size ($\eta^2 = .26$).
	H7		The increase in employees' energy-saving intention, self-reported behaviour, and habit will lead to actual energy savings (H7), compared to baseline consumption before the intervention	A total of 6413 kWh of energy were conserved during the intervention, which corresponds to 12.99%, compared to baseline energy consumption before the intervention

(*continued on next page*)

Table 5 (*continued*)

Model	ID	Description	Validation Based on Findings in this study
Additional Findings	The employees' self-reported energy-saving behaviour, habit and intention were significantly and strongly inter-correlated (r = .494** – .652**). The three self-reported behavioral outcome variables were significantly intercorrelated, indicating that, for example, employees with a strong intention to conserve energy at work seem to also (r = .518**) have acquired the habit to do so, that tends to result in them also (r = .652**) reporting o n – and hence knowingly – exhibiting energy-saving behavior at work. The % energy saved (12.99%) is more comparable to the participants' average perceived change in energy saving habit (13.50%), followed by their increase in intention to conserve energy at work (11.35%), and the average change in self-reported behavior (4.66%) during the behavioral intervention.		

so, which tends to result in them also reporting on – and hence knowingly exhibiting – energy-saving behavior at work. Considering this triad of self-reported energy saving along with our finding that the digital self-monitoring intervention had the higher effect on the employees' perceived energy saving habits, we are more persuaded that digital interventions can be an effective means towards energy behaviour change, especially for employees with strong intention.

A summary of our research hypotheses, along with existing supporting evidence revealed during the present research, as well as extant from the literature, with regards to the forementioned findings and takeaways, are presented in Table 5.

Elaborating on the evidence revealed throughout this research in the process of investigating our hypotheses, the main findings and takeaways are:

- **Finding #1:** *«Employees' self-determination to conserve energy significantly explains their energy-saving behavior at work»*
- **Finding #2:** *«Employees' energy-saving at work can be explained as a planned behavior»*, but *« The energy behavior change attained through a gamified IS intervention cannot be explained by the planned behavior model»*
- **Finding #3:** *«Employees' levels of personal energy-saving norms significantly explain their energy-saving behavior at work»*
- **Finding #4:** *«Employees' personal and organizational profile significantly affects their energy-saving behavior at work»*
- **Finding #5:** *«The provision of feedback to employees, via an IoT-enabled gamified IS, is an effective strategy for effecting actual energy conservation at work»*
- **Finding #6:** *«Behavioral interventions at work aimed at energy conservation, should primarily focus on monitoring and positively affecting employees' energy-saving habits and intention»*

Supporting evidence revealed during the present research, as well as extant from the literature, with regards to the forementioned findings and takeaways, is presented in Table 6.

5.2. Suggestions for organizations towards increasing their CEP

Considering that CEP (corporate environmental performance) is beneficial for both the environment, as well as firms' economic performance [6] and competitive advantage [7], and that the environmental orientation and actions of a firm relate with individual-level employee environmental behavior within the firm [142], our research findings lead us to produce specific suggestions and actions for organizations that intend to encourage employees to save energy in their workplace and support the firms in attaining their CEP goals:

- Organizations that aim to decrease their energy footprint, should focus on increasing their employees' self-determination to conserve energy and embedding and amplifying their energy-saving personal norms at work, that will in turn amplify their energy-saving habits and intention.
- Satisfying employees' basic psychological needs for autonomy, competence, and relatedness, and activating their personal energy-saving norms (by taking measures to raise their awareness of the negative consequences of not taking actions to conserve energy for the environment, and by amplifying their beliefs that by abiding to energy-saving actions they can reduce their negative impact on the environment) in the context of taking actions to conserve energy at work, as well as educating and encouraging them towards specific energy-saving behaviors at work are powerful means towards that end.
- Utilizing gamified IoT-enabled IS that keep their energy-saving "in shape" can help towards achieving the above with increased participation, engagement, and effectiveness.
- By monitoring their employees' energy-saving habits, intention, and self-reported behavior, organizations can also estimate the actual energy they conserve at work. Habits are the strongest indicator, intention second best, and self-reported behavior the least indicative of actual energy savings achieved. Therefore, while the higher the employees' reported score in these indicators, the more energy conscious their behavior at work, at the same time the less they score in these three indicators, the more the savings that can be achieved through a behavioral intervention.
- Since the energy-saving behavior of those employees that are not internally motivated to conserve energy may also not be possible to significantly improve by applying pro-environmental behavioral change interventions at work, to further boost their potential for energy-savings, organizations can also incorporate appropriate HR selection strategies. They can hence ensure that they recruit energy-conscious personnel (with strong energy-saving norms/internal rules of conduct for energy-saving at work, and self-determination to conserve energy/an internally regulated energy-saving motivation), when hiring.

Table 6
Research Findings and Takeaways - Supporting Evidence from this research, as well as existing literature.

	Supporting Evidence from this Research	Existing Evidence from the Literature
Finding #1	***«Employees' self-determination to conserve energy significantly explains their energy-saving behavior at work»***	
	• Identified regulation was the most influential motivational force behind employees' energy-conservation	• Identified regulation has been found to be a significant predictor of self-reported energy-saving behaviors at home [71]
	• Intrinsic motivation had a direct effect on employees' self-reported energy-saving behavior	• Being intrinsically motivated to protect the environment is related to acting in an environmentally responsible manner [153]
	• The behavioral change effected through the intervention was positive across the self-determination continuum, and statistically significant for all the types of motivation, except the most controlled (external regulation), and amotivation	• Building and supporting self-determination for energy-saving is important towards achieving it [71]
Finding #2	***«Employees' energy-saving at work can be explained as a planned behavior», but « The energy behavior change attained through a gamified IS intervention cannot be explained by the planned behavior model»***	
	• Intention explained a significant proportion of self-reported energy-saving behavior and habit	• Intention has been found to significantly explain pro-environmental [81], and energy-saving [80] behavior
	• The increase in intention to conserve energy at work was strongly related with the change in self-reported behavior, and energy-saving habit in the intervention	• Intention has been found to adequately explain the variance in PEB [81], and energy-saving behavior change [80]
	• Subjective norms, attitude, and perceived collective impact explained 49.5% of the variance in employees' behavioral intention to conserve energy at work	• TPB constructs have explained between 46% and 61% of the variance in employees' intentions to engage in PEB in the past [154]
	• We found a significant effect of attitude, and sense of collective impact, on employee's intention to conserve energy at work	• Attitude and perceived behavioral control significantly contributed in predicting energy-saving intentions at home [80, 81, 155]
	• In contrast to existing literature, the most significant predecessor of employees' intention to conserve energy at work was their level of subjective norms – The contribution of employees' sense of personal impact on energy-saving at work was shadowed by collective impact	• Subjective norm was not found to have a significant influence on energy-saving intention at home [80] – This contradiction may be attributable to the workplace context that increases the weight of subjective norms (and peer-pressure) on employees' energy-saving intention [17], and collective actions are often considered the most impactful on energy conservation at work [156], and energy is often consumed through collectively controlled devices [157]
	• The positive average change recorded in subjective energy-saving norms, attitude, personal and collective impact at work, was not statistically significant during the intervention	• In a feedback intervention for energy conservation at a university, although actual energy savings were recorded, attitudes, subjective norms, and perceived behavioral control were statistically insignificantly affected [22]
Finding #3	***«Employees' levels of personal energy-saving norms significantly explain their energy-saving behavior at work»***	
	• The level of employees' energy-saving personal norms significantly explains their energy-saving intention, self-reported behavior, and habit	• Personal norms have been found to be a predictor of energy-saving intention and behavior in the past, both at home [88–90] and at work [91,92]
	• A positive and statistically significant average change was also recorded in the participants' personal norms for conserving energy at work during the behavioral intervention	–
Finding #4	***«Employees' personal and organizational profile significantly affects their energy-saving behavior at work»***	
	• Vigor overall seems to affect all the energy-saving behavioral indicators we employed	• Vigor is characterized by the willingness of a person to invest effort in their work [93] • Vigor has been correlated with increased organizational citizenship behaviors (OCBs) and decreased deviance [94]
	• Employees' intention to conserve energy at work tends to increase with age	• Engagement towards pro-environmental behavior tends to increase with age [95]
	• Employees with children tended to also record higher levels of intention to conserve energy, as well as self-reported energy saving behavior at work	• Higher levels of motivation to conserve energy have been reported for residential users with children [100]
Finding #5	***«The provision of feedback to employees, via an IoT-enabled gamified IS, is an effective strategy for effecting actual energy conservation at work»***	
	• Introducing gamification can intrinsically motivate the end-users to engage on energy conservation • The behavioral intervention yielded both self-reported, as well as actual energy saving results (6412.45 kWh saved, translatable to 12.99% conservation)	• Satisfaction with a participatory intervention "triggers a positive affect towards energy-savings, and helps participants to internalize energy-saving motivation" [33]. • Game design elements have been proven useful in satisfying users' autonomy, competence and relatedness [158] – the predecessors of all types of motivation in the self-determination continuum

(*continued on next page*)

Table 6 (*continued*)

	Supporting Evidence from this Research	Existing Evidence from the Literature
Finding #6	***«Behavioral interventions at work aimed at energy conservation, should primarily focus on monitoring and positively affecting employees' energy-saving habits and intention»***	
	• The effect of the gamified IS intervention on was stronger and statistically more significant in terms of employees' energy-saving habit, and intention to continue saving energy at work in the future	• Intention was found to be the strongest direct predictor of pro-environmental printing behavior (using the printers less), and habit the strongest direct predictor of switching off lights and monitors (when not in use), in an experiment in office buildings [159]
	• Although there was a positive average change recorded in the participants' self-reported energy-saving behavior during the intervention, it was not statistically significant, and disproportionate to the actual energy savings achieved (explaining a mere 36%)	• Self-reported behavior has been criticized as a relatively weak indicator of objective pro-environmental behavior in the literature, leaving 79% of the variance unexplained [61].
	• Energy-saving habit emerged as the most salient proxy of actual energy-savings at work, followed by intention to conserve energy	• Habits should be included in organizational PEB models, as they play an important role for their enactment [11] • Energy-saving behaviors at work are not necessarily motivated by employees' pro-environmental intentions, but may instead come as a result of, among others, routine or habit [63]

5.3. Suggestions for designers of workplace energy-saving behavioral interventions

If we put on one's designer hat, our research outcomes can be transformed to the following suggestions on designing effective interventions that can foster energy saving behavior in workplaces:

- Employees' self-determination is found to most significantly explain the drivers behind their energy-saving at work. Identified regulation was the most influential motivational force behind employees' energy-conservation. Therefore, behavioral interventions that aim to nurture employees' energy conservation, should foremost focus on cultivating and strengthening the sense of personal importance that they vest on it.
- Our findings also suggest that behavioral interventions may also benefit to an extent by focusing on strengthening employees' motivation across the self-determination continuum, except for the most controlled form (external regulation), and amotivation.
- Focusing on increasing employees' subjective norms for energy saving at work (beliefs that others expect them to conserve energy at work) would also be a potentially impactful strategy towards increasing their intention to conserve energy at work which, in turn, is expected to lead to an increase in both self-reported energy-saving behavior and energy-saving habits. Moreover, emphasizing the collective (and not the personal) impact that employees' actions can have on energy consumption at work can be more effective. So, an intervention could also include services that require collective actions e.g. a gamified intervention with challenges that require team playing.
- In addition, we also found that, focusing on establishing, and activating employees' personal norms for energy saving at work in behavioral interventions could be a potentially impactful strategy towards increasing their intention, self-reported energy-saving behavior, and energy-saving habits.
- Further, as vigor overall seems to affect all the behavioral indicators, we deduce that organizations that emphasize on employees' work engagement, can concurrently succeed in conserving energy, through their employees' positive energy behavior change.
- Moreover, as employees with children seemed to be more positive towards energy-saving at work and this inclination tended to increase with age, it may be beneficial to consider older employees with children as candidates for communicating, or even leading, energy-behavior change interventions at work. We also found that the adoption of IoT-enabled, gamified IS that provide tailored feedback to employees is an effective strategy for increasing motivation for, and achieving actual, energy conservation at work. Moreover, energy-saving habit is a significant factor to measure and potentially target, together with energy-saving intention, towards making future energy-saving interventions at work more successful. Therefore, future researchers and practitioners designing behavioral interventions should focus on addressing both habitual, as well as intentional behavior. We note that "successful habit change interventions involve disrupting the environmental factors that automatically cue habit performance", and replacing them with new ones [62].
- Finally, as already suggested in the literature, our findings confirm that habitual energy-consumption behavior at work is better addressed by systematically reminding employees to consciously reflect upon the behaviors that they automatically perform (e.g. switching off lights, or computers), as well as offering primes and providing cues to do so [92]. Thus, designers should integrate real-time monitoring and the provision of feedback when developing interventions towards energy behavior change.

6. Conclusion

Overall, in the present research we studied employee energy consumption and conservation behaviour. Accordingly, we focused on a variety of motivational, social and work-related factors that, as acknowledged in existing theory, may affect it at an individual behavior level. Then, we explored in practice how an IoT-enabled gamified feedback intervention can affect the employees' motivation to conserve energy at work and lead to actual energy savings. Essentially, the insight gained about the employees' behavioral and motivational drivers support a deeper understanding of the motivational and energy behavior change capacity of a gamified intervention, and therefore can guide the design of the 'right' intervention in future similar endeavors.

We conducted a survey with employees in three workplaces across different EU countries, to explore their self-perceptions on their energy conservation behavior and the effect of the factors under study on it. Then, during a series of energy-saving 'campaigns' that took place over one year, the employees interacted with a real IoT-enabled gamified IS that prompted them to conserve energy during their daily work routine. Their actual energy savings were collected before participating to the survey once more. This allowed us to compare their actual with their perceived/self-assessed behaviour change.

In sum, our findings suggest that employees' level of self-determination to conserve energy, energy-saving personal norms, and personal and organizational profile, significantly explain both their actual energy-saving behavior at work and the energy behavior change that comes as the result of a gamified IS intervention. Moreover, the provision of feedback to employees, via an Internet-Of-Things (IoT)-enabled gamified IS, is an effective strategy for effecting actual energy conservation at work. Furthermore, according to our findings, behavioral interventions aimed at energy conservation at work, should primarily focus on monitoring (to decide whether a behavioral intervention would be worth organizing) and ultimately positively affecting employees' energy-saving habits and intention. The following two subsections describe some of the theoretical, as well as practical implications of our research in more detail.

To the best of our knowledge, this is the first study concurrently exploring employees' energy-saving as an act of self-determination, activation of personal norms, and as a planned behavior, especially also involving a practical behavioral intervention. Although recent studies have in some cases included extended models of TPB that have included personal norms or self-determination in the context of PEB (e.g. Refs. [15,37–41]), to our knowledge there is a lack of a study that assesses these three theories together towards explaining energy conservation, and especially in the context of the workplace. At the same time, energy-saving has been studied in models combining self-determination and planned behavior in the past, in various contexts [143–146] and in the context of PEB [39], and personal norms have also been studied alongside planned behavior in the past, in order to more accurately explain pro-environmental [38,41] and energy-related decisions and behaviors [15,39,40,56,147], and energy-saving at work in specific [148]. However, the present study considers and examines all three perspectives in parallel, with regards to their fitness to explain users' motivation to conserve energy.

In other words, we have adopted a more holistic approach building a research model incorporating all three behavioural viewpoints. Moreover, the motivation behind this study was not just theoretical; we aimed to realize more about the employees behavioral and motivational drivers for understanding the effect of gamified feedback interventions with IoT-enabled behavior monitoring ability on employees' motivation and energy usage behavior. The more we understand about the behavioral and motivational profile of employees/users, the higher the potential to design gamified feedback interventions with improved motivational capabilities that will improve employees' energy consumption behavior.

More importantly, we contribute to existing research by combining two research fields: the behavioral science and the IS. Indeed, we investigate the effect on employees' energy consumption behavior, when they receive real-time IoT-enabled feedback through a gamified IS, in connection to all three perspectives. Existing research has investigated the users' self-determination, personal norms, and planned behavior separately to assess the impact of gamified interventions on their motivation and behavior in various contexts [126–134]. We investigated the gamified interventions' motivational capacity and potential to cause energy behaviour change, in order to be able to design better, more effective interventions that will keep the employees engaged and improve their energy consumption behavior.

Further, we highlight that this research exemplifies how we can increase the validity of research findings and overcome the criticism of self-reported energy usage [58] by combining survey data reflecting perceptions (e.g. the users' self-assessment of energy consumed) with objective data (in our case energy consumption data recorded via an IoT infrastructure in the offices), in order to produce more reliable findings. Last, our research approach, also constitutes a structured procedure for assessing and measuring theory-driven behavioral factors that explain employees' energy consumption behavior in the workplace. Moreover, as already detailed in the discussion, apart from its theoretical contribution, we believe that our research also carries useful, practical insights concerning (a) the design of effective behavioral interventions, and (b) suggestions to organizations that want to improve their CEP, by leveraging the acquired insight from this research to positively affect their employees' energy consumption and energy-saving behaviour.

As with all research, apart from its merits, our study results also bear their limitations. Firstly, the statistical analyses performed, and results attained, are bound by sample size limitations. A higher number of participants would have provided higher confidence in the results obtained. Moreover, we assessed energy consumption (and savings) on a collective manner and not individually (per person). This kind of energy consumption disaggregation was unfortunately not technically possible. Hence, further research with larger samples, involving a larger number of participants across different work environments is suggested, so that our findings are further corroborated, fortified, and enriched. Experimental designs that include energy disaggregation in the personal-individual and appliance-based level of analysis could additionally allow for more rich comparisons between self-reported behavioral indicators and actual energy-savings actions. Such data could fortify, prove and/or disprove existing theoretical findings, with regards to the effect of behavioral parameters, as well the application of IS & gamification on actual energy-saving by employees at work.

Production notes

Author contribution statement

Dimosthenis Kotsopoulos: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Cleopatra Bardaki: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Katerina Pramatari: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data.

Data availability statement

The data that has been used is confidential.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix I. Statistical Analyses Results (Regression & Paired-sample T-tests)

Table 7
Summary of Regression Analyses

Self-Determination									
Variable (Energy Sav.)	Behavioral Intention			Self-Report. Behavior			Habit		
	B	SE B	β	B	SE B	β	B	SE B	β
Intrinsic motivation	.030	.113	.030	.237	.083	**.298****	.036	.100	.038
Integrated regulation	.007	.103	.007	−.057	.076	−.075	.279	.091	**.311****
Identified regulation	.905	.120	**.727****	.642	.088	**.661****	.450	.106	**.389****
Introjected regulat.	−.079	.108	−.076	−.096	.080	−.118	.127	.096	.131
External regulation	.216	.084	**.217***	−.015	.062	−.019	−.020	.074	−.021
Amotivation	−.033	.074	−.035	−.034	.054	−.046	−.074	.065	−.085
R^2		.549			.599			.588	
Adj. R^2		.522			.576			.564	
Intercept		−0.271			1.695			1.062	
F		20.86**			25.67**			24.51**	

Planned Behavior										
Variable (En. Saving)	Behavioral Intention			Variable (En. Saving)	Self-Reported Behavior			Habit		
	B	SE B	β		B	SE B	β	B	SE B	β
Subj. Norms	.498	.075	**.509****	**Behavioral Intention**	.385	.065	**.494****	.481	.076	**.518****
Attitude	.294	.079	**.291****							
Pers. Impact	.115	.105	.093							
Coll. Impact	.243	.092	**.219****							
R^2			.495	**R^2**			.244			.269
Adj. R^2			.476	**Adj. R^2**			.237			.262
Intercept		−0.157		**Intercept**		3.593			2.770	
F		25.72**		**F**		34.93**			39.68**	

Personal Norms									
Variable (Energy Sav.)	Behavioral Intention			Self-Reported Behavior			Habit		
	B	SE B	β	B	SE B	β	B	SE B	β
Personal Norms	.875	.085	**.703****	.617	.072	**.636****	.790	.081	**.684****
R^2		.494			.404			.468	
Adj. R^2		.489			.399			.463	
Intercept		.817			2.551			1.372	

(*continued on next page*)

Table 7 (*continued*)

Personal Norms									
Variable (Energy Sav.)	Behavioral Intention			Self-Reported Behavior			Habit		
	B	SE B	β	B	SE B	β	B	SE B	β
F		105.27**			73.29**			95.10**	

Personal Factors									
Energy Saving …	Behavioral Intention			Self-Reported Behavior			Habit		
Personal Factor	B	SE B	β	B	SE B	β	B	SE B	β
Vigor (Engagement)	.384	.101	**.343****	.425	.076	**.488****	.304	.100	**.293****
Age	.034	.018	.189	.005	.014	.038	.003	.018	.016
Gender (M/F)	.801	.295	**.242****	.163	.221	.063	.158	.292	.052
Children (Y/N)	−.154	.306	−.051	−.262	.230	−.112	−.272	.303	−.098
R^2		.216			.273			.106	
Adj. R^2		.186			.245			.072	
Intercept		2.453			4.131			4.362	
F		7.24**			9.84**			3.11*	

N = 110, *p < .05, **p < .01.

Table 8
Impact of the behavioral intervention on employees' energy-saving behavior (N = 54)

		Pre-		Post-		Δ %	t (54)	P	95% CI		η^2
Variable (Energy Saving)		M	SD	M	SD				LL	UL	
Behavioral Outcomes	Self-Reported Behavior	5.58	1.06	5.84	.99	4.66	1.82	.075	−0.027	0.545	.059
	Behavioral Intention	5.11	1.24	5.69	1.29	11.35	2.79	**.007****	0.161	0.987	.128
	Habit	5.11	1.21	5.80	1.06	13.50	4.36	**<.001****	0.375	1.014	.264
Self-Determination	Intrinsic Motivation	4.56	1.32	5.52	1.22	21.05	5.57	**<.001****	0.614	1.303	.370
	Integrated Regulation	4.10	1.44	5.29	1.15	29.02	5.57	**<.001****	0.749	1.631	.356
	Identified Regulation	5.41	1.10	5.90	1.00	9.06	5.41	**.004****	0.162	0.810	.146
	Introjected Regulation	4.01	1.27	4.77	1.52	18.95	3.01	**<.001****	0.320	1.198	.185
	External Regulation	2.94	1.36	3.24	1.54	10.20	3.47	.227	−0.193	0.795	.027
	Amotivation	2.91	1.55	2.60	1.41	−10.65	1.22	.243	−0.837	0.217	.026
Planned Behavior	Subjective Norms	4.28	1.42	4.61	1.65	7.71	1.39	.170	−0.147	0.813	.035
	Attitude	4.94	1.31	5.36	1.44	8.50	1.78	.080	−0.052	0.895	.057
	Personal Impact	3.83	1.13	4.15	1.31	8.36	1.57	.122	−0.089	0.731	.045
	Collective Impact	5.32	1.10	5.74	1.31	7.89	1.96	.055	−0.010	0.862	.068
P. Norms	Personal Norms	4.81	1.03	5.25	1.44	9.15	2.31	**.025***	0.057	0.822	.091
Energy	Energy Consumption	55,778 kWh		49,365 kWh		−12.99	–	-	–	–	–

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit; η^2 = eta squared; M = mean; SD = standard deviation; *p < .05; **p < .01.

References

[1] UN News Centre, ' Today is an historic day ,' says Ban , as 175 countries sign Paris climate accord. www.un.org, 2016. Paris.
[2] International Energy Agency, World Energy Outlook, France, Paris, 2016.
[3] UN, Transforming Our World: the 2030, Agenda for Sustainable Development, 2015.
[4] M.E. Porter, M.R. Kramer, Strategy & Society: the Link between Competitive Advantage and Corporate Social Responsibility," Harv, Bus. Rev., December, 2006.
[5] W.Q. Judge, T.J. Douglas, Performance implications of incorporating natural environmental issues into the strategic planning process: an empirical assessment, J. Manag. Stud. 35 (2) (1998) 241–262.
[6] M.V. Russo, P.A. Fouts, A resource-based perspective on corporate environmental performance and profitability, Acad. Manag. J. 40 (3) (1997) 534–559.
[7] J.A. Aragón-Correa, S. Sharma, A contingent resource-based view of proactive corporate environmental strategy, Acad. Manag. Rev. 28 (1) (Jan. 2003) 71.
[8] European Commission, Buildings [Online]. Available:, 2017 https://ec.europa.eu https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings.
[9] E. Delzendeh, S. Wu, A. Lee, Y. Zhou, The impact of occupants' behaviours on building energy analysis: a research review, Renew. Sustain. Energy Rev. 80 (2017) 1061–1071. September 2016.
[10] J. Conti, P. Holtberg, J. Diefenderfer, A. LaRose, J.T. Turnure, L. Westfall, International Energy Outlook 2016, U.S. Energy Information Administration (EIA), Washington, DC, U.S.A., 2016. *With Projections to 2040*, May 2016.
[11] R. Lülfs, R. Hahn, Corporate greening beyond formal programs, initiatives, and systems: a conceptual model for voluntary pro-environmental behavior of employees, Eur. Manag. Rev. 10 (2) (2013) 83–98.
[12] L. Lutzenhiser, Social and behavioral aspects of energy use, Annu. Rev. Energy Environ. 18 (1993) 247–289.
[13] M.A. Delmas, M. Fischlein, O.I. Asensio, Information strategies and energy conservation behavior: a meta-analysis of experimental studies from 1975 to 2012, Energy Pol. 61 (2013) 729–739.
[14] M.A.R. Lopes, C.H. Antunes, N. Martins, Energy behaviours as promoters of energy efficiency: a 21st century review, Renew. Sustain. Energy Rev. 16 (6) (2012) 4095–4104.
[15] J. Du, W. Pan, Examining energy saving behaviors in student dormitories using an expanded theory of planned behavior, Habitat Int. 107 (2021) 1–35.
[16] ODYSSEE, "Free Energy Indicators, ODYSSEE Database [Online]. Available:, 2015 http://www.indicators.odyssee-mure.eu/online-indicators.html. (Accessed 21 November 2017).

[17] S.C. Staddon, C. Cycil, M. Goulden, C. Leygue, A. Spence, Intervening to change behaviour and save energy in the workplace: a systematic review of available evidence, Energy Res. Social Sci. 17 (2016) 30–51.
[18] T.A. Nguyen, M. Aiello, Energy intelligent buildings based on user activity: a survey, Energy Build. 56 (2013) 244–257.
[19] S.H. Lo, G.J.Y. Peters, G. Kok, Energy-related behaviors in office buildings: a qualitative study on individual and organisational determinants, Appl. Psychol. 61 (2) (2012) 227–249.
[20] P.C. Stern, Toward a coherent theory of environmentally significant behavior, J. Soc. Issues 56 (3) (2000) 407–424.
[21] C. Scherbaum, P. Popovich, S. Finlinson, Exploring individual-level factors related to employee energy conservation behaviours at work, J. Appl. Soc. Psychol. 38 (3) (2008) 818–835.
[22] G.N. Dixon, M.B. Deline, K. McComas, L. Chambliss, M. Hoffmann, Saving energy at the workplace: the salience of behavioral antecedents and sense of community, Energy Res. Social Sci. 6 (2015) 121–127.
[23] P. Bansal, J. Gao, Building the future by looking to the past: examining research published on organizations and environment, Organ. Environ. 19 (4) (2006) 458–478.
[24] R.N.L. Andrews, E. Johnson, Energy use, behavioral change, and business organizations: reviewing recent findings and proposing a future research agenda, Energy Res. Social Sci. 11 (2016) 195–208.
[25] M.B. Deline, Energizing organizational research: advancing the energy field with group concepts and theories, Energy Res. Social Sci. 8 (2015) 207–221.
[26] X. Xu, A. Maki, C. fei Chen, B. Dong, J.K. Day, Investigating willingness to save energy and communication about energy use in the American workplace with the attitude-behavior-context model, Energy Res. Social Sci. 32 (2017) 13–22.
[27] G.T. Gardner, P.C. Stern, Environmental Problems and Human Behavior, Allyn & Bacon, 1996.
[28] P.C. Endrejat, F.E. Klonek, S. Kauffeld, A psychology perspective of energy consumption in organisations: the value of participatory interventions, Indoor Built Environ. 24 (7) (2015) 937–949.
[29] B. Karlin, R. Ford, J. Zinger, The effects of feedback on energy conservation: a preliminary theory and meta-analysis, Psychol. Bull. 141 (6) (2015) 1205–1227.
[30] B.K. Sovacool, What are we doing here? Analyzing fifteen years of energy scholarship and proposing a social science research agenda, Energy Res. Social Sci. 1 (2014) 1–29.
[31] IEA Digitalization & Energy Working Group, Digitalization & Energy, 2017.
[32] IEA EEfD, Energy Efficiency, 2017.
[33] P.C. Endrejat, S. Kauffeld, Can't get no satisfaction? Motivating organisational energy efficiency efforts in Germany, Energy Res. Social Sci. 44 (May) (Oct. 2018) 146–151.
[34] E.L. Deci, R.M. Ryan, Intrinsic Motivation and Self-Determination in Human Behavior, Springer Science and Business Media, 1985.
[35] R.M. Ryan, E.L. Deci, Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being, Am. Psychol. 55 (1) (2000) 68–78.
[36] I. Ajzen, The theory of planned behavior, Organ. Behav. Hum. Decis. Process. 50 (1991) 179–211.
[37] A. Yuriev, M. Dahmen, P. Paillé, O. Boiral, L. Guillaumie, Pro-environmental behaviors through the lens of the theory of planned behavior: a scoping review, Resour. Conserv. Recycl. 155 (2019) 2020. December.
[38] A. Gkargkavouzi, G. Halkos, S. Matsiori, Environmental behavior in a private-sphere context: integrating theories of planned behavior and value belief norm, self-identity and habit, Resour. Conserv. Recycl. 148 (May) (2019) 145–156.
[39] Q.C. Wang, K.X. Xie, X. Liu, G.Q.P. Shen, H.H. Wei, T.Y. Liu, Psychological drivers of hotel guests' energy-saving behaviours—empirical research based on the extended theory of planned behaviour, Buildings 11 (9) (2021).
[40] I. Hossain, M. Fekete-Farkas, M. Nekmahmud, Purchase behavior of energy-efficient appliances contribute to sustainable energy consumption in developing country: moral norms extension of the theory of planned behavior, Energies 15 (13) (2022).
[41] H. Ateş, Merging theory of planned behavior and value identity personal norm model to explain pro-environmental behaviors, Sustain. Prod. Consum. 24 (2020) 169–180.
[42] E.H. Borgstein, R. Lamberts, J.L.M. Hensen, Evaluating energy performance in non-domestic buildings: a review, Energy Build. 128 (2016) 734–755.
[43] O.T. Masoso, L.J. Grobler, The dark side of occupants' behaviour on building energy use, Energy Build. 42 (2) (2010) 173–177.
[44] D.E. Yeatts, D. Auden, C. Cooksey, C.F. Chen, A systematic review of strategies for overcoming the barriers to energy-efficient technologies in buildings, Energy Res. Social Sci. 32 (2017) 76–85.
[45] J. Von Grabe, How do occupants decide their interactions with the building? from qualitative data to a psychological framework of human-building-interaction, Energy Res. Social Sci. 14 (2016) 46–60.
[46] I.N. Pettersen, E. Verhulst, R. Valle Kinloch, A. Junghans, T. Berker, Ambitions at work: professional practices and the energy performance of non-residential buildings in Norway, Energy Res. Social Sci. 32 (2017) 112–120.
[47] C. Schelly, J.E. Cross, W.S. Franzen, P. Hall, S. Reeve, Reducing energy consumption and creating a conservation culture in organizations: a case study of one public school district, Environ. Behav. 43 (3) (2011) 316–343.
[48] L. Steg, C. Vlek, Encouraging pro-environmental behaviour: an integrative review and research agenda, J. Environ. Psychol. 29 (3) (2009) 309–317.
[49] B.F. Daily, J.W. Bishop, G. Nalini, A conceptual model for organizational citizenship behavior directed toward the environment, Bus. Soc. 48 (2) (2009) 243–256.
[50] C. Leygue, E. Ferguson, A. Spence, Saving energy in the workplace: why, and for whom? J. Environ. Psychol. 53 (2017) 50–62.
[51] N. Murtagh, et al., Individual energy use and feedback in an office setting: a field trial, Energy Pol. 62 (2013) 717–728.
[52] R. Galvin, N. Terry, Selling energy savings in the United Kingdom: a case study of top-down pro-environmental behaviour change in commercial office buildings, Energy Res. Social Sci. 11 (2016) 155–163.
[53] Committee on Communication for Behavior Change in the 21st Century, *Speaking Of Health: Assessing Health Communication Strategies For Diverse Populations*, National Academies Press, Washington, D.C., 2002.
[54] S. Suntornsan, S. Chudech, P. Janmaimool, The role of the theory of planned behavior in explaining the energy-saving behaviors of high school students with physical impairments, Behav. Sci. 12 (9) (2022).
[55] N.L.D. Chatzisarantis, S.J.H. Biddle, Functional significance of psychological variables that are included in the Theory of Planned Behaviour: a Self-Determination Theory approach to the study of attitudes, subjective norms, perceptions of control and intentions, Eur. J. Soc. Psychol. 28 (3) (2002) 303–322.
[56] T. Brosch, M.K. Patel, D. Sander, Affective influences on energy-related decisions and behaviors, Front. Energy Res. 2 (2014) 1–12. MAR.
[57] J.A. Ouellette, W. Wood, Habit and intention in everyday life: the multiple processes by which past behavior predicts future behavior, Psychol. Bull. 124 (1) (1998) 54–74.
[58] P.C. Stern, et al., The effectiveness of incentives for residential energy conservation, Eval. Rev. 10 (2) (Apr. 1986) 147–176.
[59] W. Kempton, L. Montgomery, Folk quantification of energy, Energy 7 (10) (1982) 817–827.
[60] S. Darby, The effectiveness of feedback on energy consumption: a review for defra of the literature on metering , billing and direct displays, Environ. Chang. Institute, Univ. Oxford 22 (April) (2006) 1–21.
[61] C. Kormos, R. Gifford, The validity of self-report measures of proenvironmental behavior: ameta-analytic review, J. Environ. Psychol. 40 (2014) 359–371.
[62] B. Verplanken, W. Wood, Interventions to break and create consumer habits, J. Publ. Pol. Market. 25 (1) (2006) 90–103.
[63] C. Littleford, T.J. Ryley, S.K. Firth, Context, control and the spillover of energy use behaviours between office and home settings, J. Environ. Psychol. 40 (2014) 157–166.
[64] W. Samuelson, R. Zeckhauser, Status quo bias in decision making, J. Risk Uncertain. 1 (1) (1988) 7–59.
[65] J.A. Bargh, T.L. Chartrand, The unbearable automaticity of being, Am. Psychol. 54 (7) (1999) 462.
[66] T.L. Webb, P. Sheeran, Does changing behavioral intentions engender behavior change? A meta-analysis of the experimental evidence, Psychol. Bull. 132 (2) (2006) 249–268.

[67] B. Gardner, P. Lally, Modelling habit formation and its determinants, in: The Psychology of Habit, Springer International Publishing, Cham, 2018, pp. 207–229.
[68] S. Wang, J. Wang, X. Ru, J. Li, D. Zhao, Understanding employee's electricity conservation behavior in workplace: do normative, emotional and habitual factors matter? J. Clean. Prod. 215 (2019) 1070–1077.
[69] M. Gagne, E.L. Deci, Self-determination theory and work motivation, J. Organ. Behav. 26 (4) (2005) 331–362.
[70] R. Darner, Self-determination theory as a guide to fostering environmental motivation, J. Environ. Educ. 40 (2) (2009) 39–49.
[71] D. Webb, G.N. Soutar, T. Mazzarol, P. Saldaris, Self-determination theory and consumer behavioural change: evidence from a household energy-saving behaviour study, J. Environ. Psychol. 35 (2013) 59–66.
[72] K.J. Lavergne, E.C. Sharp, L.G. Pelletier, A. Holtby, The role of perceived government style in the facilitation of self-determined and non self-determined motivation for pro-environmental behavior, J. Environ. Psychol. 30 (2) (2010) 169–177.
[73] E.L. Deci, R.M. Ryan, Self-determination theory: a macrotheory of human motivation, development, and health, Can. Psychol. 49 (3) (2008) 182–185.
[74] C. Lewis, Irresistible Apps: Motivational Design Patterns for Apps, Games, and Web-Based Communities, Apress, Berkeley, CA, 2014.
[75] R. Ryan, E. Deci, Intrinsic and extrinsic motivations: classic definitions and new directions, Contemp. Educ. Psychol. 25 (1) (2000) 54–67.
[76] R.J. Vallerand, Toward a hierarchical model of intrinsic and extrinsic motivation, Adv. Exp. Soc. Psychol. 29 (1997) 271–360.
[77] L.G. Pelletier, K.M. Tuson, I. Green-Demers, K. Noels, A.M. Beaton, Why are you doing things for the environment? The motivation toward the environment scale (MTES), J. Appl. Soc. Psychol. 28 (5) (1998) 437–468.
[78] L.M. Graves, Understanding employee proenvironmental behavior: a test of a theoretical model, Acad. Manag. Annu. Meet. Proc. 8 (1) (2011) 1–6.
[79] I. Ajzen, Constructing a theory of planned behavior questionnaire, Biofeedback Selfreg. 17 (2010) 1–7.
[80] D. Lynch, P. Martin, How energy efficiency programs influence energy use: an application of the theory of planned behaviour, in: European Council for an Energy Efficient Economy Summer Study, 2013, pp. 2037–2048.
[81] S. Bamberg, G. Moser, Twenty years after Hines, Hungerford, and Tomera: a new meta-analysis of psycho-social determinants of pro-environmental behaviour, J. Environ. Psychol. 27 (1) (2007) 14–25.
[82] R.M. Mancha, C.Y. Yoder, Cultural antecedents of green behavioral intent: an environmental theory of planned behavior, J. Environ. Psychol. 43 (2015) 145–154.
[83] M.F. Chen, Extending the theory of planned behavior model to explain people's energy savings and carbon reduction behavioral intentions to mitigate climate change in Taiwan-moral obligation matters, J. Clean. Prod. 112 (2016) 1746–1753.
[84] M. Cordano, I. Freeze, Pollution reduction preferences of US environmental managers: applying Ajzen's theory of planned behavior, Acad. Manag. J. 43 (4) (2000) 627–641.
[85] M.L. Martín-Peña, E. Díaz-Garrido, J.M. Sánchez-López, Relation between management's behavioural intentions toward the environment and environmental actions, J. Environ. Plann. Manag. 53 (3) (2010) 297–315.
[86] R. Lülfs, R. Hahn, Sustainable behavior in the business sphere: a comprehensive overview of the explanatory power of psychological models, Organ. Environ. 27 (1) (2014) 43–64.
[87] S.V. Russell, Explaining workplace proenvironmental behaviors: the role of emotion, values and issue ownership, Acad. Manag. Proc. (1) (2008) 1–6, 2008.
[88] M.H. Ibtissem, Application of value beliefs norms theory to the energy conservation behaviour, J. Sustain. Dev. 3 (2) (2010) 129.
[89] F. Fornara, P. Pattitoni, M. Mura, E. Strazzera, Predicting intention to improve household energy efficiency: the role of value-belief-norm theory, normative and informational influence, and specific attitude, J. Environ. Psychol. 45 (2016) 1–10.
[90] L. Steg, L. Dreijerink, W. Abrahamse, Factors influencing the acceptability of energy policies: a test of VBN theory, J. Environ. Psychol. 25 (4) (2005) 415–425.
[91] C.A. Scherbaum, P.M. Popovich, S. Finlinson, Exploring individual-level factors related to employee energy-conservation behaviors at work, J. Appl. Soc. Psychol. 38 (3) (2008) 818–835.
[92] F. V Mcdonald, Developing an integrated conceptual framework of pro-environmental behavior in the workplace through synthesis of the current literature, Adm. Sci. 4 (2014) 276–303.
[93] W.B. Schaufeli, A.B. Bakker, M. Salanova, The measurement of work engagement with a short questionnaire: a cross-national study, Educ. Psychol. Meas. 66 (4) (2006) 701–716.
[94] L.M. Little, D.L. Nelson, J.C. Wallace, P.D. Johnson, Integrating attachment style, vigor at work, and extra-role performance, J. Organ. Behav. 32 (3) (Apr. 2011) 464–484.
[95] R. Gifford, A. Nilsson, Personal and social factors that influence pro-environmental concern and behaviour: a review, Int. J. Psychol. 49 (3) (2014) 141–157.
[96] G. Arabatzis, C. Malesios, Pro-environmental attitudes of users and non-users of fuelwood in a rural area of Greece, Renew. Sustain. Energy Rev. 22 (2013) 621–630.
[97] A. Ramos, X. Labandeira, A. Löschel, Pro-environmental households and energy efficiency in Spain, Environ. Resour. Econ. 63 (2) (2016) 367–393.
[98] J.A. Palmer, J. Suggate, Influences and experiences affecting the pro-environmental behaviour of educators, Environ. Educ. Res. 2 (1) (1996) 109–121.
[99] S. Longhi, Individual pro-environmental behaviour in the household context, in: ISER Work. Pap. Ser., 31, 2013.
[100] A.H. McMakin, E.L. Malone, R.E. Lundgren, Motivating residents to conserve energy without financial incentives, Environ. Behav. 34 (6) (2002) 848–863.
[101] A. Meyer, Does education increase pro-environmental behavior? Evidence from Europe, Ecol. Econ. 116 (2015) 108–121.
[102] A. Mikuła, M. Raczkowska, M. Utzig, Pro-environmental behaviour in the European Union countries, Energies 14 (18) (2021).
[103] C. Boomsma, J. Goodhew, S. Pahl, R.V. Jones, The feasibility of saving energy in challenging organisational contexts: testing energy visualisation in a social services office in the United Kingdom, Energy Res. Social Sci. 15 (2016) 58–74.
[104] J. Burgess, M. Nye, Re-materialising energy use through transparent monitoring systems, Energy Pol. 36 (12) (2008) 4454–4459.
[105] S. Hermsen, J. Frost, R.J. Renes, P. Kerkhof, Using feedback through digital technology to disrupt and change habitual behavior: a critical review of current literature, Comput. Hum. Behav. 57 (2016) 61–74.
[106] K. Buchanan, R. Russo, B. Anderson, The question of energy reduction: the problem(s) with feedback, Energy Pol. 77 (2015) 89–96.
[107] R. Bull, K.B. Janda, Beyond feedback: introducing the 'engagement gap' in organizational energy management, Build. Res. Inf. 46 (3) (2018) 300–315.
[108] I. Blohm, J.M. Leimeister, Gamification: design of IT-based enhancing services for motivational support and behavioral change, Bus. Inf. Syst. Eng. 5 (4) (2013) 275–278.
[109] E.N. Webb, Gamification : when it works , when it doesn ' t, Lect. Notes Comput. Sci. 8013 (2013) 608–614. LNCS, no. PART 2.
[110] T. Pickard, 5 statistics that prove gamification is the future of the workplace, business.com, [Online]. Available: http://www.business.com/management/5-statistics-that-prove-gamification-is-the-future-of-the-workplace/, 2015. (Accessed 27 February 2016).
[111] K. Seaborn, D.I. Fels, Gamification in theory and action: a survey, Int. J. Hum. Comput. Stud. 74 (2015) 14–31.
[112] K. Robson, K. Plangger, J.H. Kietzmann, I. McCarthy, L. Pitt, Is it All a Game? Understanding the Principles of Gamification, Bus. Horiz., 2015.
[113] K. Werbach, D. Hunter, For the Win: How Game Thinking Can Revolutionize Your Business, Wharton Digital Press, The Wharton School, University of Pensylvania, Philadelphia, PA, 2012.
[114] B. Reeves, J.J. Cummings, J.K. Scarborough, J. Flora, D. Anderson, Leveraging the engagement of games to change energy behavior, in: Proc. 2012 Int. Conf. Collab. Technol. Syst. CTS, 2012, pp. 354–358.
[115] J.D. Fijnheer, H. Van Oostendorp, R.C. Veltkamp, Gamification in a prototype household energy game, in: Proceedings of the 10th European Conference on Games Based Learning, 2016, pp. 192–201.
[116] E. Knol, P. De Vries, EnerCities-A Serious Game to Stimulate Sustainability and Energy Conservation: Preliminary Results, vol. 45, eLearning Pap., 2011, pp. 1–10.
[117] R. Brewer, Y. Xu, G. Lee, Energy feedback for smart grid consumers: lessons learned from the Kukui Cup, Smart Grids, Green (2013) 120–126, c.
[118] D. Geelen, D. Keyson, B. Stella, H. Brezet, Exploring the use of a game to stimulate energy saving in households - journal of design research - volume 10, number 1–2/2012 - inderscience publishers, J. Des. Res. 10 (2012) 102–120.

[119] B. Orland, N. Ram, D. Lang, K. Houser, N. Kling, M. Coccia, Saving energy in an office environment: a serious game intervention, Energy Build. 74 (2014) 43–52.
[120] A. Bourazeri, J. Pitt, Serious game design for inclusivity and empowerment in SmartGrids, in: First International Workshop on Intelligent Digital Games for Empowerment and Inclusion, 2013.
[121] J.D. Fijnheer, H. Van Oostendorp, Steps to design a household energy game, Int. J. Serious Games 3 (3) (Sep. 2016) 12–22.
[122] F. Grossberg, M. Wolfson, S. Mazur-Stommen, K. Farley, S. Nadel, Gamified Energy Efficiency Programs, U.S.A., Washington, DC, 2015.
[123] Energic, Energic - Smart Energy Challenge [Online]. Available:, 2019 http://www.energic.io/. (Accessed 16 April 2019).
[124] WeSpire, Wespire - Employee Engagement Platform Powered By Behavioral Science [Online]. Available:, 2019 https://www.wespire.com/. (Accessed 14 February 2019).
[125] Cool Choices, Employee Engagement Sustainability Game [Online]. Available:, 2019 https://coolchoices.com/. (Accessed 14 February 2019).
[126] A.F. Aparicio, F.L.G. Vela, J.L.G. Sánchez, J.L.I. Montes, Analysis and application of gamification, in: Proc. 13th Int. Conf. Interacción Pers. - INTERACCION '12, 2012, pp. 1–2.
[127] J. Hamari, J. Koivisto, H. Sarsa, Does gamification work? - a literature review of empirical studies on gamification, in: Proc. Annu. Hawaii Int. Conf. Syst. Sci., 2014, pp. 3025–3034.
[128] M. Sailer, J. Hense, H. Mandl, M. Klevers, Psychological perspectives on motivation through gamification, Interact. Des. Archit. J. - IxD&A 19 (2013) 28–37.
[129] D.L. Kappen, L.E. Nacke, The kaleidoscope of effective gamification, in: Proceedings of the First International Conference on Gameful Design, Research, and Applications., 2014, pp. 119–122.
[130] G. Villalobos-Zúñiga, M. Cherubini, Apps that motivate: a taxonomy of app features based on self-determination theory, Int. J. Hum. Comput. Stud. 140 (2020) 1–24. Article 102449.
[131] J. Hamari, J. Koivisto, Social motivations to use gamification: an empirical study of gamifying exercise, in: Proceedings of the 21st European Conference on Information Systems (ECIS), vol. 105, 2013. Utrecht, Netherlands.
[132] J. Hamari, J. Koivisto, 'Working out for likes': an empirical study on social influence in exercise gamification, Comput. Hum. Behav. 50 (2015) 333–347.
[133] J.V. Bittner, J. Shipper, Motivational effects and age differences of gamification in product advertising, J. Consum. Market. 31 (5) (2014) 391–400.
[134] D. Kotsopoulos, C. Bardaki, K. Pramatari, Gamification , geolocation and sensors for employee motivation towards energy conservation at the workplace, in: Proc. 10th Mediterr. Conf. Inf. Syst., 2016, pp. 1–11.
[135] C. Henkel, J. Kranz, Pro-environmental behavior and green information systems research - review, synthesis and directions for future research, in: International Conference on Information Systems 2018, vol. 2018, ICIS, 2013, pp. 1–17, 2018.
[136] J.C. Nunnally, I.H. Bernstein, Psychometric Theory, third ed., McGraw-Hill, 1994.
[137] J. Pallant, SPSS Survival Manual - A Step by Step Guide to Data Analysis Using SPSS, fourth ed., McGraw-Hill, Maidenhead, Berkshire, England, 2010.
[138] A.C. Michalos, Encyclopedia of Quality of Life and Well-Being Research, 2014.
[139] S.B. Green, How many subjects does it take to do A regression analysis, Multivariate Behav. Res. 26 (3) (1991) 499–510.
[140] C.R. Wilson VanVoorhis, B.L. Morgan, Understanding power and rules of thumb for determining sample sizes, Tutor. Quant. Methods Psychol. 3 (2) (Sep. 2007) 43–50.
[141] E.V. O, IPMVP - Efficiency Valuation Organization, 2019 [Online]. Available: https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp. (Accessed 25 February 2018).
[142] R.O. Salvador, A. Burciaga, Organizational environmental orientation and employee environmental in-role behaviors: a cross-level study, Bus. Ethics 29 (1) (2020) 98–113.
[143] N.L.D. Chatzisarantis, S.J.H. Biddle, Functional significance of psychological variables that are included in the Theory of Planned Behaviour: a Self-Determination Theory approach to the study of attitudes, subjective norms, perceptions of control and intentions, Eur. J. Soc. Psychol. 28 (3) (1998) 303–322.
[144] M.S. Hagger, N.L.D. Chatzisarantis, Integrating the theory of planned behaviour and self-determination theory in health behaviour: a meta-analysis, Br. J. Health Psychol. 14 (2) (May 2009) 275–302.
[145] L. Girelli, M. Hagger, L. Mallia, F. Lucidi, From perceived autonomy support to intentional behaviour: testing an integrated model in three healthy-eating behaviours, Appetite 96 (2016) 280–292.
[146] M.S. Hagger, K. Hamilton, Motivational predictors of students' participation in out-of-school learning activities and academic attainment in science: an application of the trans-contextual model using Bayesian path analysis, Learn. Indiv Differ 67 (2018) 232–244.
[147] P. Harland, H. Staats, H.A.M. Wilke, Explaining proenvironmental intention and behavior by personal norms and the theory of planned Behavior1, J. Appl. Soc. Psychol. 29 (12) (1999) 2505–2528.
[148] L. Gao, S. Wang, J. Li, H. Li, Application of the extended theory of planned behavior to understand individual's energy saving behavior in workplaces, Resour. Conserv. Recycl. 127 (August) (2017) 107–113.
[149] B. Gardner, C. Abraham, P. Lally, G.-J. de Bruijn, Towards parsimony in habit measurement: testing the convergent and predictive validity of an automaticity subscale of the Self-Report Habit Index, Int. J. Behav. Nutr. Phys. Activ. 9 (1) (2012) 102.
[150] W. Abrahamse, L. Steg, How do socio-demographic and psychological factors relate to households' direct and indirect energy use and savings? J. Econ. Psychol. 30 (5) (2009) 711–720.
[151] G.M. Spreitzer, Psychological empowerment in the workplace: dimensions, measurement, and validation, Acad. Manag. J. 38 (5) (1995) 1442–1465.
[152] A.R. Carrico, M. Riemer, Motivating energy conservation in the workplace: an evaluation of the use of group-level feedback and peer education, J. Environ. Psychol. 31 (1) (2011) 1–13.
[153] A. Ebreo, J. Vining, How similar are recycling and waste reduction? Future orientation and reasons for reducing waste and predictors of self-reported behavior, Environ. Behav. 33 (3) (2001) 424–448.
[154] M. Greaves, L.D. Zibarras, C. Stride, Using the theory of planned behavior to explore environmental behavioral intentions in the workplace, J. Environ. Psychol. 34 (2013) 109–120.
[155] E.R. Frederiks, K. Stenner, E.V. Hobman, Household energy use: applying behavioural economics to understand consumer decision-making and behaviour, Renew. Sustain. Energy Rev. 41 (2015) 1385–1394.
[156] D. Li, X. Xu, C. fei Chen, C. Menassa, Understanding energy-saving behaviors in the American workplace: a unified theory of motivation, opportunity, and ability, Energy Res. Social Sci. 51 (2019) 198–209. January.
[157] D. Kotsopoulos, C. Bardaki, S. Lounis, T. Papaioannou, K. Pramatari, Designing an IoT-enabled gamification application for energy conservation at the workplace: exploring personal and contextual characteristics, in: 30th Bled eConference, 2017, pp. 369–384.
[158] S.C. Wee, W.W. Choong, Gamification: predicting the effectiveness of variety game design elements to intrinsically motivate users' energy conservation behaviour, J. Environ. Manag. 233 (2019) 97–106. November 2018.
[159] S.H. Lo, G.J.Y. Peters, G.J.P. van Breukelen, G. Kok, Only reasoned action? An interorganizational study of energy-saving behaviors in office buildings, Energy Effi. 7 (5) (2014) 761–775.