Energy Consumption Awareness in the Workplace: Technical Artefacts and Practices

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ABSTRACT
Despite all technological advances in the energy research field and the ubiquitous presence of technology in all aspects of life, the lack of information is still recognized as a gap to engage people in a pro-environmental behaviour towards energy conservation. Consumption feedback is elementary to tackle this paradox, but not enough to trigger a social change. It is still necessary to motivate people in order to raise awareness effectively. This study associated the feedback provided by smart monitors with a debate tool and a tangible motivational device for building energy awareness collectively in a workplace. The analysis of the role of each technology considered assessments and interviews, and also the content of the online discussion, which encompassed more than 170 ideas for changing behaviour for around 100 issues about how the energy has been consumed. Results demonstrated that for raising energy awareness, beyond technology, it is also necessary to deal with formal and informal elements, such as institutional practices and individual's motivation. These technical, formal, and informal levels shaped our qualitative analysis to identify elements participants considered relevant to learn and to discuss, suggesting their importance to similar initiatives that aims to raise energy awareness in a wider perspective.

Categories and Subject Descriptors
H.4 [Information Systems Applications]: Miscellaneous;

Keywords
Energy consumption, awareness, collective knowledge construction, organisational semiotics

1. INTRODUCTION
The great majority of efforts to introduce innovation in the way energy is generated, distributed and consumed are actually coping strategies to deal somehow with the limit of the planet regarding natural and socioeconomic resources. New policies or economic models are also attempts to reconsider this system that is in fact one of the foundations of the social life in the planet. Framed in the Human-Computer Interaction (HCI) field, this study is grounded in the conviction that there is no effective change in such a complex system when human aspects are not centrally considered. People must be engaged in innovation development to the same extent as technology, however according to a recent official European report [1], "*the interaction between humans and new energy technologies remain challenging*". Cultural factors and the cognitive impact related to the design of feedback devices are among the outlined reasons.

Raising *awareness of energy consumption* is then a research topic that represents the challenge of assigning responsibility also to individuals to make the energy system more sustainable and efficient. Awareness is understood as a necessary, although not sufficient, condition for changing behaviour towards conservation, which occurs whether the person is also motivated. Promoting awareness embraces from "*making energy visible*" [2] in daily routine to providing "*knowledge about how and why to reduce waste by operating devices more efficiently*" [3].

Despite the ubiquitous presence of technology (and of energy) in all aspects of life, people still know very little about their own energy consumption, even in the developed contexts. This recent study [4] points out that consumption is usually understood at a high level, being related to seasonal effects as the weather, and rarely associated with appliances usage itself. Providing appropriate information is the first step to raise awareness. For [5], the lack of information is also the main gap that needs to be bridged to transform awareness into behaviour change. To make different choices that sometimes impact in their comfort, people must be aware of the benefits too.

Different motivations drive people to be engaged in saving energy. Some are concerned about money, others about the environmental impact and, while some do not care about it, other people are keen to study and disseminate ideas for conservation [6]. We argue that exploring the energy consumption topic by sharing experiences within the social group, and then building awareness collectively, may be a promising way to fill the gap of information towards a social change.

This study addresses energy awareness in the workplace, particularly in a computer science research lab in the United Kingdom, where people are closely acquainted to technology. In this context, people usually bring from home different experiences with energy consumption in such way that the individuals' perception, control and autonomy to act are rather different. We therefore applied three different technologies to support this energy awareness study: 1) a social tool for sharing knowledge and debating about perceptions and experiences; 2) smart monitoring devices for learning about individual consumption; 3) the Energy Tree, a tangible device used as a feedback of contributions to the debate tool to motivate engagement.

By analysing the content generated by participants and their evaluations within the study, this paper discusses how these technologies contributed to the process of raising awareness and presents some findings related to relevant information to be provided for promoting energy conservation in a workplace.

The paper is organized as follows: Section 2 contextualizes studies that address energy awareness collectively and consumption perception. Section 3 conceptualizes the role of technology to promote social changes and briefly describes the three technical artefacts applied in this study. Section 4 defines the study methodology. Section 5 reports results that are discussed in Section 6. Section 7 presents our conclusions.

2. RELATED STUDIES

Building awareness collectively and considering the external forces that influence social changes is an emerging approach in the HCI domain. The studies have been mostly focused on providing feedback of consumption to individuals instead [6]. A collaborative approach was found in [8] relying on collective saving with the clear objective of reducing energy generation. The authors propose alternatives for design such as projecting consumption data in the street for engaging neighbours to work together.

In the workplace, studies are more focused in promoting energy literacy than assessing consumption reduction. Holmes [9] placed an artwork in a university building to represent instant data from the automation building system regarding water and energy consumption. The artwork represents how green (in number or trees) or grey the building is at the moment. Watt-Lite [10] was another initiative to publicly represent statistical data of energy consumption in a factory. Three oversized torches projected real time data on the floor. Results indicated the importance of choosing the right installation place in sociable areas, such as those close to a coffee machine, to have better engagement results. It resulted in situated engagement, but not enough to lead people to visit the project website. In [11], after building a baseline with 5 months of consumption in a working environment, researchers conducted a series of workshops to promote reflections and then tracked behaviour change. They evidenced that workers do take responsibility for conservation if they get adequate support for that, and recognized the importance of building consensual collective practices, especially towards shared equipment such as printers. They also noticed that people prefer to keep individual consumption as private.

2.1 Perceiving energy consumption

Darby [12] investigated qualitatively how people perceived energy according to the Theory of Affordances [13], a concept from Ecology that refers to the relationship between physical properties of the environment and a personal experience. She evaluated how different types of feedback affect the perception and found out that people mostly pay attention to information related to the payment of the bill instead of consumption; the In-Home Displays (IHDs) are the physical presence with the potential to lead to savings, but their effect last for few weeks only; and the online feedback requires extra effort and determination to look up consumption data. When social aspects are present, such as comparison with other people or even competition, motivation for engagement might go beyond monetary and environmental aspects.

To deal with changes in behaviour, it is necessary first to appreciate how people understand the phenomenon of energy by themselves [14]. In line with that, Schwartz et al [15] investigated what and how people in a living lab learned about energy consumption by monitoring it online. People tend to use feedback for few weeks, becoming more aware of appliances consumption level (also in stand-by), typical consumption level by the time of the day, including always-on consumption in the evening, and consequently details about the energy contract.

How people make sense of the IHD was also the focus of [2] and [16], who found out that monitoring consumption can either empower users to bring consumption into discussion among the family and to change behaviour or, in the contrary, raise a feeling of frustration or guilt by the few monetary or environmental achievements. This study also brought to light that energy consumption is a social and collective process rather than individual, and it must be discussed as a first step towards changes.

In [17], the authors conceptualize *energy culture* and propose a framework that helps to identify both individual and social factors that influence behaviour in social groups. The core concepts of the framework are those cultural, such as values and knowledge, grouped as Cognitive Norms; Material Culture, which encompasses technology usage and building forms; and Energy Practices that determine how people use technology.

3. MOTIVATION, BEHAVIOUR AND TECHNOLOGY

Motivation gives force and direction to behaviour [18]. As also observed in the literature review, some theories from Psychology [18][19] state that motivation does not rely only on internal reasons. Social and cultural factors facilitate or undermine people's resolution for acting. The way people perceive and relate to energy is also shaped by culture, which is not only learned but also acquired.

Motivation drives behaviour, which in turn happens according to three modes that alternate in dominance, according to Hall's anthropological perspective [20]: the *informal mode*, which is made up of activities done automatically and learned in everyday life; the *formal mode* which is regulated by rules and for this reason is resistant to change from the outside; and the *technical mode*, where artefacts support and reinforce behavioural patterns.

A way to introduce cultural changes is through the technical mode. At this mode changes are easily observed and transmitted to others, establishing the basis for new formal systems. When accepted and adopted, changes become embedded in the informal mode. Behaviour in the formal mode, instead, means following rules, like acting in a specific way to respect work practices. In the informal level, behaviour happens without reflection, for instance, by following other people's typical reactions. Persuasive technologies [21] are examples of technical devices designed to facilitate changes in behaviour. They act in the technical mode by persuading the way to act, for example by means of visual feedback, alarms, etc. Nevertheless, for [15], to be effective in changing behaviour, indeed, persuasive technology still needs to take individual motivation into account.

In this work, three complementary technologies were then introduced aiming at raising energy awareness from the technical to the informal modes. By exploring the social aspect of energy consumption through discussions, as pointed out by [16], **the debate tool** aims at building awareness collectively, while the **smart energy monitors** are essential learning tools [2]. **The Energy Tree** takes motivational aspects into account, which is a gap highlighted by [16], with the purpose of promoting engagement.

3.1 The debate tool

For bringing social aspects to the study, the Evidence Hub is an online discussion tool for argumentative knowledge construction [22], with which users can collaboratively build knowledge by sharing not only comments and ideas, but raising arguments in favour or against them. These Contested Collective Intelligence Platforms [23] do not aim to find the best and quickest answer to a question, but rather to develop critical thinking and collective assessment of several solutions. This approach to debate is particularly interesting in complex socio-technical domains, such as energy consumption where there are no right answers.

Users can create **issues**, such as "*printers are constantly on*" and **ideas** to overcome those issues: "*turn off printers in communal areas as well as in the offices at night*". Issues and ideas can be supported or countered by **arguments,** promoted by **votes for,** or demoted by **votes against**. Users can also add **Facts** or Web **resources** to enrich the debate. Ideas, issues, facts, arguments are all connected by themes, such as *Behaviour Change* or *Consuming Energy*, or by tags. Interactive maps of connected ideas and people strength the tool social aspect.

3.2 Smart energy monitors

Smart energy monitors are the main instrument to overcome the lack of information regarding how the energy is consumed. Connected to the In-Home Displays (IHD), the smart plugs may provide feedback of specific appliances, indicating to what extent they affect the general consumption. It is well known in literature the potential of feedback to promote savings from 5 to 15% [24], but not necessarily the devices promote users' motivation towards savings [16]. The way the information is presented in terms of frequency, granularity, place and time, whether it is in an attractive way or not, are factors that might influence the feedback efficacy [25].

Participants of our experiment received a kit [26] composed by a sensor to be clipped close to the meter for getting the overall consumption, an IHD, a set of smart plugs, and a Web device to make the consumption data available online. The objective of this study is not to reproduce results from literature regarding the impact of feedback (i.e. [2][12][16][24][25]), but to evaluate how the smart monitors complement the whole experimental setting.

3.3 The Energy Tree

The Energy Tree, illustrated in Figure 1, is a tangible motivational device created to favour a new *social affordance* of energy consumption, which means new patterns of behaviour that are shared in a social community for a specific time [27]. The metaphor of a tree aims at connecting energy consumption to the natural environment. Functionally, it consists of a led-lights tree that can be solar powered with 7 branches that get illuminated independently. The way in which the tree lights represents achievements of collective actions.

Figure 1 - The Energy Tree

Initially conceived to represent collective savings for a period of time [28], it was applied as a feedback of engagement to reflect contributions to the debate tool. The effect of the Energy Tree to promote social engagement has been also evaluated in a different context in Brazil.

4. THE STUDY METHOLOGY

The study happened during October and November of 2013 involving a total of 33 volunteer participants, most of them researchers in the university department. It was composed by 4 phases: 1) Online survey; 2) Two workshops on the debate tool; 3) Smart monitors trial; 4) Sample interview.

The online survey comprised 3 topics: ideas to save energy in the workplace, ideas for personal behaviour change, and problems related to the building, splitting individual responsibilities from installation issues or working practices. The survey aimed at collecting preliminary ideas for populating the debate tool, avoiding the potential inertia from people to start using an "empty" social software.

The Energy Tree was connected to the debate tool during phases 2 and 3. In phase 2, the two workshops (WS1 and WS2) were planned for exploring the debate tool and also to evaluate the impact of the Energy Tree to motivate engagement. Half of attendees started promoting or demoting Facts related to Consuming Energy by voting, then discussed and prioritized Issues. The other group created Ideas for Behaviour Change, voted for or against these new ideas, and then provided pro and cons arguments. After 20 minutes, they swapped roles. The groups engaged in some face-to-face discussions, but most of the activities were done online, on the debate tool. Contributions created in the WS1 were not visible for the participants of WS2, and vice versa, to avoid influencing the creation of new content. Both workshops had the same dynamic, except for the presence of the Energy Tree in the WS2, placed in the centre of the room (Figure 2), as a feedback mechanism by reflecting the number of new contributions submitted to the debate tool. It was expected that the Energy Tree would motivate a higher number of contributions to the debate tool in WS2.

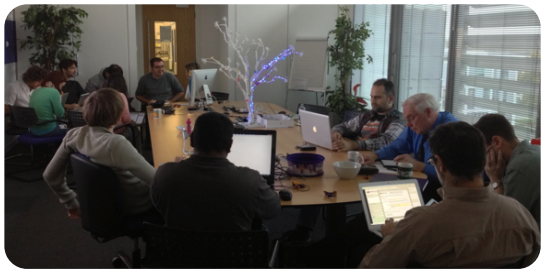

Figure 2 - The WS2 workshop with the tree

In phase 3, volunteers of both workshops were asked to install the smart monitors at home or in the office to learn about their consumption, and sharing their findings in the debate tool during the following week. During that time, the Energy Tree was placed in a social area of the department as a feedback of engagement. Every 60 new contributions to the tool (new issues, ideas, arguments, facts, resources or votes) turned on a new branch of the tree. Results of each group were identified and kept alternating from time to time.

In phase 4, after the trial, a sample of participants, including the top and bottom contributors, was interviewed about their motivations, perception of the tree and the smart monitor, as well as their overall experience with this study.

4.1 Analysing Energy Consumption Dynamics

Aiming at understanding how people perceive energy consumption and how technology is related to this process, concepts of the Organisational Semiotics (OS) [28][30] have been applied to analyse the collected data. Aligned to the three modes of behaviour from Hall [20], through OS, every technical system is within the core of a socio-organisational context and surrounded by the formal and informal layers of the society or the social organisation. Thus, the technical systems are under the influence of both formal and informal levels and, at the same time, they have an impact on them. The relations among the informal, formal, and technical levels of the information system are explained through the metaphor known as the "organisational onion", illustrated in Figure 3. The aspects underlined in the Figure are those introduced by this study.

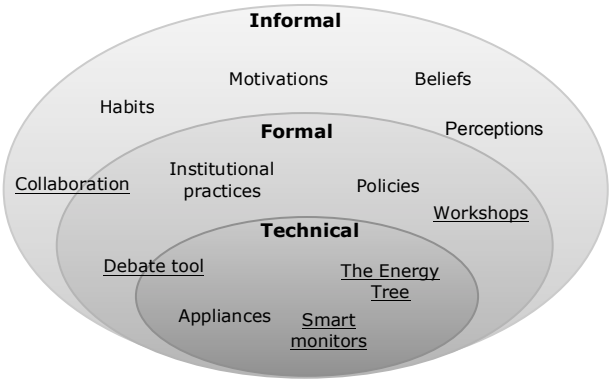

Figure 3 - Energy Awareness "Organisational onion"

In this context, electrical appliances in general, the smart monitors, and the Energy Tree are in the technical level. Between the technical and the formal is the debate tool that aims at supporting the collaboration by connecting people to discuss about energy consumption. In the formal level are the policies, institutional practices and the workshops (phase 2) realized to engage people. The informal level contains the cultural and individual aspects: habits, motivations, beliefs, perceptions as well as the expected collaboration to the study.

5. RESULTS

The next sections present results related to participants' interaction with the three technologies: the debate tool, the smart monitoring, and the Energy Tree.

5.1 The online debate in numbers

A total of 19 people filled out the phase 1 online survey. As already mentioned, the answers to the survey were added to the debate tool as the initial input for both workshops.

The workshops attracted 24 people (12 each), including 10 of those who answered the online survey. Five people in each session volunteered for the smart monitor trial. The online discussion started with the workshops (phase 2) and continued for the smart monitor trial (phase 3), spontaneously attracting also people who did not participate in previous activities. Table 1 synthesizes the total of contributions to the debate tool for both Group 1, in the WS1, and Group 2 in the WS2. Group 1 had a lower number of contributions in the workshop compared to Group 2, which had the tree. But the score inverted in the following week when both groups had the tree as a feedback in the public space.

Table 1 – Total of contributions to the debate

	Group 1	Group 2
In the workshop	348	542
After the workshop	247	78
Total of contributions	595	620

Group 1 created a total of 92 ideas for 58 issues and voted 430 times. Group 2, instead, pointed out 84 ideas for 46 issues and gave 331 votes. The chart in Figure 4 presents the distribution of types of contribution within the groups.

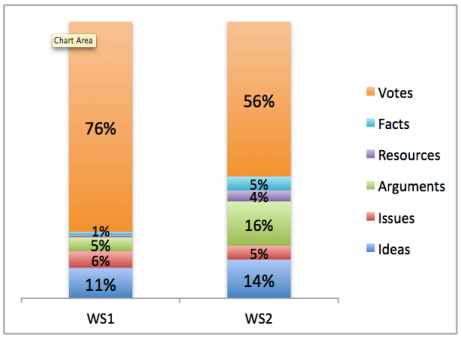

Figure 4 – Types of contributions

The five most cited appliances/devices were: Lights (26%), Computers (17%), Kettle (8%), PC monitors (7%) and Printer (7%).

New posts on the debate needed to be annotated by the user with one or more of the six themes: Behaviour Change, Consuming Energy, Institutional Actions, Environmental Actions, Good Practices, and The Tree. Discussions about possible Behaviour Change engaged most, representing 41% of issues, ideas, arguments, facts and votes. 30% discussed how the energy has been consumed. Institutional actions were 21%. Good practices and discussions about the study were few, 6% together, and only 2% discussed about Environmental Impact, as in Figure 5.

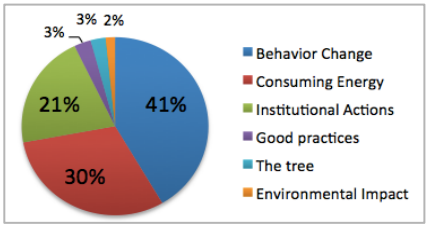

Figure 5 – Distribution of contributions' themes

People who did not contribute pointed out the complexity of the debate tool as a reason. Such perception of complexity was also evidenced by user experience evaluation with workshops participants. However, details of this evaluation are out of the scope of this paper.

5.2 Monitoring consumption

Volunteers monitored consumption during the phase 3 of the study and reported difficulties when installing the smart monitor devices at the office during that time. The issues were mostly related to network security constraints that prevented the setup of the Web device, and to clip the sensor close to the main meter, which is hidden and locked. So, most of them took the kit home instead.

Even though, only 2% of the contributions within the debate tool referred to data collected from the monitoring devices or shared experiences about the usage/installation. When asked to score from 1-5 how they like the equipment, 83% of respondents of the sample survey scored with the maximum value (5), and 17% scored as 3.

5.3 The Energy Tree and motivation

Participants' motivation and the impact of the Energy Tree were assessed by means of the sample interview (phase 4) with 10 participants, 4 people from Group 1, and 6 from Group 2, including both: those who most contributed and those who did not contribute at all after the workshop. When asked to choose up to tree reasons to be engaged in this study, the Energy Tree was in the second place, leaded by the interest for the energy topic: 1) To learn about energy (33%); 2) To see the tree functioning (26%); 3) Interest in the smart monitor devices (19%); 4) The social aspect of the activity (7%); Others (4%).

Participants were also asked to score from 1 to 5 the level of attention they spent to the tree during the WS2 and during the time it was installed in the public area. The public space gathered more attention (Figure 6). The average score of attention in the workshop was 3.5, while in the public space was 3.9.

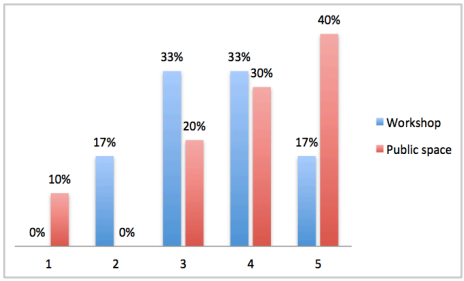

Figure 6 - Score of the level of attention to the tree

6. DISCUSSION

Based on qualitative analysis of the contributions to the debate tool and feedback from participants, the role of the technologies to raise energy awareness is discussed in the next sections, evidencing how participants perceived and used them. This analysis also led to a categorization of topics of discussion and to a list of information of interest to promote awareness.

6.1 Technical artefacts

The three technologies are represented at the core of the semiotic onion, however the impact of them is disseminated through the formal and informal levels in different ways, as described below.

6.1.1 Learning about consumption

The knowledge acquired by means of smart monitors constitutes an important source to guide perception and choices in the informal level. The short-term aspect of the study due to a time constraint prevented longer-term adoption evaluation. Answers to the interview evidenced how that smart monitors were used. The results are in line with [15] findings, obtained in a longer and broader term.

- For learning about the cost of specific appliances consumption: *"I have calculated some basic costs of e.g. a washing cycle, a toast, one year of fridge",* reported a participant.

- For tracking the consumption along the day: *"I am usually monitoring consumption of specific devices over a period of a few days and using the general meter reading to pay attention to the energy intense usage periods during the day*."

- For comparing consumption appliances: *"I observed consumption while the laundry or pot is running: reasoned that pot even if it runs for a short period of time and such a small electrical device it actually consumes a lot of energy"*, and guiding choices: *"(...) it has changed the way we use quite a few things in our house. For example, we don't cook rice using the electric cooker or microwave because it consumes too much energy. Instead we use a pressure cooker. We also stopped using the kettle to boil water*".

- For understanding cause-effect: "*I was using the smart devices at KMi. I was curious how much energy does my laptop and monitor use on daily basis and also whether the monitor keeps using energy while in standby mode. This was the reason why I now started switching the monitor completely off before going home every day*".

- For mapping consumption in the house: "*creating usage stats for the following items, so that I can then target high usage areas. Monitoring Fridge, Freezers, Dish Washer, Washing machine, Kettle, Two TV's, Home Server, Printers, PC, Lighting".*

One participant reported the preference for seeing the consumption online instead of by the IHD because of the need to plug it on. As already mentioned, information related to monitoring consumption was not typically discussed in the online debate. Instead, it was observed that the discussions about the device installation and the findings obtained by using them happened among colleagues mostly at the informal level, during coffee breaks, lunchtime or around the tree installation, for instance. A possible reason is that personal information like "*the old one (fridge) is consuming twice as much as a new one would. Could half my energy costs for the fridge per year down to £25 or so"* was considered of private interest, and not suitable to be shared trough a "formal" social tool.

6.1.2 Formalizing the knowledge built collectively

Besides promoting an online environment to build awareness collectively, the debate tool plays the role of formalizing the discussion.

The number of arguments and votes suggests that the tool was effective to promote the debate. The screenshot of the Evidence Hub in Figure 7 illustrates the knowledge tree of the discussion about how to motivate people to save energy, considering the issue that "*saving energy is a very boring thingy"*.

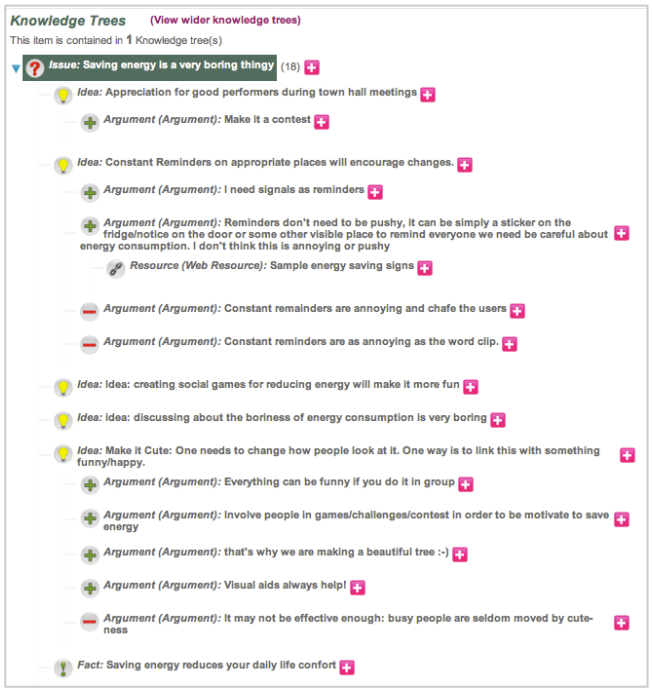

Figure 7 - Knowledge Tree in the debate tool

The software was perceived as a working tool. In spite of that, people usually expressed themselves like in an informal conversation (the hierarchy seems to not have affected discussion). They did not restrict the discussion to possible behaviour change, some evidenced behaviour pro-conservation they already had, suggested things for the current study, and others pointed out Web references, which demonstrates that they had often analysed the topic before adding a new idea, issue, fact or argument. The online discussion also attracted people in the department beyond the participants. It was rarely accessed to post domestic consumption data.

Some posts reflected participants' expertise, such as ideas for new research developments, like this external resource posted about Collective Action Theory [31].

Being the most simple and direct action, voting represented the majority of contributions (Figure 4). Nevertheless, it was not clear how people evaluated the voting action, whether considering it by the relevance or as a feeling evaluation (good or bad). As an example, the fact of informing the amount of annual money spent in the building and comparing it to the number of houses that could be powered received 3 votes promoting it and 4 votes demoting. The complexity of the tool seemed to affect contributions, being told as one of the reasons that prevented some people to generate more contributions.

6.1.3 Informally motivating engagement

The presence of the tree in the WS2 and in the public space seems to have influenced participants' perception and motivation, both informal level aspects. The workshop that had the tree produced more, but interestingly, seems to have hampered their motivation in the phase 3. A participant declared: "*I left the workshop with the feeling of mission accomplished, we lighted the tree on. It did not make sense to me to light the tree once again*".

Considering that during the workshop people spent most of the time working on their laptop, the tree in the public space was more effective in attracting participants' attention (Figure 6). When asked about their thoughts when they saw the tree in the public area, participants of Group1 and Group 2 reported different perceptions:

- Group 1: Competition - "*Shamelessly competitive: Is my group doing best?*" and "*is our team ahead?*"; how much progress was done "*I wanted to see all the lights on*"; collectivity: "*some people are saving energy*".

- Group 2: For the group that did not create new posts after the workshop, the tree had a negative feeling. Three people mentioned being guilty, like "*it makes me feel a bit guilty when it is switched off - like I am not fulfilling my responsibilities*", other two people were always comparing to the other group. One participant highlighted the characteristic of the tree of being both decorative and meaningful together.

The comparison (and consequent competition) between groups caused a bad feeling for the group that was not doing well. The Energy Tree definitely worked as a symbol, a reminder of the ongoing activity, as illustrated by this post: "*It looks like thanks to the tree we started switching off the lights during the day*".

6.2 Technical, formal and informal levels

The tag cloud in Figure 8 highlights the most frequent words of phase 1 survey evidencing an issue: *switching* off the *lights* in the *office*. The content analysis pointed out that people **want** to switch the lights off, but they cannot due to the automation system, which is ineffective. It evidences that behaviour change is not only a matter of applying **technologies**, but there is a system composed by

Figure 8 – Initial survey tag cloud

individuals, **formal** environment constraints and the culture, perception and motivation (**informal** level) of people that shapes both current behaviour and possible changes. These tree levels of the organisational onion, technical, formal, and informal, set up the analysis on what interests people for sharing and learning.

The qualitative analysis of the contributions of Groups 1 and 2 taken together identified the topics more explored; therefore supposedly considered more relevant by the participants. This subjective analysis took into account some tags initially added by participants to the items in the debate tool. Other tags were added during the analysis and grouped by affinity leading to a set of 18 distinct topics. Table 2 enumerates these topics ordered by number of post, indicating which level(s) they impact more, (T)echnical, (F)ormal, and (I)nformal.

Table 2 – Summary of topics by posts

Number of contributions about		T	F	I
40	The working environment (comfort)			x
37	Switching off, turning-off, shutting-down, unplugging, stand-by	x		x
27	The automation system efficiency (sensors)	x	x	
27	Working infrastructure (computers, kettle, phones)	x	x	
22	Efficient usage of appliances (battery x power, configuration, adjustments)	x	x	
19	Reminders for conservation	x	x	x
19	Personal attitude towards saving			x
16	Replacing devices (cost of manufacturing)	x		x
15	Motivation strategies (group work, competition, games…)			x
15	Costs of consumption in £ (monitoring or Web resources)	x		
15	Reviewing working practices (printing, coffee breaks, meetings, working time)		x	
12	Outcome (feedback of performance and claims for rewards)		x	x
11	Instructions for changing behaviour	x	x	
10	Claim for getting more information about consumption (institutionally or personally)	x	x	
6	Presentation of consumption feedback (personalization, granularity, etc)	x		
6	Report of appliances consumption (monitoring or Web resources)	x		
5	Dealing with stakeholders		x	
4	CO2 emission			x

6.2.1 The technical level

The 2nd most voted contribution is the issue that refers to the lack of information: *"People usually have very few information about the impact of their consumption"*. In general, 20% of ideas, issues and arguments together refer to claims for information about individual or institutional consumption, outcomes or suggestions about how to present feedback, reinforcing the lack of information as a gap for awareness. What was considered relevant to be informed and how to present reminders are the main results of the technical level. What to inform:

- Quantify the benefits of shutting-down, or unplugging every day use devices, comparing to stand by mode.
- How to configure or adjust appliances to use it efficiently (ex: monitor brightness, cooler speed, etc.).
- Direct costs of daily actions, i.e. "*how much do I spend laundering during all the year*" or the cost of using a kettle for making the daily teas. Cost was also the argument against the issue about big monitors consumption: "*the consumption is 19.8 kWh/month, between 2.12£ and 3.31£ per month depending on the energy supplier*".
- The energy spent to produce new devices and hints about when replacing them. "*The energy required to produce 1 PC is more or less the same as what 3 family members use in 1 year!"*, is an example.
- Reminders. They were stated by participants as necessary, but how to present them was deeply discussed: *"People are already bombed by caution messages everywhere in their daily life ("mind the gap", "fire safety",...). Such reminders shall be carefully chosen not to be categorized in a person's perspective as " not so necessary" messages."*. Energy saving stickers were suggested as a kind of reminder to be evaluated. A "*cute and non-intrusive way*" of reminding people about savings was also a supported idea.

Automation is a topic, besides information, that is worth to be mentioned in the technical level as a lesson learned. It was evidenced that sensors in the workplace have not worked properly: *"The automatic lights are sometimes on, even during bright sunny day!"* was the 3rd contribution that received more votes. It suggests that not always an automation system is the best solution in terms of energy savings, and it might even prevent the control by the people who want to save energy. This issue justifies why lighting was the most cited appliance.

6.2.2 The formal level

In line with [11], the need of institutional support was found as the main message of the formal level. This support is necessary to keep people motivated to act and to promote the feeling that individuals' efforts compose a bigger initiative. Participants identified the need of support for:

- Providing simple instructions of what to do, such as "switch off the printer after using it" or "replace your fridge when…".
- Publishing outcomes. *"Provide monthly figures about how much energy/ money has been saved by following simple instructions such as: turning off monitors, PCs, lights, etc."* was the 4th idea most voted among all contributions.
- Reviewing working practices, such as promoting paperless behaviour.
- Assigning responsibility for people switching off appliances and devices.
- Publicly recognizing good behaviour both namely or in general. A suggested way was by promoting achievements, such as using a sign "*congratulations for using the stairs! We can save # of CO2 (or £) in a year if # people do the same everyday"*.
- Making sure and evidencing that shared infrastructure is energy efficient, such as kettle, hand dryers, etc., as suggested by the contribution "*Buy new kettles that allow you to set the temperature"*.
- Evidencing that saving energy is not a disconnected action from the whole organisation and policies, and other necessary stakeholders are involved.

Still in the formal domain, the debate expanded from energy consumption to general sustainable practices such as promoting virtual meetings instead of travelling and promoting car sharing initiatives.

6.2.3 The informal level

The informal level encompasses individual and cultural aspects such as feelings, motivations, perceptions, etc., which should be promoted to influence individuals' engagement:

- Recognition. The most supported contribution in the debate tool is a fact declaring a good behaviour: *"I always shutdown the computer at night"*. It reinforces the formal level result about the importance of rewards or recognition.
- Deal with comfort. People are worried about loosing comfort due to energy saving "*knowing what the long term benefits are could offset the short term inconvenience"*. A fact informing the consumption of big monitors and the negative votes it received is another example. Instead of feeling threatened by consumption information, people must receive instructions to avoid energy wasting, i.e. turning off monitors when they are not in use. How motivated a person is determines his/her willing to leave the comfort zone, witch is a subjective variable too.
- Consider different levels of motivation. Some people just want to learn about the topic, or to listen other people's ideas. Not all of them are willing to change behaviour. But it is important that everybody feel motivated to engage with the awareness initiative in order to instigate such motivation. As a research-

working environment, the interest to learn about energy as a research topic was also declared as a motivation for being engaged.

- Keep personal data as private. The preference for not sharing personal data was evidenced not only by the few who reported consumption data from home, but also by posts like this one: *"access to information about our energy use at a useful (but not too personal) level of granularity"*.
- Make it funny. A cute and non-intrusive reminder was claimed, as well as initiatives to work in groups. *"Everything can be funny if you do it in group"*.
- Environmental appealing must be promoted. Only one participant declared to be motivated for being part of the study by environmental reasons. The very few number of items connected to the theme Environmental Impact also evidenced that. Despite being the main reason behind the study, the connection with the natural environment was not an attractive perspective for people in this scenario. The fact *"approximately 48 trees are needed to absorb the CO_2 equivalent an 11 months of using a 27" monitor 6 hr/day",* for instance, did not have any repercussion.

Summarizing the analysis, the main new elements that emerged from the debate content that can contribute to raise awareness were then added in italic to the semiotic onion in Figure 9: Information about efficient use and configuration of appliances, reminders, clear instructions, publishing outcomes and rewards, review of institutional practices.

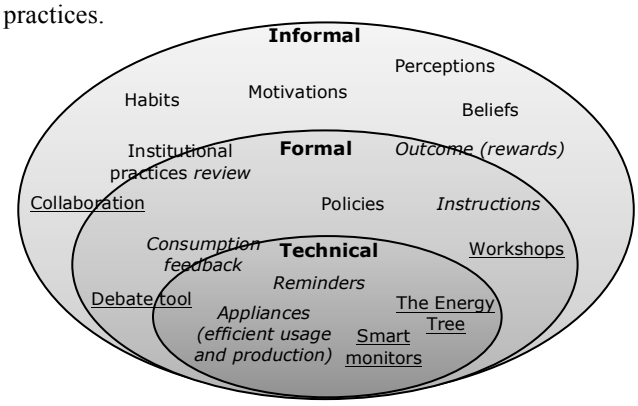

Figure 9 - "Organisational onion" with resulting elements

7. CONCLUSION

This study evaluated the role of three technologies to promote energy awareness in a research workplace: a debate tool, smart monitors, and a tangible device to motivate engagement. The analysis evidenced the lack of information as a barrier towards conscious consumption of energy even in a developed scenario, and also pointed out that providing new technical artefacts as a consumption feedback is not enough for promoting awareness. The artefacts actually need to dialogue with the formal context where current institutional practices are, and also with informal and personal elements, such as motivation to deal with comfort and the existing (or not) environmental concern.

The debate tool has demonstrated to be adequate for gathering opinions to build awareness collectively. As a simple action, voting was an effective way to engage people in the discussions. The possibility of easily interact with other people's opinion might be a motivation to engage those who are not willing to change behaviour initially, but are interested in learning. On the other hand, it was perceived as a working tool, in which private consumption data, which was supposed to be shared, did not appear. Exchanging experiences and ideas about how to save energy is an important way to raise awareness, but real consumption measurements play a fundamental role to complement this scenario with contextual and personalized information. However, in this cultural context, this information is not suitable for a public discussion according to the results.

The motivational role of the Energy Tree was noticed, but it may not have been the only factor promoting participants' motivation. Nevertheless, its role as an attractive reminder was evidenced. The three technical elements complemented each other and together promoted ideas, issues, arguments, and facts that were analysed pointing out aspects that people are interested to discuss in an energy awareness initiative in the workplace.

A resulting limitation of the study was the connection between energy consumption and the natural environment that did not flow spontaneously in the discussion. The reasons could not be evaluated suggesting, therefore, the need for further investigations. It can be expected that the role these technologies play differ according to the workplace scenario mainly due to the sociocultural influences. Complementary studies have been handled to evaluate their impact in raising awareness in a broader perspective, considering also socially disadvantaged groups in a developing scenario. Still, the "intangible" aspect of energy has been evidenced as a global challenge that can be tackled by from different perspectives when technology and people, with all their complexity, are equally considered as part of a solution.

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