Sensing the Workspace

An Innovative Way to Improve Eco-Awareness at Work

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Abstract. During last years, Europe has witnessed remarkable progress in the field of new technologies focused on reducing our carbon footprint. Big retrofit projects, low carbon emission automobiles, combined heat and power systems (CHP) have contributed to promote environment-improving practices at a large scale. In 2005, the EU Ecodesign initiative was developed to address the environmental impacts of the energy use of appliances and devices and to assess the efficiency of the proposed measures. Moreover, the EU has made major efforts in setting the minimum requirements on energy-using and energy-related products placed on the market. According to the 2012 EU Energy Efficiency Report, major energy savings will be realized through simple consumer behaviour shift, such as equipment usage and office lighting in the tertiary sector.

This project intends to create an innovative, multi-level, game-like system to increase eco-awareness and consumer engagement as well as to generate cost-effective, sustainable competitive advantages for energy conservation and increase in renewable energy use. The project's main scope is to create a smart-sensor network that evolves without human involvement as well as to establish an 'internet-of-everything' setting in energy-consumption related activities in the work sector, by adopting energy-efficiency and renewable energy technologies suitable for work applications.

The proposed project will act as a platform for knowledge and exchange of ideas, to provide information, support and guidance to communities and to invent ways to disseminate and share the gained information to working communities that are more or less familiar to the sustainable way of life. This platform is also intended as an open source hub that intends to provide real-time information on the end-user behaviour, analyse and improve it through a peer-to-peer network focused on energy consumption. Sensor and network capabilities will contribute to the shaping of the "sustainable lifestyle" that work hubs are invited to share and promote. The project will project urban living as a "parameterized variation" of dynamic urban factors such as carbon footprint, energy waste, energy consumption, allowing the users of urban space to change these qualities by actively participating in it. Members of the work hub are treated as end-users that will be able to manage their personal data and take advantage of the IoT network to take back control of their energy consumption levels. A bottom-up approach will be identified to suggest sustainable strategies regarding consumer energy saving in terms of consumption during working hours.

The project suggests dynamic ways to alter this situation: bridge across users, companies and consultants in order to create multiple ways to alter the work habits by approaching different work members according to their education, gender, age and willingness to change their lifestyle. Users will be able to observe the relation between their habits and their energy consumption levels, while new sustainable technologies focusing on the quantification and evaluation of consumer behaviour will be developed.

Keywords: workspace; user-engagement; sustainability; real-time

I. Introduction

Workplaces are often contexts where potential impacts of individual behavior change are mediated by organizational and group issues. With the presence of user-controlled infrastructure systems such as air-conditioning, lighting and heating, staff is gaining control over decisions related to the working environment. Moreover, the majority of the working staff is not able to recognize the invisible link between disrupting a habit and the overall environmental impact of the specific action. Daily life is characterized by repetition, which associates form in memory with the practiced action and typical performance times [1]. In that respect, changing long-established habits into a sustainable working lifestyle requires a multidisciplinary motivation system.

II. Project Background

This study is based on the notion that automated control of buildings, transport and other energy management processes are not sufficient to radically reduce energy consumption levels [2]. On the one hand, new technologies have allowed for the emergence of virtual workspace, which is linked to the urban scale, while traditional workspace relates to the building scale. On the other hand, multi-tasking has allowed for a higher mobility rate nowadays [3]. According to a Typical Work Space Utilization Survey [AECOM, 2013], internal mobility corresponds to a minimum of 20% of a typical working day (Fig.1). As a result, a major behavioural shift in the way users perceive and control space is necessary. A number of solutions have been suggested for the motivation of users to consume less energy through the shift of everyday habits. The usual aim is to model users and their decision-making, intending to promote a household sustainable behaviour. However, there is a major difference between the hours spent at home and the workplace. According to the ATUS (American Time Use Survey), on an average day in 2013, employed persons, ages 25 to 54, spent 8.7 hours in working and related activities, while 2.8 hours in household and other activities. Energy behaviour in the workplace has been analysed by the American Council for an Energy-Efficient Economy, aiming to employ communication tools, such as emails, websites and prompts as well as deploy engagement techniques, such as feedback, rewards and competition mechanisms. In April 2009, a retrofit program was launched at the Empire State Building, aiming to reduce energy use by 38% and lead to annual energy savings values at $4.4 million [4]. The program studied the role of occupant comfort requirements, system design characteristics, changed operating schedules and incentives in building energy use. In Europe, myEcoNavigator was launched in 2013 with the aim to provide independent support by modern means of communication to help consumers find truly sustainable and efficient products.

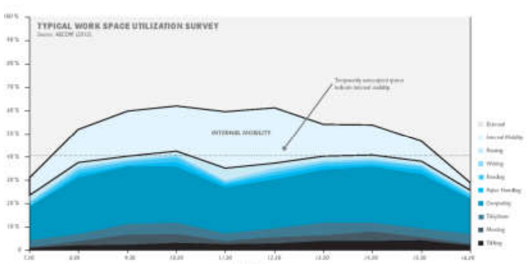

Fig. 1. Typical Work Utilization

III. Platform Implementation

A. Aims and Objectives

The platform aims to provide a real-time feedback system based on an open-source model of knowledge that is able to track, log and monitor energy-management issues and will engage users into disrupting their everyday habits, aiming to reduce energy consumption.

The idea is based on two layers: user engagement through energy visualization and productivity boost through the understanding and controlling workspace. On the one hand, visualization of the building's electricity and gas use with kWh, costs and CO2 data will demonstrate the links between the behavioural aspects of the employees and the overall impact of the company workspace. On the other hand, taking back control of their workspace will enable users to be more efficient and productive. In that framework, the suggested platform will act as a catalyst in minimizing the Sick Building Syndrome (SBS) effects, a worldwide problem of building occupants experiencing acute health and comfort effects that appear to be linked to time spent in a building [5].

Users will be encouraged to take advantage of natural lighting, use less air-conditioning, make sure that all equipment is turned off at the end of the day rather left on standby, telecommute, use the carpool system, use fans in the summer, turn the thermostat down slightly, limit car use, use the recycling facilities accordingly and change a huge pool of everyday habits that later the overall picture of a sustainable workplace.

B. Parameters

Field studies have shown that it is impossible to achieve thermal comfort for 100% of the occupants within a thermal environment, even if their clothing and level of activity are similar [6]. Although there is a large pool of parameters that alter thermal comfort and influence energy consumption, the platform provides data for the following parameters: CO2 emissions, electricity and water consumption, temperature and noise levels, as well as workspace occupancy. It was also necessary to get an overall picture of the user's thermal comfort. In that respect, there is a 'user happiness' option, where the user can show if he feels comfortable in his workspace (Fig.2).

C. Processes

The platform is defined through a series of adaptive and event-driven processes. In order to achieve maximum user-engagement, the system goes through the following steps:

- Data Collection through Wireless Sensor Network. Each office will be connected to the platform through wi-fi sensors measuring each parameter of every workspace user separately. High-resolution data acquisition and ubiquitous computing are the powerful components to set up the platform.
- Data Verification and Analysis. The modeling of the system possesses extended capabilities of synchronizing, mining and parsing acquired data in order to process the stored information.
- Energy-to-Cost Conversion. One of the most demanding processes of the system is the cost

calculation of the energy saved. How much energy has the user saved by switching off the air condition, or how much has he reduced his CO_2 emissions by using the carpool system to go to work?

- Data Visualization. Captured data will be available to users through graph APIs that will visualize the relevant information. Analyzed data will be projected on a daily, weekly or monthly basis.

D. *Structure*

The platform is defined by the following elements:

- **User-friendly Interface**. The interface follows a clear and simple layout. The sidebar on the left gives details regarding the company, office and user, as well as quick data regarding energy cost, awards and levels. Through the top right buttons, the user can login, register and search data within the platform. By choosing the main parameter buttons, the user can be informed on the current, daily, weekly, monthly and yearly basis, while he can get quick information on the level achieved through the green attitude meter.

- **Manager / Employee Environment.** While the welcome screen is common both for the managers and employees, depending on the position of the user in the company, when he/she logs into the platform, the relative interface is loaded. The employee can track his/her energy data, cost conversion and awards, while the manager is able to switch between the employee and manager environment through the upper right buttons. In the manager environment, he/she can track and compare data among different employees of the company, as well among different companies of the platform League.

- **Levels of green attitude.** According to the data gathered for each parameter (CO_2, Electricity, Water, Temperature and Noise), the user can track his/her level both for each separate component and the average level of the components. The green attitude meter informs the user in an intuitive and direct way and works as the synopsis of his environmental behavior.

- **Badge system.** The badge system works in accordance with the distinct levels. When the user evolves from one level to an upper one, he/she unlocks badges. This means that he/she is awarded a promotion by being able to track more data. For example, a red employee (lowest level) can only track his data and the other red employees data. When he/she jumps to the orange level, he/she can track both reds and oranges and so on. The same applies to the Manager (CSOs, FMs etc.) levels within the platform League, who can unlock badges as single users/employees or as company teams by improving the average employee energy use of their group of employees.

- **Reward System.** The reward system intends to become the commercial part of the platform and is inextricably linked to the badge system. The badge system works on the aggregate model basis. In that sense, employees can just add and not subtract credits from it. The accumulation of credits through the badges collection generates benefits that are interpretated into products and bonuses of the platform League companies.

IV. PLATFORM CALIBRATION

During the design of the platform, a few problems had to be solved. The first issue pertained to the variability and volatility of the workspace under examination. The above-mentioned methodology is easily applied when workspace is distributed to rooms of one or two persons. The evolution of workspace within the context of mobility, client-focused work and working from home demands a more complex approach to data collection. Organizations reuse and transform the existing stock of workspaces, by creating Open Houses, Co-habited spaces and Co-working hubs. In that case, data will inevitably be captured through the combination of sensors and data loaded manually by the user. Moreover, due to the fact that the platform is a web event-driven mechanism, it was necessary to verify the events during the data analysis phase. Currently, the code goes through further analysis and development to integrate verification tests. For example, noise levels should change during the day in a meeting room, or water consumption should be limited during the weekend. Finally, the internal mobility, as previously mentioned, is a factor that cannot be measured. If a user has more meetings during one week but stays more at the office another week, the projected energy consumption reduction will be actually less than in reality.

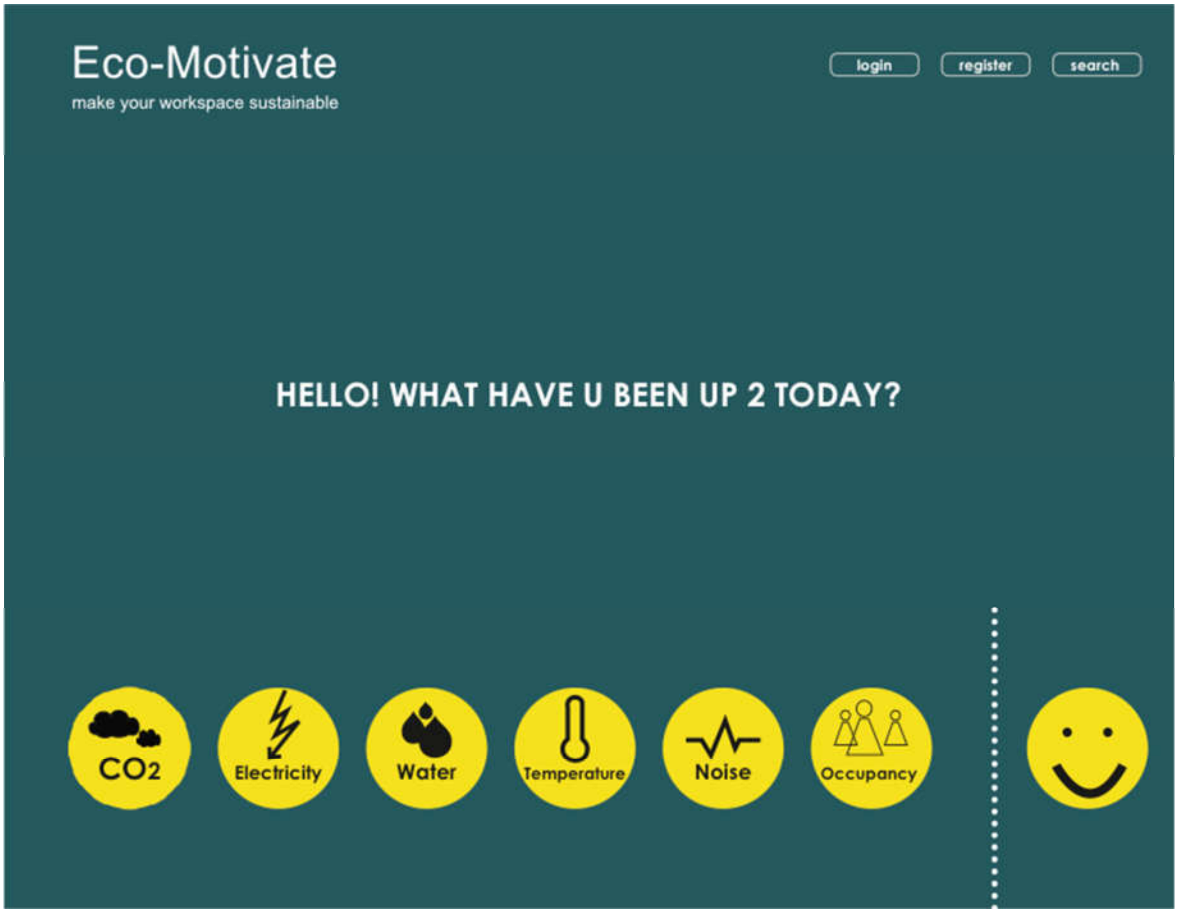

Fig. 1. User Interface Welcome Screen

V. Further Application

The platform incorporates the design of an experience that is personalized to each user's profile, preferences and sustainability behavior. By evolving social and digital intelligence tools, the platform could contribute to the improvement of sustainability performance through tips and advising on how to achieve a higher level. Personalized comments, RSS feeds, user tagging and subjective information can be used further to calibrate the application system and render it more efficient and easier to engage.

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