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More sustainable for home automation and information systems

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Abstract

This paper seeks to demonstrate the possibilities of residential automation and information systems, so that its residents can recover part of the knowledge about the cycles of nature, lost in the course of history. These possibilities are evaluated from systems for zero energy homes and, more specifically, to the houses built for the academic competition idealized at the North-American Energy Department, the Solar Decathlon. The graphical interfaces of the residential automation and information systems assume an important role in this context and still have many limitations, even in the experimental houses of Solar Decathlon. For this reason, the development of interfaces that integrate the data of the house systems with the environment is an important challenge, thus the automation and information systems have a significant impact on the daily lives of residents. Therefore, we believe that from these interfaces, the residential automation and information systems may facilitate the approach of the residents to the cycle of the nature, and the sense of belonging to the planet.

Keywords: residential automation and information systems, Solar Decathlon, zero energy homes, sustainability.

Introduction

Populations of different communities spread all over the world, throughout the history, have built dwellings that adapted to their customs and environmental conditions. These homes were developed through many generations which empirically verified the solutions that obtained best results and seemed to be more comfortable. Creative and ingenious techniques were developed by people considered primitive and adapted the materials available from the cycles of nature in each region. In the same way that the habits of these groups were important for the creation of their shelters, the manner of how the latter would work in each season or climatic changes, also influenced the habits of its residents. Over the course of time, the house of a certain village was being associated to this group as an important image of its people. Moreover, these houses, their materials and solutions, represent regions and the proper environment they are located.

Most of these buildings have a dynamic configuration and adapt to different times, seasons etc. Its dynamism approaches even more the dwellers and their habits to the cycles of nature. Its windows and doors are closed when the wind changes direction and sometimes even the place where the families cook is related to the climate. In other cases, the houses are formed by a series of layers that are closed by their residents on coldest days or opened when the temperature rises. However, these houses are devices that help to connect men with nature.

The development of key technologies, among them, the incandescent lamp and the air-conditioning, is altering the relationship between households and their natural environment. The differences between dwellings have decreased, no matter if located in regions without any similarity. Finally, what we call "International Style" revealed a tendency of rupture of the dwellers with the environmental variations. This separation is due to the development of a range of equipments and techniques to ease the discomfort caused by climatic changes or cycles of nature. The new buildings could, with minor adjustments, exist in any region of the world. Its new residents do not need to know the lunar cycle or the wind patterns of the place anymore, and the buildings represent less and less the environment where they are built. The detachment between men and nature occurs in different daily situations and buildings represent only a part of this change in the habits of modern man.

Recognized authors in different countries often highlight the dimensions of loss due to the impact these new technologies on the peoples culture, our way of living and, more specifically, on architecture. In the 30's, the renowned Japanese writer Junichiro Tanizaki wrote a remarkable essay about the importance of the twilight to the perception of Japanese constructions of space. According to Tanizaki, the profusion and the homogeneity of the electric lighting reduced the perception of the beauty of shadow and texture of materials, essential features of the traditional Japanese architecture (Tanizaki, 2007). More recently, in the 90's, the Finnish architect Juhani Pallasmaa published an essay about the meanings and

architecture that would become an important source of reading in engineering schools all over the world. Pallasmaa seeks to recover in architecture the quality of the senses that humanity has lost, privileging the sight. According to Pallasmaa, we are exposed to a large amount of images and our culture turns more and more to the sight. The standardization of architecture and the relevance of its photographic images, instead of an experience of the spaces, illustrate how we use less the others senses. Pallasmaa highlights the work of architects who address other senses like touch, sound and smell in their projects (Pallasmaa, 2005). The relationship of primitive people with their environment is established through all senses. These people are part of the environment and it seems strange to them to think and even discuss about their relationship with the natural environment, since they are one. Through the skin, upcoming climatic alterations are perceived and then confirmed by hearing, smell and also by sight. Not even the eye of the modern men, exercised in different types of screens, can accurately distinguish those changes of the cycles of nature anymore.

However, a new change is coming. A few decades ago, a relatively small group, whose members were often labeled as radicals, started a series of initiatives that sought to demonstrate the unsustainable situation of mankind, their way of life and relationship with the planet. Currently, there is already a consensus that we need to change this direction, but we still are far to take truly effective attitudes. The force of the term sustainability is being lost due to the trivialization of the use. Recently, in the introduction of his book about Ecological Urbanism, Mostafavi, dean of the Harvard Graduate School of Design, said the ethnical-political concept of Guattari called ecosofia, which defends that only an articulation between the three ecologies (the environment, the social relationship and the human subjectivity) could offer an answer to the ecological crisis we live. Therefore, it is important and necessary that this response occurs at a global scale, but also on the scale of the individual (Mostafavi, 2010).

Residential automation and information systems in zero energy homes

Another significant change is occurring through technologies directed to buildings and, more specifically, for zero energy homes (which produce throughout the year all energy they consume). These homes should generate locally large amount of energy through renewable sources. In addition, the development of technologies directed to the reduction of the energy consumption through more efficient systems and equipments should be priorized. In the context of these houses, the energy efficiency of the systems is still the main debate, but an important aspect is that we should concentrate on is the use of passive systems that do not require energy or only use a minimal amount, facilitating the adaptation of these houses to the variations of nature. We believe that these technologies have a significant potential to reconnect contemporary men with the natural environment and its cycles. Much of these possibilities of energy generation are not constant, being directly related to the cycles of nature. Moreover, efficient systems and equipment are preferably passive, not depending on the energy use of the house and therefore require external available energy, such as wind or

temperature differences. Unlike the houses that can be reproduced in any region of the planet, these houses must be adapted to the local climate, the availability of energy and natural resources, which are highly variable and differ from region to region.

More recently, these residence systems have been interconnected through increasingly complex residential automation and information systems. The most basic systems organize pre-set information by users in order to automate some routine activities. However, automation systems can be more and more dynamic when adapting to the residential and environmental changes, measured by different kinds of sensors. These sensors allow the best possible performance to the house, even without the presence of the resident. Windows can be opened, according to the wind direction or the external temperature. Louvers can be adjusted to allow or reduce the heat gain by sun position. Returning home, residents will find much better comfort conditions, which will reduce the use of mechanical equipment. The resource management of the houses can also be adjusted by these systems while residents are away. Activities that require hot water, such as the use of the dishwater, can be initiated when there is much insolation and weather forecast without cloudiness. Moreover, several household activities can be realized when there is increased production of energy through photovoltaic panels. With the implementation of smart-grids[1], the energy management will be important so that the activities are performed in periods of lower consumption and, consequently, lower energy costs.

When residents are home, the home automation and information systems allow more comfort for performing these activities automatically, but they also provide information for the users to take better decisions. The dwellers can make more sustainable choices, based on information about the house systems, available resources and weather forecasts. Activities like taking a bath, for example, can be performed at another time, if possible, and even choices like the best place to read a book, can depend on the management of information about the insolation, lighting and heat gain conditions.

The connection of automation systems to local or remote meteorological stations, via Internet, opens a wide space for major innovations in the field of residential automation for more sustainable houses. The perception through our senses of the natural environment, lost by modern men, can be complemented by these residential automation and information systems. Maybe the most relevant potential to facilitate a new connection of the residents with the cycle of the nature is right there. Managing the information provided by sensors connected to the systems of the house, as well as information related to climatic conditions, the residential automation and information systems should provide the user with relevant and organized information that to make their choices. Connected to the Internet, these systems can also

[1]The term Smart Grid should be understood more as a concept than a technology or specific equipment. It carries the idea of the intensive use of information and communication technology in power systems, through the possibility of communication of the various network components state, which allow the implantation of control strategies and optimization of the network in a more efficient way than the currently in use (Falcão, 2009).

associate information of weather forecast services. Many possibilities open up so that the residents are aware about the energy demand to each choice, natural resources and, ultimately, the environmental impact. Furthermore, the user can know the best time to perform some activity, depending on the availability of energy or the prediction that these resources may be more or less abundant in the following hours.

The Solar Decathlon Competition

The Solar Decathlon is an initiative of the United States Energy Department that came up with the objectives to encourage the realization of academic research that makes the spread of solar energy use in houses more viable as well as the dissemination of this energetic alternative for the general public to adopt. Around 20 teams, representing universities throughout the world, must design, build and inhabit the most efficient, sustainable and innovative house that works exclusively with solar energy (thermal and photovoltaic). The teams, consisting mainly of students, must fulfill 10 contests that evaluate the innovations of the house, its capacity of energy generation and efficiency, the comfort, the spatial and constructive quality, the viability of implementation etc. The houses are built and tested on the campus of each university or university groups and then transported to the site of the competition. There they are assembled during one week, remaining in exhibition side by side for 10 days, while they are open to public visits and being tested. This competition traditionally takes place on the National Mall in Washington (Figure 1) since 2002. After the second edition in 2005, the event would happen every two years, always in the same place. In 2010, the Universidad Politécnica de Madrid, in conjunction with the Spain Ministry of Housing, organized the first version of the event outside the United States, which occurred in a recently created park on the banks of the Manzanares River, next to the Royal Palace, in Madrid (Figure 2). Besides the North American edition of 2013, there are editions planned in Europe, in Madrid in 2012 and in China in 2013.

Figure 1. Solar Decathlon 2009, Washington. Photo by Stefano Paltera/U.S. Department of Energy Solar Decathlon.

The North-American version has most of the competitors from universities of the United States and Canada, with some European participants. In 2011 there will be participating teams from New Zealand, China and Belgium, in Washington. On the other side, two Chinese and two North-American teams participated in the first European version, as well as teams from Spain, Germany, France, United Kingdom and Finland. The ten tests of the last competition, realized in Europe, were the following: Architecture, Engineering & Construction, Solar Systems, Energy Balance, Comfort Conditions, Equipments, Communication, Processing and Marketing, Innovation and Sustainability (Ministerio de Vivienda, Gobierno de España, 2009). The innovation and sustainability contests pass by the other eight contests and are one of the major differences in the European version. Probably this differential, combined with the amount of different participating countries, has given a greater diversity of proposals in Madrid than in the recent North American versions.

The competition represents for the participating universities an innovative opportunity in many ways (Yeang, 2007). The small house with a maximum area of 75m^2 allows different research groups, who normally work separately in their universities, to interact in the search of a maximum efficiency. It even enables a revolutionary form of collaborative learning to happen, integrating students of different areas that need to design, construct, develop a series of tests, correct construction or project problems and finally transport the result to the competition, where it is assembled, tested and visited. The success of the event showed the relevance of the initiative in the education of professionals, committed and capable of changing one of the areas with the highest potential in reducing the impact we cause on the environment. More and more, the educative aspect became one of the major concerns of the event, for students and researchers on the one hand, as well as for the public on the other hand.

Figure 2. Solar Decathlon Europe, 2010, Madrid. Photo by authors.

The Solar Decathlon represents an excellent opportunity for research and teaching experiences in the context of projects for residences towards a more sustainable society. One of the major challenges posted to the participating teams is really to establish a collaborative work among researchers from different areas. This challenge represents one of the main paradigms to be changed in the university teaching and research, if we really want to promote more sustainable buildings. With some significant exceptions, the teams represent a predominance of architecture schools members. The rather general education of the architects that includes disciplines of project which synthesize the knowledge of the related areas, seems to be a sign of a more collaborative preparation. However, all teams have difficulties establishing this collaboration, especially in the early stages of the projects. The integration of the different research in the design of the house is the great difficulty but at the same time, it is where the most successful experiences occur.

The residential automation and information systems in the Solar Decathlon

All teams participating in the latest editions of the Solar Decathlon used some kind of residential automation and information systems to manage the resources of their houses. Some of them have invested large amount of research and work in the development of these systems. Several systems allow remote access through cell phones and tablets, enabling the resident to control the systems while being away from home as well as being at home. The winning team of the European version of 2010, from the Virginia Polytechnic Institute & State University[2], presented a sophisticated system with interface for iPhones and iPads. As the houses are not always being occupied, their monitoring is essential in order to identify and correct eventual failures. The companies that develop photovoltaic systems already offer various types of monitoring. The North-American company SunPower develops extremely efficient photovoltaic panels and is therefore one of the most required companies by the participating teams. The company has developed a wireless monitoring system in screens inside the house, through web sites or iPhone, that allow the visualization of the energy production in real time or from historical reports (SunPower Corporation, 2011). Other companies, like those that work with air conditioning, offer similar solutions. However, the great challenge for the teams is the integration of these systems – often proprietary systems – into a single one which allows managing all systems of the house.

[2] Available at: <http://www.solar.arch.vt.edu> [Accessed 24 February 2011].

Figure 3. House of the Darmstadt University, 2009, and its residential automation and information interface. Photographs: on top by Stefano Paltera/U.S. Department of Energy Solar Decathlon and on bottom by authors.

The German team of the Technische Universität Darmstadt (Figure 3), winner of the 2009[3] North-American edition, developed a system (Figure 4) that made it possible through various monitors, which could be used outside the house, to obtain varied information about the performance of the house and to initiate scheduled tasks as well. The system menu was structured in 4 main areas: energy, temperature, light and sound. At first, the resident visualizes information on energy generation in each group of photovoltaic panels, energy consumption of the house, energy balance and saving values as well as on the domestic appliances. In the menu related to the temperature, you can execute the vents that regulate the systems of thermal mass to heat or cool the house in a passive way, or control the air conditioning and heating systems based on the information of air temperature, internal and external, and of the stored water in tanks. The opening of windows, the inclination and opening of the blinds as well as the illumination are controlled through the light menu and, from the sound menu, you select the music, volume and location where the sound system shall work. The integration of these systems facilitates managing the functioning of the house and in terms of climate variations it ensures a more sustainable use of the house.

[3] Available at: <http://www.solardecathlon.tu-darmstadt.de> [Accessed 28 July 2011].

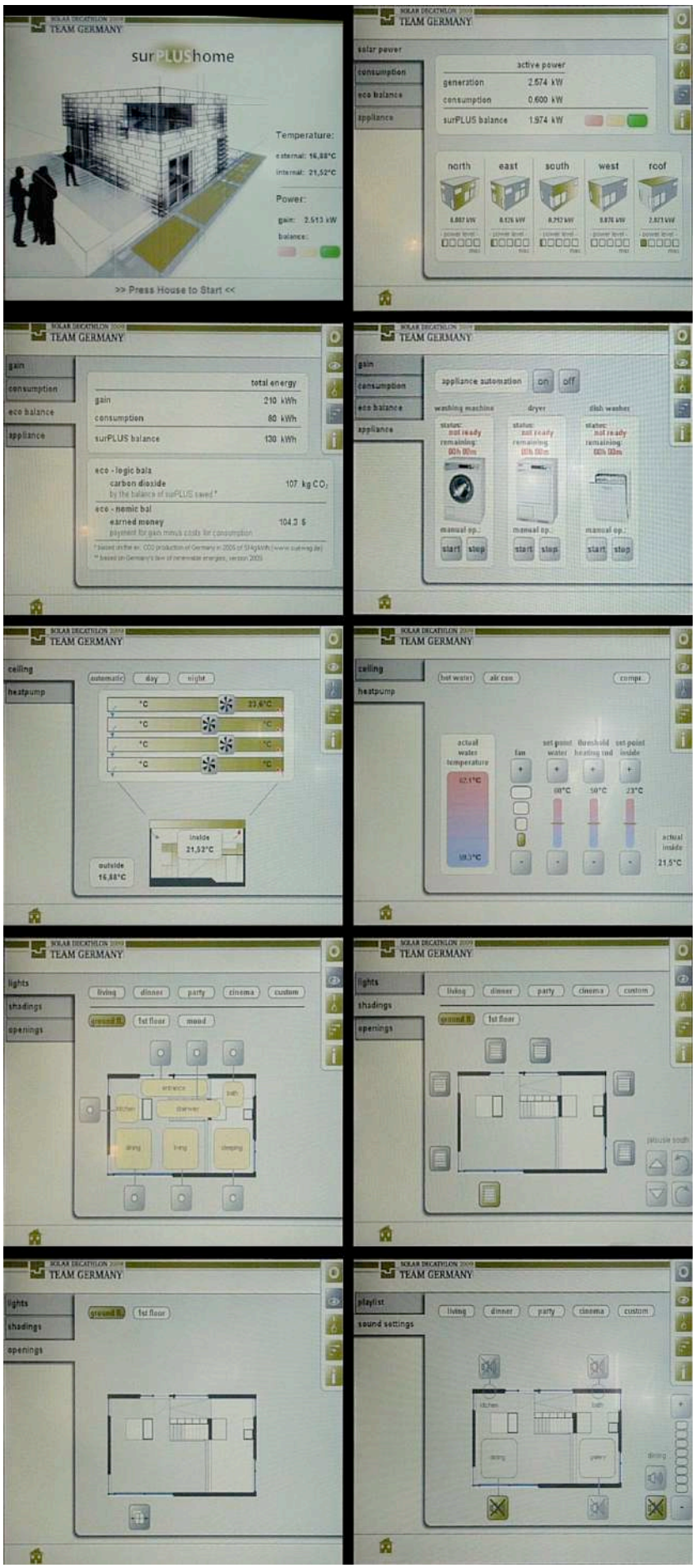

Figure 4. Images of the display of the residential system of automation and information of the Darmstadt University, 2009. Photos by authors.

The Darmstadt team was also the one which developed the best interface on the 2009 edition of the Solar Decathlon, which facilitated the visualization of the data and the decisions of the users. This is an area that is not much explored commercially, and even by the Solar Decathlon teams. The systems for the biggest part of the houses are still developed by researchers of the computing area and generally do not have compatible interfaces with its complexity of data and resources. The communication with users and consequently its usability is often compromised by interface problems.

The integration of meteorological data in the residential automation and information systems is still little explored. The visualization of these data would enable the resident to make decision based on anticipations of the houses performance in the next hours or days. It certainly would add a much greater complexity to the visualization of these data, but it would allow the user to save energy when the forecast foresees a reduction of the intensity of the sun, or to anticipate tasks, especially when the actual energy production is higher than the expected one in the near future or even, when a large amount of hot water is saved and a continuation of the sun hours is predicted.

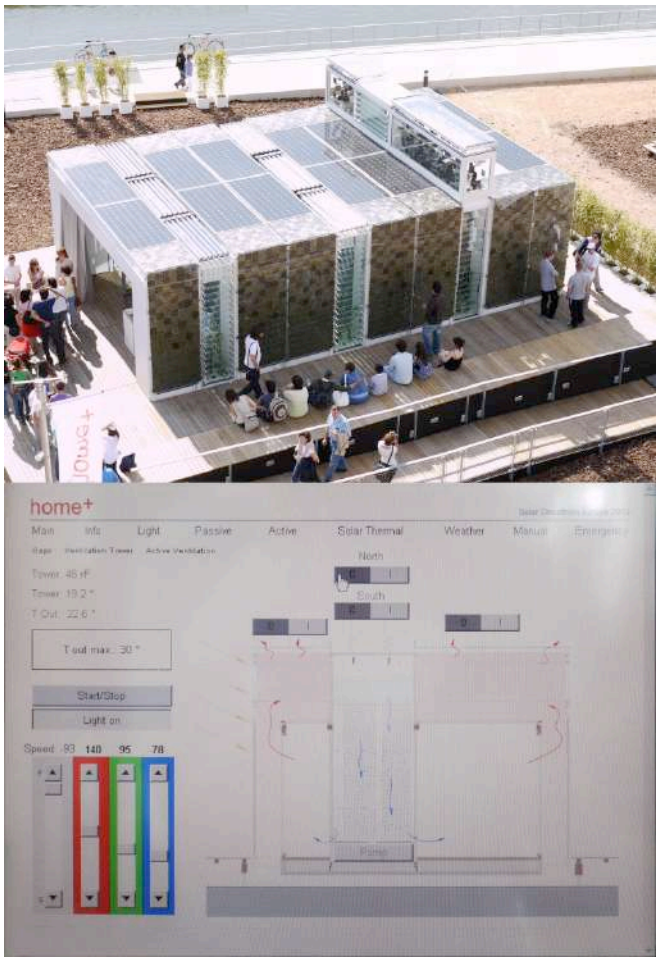

Figure 5. House of the Stuttgart University, 2010, and its residential interface of automation and information. Photo by authors.

The Solar Decathlon competition also values the integration of the technologies used by each team in the design of their houses. One of the verified directions is the integration of the solar systems on the facades. The best example of this direction is again the Darmstadt team when it used a moving blinds system, with photovoltaic cells on the external face in 2007 and created a facade with different types of photovoltaic cells in 2009. In 2010, the European event showed a great variety of such solutions and, among the teams that integrated solar systems on the facades, were the Catalonia Advanced University[4], the Stuttgart University[5] and the Valladolid University[6]. The automation systems, on the other hand, are still poorly integrated in these drafts. The greatest potential should lie within the visualizing and controlling interfaces, which are the most apparent elements of this system, constituted by frames of devices that connect sensors to other devices which command the automatized systems of the houses. The interfaces are also visualized through traditional tools, such as screens positioned on wall, through television or small movable monitors.

The sustainable management by data visualization

A search in late February 2011, at the Apple store for applications using the words "home automation" resulted in 74 app options only for iPad and 167 app for the iPhone. Most of them are offered by automation companies for the management of their products. The interfaces usually mix basic icons with reproduction of analog controls or rudimentary graphics. This observation is not a surprise, hence we do not even see graphics in the house systems of the Solar Decathlon, that are much more elaborated than the standard Microsoft Excel.

Residential automation and information systems of zero energy houses will be more and more complex, integrating big quantities of different types of data. These systems are intended for residents with differential education and should therefore prioritize the easy understanding, providing enough information for the user to operate it and mainly to take the most appropriate decision. For this reason, the design of the interface and data visualization is essential for the proper use of these systems and, what we see, is that it is undervalued by most of the developers.

Julio Bermúdez and Jim Agutter commented on an article about computer architecture – or information architecture – that "the vast majority of the XXI century control systems will necessarily be in an indirect way, through data representations" and that "there is so much information that is so complex and that accumulates and change so quickly that it seems impossible to be understood and, even less, to be used". They complement by saying that "we

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[4] Available at: <http://www.fablabhouse.com> [Accessed 24 February 2011].

[5] Available at: <http://www.sdeurope.de> [Accessed 24 February 2011].

[6] Available at: <http://www.urcomante.uva.es> [Accessed 24 February 2011].

cannot keep using quantitative methods of the early XX century, childish notions of human cognition and spaces of simplistic representation, when we should confront environments and computational demands of the third millennium" (Bermúdez and Agutter, 2005).

The residents of these new houses must manage a variety of interrelated data such as temperature, humidity and luminosity both internal and external, current and planned; production and consumption of electric energy; water temperature in the hot water tank; drinking water consumption and availability of rainwater; atmospheric pressure and wind speed and direction; consumption of water or electric energy by system or equipment; etc. The combination of the various residential technologies and the natural environment will determine the success of these new homes. We believe that the success of this combination passes through a visualization interface of data well done and clear. More than that, the visualization of these data will demonstrate the importance the cycles of nature have for these systems and how these cycles are linked to a series of phenomena that can be identified in nature. And it is these phenomena that we failed to appreciate in the course of history and the knowledge which made us living closer with the rhythms of the planet was being lost. Thus, it is likely that the interfaces of residential automation and information systems are a vital link with the cycles of nature and that our activities go back to being more linked to these cycles.

In that sense, the residential automation and information systems also have an important educative character. They enable a relevant impact in the dwellers habit changes and in the way they relate to nature. The preservations of natural resources, in a first and significant moment, is related to the drastic reduction of waste. The houses currently consume most of the drinking water consumed in cities as well as a big amount of electricity. They are also responsible for the biggest waste of these resources. For this reason, the increase of the efficiency and the reduction of waste in residential systems will have a great impact in the natural resources economy such as drinking water, electric energy and gas (Mayer, 2011).

Much of the waste reduction can be obtained through the awareness of the residents. The clarity in the visualization of the consumption and availability of resources is the main instrument for this awareness. The dwellers have their consumption data on the bills or the consumption meter registered when they pay for electric energy and drinking water utility. However, these data are extremely abstract, difficult to read and evaluate in order to effectively generate savings. The change in consumers' habits is related necessarily with the implementation of new systems for these data visualization. This fact is demonstrated by the efforts towards this direction of big companies such as Google or the Electric Energy National Agency (Agência Nacional de Energia Elétrica – ANEEL), responsible for regulating the distribution of electricity in Brazil. Google is launching through some utilities in the United States, United Kingdom and Germany, the Google PowerMeter (Figure 6), released as a free tool of energy monitoring (Google, 2011) and ANEEL pretends to change all the traditional clocks for smart meter devices. According to the director of the Electric Energy National Agency (ANEEL), André Pepitone da Nóbrega, "As this meter is connected to the utility, the

consumers have the information in real time about their consumption" (Jornal Hoje, Rede Globo, 17 February 2011, cited in Conselho Brasileiro de Construção Sustentável, 2011).

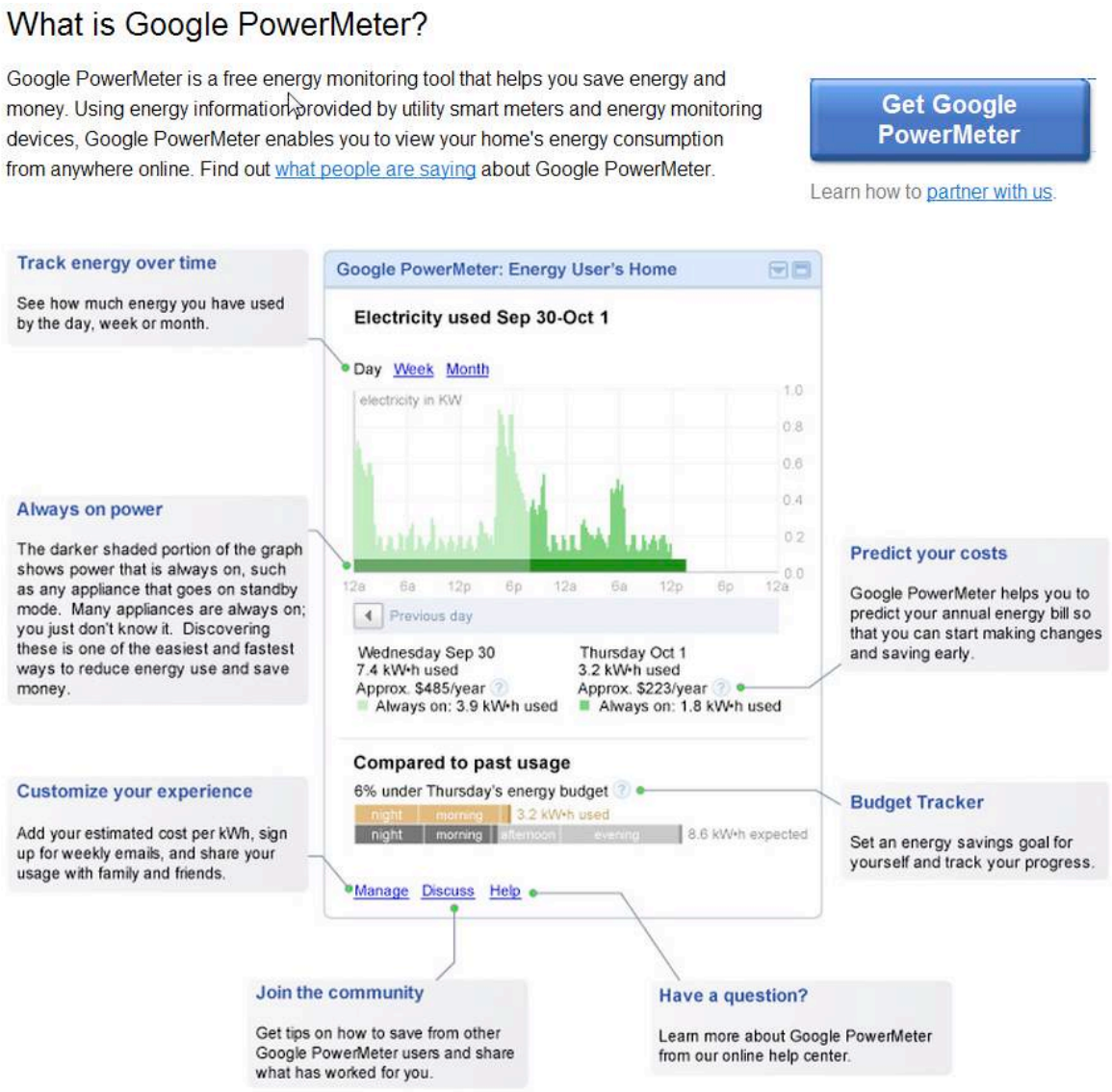

Figure 6. GoogleMeter. Source: Google.

Final Considerations

The development of buildings technologies, one of the main reasons for the gradual separation of men from their habitat, may now be one of the main vehicles for this reconnection. Systems that reproduce information, that primitive people understand much easier than modern men, would help to enhance this knowledge again. They would even clarify, that instead of simply inhabiting the Earth, we are part of it and its cycles are directly connected to ours. Residential automation and information systems, mediating environmental information with the residential systems can be facilitators of this movement.

Nowadays, we have a large amount of resources to visualize climatic changes on a planetary scale with its effects on our city. Climate alerts go beyond borders and are transmitted to

different countries or even continents. The increase of weather disasters and the development of warning systems, especially in countries with more technological resources, that are influenced by these phenomena, also show how they are connected. Earthquakes and tsunamis across the world display that we are all connected by just one ocean. In a parallel way, a series of social networks often present a higher efficiency providing real time information about these disasters than traditional media. They also demonstrate the global interconnection and our universal responsibility as humanity, both in terms of our actions in the world, the way we use our natural resources and energy, as well as in the way we discard what we do not want, affecting the local as much as the global network.

Cell phones have reached a mass scale and change in an unimaginable way our way of life. We can glimpse the monitoring systems of nature directly connected to the residential systems and to devices of mobile communication that approximate our activities to the cycles of nature. The densification of the cities should enhance important sources of natural resources like sun and wind. The zero energy houses and their residential automation and information systems can also change the patterns of the urban way of life and make even residents of dense cities change their relationship with our planet.

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