Taking the Guesswork out of Environmentally Sustainable Lifestyles

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Abstract

A large number of global environmental conferences, protocols, pacts and inter-governmental panels have been doing some excellent work in providing long-term guidelines, regulations and credible data for making decisions as well as for actions needed. However, a majority of these are geared towards large organizations such as governments or corporations. There is a considerable potential for impact by targeting individuals and providing them with relevant information to induce small incremental steps that can collectively result in large impacts. The focus of this paper is to identify ways and means wherein pervasive sensor-based technologies can assist individuals, who are unaware of global environmental protocols, in making daily decisions which can result in an environmentally sustainable lifestyle. Specific scenarios are discussed which explore the use of existing technologies where feedback can be provided to an individual for his/her actions. This feedback could use real-time collaborative data as well as historical trends and averages.

1. Introduction

1.1. Daily Lifestyle Trends In Energy Consumption

The use of energy in daily life is unavoidable. It is important to understand energy use distribution by end use in order to understand where the largest savings impacts are possible by user intervention. In the United States, the Energy Information Administration (EIA) provides data, forecasts, and analyses to promote sound policy making and public understanding regarding energy and its interaction with the economy and the environment. Looking at electricity consumption by end use in US households closely reveals that household appliances, including refrigerators account for over 50% of US household energy use[1]. Equipping the end users and/or appliances with energy meters as well as communications capabilities can be a first step in providing feedback to users.

This is where pervasive networks with distributed sensors can provide significant benefits by way of providing feedback to individual within households as well as by making these data available to a larger database to progressively improve the rigor in policy making and implementation. Coupled with real-time feedback to users about the environmental impact of their usage patterns (amount of

[1] **U.S. Energy Information Administration**, from http://www.eia.doe.gov/emeu/recs/recs2001/enduse2001/enduse2001.html, accessed 2008-01-05

resultant carbon emissions, etc.) *and* concrete suggestions to reduce their impact, there is a significant potential to achieve widespread and radical levels of impact reduction.

2. Using Pervasive Ad-Hoc Networks for Making Environmentally Sustainable Lifestyle Choices

2.1 Current Applications of Sensor Based Networks

Buildings have long used sensor-based Building Management Systems (BMS) or Energy Management Systems (EMS). A BMS/EMS is typically defined as a fully functional control system, which includes sensors, controllers, various communications devices and the full complement of operational software necessary to have a fully functioning system[2]. In addition, there are also industry-accepted data communications protocols such as BACnet[3] (Building Automation and Control Networks), that have been designed to meet the communication needs of various building systems and the information is made available to building operators and facility managers.

However, with the increased interest in green buildings and the resulting need for providing feedback and education to users; there are some products/systems that are more geared towards providing building users/occupants with real-time feedback on the reduced environmental impacts of buildings that have been designed as green or energy-efficient[4]. These products typically tie in with building automation and control systems to provide feedback to users/occupants. Furthermore, wireless applications too are coming to the fore[5]. At a larger scale, Automatic Meter Reading (AMR) is gradually and increasingly being adopted by utilities and offers exciting possibilities in the context of this discussion. From UtiliMetrics[6], AMR is the remote collection of water, gas and electric consumption data from customers' utility meters using remote sensing technologies.

2.2 Use of Pervasive Technologies to Encourage Action and Change.

The first step in making sustainable lifestyle choices would be to provide the end users with a simple, easy to understand view of their energy consumption as described in 1.1. Simple energy meters are available[7] that can measure “Watts” used by various appliances (dryers, water heaters, air-conditioning, etc) and can make a cumulative reading. These can be easily extended to provide a SMS alert or an email at every periodic time interval (every 24 hrs) to the end user. This would enable the user to get an accurate idea of their energy consumption. Similar energy meter readings collected from a community in the same neighbourhood and hence having similar space heating and cooling requirements can provide energy usage patterns and comparisons to the members of

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[2] See **DDC Online**, http://www.ddc-online.org/intro/intro_chapt01.aspx for a description, in generic terms of “Direct Digital Control” systems; accessed 2008-01-05.

[3] See **BACnet - A Data Communication Protocol for Building Automation and Control Networks**, http://www.bacnet.org/, accessed 2008-01-05.

[4] See iBPortal™ and GreenTouchscreen™ from Quality Attributes on http://www.qualityattributes.com/; and Building Dashboard™ and IRIS™ from Lucid Design Group on http://www.luciddesigngroup.com/; accessed 2008-01-05.

[5] See ArchRock – Applications for Environmental Monitoring on http://www.archrock.com/applications/, accessed 2008-01-06

[6] See Utilitmetrics – About AMR on http://www.utilimetrics.org/about/amr.htm, accessed 2008-01-10

[7] See Kill-A-Watt devices made by P3 International, http://www.p3international.com/products/special/P4400/P4400-CE.html; accessed 2008-01-06.

that community in a collaborative manner. These comparisons can also provide classification based on the type of appliances used and their specific brands, to help determine the most effective and energy-efficient appliances. An intuitive user interface and easy to understand information is imperative in enabling the end-user to take relevant action. Devices like MorePower Multi[8] are possibly the next generation of "smart-energy meters" which provide actionable and easy to understand information. To make this more actionable, such a system maybe enhanced so as to provide examples of simple everyday actions and how they can reduce energy use, costs and emissions, on a daily, monthly and annual basis; without compromising quality of life, such as running your refrigerator on the "Medium-Low" setting (typically 3-4°C), instead of the "High Cool" setting (typically 1°C); running your hot water at 50°C at opposed to 55°C; changing all your light bulbs to compact fluorescent lamps, etc.

A logical next step to collecting data and information is to analyze the same and to determine how it compares to that of the people around. A fair amount of information is available on personal carbon trading, such as the RSA CarbonLimited project[9].

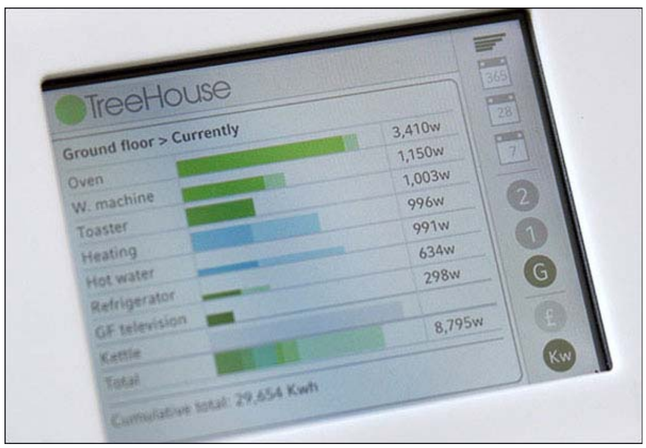

Figure 1: Image MoreAssociates

According to the U.S. Environmental Protection Agency (EPA), typical annual CO_2 emissions due to electricity are 16,290 pounds (7.39 metric tons) per household, assuming approximately 900 kWh per month, while typical annual CO_2 emissions of 11,000 pounds (4.99 metric tons) per household based on national average monthly consumption of 7,680 cubic feet of gas; amounting to a total of 27,290 pounds (12.38 metric tons) of CO_2 emissions for household energy use[10]. In comparison, annual emissions from a typical passenger vehicle are estimated at 5.5 metric tons of CO_2 emissions[11]. Given the nationwide average of nearly two vehicles per household[12], vehicles can be seen to contribute as much to household emissions as electricity and natural gas.

An extension to the household energy meters is to fit vehicles with "mileage meters". These meters show the mileage given by the car over a short period. The mileage data of the car as well as of the cars driving around it can be made available to the driver using vehicular networks. The advantage

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[8] See MoreAssociates energy literacy, http://www.moreassociates.com/research/energy_literacy, accessed 2008-01-06.
[9] Carbon Limited, exploring personal carbon trading, from http://www.rsacarbonlimited.org/viewarticle.aspa?pageid=577&nodeid=1; accessed 2008-01-06.
[10] http://www.epa.gov/climatechange/emissions/ind_assumptions.html; accessed 2008-01-10
[11] http://www.epa.gov/otaq/climate/420f05004.htm; accessed 2008-01-10
[12] http://www.bts.gov/press_releases/2003/bts019_03/html/bts019_03.html; accessed 2008-01-10

of providing real-time collaborative data would be to provide the end-user with information which is relevant and specific to the vehicles which are being driven in the same environmental and road-conditions but providing better mileage. This can lead to a competitive outlook to getting the best mileage possible. This is similar to a multi-player video game where the statistics for each user are displayed on the screen and the players try to better their games based on the opponent's scores and skills.

About the authors:

Ronak Sutaria is an Entrepreneur at Urban Sensors and a Senior Engineer with Arcot Systems. He has travelled nationally and internationally as a technical solutions architect and has extensive experience with enterprise-level e-commerce applications. He has a Master's degree in Computer Science from the New Jersey Institute of Technology where he did his thesis in the field of Anomaly based Malicious Code Detection and took courses in Advanced Networking, Mobile Computing and Sensor Networks. He has peer-reviewed papers for the ICPS 2006 and worked, in an academic capacity, with technologies such as TinyOS, nesC, Maté and Trickle. He has a keen interest in applications of sensor based technologies to urban cities in developing countries.

Aalok Deshmukh is a Senior Consultant with Rocky Mountain Institute's Built Environment Team, and has over 5 years of experience spanning contributions to more than 125 projects. He has a Master's degree in building science from Arizona State University; and has published several peer-reviewed technical and research papers. He is a LEED™ Accredited Professional and part of the U.S. Green Building Council's LEED certification review team; and has served as an elected member on the LEED NC Core Committee. He has a keen interest in the development and application of appropriate technologies, standards, and sustainability indicators as they pertain to the environmental impact of buildings—across various corporate and international contexts in general—and especially in India and other developing economies.

Motivation for attending the Pervasive Persuasive Technology and Environmental Sustainability workshop:

The conference is addressing a lot of the real-world sustainability issues. The idea of motivating people in real time to take action based on concrete data is very appealing. The use of pervasive technologies in such a scenario, if made intuitive enough, seems very plausible. The authors also have a keen interest in making these technologies viable and accessible across the economic divide.

The hands-on and interactive nature of the workshop seems like an excellent platform to understand the current knowledge base of the participants on these topics as well as brainstorm new realistic ideas. The idea of keeping the participants engaged beyond the workshop is especially exciting. The design challenge 2009 would be an interesting exercise to know how practical some of the ideas are and to be able to collaboratively design some of these prototypes.