Leveraging residential energy management through the Internet of Things

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Abstract

Energy consumption in buildings accounts for about 40% of the total energy used. It has been continuously increasing over the last 50 years, in particular electricity by 54% since 1991 in the residential sector. In large parts this increase can be backtracked to the growing number of electrical appliances. While most large appliances (e.g., dishwashers, washing machines, etc.) have become more efficient over the years the numerous small appliances introduced into the residential environment contribute significantly to today's energy consumption. However, there exists a lack of transparency and support with respect to the energy consumption that allows residents to address important questions. How to save electricity or adjust your behavior if you don‘t know how much you consume? How to set efficiency goals without access to consumption data? Until now it was difficult for consumers of electricity (or other forms of energy) to answer these questions. “Smart” pervasive computing technology can help to generate this information and in combination with its feedback and automation capabilities leverage energy saving effects thereafter.

Energy conservation that can be achieved in an automated fashion is the most desirable form of energy savings. However, while the industrial and commercial domain still offer many opportunities for energy saving through automation and optimization with classical information and communication technology, this is more difficult in a highly individualized home environment. Recently, technological progress, such as the advent of smaller and more powerful hardware that can be embedded into every day's objects (e.g., low-power sensors, cheap wireless communication, embedded Web servers, etc.), offers new opportunities to conserve energy.

While such automated energy savings without much user involvement are preferable, yet, some important savings can only be achieved by taking consumers “in the loop”. User-induced saving effects mainly result from two factors: First, the energy demand of many appliances and systems is highly dependent on how we operate them. Energy consumption in identical homes can easily differ by factor two or more, depending on the inhabitants' behavior. Second, the decision to invest in efficient appliances and energy saving technologies is, within the limits set by the regulator, up to the user. Therefore, awareness and the willingness to take action are crucial and can only be achieved with adequate information at hand.

Thus, conserving energy in residential spaces requires making use of automated savings wherever possible as well as the provisioning of consumption information where necessary. Both can be addressed with the help of Pervasive Computing and the Internet-of-Things. A networked interconnection of physical appliances combined with features becoming available through the smart grid (e.g., demand response) can enable automated savings in the background and mostly invisible for users, which will be without doubt essential to reach the saving targets. Utilizing the sensing and visualization capabilities of ubiquitous technologies (e.g., smart phones) enables new forms of user interaction and engagement, which is important to foster energy efficient behavior.