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Using human-powered products for sustainability and health: Benefits, challenges, and opportunities

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ABSTRACT

This paper presents a novel research work on the potential benefits of using, a unique and sustainable energy source - the human-power. The paper discusses the benefits and the practicality of using human-power as a domestic energy source to power electrical and electronic devices and explores the benefit of its use in a more diverse perspective for possible change in behaviour and energy savings for improved sustainability in the society. The economic and sustainability gains of using Human-Powered Products (HPPs) are investigated. Two studies have been conducted, the first is a study which involves assessing the environmental impact of a human-powered products via Life Cycle Assessment (LCA); and the second is a case study called Home User Study (HUS), where the technology is experimentally tested. The human-powered system is used to explore the real benefits and life-cycle analysis towards assessing the sustainability of such products. The Home User Study (HUS) has been conducted to explore the in-situ use of human-powered systems using a new prototype that has been built and deployed. The study has used a monitoring device to measure the outcome of the interaction between the user and human-powered products. The results interestingly have revealed various other forms of benefits beyond renewable energy that could add extra motives for using human-powered products, such as health benefits. The paper also puts an emphasis on the opportunity of using Human-Powered Products which can be perceived as a great viable solution against counter measuring social issues such as physical inactivity and increasing sedentary behaviour. The results of the theoretical study indicate that Human-Powered Products (HPP) do not offer significant financial savings. The results of the HUS indicate that using human-powered products for health prospective outweigh the benefit gained from the prospective of energy savings and renewable energy. Based on the findings of this study, the paper suggests an approach that shows how the implementation of Human-powered systems could provide the opportunity to sustainable energy generation and energy savings, but in all cases they can be retained through a motivational drive in improving the health benefit via encouraging physical activities.

1. Introduction

Renewable energy has been attracting significant attention in recent years to reduce pollution and at the same time to provide sustainable and clean source of energy. The most common types of renewable energy are solar, wind, tidal, geothermal and wave. These developments therefore promote new technologies of renewable energy production as well as encourage a new culture of energy consumption. One of the sustainable and renewable energy resource that has not been recognised is the use of human-power. This paper discusses the implications of using human-power as a domestic energy source to power or control electrical devices and the expected impact towards sustainability.

In developing countries where there is a lack of energy and comfort, people use human-power as a sustainable way to achieve many daily tasks at home and work. Physical activities and human-power normally include activities such as walking for long distances for water access, cycling to work, collecting animal waste as fuel for daily cooking, and grinding grains. This societal lifestyle does not depend upon the need of using fossil fuel and hence carbon emission; and at the same time, keeps people physically active and prevents obesity. In developed countries, on the other

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hand, people are surrounded by modern technologies and transportation, which may avail reducing the required physical activities and consumes more energy per capita. This is causing, not only pollution and carbon emission, but also causing physical inactivity, obesity epidemic and many public health problems.

As recently as 150 years ago, human-powered products (HPP) were the norm in every nation, e.g. hand crank grinder, bicycle, pedal-powered lathe and sewing machine. However, with the development and wide-spreading of the electro-mechanical motors and electricity, everyday 'products' have evolved significantly. Simultaneously, using human-power for powering such products has also gradually diminished (Dean, 2008). Technologies have been constantly evolving and through these advances, our life styles have become notably more efficient. The ever-increasing efficiency of products offers a convenience that less and less physical human effort is required to carry out a task. However, will it be possible to abandon these new accustomed efficiencies and use the human-power once again to power electrical devices or perhaps create new practice? The bicycle is a great example of a means of utilising relevant human-power that allows user to exercise, transport, and save consumption of conventional energy at the same time. If, for example, we can design human powered systems to become more 'entertaining' or 'a necessity', this may be an optimal method for encouraging new behaviour of using human-power, and hence reduce energy consumption.

In the past two decades, there has been an exponential and significant increase in the number of consumer electronics and portable electronic devices providing increased mobility; and new applications of ICT (Information and Communication Technology) related devices such as mobile phones (Bertoldi and Atanasiu, 2007). The increase in electricity consumption from using consumer electronics such as televisions, home computing, tablet PCs and other power supply units outstands as their energy usage are still at an incremental rate (DECC, 2011). Human-powered products (HPP), has been perceived in recent research as alternatives to mobile battery running electronic products (Jansen, 2011; Jansen and Stevels, 1999), and a generator to power electronics in rural communicties (Louie et al., 2010). Scholars have often looked at parasitic ways to harvest the energy from daily human movements such as using children's play energy (Pandian, 2004), using walking energy to power implantable medical devices (Jia and Liu, 2009; Rao et al., 2014), and using body heat to power wearable computing devices (Starner, 1996). Such products are considered as one solution to curb the energy related problems caused by the increase in Energy using Products (EuP). In other words, EuP can be powered by human-power and therefore no longer relies on the use of electricity from the grid. Another aspect to human-power that can be worthy of attention is the availability and portability of energy generation. Despite the rapid growth in wireless and portable electronics, power storage technologies of EuP have been lagging. It is assumed that its power storage capacity or energy density will never satisfy its frequency of usage. Thus, against these proliferated usages of portable electronics, human-power becomes a more viable and practical solution.

Arjen Jansen (2011) has described the advantage of using human-powered devices. Three benefits of a HPP from eco-design stand point, and they are (Jansen and Stevels, 2006, p.499): (1) material benefit as they do not consume energy from non-renewable resources during the use-phase of the life cycle; (2) immaterial benefit in the convenience of having power available all the time; and (3) emotional benefit as human-powered products enhance the quality of life by making the consumer feel environmentally pro-active.

However, the frequency of HPP use has not been well investigated, especially in understanding the motivational factor and the links to physical activities. Considering the rapid growth of efficiency in many electronics, it is realised that ever decreasing wattage of EuP power use makes the feasibility of human-power may perceive more practical. This would mean that the physical activities needed in generating the required power and performance of using stored energy will likely be reduced over the years. For example, a study conducted by Louie et al. (2010) shows that 80 percent of full voltage of a mobile phone can be charged in 1 h (hour) using the small human-powered generator. The key question that the authors would like to address in this paper is: can we still live in a developed society but also improve its sustainability by bringing back or integrate the daily physical activities? Can human-power be used to address excessive energy consumption and/or improve health and well-being of the society in more innovative way?

This paper starts with a literature review with a theoretical investigation of the benefits of human powered products. Arguments made by scholars in the field to outline different types of factors that are involved in understanding the benefit of using HPP are discussed. An experimental Home User Study to investigate the benefits of HPP is presented, where the change in behaviour of introducing this physical activity of using human-power are explored via condition of watching TV in a domestic environment. The findings of this work are discussed and analysed in the results and discussion section followed by the conclusion.

2. Theoretical investigation of the benefits of human-powered products

2.1. Direct benefits: financial benefit and environmental impact

The cost factor may be a real driver when consumers decide to purchase a HPP. The amount of potential savings may work as a stimulus for their purchase or they may consider the size of the required contribution against the value of money invested. For example, running a 100 Watt TV for an hour will cost about an average of £ 0.0145 (based on £0.145 per kWh in the UK). This means the cost savings for applying human labour to power 1 h worth of TV watching will be equal to this figure. It can be argued that this is an insignificant benefit. However, in the case of using HPPs as replacement to battery running products, the cost benefit brings a different view due to further consumption of batteries. A study conducted by Jansen et al, (1997) concludes that in between 1.4 and 2.9 y, the environmental impact of the battery powered radio will equal the value of human-powered radio; as known as 'break-even point' (Jansen, 2011).

Whilst recognising the potential of using human-power as alternative power for EuP, HPP should not solely be considered as battery replacement but also for the 'plug-in' power. It can be assumed that the increased use of HPP in household through substituting existing EuP will entail some incentives by being off the power grid. A quick simple calculation can be measured to predict the potential incentive size. For example, a report shows that the average in-use power consumption of table top/portable radio (DAB) measures at 2.04 Watt (MCMS, 2013). An average weekly listening hours per listener is 22.6 h (RAJAR, 2011). Therefore, 0.00204 (kW of radio) x 22.6 (average h/w) x 52 (weeks in a year) x £0.145 (average cost per kWh in UK) is equal to £0.3476. Therefore, it can be stated that the incentive of using HP Radio over the plug-in power radio is compensated at a rate of saving of £0.3476 per year. If these figures are used in total life cycle cost, the average cost of the radio is approximately £25, when this is divided by £0.3476, it will require 72 years of consistent use of HP Radio to meet the 'break-even point' for the cost of ownership.

In speculating a 'break-even point' from environmental impact