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Energy perceptions in South Africa: An analysis of behaviour and understanding of electric water heaters

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ABSTRACT

Using data from an online national survey conducted in South Africa, this paper aims to investigate: the awareness of energy savings measures for electric water heaters (EWHs); whether or not consumers are implementing suggested measures; and if consumers understand and effectively control their EWHs' energy usage. Additionally, the data is used to determine the success of educational and rebate programmes aimed at reducing residential energy usage and to determine possible motivations for encouraging users to reduce or alter their EWH energy and warm water consumption. The results of this questionnaire indicate that: convenience is a key factor in consumers' willingness to implement curtailment actions; users don't understand the energy consumption of their EWHs; and they don't know how to control their EWHs efficiently.

Introduction

South Africa is currently in the midst of an energy crisis as the national utility, Eskom, is unable to meet the nation's energy demands. However, this is not the first time the country has faced an electricity shortage. The start of 2008 saw the implementation of rolling blackouts (i.e. load shedding) across the country, which have subsequently returned. These blackouts typically last 2 to 4 h and are implemented at different times according to the pressure on the grid and the area in which they occur. Additionally, these blackouts can be implemented during business hours, which has a devastating effect on the country's economy, with a predicted cost of R89 billion (US$ 7.2 billion) per month to the private sector due to lost production, revenue and wastage (Mannak, 2015).

Since the beginning of the energy crisis in 2008, the government and Eskom have implemented various programmes to reduce the pressure on the national grid by promoting energy efficiency. The first of these initiatives is the Power Alert system which displays public messages on national television that are used to inform homeowners of the status of the national electrical grid (Eskom, 2015a). Additionally, users may also view forecasts of the national electrical demand for the current day in half hour intervals. These messages are divided into four colour-coded alert states (green, orange, red and black) which indicate the increasing severity of the load on the national grid. Each message also presents suggestions on which appliances to switch off during the present state. For example in the red state (second most severe) users are instructed to switch off lights in all unoccupied rooms as well as their electric water heaters (EWH), pool pump, air conditioner, dishwasher, tumble dryer and stove.

Additionally, the solar water heater (SWH) rebate programme is a joint effort from the South African Department of Energy (DoE), Eskom and the National Energy Regulator of South Africa (NERSA) and is aimed at promoting the use of alternative energy. Initially, Eskom subsidised the purchase of SWHs to incentivise households to heat water using solar power. The programme aimed to install one million SWHs by 2013 but only between 400,000 and 420,000 installations have been subsidised to date (Moodley, 2015; Pressly, 2015). Although the programme fell short of its ambitious target, it has still been successful in reducing national demand and providing warm water to communities who are not on the grid. However, Eskom has since withdrawn from the programme and it is presently being managed by the DoE, which suspended the programme due to numerous inefficiencies (e.g. poor quality of installations, lack of verification of number of installations). Additionally, the overall penetration of the SWH technology is still severely limited. A recent national household survey consisting of 2518 participants conducted by the DoE indicated that only 1% of surveyed households had a SWH installed (Department of Energy South Africa, 2013), indicating that the number of installations may be significantly lower than the reported estimates.

Interest in smart grids has been demonstrated by the establishment of the South African Smart Grid Initiative (SASGI) under the South African Energy Development Institute (SANEDI). SASGI was created with the purpose of assisting in the development of the South African smart grid and providing inputs and direction for related policies. South African municipalities are already in the process of conducting smart grid related pilot projects (Slabbert, 2015). The City of Johannesburg and its power utility, City Power, are presently implementing a

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smart metering pilot project in certain suburbs which is aimed at reducing the effect of load shedding on its customers (residential, businesses and industry). Requests are sent to consumers, prompting them to reduce their usage to a specified limit, using messages sent via short messaging service (SMS) as well as the smart meter's in house display (IHD) unit. Since the IHD displays their present consumption, customers are able to disconnect appliances (e.g. stove, EWH) until their consumption is below the specified limit. If consumers fail to comply they will experience a 30 s power cut, followed by 30 s of power provision in which to reduce their usage. This process is repeated five times or until the user complies with the request. If consumption is still above the given limit after the fifth iteration, a 30 min power outage is implemented. After this 30 min period has expired the process is repeated until the user complies or load shedding is suspended. A total of 65,000 households were equipped with the smart meters necessary to implement this scheme in April of 2015 and this number is expected to reach 150,000 by October 2015 (Slabbert, 2015).

Eskom has also released educational material, including several brochures, savings tips and videos, relating to energy conservation practices for commercial and residential customers (Eskom, 2015b). Since EWHs are one of most energy-intensive appliances in households, this material includes several means of reducing the energy consumption of EWHs. For example, the EWH fact sheet published by Eskom suggests lowering the set temperature of the EWH, resulting in a reduction in the standing losses. Eskom also produced educational videos that encourage users to switch their EWH off during peak hours (5 pm to 9 pm). Although this may have no net effect on the overall usage of the EWH, it reduces the peak demand on the national grid. Other proposed methods of reducing warm water energy consumption include: insulating the EWH tank and pipes to increase its thermal resistance; and the use of SWHs, which may not reduce users' energy consumption, but can reduce the pressure on the electrical grid as energy is obtained from an alternative source.

Contribution

Using data from an online national survey conducted in South Africa, this paper aims to investigate: the awareness of energy savings measures for EWHs; whether or not consumers are implementing suggested measures; and if consumers understand and effectively control their EWHs' energy usage. Additionally, the data is used to determine the success of the aforementioned programmes in reducing residential EWH energy usage and to determine possible motivations for encouraging users to reduce or alter their EWH energy and warm water consumption.

The rest of this paper is organised as follows: Related work section describes related work in examining household perception on energy usage; Survey description section describes electricity supply in South Africa and the demographics of the survey participants; Results section discusses the results of the survey conducted; and Conclusion section concludes the paper.

Related work

Attari et al. (Attari et al., 2010) conducted an online national survey which included 505 participants in the United States of America (USA). The survey was aimed at investigating the public's perception of energy consumption and savings for several household, recycling and transportation activities. Participants were first asked about the most effective strategy they could implement to conserve energy. The majority of participants responded with curtailment actions (e.g. use appliances less) as opposed to efficiency actions (e.g. using energy efficient light bulbs). This might be attributable to the cost associated with efficiency improvements in comparison to curtailment actions which have no cost (e.g. reducing speed in comparison to purchasing low-rolling resistance tires). Gardner and Stern (Gardner and Stern, 2010) found that efficiency-improving actions tend to save more energy than curtailing the usage of inefficient appliances for realistic alternative scenarios for households in the USA. However, it should be noted that there may be unforeseen consequences as a result of these efficiency improvements. A rebound effect may occur when consumers use efficient appliances more regularly as a result of their efficiency, which can result in a net increase of energy consumption (Hertwich, 2005). Participants were then asked to estimate the energy used by nine appliances (e.g. a laptop) and the energy saved by six household activities (e.g. replacing incandescent bulbs with compact fluorescent lamps). The results of this data indicate that individuals underestimate energy use and savings by a factor of 2.8 on average, suggesting that information on the energy use and potential energy savings may have positive influences on household energy conservation.

Iwata et al. (Iwata et al., 2015) conducted a household residential survey with similar aims to that of Attari et al. but for a Japanese sample group. The survey was conducted in Soka City, a suburb of Tokyo, and included 250 respondents. In contrast to Attari et al., their results show that individuals overestimate the benefits of energy savings actions by US$ 100 per year on average. The difference in the results from these studies suggests that the provision of information about the benefits of energy saving actions may be an effective policy to address global warming issues in one country but not necessarily in all countries. For example, consumers may cease an energy-saving action if they are informed that they are overestimating the financial benefits of the action. However, the results also show that there are disparities amongst individuals and indicate that energy saving initiatives should be targeted at specific individuals as well as specific activities. For example, they found that a 70 year old married woman who lives with several family members underestimated the impact of energy saving actions with a large associated benefit (i.e. more than US$ 45 per year). In comparison, a 20-year-old unmarried man who lives alone overestimates the monetary benefits of all energy saving actions, indicating that individual perceptions may differ significantly from the average.

The DoE of South Africa (Department of Energy South Africa, 2013) conducted an annual national household survey with the purpose of obtaining information about the energy related behaviour in South Africa (2518 participants), including non-electrified households and all end uses of energy (cooking, space heating, etc.). Their survey reports on the public awareness of energy savings measures, such as closing windows and doors when an electric heater is in use. The results indicate an increased average awareness of 10% over the previous year, with a maximum increase in awareness of 19% for boiling only as much water as needed. Additionally, the survey also investigates the number of respondents who are aware of these measures and practice them as part of their lifestyle. Table 1 shows a summary of the energy saving measure awareness and practices relating to EWHs. From these results, it is clear that individuals are more aware of curtailment actions than efficiency actions for their domestic warm water energy usage. Additionally, individuals are also much more likely to practice curtailment actions, such as switching their EWH off intermittently, than efficiency actions, such as insulating their EWH and pipes.

The survey also investigated which policies individuals believed should be prioritised by government (e.g. free energy for low income

Table 1
Awareness and practice of various energy savings measures in South Africa. (Department of Energy South Africa, 2013).

Energy saving measures	Aware (%)	Practice (%)	Aware vs practice (%)
Take short shower or bath with minimal water	47	26	55
Switch off EWH at certain times	56	28	51
Insulate your EWH and pipes	28	6	22
Install SWH instead of EWH	37	4	12