
# Are South African consumers arm-chair environmentalists? Implications for renewable energy

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# Are South African consumers arm-chair environmentalists? Implications for renewable energy

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**Abstract**

Discussions between policymakers about renewable energy have gained momentum in recent years, amid growing recognition of the need for more investment in green energy sources. The question is whether households in developing countries like South Africa will support green energy actions if it comes at an additional cost or whether they are simply arm-chair environmentalist. To assess this, we use the contingency valuation method (CVM) to identify the determinants of support for renewable energy. It is vital that households' determinants of the additional cost burden associated with renewable energy are assessed, in an effort to win public acceptance of the introduction of renewable energy. The US$966 willingness to pay (WTP) for renewable energy represents a significant premium over generation costs, and signals social acceptance of renewable energy. Most importantly, given the wide degree of heterogeneity in WTP models, a clear message to policymakers and stakeholders is that they need to do more to communicate the economic and environmental benefits associated with renewable energy.

***Keywords:*** bivariate probit, renewable energy, willingness to pay.

## 1 Introduction

In terms of global warming, coal is the worst offender, as it is a dirty energy source. There are various damaging environmental impacts associated with coal during its mining, transportation, combustion and disposal. Our focus is

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on the impact that is associated with combustion. Air pollution from coal-fired power stations includes carbon dioxide emissions, which are cited as the primary cause of global warming. According to the International Energy Agency (2015) countries around the world are working together to address climate change, a major cause of which – greenhouse gas emissions – originates from energy production.

South Africa is the biggest polluter in Africa and among the biggest in the world – mainly due to emissions from its coal-fired power plants. Cohen and Wrinkler, (2013) state that Eskom alone emitted approximately 230 million tons of carbon dioxide from its coal power stations in 2012. Eskom, (2015) argue that this is mainly due to the age of the power stations, which are inefficient and produce high volumes of carbon dioxide.

The abundance of cheap coal in emergering economies like South Africa has provided little incentive for significant investment in other energy sources, such as renewable energy. The need for electricity generation to be clean and safe has never been more obvious. South Africa has traditionally made up the shortfall from coal-fired power stations with nuclear power. According to the International Energy Agency (2015), the conclusion reached after Fukushima is that renewable energy is now favoured over nuclear power around the world. In 2014, 128GW of new renewable energy capacity was installed worldwide.

In light of mounting power outages in South Africa, a balanced energy mix towards renewables is seen as the best strategy to safeguard energy supply. Discussions between policymakers about renewable energy have gained momentum in recent years, amid growing recognition of the need for more investment in green energy sources; hence, we consider the factors that affect the public's support for renewable energy.

It is recognised that by increasing renewable energy use, significant cuts in global warming emissions can be achieved, as well as a reduction in the heavy reliance on coal and other fossil fuels. However, compared to fossil fuels, most renewable energy sources require significantly large capital investment, which is scarce in developing countries. A move towards this cleaner, healthier energy source may come at an additional cost to households.

According to Zografakis *et al.* (2010) and Walwyn and Brent (2015), the costs of some renewable-energy-generating sources (e.g. wind and solar photovoltaic, or PV) have decreased, and there is a possibility that they will continue to decrease in the near future. These recent developments will enable developing countries such as South Africa to invest more in renewable energy. That said, it is important to ascertain households' WTP for renewable energy.

The primary objective of this study is to assess support for renewable energy. In this study, the contingency valuation method (CVM) is used to identify the determinants of support for renewable energy. New investment is required to expand current electricity-generating capacity. Households will be expected to contribute towards the capital required to invest in increasing and diversifying the power supply. Given this background, the objectives of our study are to assess support for and whether households are WTP a premium towards a renewable energy supply or whether they are simply arm-chair environmentalists.

It is vital that households' determinants of the additional cost burden associated with renewable energy are assessed, in an effort to win public acceptance of the introduction of renewable energy. South Africa and other developing countries also have renewable energy targets, but only a few renewable energy WTP studies have been conducted in Africa (see Abdullah and Jeanty, 2011). The few studies on renewable energy undertaken in South Africa to date generally discuss opportunities, barriers, policies and milestones (Sebitosi and Pillay, 2008; Krupa and Burch, 2011; Walwyn and Brent, 2015). Therefore, this study contributes to this scant literature.

By contrast, there is a growing literature on renewable energy in developed countries. Most of these studies discuss public opinions, preferences and WTP for renewable energy (Dimitropoulos and Kontoleon, 2009; Yoo and Kwak, 2009; Zografakis *et al.* 2010; Mozumder *et al.* 2011; Ertor-Akyazi *et al.* 2012; Zoric and Hvrovantin, 2012; Bigerna and Polinori, 2014; Guo *et al.* 2014; Stigka *et al.* 2014, Ribeiro *et al.* 2014; Park and Ohm, 2014). Overall, our study will aid policymakers by revealing what energy sources are socially acceptable, and the determinants of such choices.

## 2 South African Electricity-Generation Mix

Renewable energy is seen as a solution to global warming. It also reduces dependency on fluctuating-price imported fuels. The initial start-up costs are very high relative to traditional coal power stations, and this is cited as a reason for the slow rollout of renewable energy. However, after the initial sunk construction costs, the operational and maintenance costs are mostly low (because of free sun and wind). In general, renewable energy is perceived favourably by the general public, because as it is considered clean and accident-free compared to nuclear. The question is whether South African households would support such green energy actions if it comes at an additional costs.

By the end of 2013, renewable energy was contributing around 26 percent of total global energy generation (REN21, 2014). In 2014, around $270 billion was spent on new renewable energy investments (International Energy Agency, 2015). The number of countries with renewable energy technologies increased from 138 in 2013 to 144 in 2014. Policies have been put in place to increase the contribution of renewable energy. In some countries, the targets have been exceeded. By contrast, South Africa has failed to meet its 2013 target of 10 000 GWh renewable energy electricity generation (REN21, 2014). However, in 2014, South Africa became one of the top 10 countries in the world in the installation of solar photo-voltaics; it is also the leader in Africa in terms of wind power generation, and a leader in solar water heating. In addition, 300MW of concentrated solar plants (CSP) were in operation by the end of 2014 (REN21, 2015).

To increase the role of private entities in the electricity generation industry, renewable energy independent power producers (REIPP's) are contracted to provide renewable energy technologies, for which there is already an agree-

ment with the Department of Energy to supply 3 725MW (IRP, 2013). The introduction of these private investors eases the government's burden of having to fund such investments, and provides the public with clean electricity supply (Msimanga and Sebitosi, 2014). The recent Integrated Resource Plan for Electricity 2010-2030 (IRP) outlines that 17.8GW of electricity will be generated by renewables; all other power generation will be catered for by current traditional sources, including coal.

Table 1 shows the supply mix of Eskom's total nominal generation capacity in their 2014 financial year in megawatts (MW). Gas/liquid fuel turbine stations are called 'peaking plants' and are used mainly during peak periods, as they can be brought online within a very short period. They are very expensive to run, and are not intended to be operated for long periods, or as base-load plants.

As shown in Table 1, coal-fired energy accounts for most of the electricity. The remaining electricity-generating sources are nuclear, which accounts for five percent, and renewables, accounting for two percent (Msimanga and Sebitosi, 2014). Given the desire to significantly reduce carbon emissions and reliance on coal, South Africa's strategy is to diversify, and increase the contribution from renewable energy sources. South Africa, which historically has relied heavily on coal, is exploring ways to diversify its power-generating capacity. Diversification of the country's energy sources is deemed critical for overcoming the growing energy crisis, and meeting its numerous developmental goals. The current plan includes among others the exploration of economically feasible renewable-energy alternatives.

In light of the growing recognition of the need for energy transformation, discussions among policymakers about renewable energy have gained momentum in recent years. Renewable energy is seen as part of the solution to global warming. Compared to traditional coal power stations it is expensive, especially in terms of start-up costs. However, the operational costs of renewable energy are lower. The variable costs are mostly for maintenance and operations – unlike coal power stations, which require piles of coal to operate (Heal, 2009).

It is important to assess households' attitudes towards renewable energy, and whether they are willing to contribute financially towards the high initial costs. A pilot renewable energy project in China, which required households and businesses to buy renewable power voluntarily, saw renewable-generated energy costing more than twice the usual cost of electricity. The high price resulted in very low participation, particularly among households, which shows that cost plays a large role in the type of energy households choose to use (Hast *et al.* 2015). In addition, Zhang and Wu (2012) state that in another trial, only those concerned for the environment were willing to increase investment in renewable energy. Such assessments are necessary in order for policymakers to determine what is affordable for the consumer, and practical strategies for collecting the money. For this reason, this study set out to determine the factors that influence WTP a premium for renewable sources.

# 3 Literature Review

Most of the studies on renewable energy tend to focus on public opinion, preferences, determinants and social acceptance of different renewable energy sources. Evidence from different studies suggests that knowledge of renewable energy sources tends to lead to reliable estimates (Park and Ohm, 2014). However, in cases where there is limited available knowledge about renewable energy sources, this information can help in channelling awareness campaigns in the right direction.

Unlike coal and nuclear power, renewable energy is deemed an ideal source for generating electricity, because it is considered clean and safe. Park and Ohm (2014) made an interesting comparison to determine what factors influence support for renewable energy: support before and after the Fukushima accident in Japan in 2011. The findings show that before the accident, the cost of renewable energy is one reason for reluctance to use renewables. However, the public's attitude towards renewable energy changed after the accident, showing more trust in renewable energy, because of the risks related to nuclear. Cost was no longer a major concern.

Zografakus *et al.* (2010) found that households in Crete were well aware of other sources that generate electricity, and were in favour of increased investment in renewables. Furthermore, in the analysis, WTP for renewable energy increases as number of outages increases. Households with electricity-saving technologies were WTP for investment in renewable energy. Additionally, respondents living in large houses and with high income were WTP relatively more. A Korean study by Ku and Yoo (2010) assessed WTP for renewable energy investments using a choice experiment, in which 800 respondents were surveyed. The findings indicate that respondents had knowledge of five different types of renewable energy sources, and were WTP between two and five percent over and above their current monthly electricity bill for renewable energy investment.

According to Mozumder *et al.* (2011), income is positively correlated to WTP. In a study undertaken in New Mexico (south-west USA), affordability was taken into account; respondents were asked to consider all expenses when answering WTP questions. On average, there is a WTP of 10 percent more for renewable energy. In addition, around 40 percent of the respondents were willing to add five dollars more to the additional 10 percent initially agreed. In addition, it was found that reliability is also important when it comes to renewables; hence, people who did not have much faith in renewable energy sources in terms of reliability were not willing to add to the 10 percent bid. Also, there was a very low WTP for those who thought the electricity price was too high.

Similarly, Stigka *et al.* (2014) and Ertor-Akyazi *et al.* (2012) found that WTP is high among people interested in environmental issues. Furthermore, respondents preferred specific renewable sources to others. Solar and wind power are the most preferred sources. Borchers *et al.* (2007) assessed WTP by power source in Texas. The findings show that solar power is preferred over wind

power, which is followed by biomass-powered energy.

In Italy, there is a commitment to increasing the share of renewable energy, as part of the Italian energy diversification strategy. Although every consumer pays for renewable energy in the form of feed-in tariffs, there was still a need to establish how many Italian households were WTP to increase their share of renewables. After surveying 1 019 households, Bigerna and Polinori (2014) found that age, education and income factors are determinants of WTP. Educated people and people with more money exhibited more WTP for renewable energy. The younger population also support renewable energy. Contrary to Mozumder *et al.* (2011) and Zografakus *et al.* (2010), which demonstrated a positive relationship between WTP and household size, this study showed a negative relationship.

After the study of WTP to reduce outages in Kenya, Abdullah and Jeanty (2011) performed another WTP study on renewable energy in the same district, Kisumu. There are very low electrification rates in this area, hence the Kenyan government's goal to the number of electrified households through renewable energy technologies. The study set out to elicit WTP for grid[1] and off-grid[2] energy systems. Respondents involved in some kind of business and those with high incomes were WTP more for the programme in general. Older people and those who had lived in the area for a long time were not WTP for the programme. On average, people indicated more WTP for grid systems than for off-grid systems.

The government trust issue discovered in Kenya was also evident in the USA. Wiser (2006) calculated WTP among 1 574 households. The aim of the study was to determine people's preferred supplier (between government and private suppliers) for renewable energy technologies. The results show that respondents were WTP more to a private supplier than to the government. WTP was also higher for compulsory payments than for voluntary payments. This can be ascribed to 'free riding'; if people are not obliged to pay, they end up not paying, while still enjoying the benefits. On the other hand, a study undertaken in the United Kingdom compared responses between voluntary and mandatory WTP for green energy. The results showed that voluntary payments are preferred, but the WTP amount is less, since the payment is not compulsory but a choice. Fewer than 20 percent of those choosing voluntary payments actually paid when it was necessary to do so. Mandatory payments result in actual contribution; more money can be collected through this vehicle. However, similar to the Kenyan situation, there were trust issues because of uncertainty as to whether the money collected would serve its purpose (Akcura, 2015).

Another aspect to be taken into account in both the Kenyan and the American studies is that there is a participation expectation variable, which is positive, suggesting that some respondents may indicate WTP if they know other people are also WTP a certain amount for renewable energy (Wiser, 2006; Guo *et al.*

[1] Electricity that is connected to the main supply system; usually used in densely populated areas.

[2] An electricity system that can stand in isolation; mostly used in remote locations. May include solar power.

2014; Sardianou and Genoudi, 2013). Murakami *et al.* (2015) assessed energy preferences in Japan and in the US after the Fukushima accident. The analysis showed that there is support for renewable energy investment from both the Japanese and the Americans. The respondents in both countries had the opinion that carbon emissions need to be reduced, and that this can be achieved by using renewable energy sources. As in other studies, solar and wind energy were the most preferred sources, especially by the Americans. WTP for renewable energy was around $0.71 for Americans, while for the Japanese it was about $0.31.

A study conducted in England showed that households need to know about the costs and benefits of the renewable source they choose to support. Households had to choose the factors most important to them concerning renewable energy. On average, a reduction in emissions was the most important factor, as well as the desire to reduce blackouts. Lastly, educated people with children and involved in environmental activities were WTP to pay more, while WTP was lower for educated people without children and with no involvement in environmental activities (Longo *et al.* 2008). It is evident that determinants of WTP for renewable energy are similar even in different countries. When respondents are well informed about the subject at hand, the results become more reliable. Education increases WTP in some countries. In addition, in most countries income also tends to be correlated with WTP. This also applies to household size, with the exception of Italy. According to Jun *et al.* (2010), critics of renewable energy argue that it is not a long-term solution, due to its intermittent nature and high start-up cost.

A study conducted in South Africa compared the validity of the open-ended and double-bound dichotomous choice (DBDC) format on WTP for renewable energy, among students who are part of decision-making in their respective households. The discovery was that respondents who used more electricity had a higher WTP for renewable energy. Moreover, those who are exposed to renewable energy sources and those who are concerned about the environment are WTP more (Chan *et al.* 2015).

Efforts to mitigate climate change across the world and promote safer energy sources are focused on support for further investment in greener energy sources. Large investments are required to increase renewable energy's share of electricity production. As indicated in the review of past studies, development of new renewable resources requires large initial investment. South Africa has abundant renewable energy resources; but little is known about households' WTP more on their electricity bills to support a renewable energy programme.

WTP for renewable energy varies according to the type of energy source. Overall, consumers seem to be WTP extra for renewable-energy sources. South Africa also has renewable energy targets that need investment to be realised; hence, gauging public acceptance of such plans and of the cost burden is vital.

# 4 Modelling

To model the determinants of WTP for renewable energy, a bivariate probit model is used because there are two decisions that are connected to each other. This model calculates the joint distribution of these two binary variables. According to Green (2003), the standard bivariate probit equation is as follows:

$$\begin{aligned} y_1 i^* &= \beta_1 i x_1 i + \varepsilon_1 i \\ y_2 i^* &= \beta_2 i x_2 i + \varepsilon_2 i \end{aligned} \tag{1}$$

where both $y_1 i^*$ and $y_2 i^*$ are observed when:

$$\begin{aligned} y_1 &= 1 \text{ if } y_1 i^* > 0, 0 \text{ otherwise,} \\ y_2 &= 1 \text{ if } y_2 i^* > 0, 0 \text{ otherwise} \end{aligned}$$

In equation (1), $\beta i$ is a vector of estimable parameters, $Xi$ is a vector of explanatory variables, and $\varepsilon i$ is the error term, which is the correlation between the two equations and is jointly normally distributed.

In our study, the respondent had to respond to two WTP bids. The first question asked if the respondent is WTP 20 percent more than they are currently paying for electricity; the last question was whether they are WTP an additional 50 percent over the current electricity bill. The first bid we use is based on the Markal model forecast that wind-power generation will cost around 20 percent more than current generation costs (Boell, 2014).

According to panel discussions with the Industrial Development Commission (IDC), renewable energy generation costs are expected to be as high as 50 percent more than current costs. One reason is that these costs include the storage of the power when not in use, which is very costly (Business Day Live, 2014). As mentioned previously, there are two interrelated decisions involved in this analysis. If the respondent replies 'yes' to the first bid, the second bid follows; but if the answer is 'no' to the first bid, then only the first bid applies. The possible combinations of the responses are as follows, in Table 2.

The bivariate probit model which analyses two decisions that are related is applied in this study.

# 5 Data

A contingent valuation survey was carried out in both the Johannesburg and the Thyspunt region. Sample size determination took into consideration the elicitation format, as well as budget constraints. Six hundred and ninety-five selected respondents were interviewed. The selected descriptive statistics of the surveyed respondents are presented in Table 3.

Ages ranged from 21 to 78 years old, with the youth accounting for a large proportion. Those between 21 and 35 years old made up about 57 percent of the sample, followed by 36- to 55-year-olds who accounted for 36 percent, with the remainder being those over 56 years old. Our sample is in line with South

African demographics, in particular with the youth make-up for the majority of the country.

On average, household size was roughly four people, while the largest household in the sample had 15 people. More than half (56.8 percent) of the respondents were employed full-time, followed by 15.3 percent self-employed and 11.4 percent employed part-time. The remainder of the sample is made up of students (3.5 percent), retired people (2.5 percent) and unemployed people (8.9 percent). A significant proportion of our sample (44.6 percent) earned less than R50 000 ($4 166.67) per annum. Most respondents had gone as far as high school (45.6 percent). This is consistent with Stats SA (2013) statistics showing that for the majority of South Africans (about 64 percent of the population), highest education achieved is completion of high school.

Approximately 69 percent of our sample were aware that coal power stations contribute to carbon emissions, while 21 percent were not able to answer due to lack of knowledge. About 10 percent of the sample did not agree with this statement. Asking respondents to reveal the different energy sources that they saw as generating clean energy enabled us to assess their knowledge of clean energy. According to Dagher and Harajli (2015), when respondents have knowledge about renewable energy sources, their WTP increases.

Solar energy is the most popular renewable power source. Wind is the second most popular source, followed by hydro energy. These findings regarding solar and wind are not unique to South Africa. They are also evident in a Korean study by Ku and Yoo (2010), in which the top two well-known renewable energy sources were also solar and wind. Other studies with similar outcomes include Borchers *et al.* 2007; Zografakus *et al.* 2010; Ertor-Akyazi *et al.* 2012; Ladenburg, 2014; Ma *et al.* 2015; and Hast *et al.* 2015.

According to Ma *et al.* (2015), solar power is more popular because it is widely implemented at household level. Hast *et al.* (2015) shows that higher awareness and user-friendliness of a renewable energy source puts it in a better position to be chosen by a household. In most countries, households do not have enough information about solar PVs, but they are familiar with solar water heating; hence, the latter is widely used. Our sample shows that men are more knowledgeable about renewable energy than women. In addition, it is clear that knowledge about renewable energy comes with education; more graduates are informed about renewable energy.

We also asked respondents if they were WTP for renewable energy, and if they were aware whether or not their neighbours were also willing to pay. Half of the respondents indicated that they were not concerned about what other people are doing; this was also true in a UK study, as reported by Akcura (2015), but contradicts a Chinese study that showed that consumers influence each other in terms of renewable energy purchases (Hast *et al.* 2015). South African households stated that the main deciding factor for their WTP for renewable energy was their own budget constraints, and not 'following the crowd'.

Around 48 percent of the sample were WTP towards renewables if they knew that their neighbours were already doing so; and 25 percent would not be persuaded by anything to pay for renewable energy, even if they had the

additional money. The figure for those who would not pay because everyone else is paying is slightly more than the 48 percent who answered 'yes' to paying more than 20 percent of their current electricity bill. These findings are different to findings from Guo *et al.* (2014) in Beijing, where it was found that most households supported and were WTP for renewable energy if everybody else was paying.

A two-stage approach was used for the WTP question. First, respondents were asked to consider their current electricity bill and budget constraints, and were asked if they were WTP 20 percent more per month for electricity generated from renewable energy sources. Secondly, those who answered yes to the first question were asked if they were WTP 50 percent more per month for electricity generated from renewables. About 47 percent of the respondents were WTP 20 percent more than their current electricity bill towards green energy. Of that group, only 10 percent were WTP 50 percent more.

Since the average electricity bill paid by households is around R929, answering 'yes' to the first question means those respondents are WTP R1 011 monthly, on average (this consists of the average electricity price plus the average of the additional amount that will be paid). If everyone said 'yes' to paying 20 percent more, then the average electricity price would amount to R1 011.

The 10 percent who responded 'yes' to the second 50 percent bids were WTP R971 (US$81). The conclusion from this calculation is that if the government decided to increase the electricity price slightly to invest in renewable energy, most people would pay; but if the increase was higher than 20 percent, only a small percentage would be WTP. Moreover, WTP for renewable energy comes mostly from the respondents who have knowledge about renewable energy.

In the Eastern Cape province of South Africa, some respondents do not have trust in the government. They cited 'empty promises' as one of the reasons for not being WTP a premium for renewable energy. Households stated that before constructing wind farms, the government promised them that wind energy would decrease power outages, and that the cost of electricity would decrease. But outages are still going on as before, and the electricity price is going up rather than decreasing. Dagher and Harajli (2015) also emphasize the fact that when people trust that the government will utilise funds correctly, WTP can be higher.

# 6 Results and Discussions

We would naturally want to know who would consider themselves WTP a premium as a result of investment towards renewable energy sources, and who are not WTP a premium at all. We allow for different WTP in the first and second stage. A binary decision – whether the respondents considered the proposed increment favourably or not – is used as a dependent variable. We use a bivariate model that makes provision for the correlation between the error terms of the two decisions. Because we have respondents at household level, household characteristics such as age, education, income and knowledge about renewable energy sources are included in the model. Table 13 sets out the bivariate probit

results and the marginal effects of whether the respondents are WTP a premium of 20 percent or more on top of their current bills because of renewable energy.

The amount spent on electricity on a monthly bill, carbon emissions, medical equipment, and male dummy are all positively signed and significant in both the first and the second decision models. The higher the electricity bids, the more likely households are to be WTP to support renewable energy. Those concerned about carbon emissions from current coal-powered plants generally support renewables. Knowledge about renewable energy impacts positively on WTP. Respondents who have medical equipment that requires electricity to operate are WTP more for renewable-generated electricity.

Males are more likely to be WTP more for renewable energy. However, the significance for those WTP 50 percent more is only significant at a 10 percent level. In this study, it seems that men would pay for renewable energy; however, according to Noblet *et al.* (2015), studies in most developing countries have found that women support renewable energy more than men, because they are the ones involved in household chores, including collecting wood to make fire. The reason for the opposite finding in this study may be that the data was collected in an urban area (Johannesburg), where almost the entire population has access to electricity.

Older respondents are not WTP 50 percent more than their electricity bills for renewable energy. Wang and Zhang (2009) reported the same results in an air quality study in China, as did Abdullah and Jeanty (2011) in a similar study in Kenya. Mills and Schleich (2009) in Germany also discovered that older people were not WTA new technologies such as renewable energy, while these technologies are accepted in new neighbourhoods with a younger population.

Retired respondents were not WTP $>$ 50 percent more than their energy bill in support of renewable energy. This result is consistent with the finding that older people generally do not support newer technologies, as retired people are generally older. However, the finding that more educated people are less likely to support paying 50 percent more than their energy bill in support of renewable is a bit puzzling.

Streimikiene and Mikalauskiene (2013), in a study in Lithuania, showed that younger and more educated people with higher income are WTP more for electricity produced from renewables; the same applies in a study by Noblet *et al.* (2015). In the current study, this is not the case. There is more resistance to the 50 percent additional energy costs. According to the Department of Energy (2012), households spend around 14 percent of their total income on electricity bills. Therefore, budget constraints may be the reason for not being WTP, for most people, because they are already overburdened.

The marginal effect after running the second decision is presented in Table 13 above. If an electricity bill increases by one unit, conditional WTP increases by 0.001 units. This also applies to an increase of one unit in carbon emissions, renewable energy knowledge, medical equipment, male respondents, and retired people. This increase will be matched by a conditional WTP increase of 0.001 units. Older respondents' and educated respondents' conditional WTP is 0.001 units lower.

With the closed-ended responses that we have presented so far, we only observe if the respondents agree to pay the proposed bids or not. In addition to assessing the determinants of these WTP bids (as shown in Table 13 above), our aim is ultimately to estimate mean and/or median WTP. Using the estimated parameters, we calculate the mean/median WTP. Confidence intervals are generated based on Krinsky-Robb, which entails drawing a number of times from the asymptotic normal distribution of the parameter estimates, and calculating the welfare measure for each of these draws.

The results in Table 6 reject WTP = 50% in favour of WTP = 20% (p-value 0.0001). Thus, the mean WTP for renewable energy in our study is R11 589 ($965.77). As can be seen in Table 14 above, the relative efficiency measures for the latter yield more efficient WTP measures than the former.

Given the high investment cost and intermittent nature of renewable energy, this transition has been slow. However, the costs of renewable energy technologies are said to be going down. In addition, there have been technological innovations in power storage, increasing the capacity factor, which gives countries a platform for developing their renewable energy industries.

Households are aware of different renewable energy sources, of which solar and wind are the most popular. Although many people are in favour of cleaner energy sources in principle, especially renewable energy sources (despite their externality problems), it is not clear how far they would or could go to back this up financially. A snapshot of the results shows tha knowledge and concern about climate change has an impact on WTP. Half of the respondents would spend 20 percent more on energy bills to support renewable energy sources; anything above 20 percent is deemed too high. Unlike in most other studies around the world, education is not positively correlated with WTP for renewable energy. However, the younger population supports renewable energy.

# 7 Summary and Policy Implications

Given the high investment cost and intermittent nature of renewable energy, this transition has been slow. However, the costs of renewable energy technologies are said to be going down. In addition, there have been technological innovations in power storage, increasing the capacity factor, which gives countries a platform for developing their renewable energy industries.

Approximately 47 percent of the respondents were WTP 20 percent more in energy bills as contributions towards large initial capital costs required to setup renewable energy supplies. When the bid was increased to 50 percent, only 10 percent were WTP. Therefore, respondents are WTP a premium to support green electricity sources. Older people did not necessarily support renewable energy. The finding that educated people were not WTP is not in line with expectations.

Households are WTP towards increasing electricity generation in South Africa. WTP studies done in other countries show that many people state that they are WTP for renewable energy investments. However, when asked to

contribute voluntarily by buying renewable energy, only a very small percentage do (Zhang and Wu, 2012). This shows that sometimes, talk is cheap. Therefore, an experiment of a similar nature is the next logical step towards actually assessing if real actions would match hypothetical scenarios.

The US$966 WTP for renewable energy represents a significant premium over generation costs, and signals social acceptance of renewable energy. Most importantly, given the wide degree of heterogeneity in WTP models, a clear message to policymakers and stakeholders is that they need to do more to communicate the economic and environmental benefits associated with renewable energy. The government should make renewable energy sources such as wind and solar power even cheaper, by opening up access to the electricity national grid. Moreover, given the enormous benefits of renewables, government should invest more in renewable energy research and development, and subsidise key renewable technologies such as storage and smart grids. Germany has demonstrated that renewables have huge generation potential. It was reported in the media on Sunday, 8 May 2016 that Germany had set a new record in terms of renewable energy generation. Due to strong wind and sun that weekend, they generated more than they required; so much so that it pushed electricity prices to negative. As a result, users were paid to use excess electricity.

One of the main limitations of these analyses is that it was not possible to attribute WTP for renewable energy to a specific type of renewable energy. Future research should estimate marginal WTP for specific types of renewable energy, as this would enable future transfer of the WTP estimates.

Despite the limitations, this study gives a snapshot of household WTP for renewable energy. The study generates insight into determinants of public acceptance for renewable energy. Studies could also be done with specific renewable energy sources, to see which source is preferred.

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**Table 1:** Power stations by production source

| Production source | Total nominal capacity (MW) |
|---|---|
| Coal-fired stations | 35 866 |
| Gas/liquid fuel turbine stations | 2 409 |
| Hydro-electric stations | 661 |
| Wind energy | 1400 |
| Nuclear power (Koeberg nuclear power plant) | 1 800 |
| **Total** | **42 136** |

**Source:** Eskom Annual Report 2014

**Table 2:** Possible response combinations for the renewable energy scenario

| Bid 1 = 20% | Bid 2 = 50% |
|---|---|
| Yes | Yes |
| Yes | No |
| No | |

**Table 3:** Descriptive statistics from the renewable energy survey

| Variables | Mean | Standard Deviation |
|---|---|---|
| Male = 1 if male, otherwise 0 | 0.54 | 0.50 |
| Age – age in years | 0.36 | 11.06 |
| Household size | 4 people | 1.89 |
| Children under 18 = 1 if at least one child is < 18 years | 0.57 | 0.50 |
| Education years | 4.6 | 3.58 |
| Annual Household Income | R217 935 ($18 161) | R230 860 ($19 238) |
| Employed = 1 if working full time, otherwise 0 | 0.57 | 0.47 |
| Student = 1 if student, otherwise 0 | 0.35 | 0.22 |
| Self-employed = 1 if self-employed, otherwise 0 | 0.15 | 0.36 |
| Retired= 1 if retired, otherwise 0 | 0.02 | 0.15 |
| Available backup = 1 has backup power, otherwise 0 | 0.15 | 0.36 |
| Medical equipment = 1 use medical equipment that requires electricity, otherwise 0 | 0.14. | 0.35 |
| Monthly electricity bill | R928.89 ($77.42) | 986.87 |
| Coal power stations contribute to carbon emissions | 0.69 | 0.46 |
| Knowledge about renewable energy sources | 0.60 | 0.49 |
| Share of men knowledgeable about renewable energy | 0.33 | 0.45 |
| Share of women knowledgeable about renewable energy | 0.28 | 0.47 |
| Share of university graduates knowledgeable about renewable energy | 0.33 | 0.31 |

**Table 4 continued**

| Variables | Mean | Standard Deviation |
|---|---|---|
| Share of high-school graduates knowledgeable about renewable energy | 0.23 | 0.42 |
| WTP if neighbours are also paying for renewable energy | 0.48 | 0.48 |
| WTP not dependent on other people's choices | 0.49 | 0.49 |
| Not WTP even if other people are paying and money to pay is available | 0.25 | 0.25 |

**Table 5:** Responses to WTP for renewable energy

| Bid | Yes | Share Yes | No | Share of No | Total |
|---|---|---|---|---|---|
| *Renewable Knowledge* | | | | | |
| Willingness to pay 20% more | 203 | 0.29 | 492 | 0.71 | 695 |
| Willingness to pay 50% more | 38 | 0.05 | 657 | 0.95 | 695 |
| *Without Renewable Knowledge* | | | | | |
| Willingness to pay 20% more | 122 | 0.18 | 153 | 0.22 | 275 |
| Willingness to pay 50% more | 33 | 0.05 | 242 | 0.35 | 275 |
| *Pooled Sample* | | | | | |
| Willingness to pay 20% more | 325 | 0.47 | 370 | 0.53 | 695 |
| Willingness to pay 50% more | 71 | 0.10 | 624 | 0.90 | 695 |
| Monthly bill after the additional 20% for the 47% who said yes | R1 011 ($84.25) | 0.47 | R928.89 ($77.42) | 0.53 | |
| Monthly bill after the additional 50% for the 10% who said yes | R971 ($80.92) | 0.10 | R928.89 ($77.42) | 0.53 | |

**Table 6:** Bivariate probit model willingness to pay renewable energy results and marginal effects

| **Dependent variables** | **Wtp 20%** | **Wtp 50%** | **Marginal Effects** |
|---|---|---|---|
| **Independent variables** | | | |
| Bill amount | 0.00 *** (0.00) | 0.00 ** (0.00) | 0.00 ** (0.00) |
| Carbon emissions | 1.18 *** (0.08) | 0.97 *** (0.09) | 0.01 *** (0.00) |
| Renewable energy knowledge | 0.97 *** (0.11) | 0.6 *** (0.14) | 0.01 *** (0.00) |
| Available backup | 0.06 (0.17) | -0.13 (0.21) | -0.00 (0.00) |
| Medical equipment | 0.41 ** (0.19) | 0.51 ** (0.20) | 0.01 *** (0.00) |
| Male dummy | 0.41 *** (0.07) | 0.22 * (0.12) | 0.00 * (0.00) |
| Age | 0.00 (0.000) | -0.02 *** (0.01) | -0.00 *** (0.00) |
| Household size | 0.00 (0.02) | 0.00 (0.03) | 0.00 (0.00) |
| Kids under 18 years | 0.02 (0.08) | 0.16 (0.13) | 0.00 (0.00) |
| Education years | -0.02 (0.01) | -0.04 ** (0.02) | -0.00 ** (0.00) |
| Log income | -0.02 (0.04) | -0.08 (0.08) | -0.00 (0.00) |
| Employed | -0.01 (0.13) | -0.07 (0.22) | -0.00 (0.00) |
| Student | 0.11 (0.19) | -0.19 (0.34) | -0.00 (0.00) |
| Self-employed | -0.06 (0.17) | 0.19 (0.26 | 0.00 (0.00) |
| Retired | 0.21 (0.32) | -5.46 *** (0.41) | 0.06 ** (0.00) |
| _cons | -2.27 *** (0.51) | -1.04 (1.09) | |
| Log pseudolikelihood | -825.90 | | |
| Number of households | 695 | 695 | 695 |
| Number of observations | 11 040 | | |
| Prob > chi2 | 0.00 | | |

Note: Standard errors in parenthesis
* p < 0.10; ** p< 0.05; *** p < 0.01

**Table 7:** Predictive willingness to pay for renewable energy

| **WTP Decision** | **Mean WTP (Rands)** | **Krinsky and Robb (95% Confidence Interval for WTP Measures)** | **ASL*** | **CI/MEAN** |
|---|---|---|---|---|
| WTP = 20% > Current Bill | R11 589.27 ($965.77 ) | R8 132.31 - R20 440.07 ($677.69 - $1 703.34) | 0.0001 | 1.06 |
| WTP = 50% > Current Bill more | R20 576.58 ($1 714.12 ) | R56 805 608.00 - R58 724 812.00 ($4 733 801 - $4 893 734) | 0.4941 | 5614.66 |

ASL* = achieved significance level
CI/MEAN = A relative efficiency measure.