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External Cost of Electricity in Northern Ethiopia: households' willingness to pay to avoid blackouts and environmental costs of windfarms

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Abstract

This study aims to value the external costs of a wind farm, and households´ welfare loss due to electricity blackouts in Northern Ethiopia. A Contingent Valuation (CV) survey of a random sample of 200 households was conducted to estimate their willingness-to-pay (WTP) to avoid blackouts as well as their WTP to avoid negative external costs of a windfarm. 150 households were randomly selected from the city of Mekelle, and 50 from the nearby village of Ashegoda where a windfarm is located. OLS, interval regression, logit and tobit regressions are used to identify the factors affecting households´ WTP. The result show mean WTP/household to avoid the external costs of the wind farms to be 374 birr per year which is 24% of their current annual electricity bill. Whereas the mean WTP/household to avoid blackouts was 499 birr per year that is 34% of their current annual electricity bill. Household WTP to avoid external effects of wind power increased significantly with increasing wealth and number of people in the household; and decreasing preference over windfarm construction. Household WTP to avoid blackout increased significantly with increasing wealth, number of blackouts and average length of blackouts. Male respondents have significantly higher WTP for both avoiding blackouts and avoiding external effects of wind farm. The results shows that there is a significant WTP to avoid blackouts, which could justify larger investments by the government (particularly the Ethiopian electric power corporation (EEPCo)) to reduce blackouts. Moreover, based on the results EEPCo should also consider community compensation schemes to compensate for the external costs from the windfarm to the affected households.

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List of Abrevations

BO= blackout

CE= choice experiment

CV= contingent valuation

CVM= contingent valuation method

EEPCo= Ethiopian electric power corporation

NIMBY= not in my back yard

OLS= ordinary least square

SP= stated preference

WTA = willingness to accept

WTP= willingness to pay

1. Introduction

Insufficient and unreliable electricity service is considered as one of the bottlenecks for a sustainable development in Ethiopia (Meles, 2017). It not only blocks development but also environmental friendliness. It is common to use a wood fire, dung, charcoal and other indoor air polluting energy sources in rural Ethiopia. According to Barron and Torero (2015) electrification leads to a lower indoor air pollution. The vast majority of the rural population in the country is in absence of electricity. In 2007 access to electricity was 20 % which is below the sub-Saharan average access rate of 26 %. To make things worse, even the population who gets electricity is forced to experience frequent unplanned blackouts. In the capital city, the average duration of Blackout per year is 1 hour and 9 minutes with the longest blackouts being approximately 24 hours long (Meles, 2017). Blackouts can occur due to various reasons including poor transmission lines, short circuits and human faults in power stations, but according to government electric power officers the main explanation for the blackouts in Ethiopia is a higher demand for power, which is growing because of expansion of industries and electrification of rural areas(Mains, 2012). Blackouts can have significant damages to individual households. The damages include inconvenience in homemaking, disability to conduct electronic transactions, negative entertainment effects and vulnerability to robbers on a dark night, to name few. Therefore, in this paper, I use primary data on willingness to pay (WTP) to quantify the costs of blackouts in terms of monetary values. This helps the decision makers in the sector to weigh the cost of avoiding blackouts against the cost of having them.

These days, the Ethiopian government is looking towards different renewable energy sources to meet the country's electricity demand and to export to neighboring countries. The Ethiopian energy system is mainly dependent on hydropower. However in recent years government is developing wind power, solar power and geothermal. The government selected small and large hydropower projects in combination with some coal, gas and wind power based on the least cost analysis (*Power Sector Market Report - Ethiopia*, 2018).

Nowadays renewable resources are being utilized on a larger scale in many parts of the world. They have a huge potential since they can in principle, surpass the world's energy demand: accordingly, such resources will have a significant share in future's global energy portfolio (Ellabban, Abu-Rub, & Blaabjerg, 2014). Wind energy is amongst the various renewable resources to produce electricity. Wind energy has its actual steps centuries ago but interest in wind power revived nearly as thirty years ago following the need for electricity supply securities and environmental issues (Kaldellis & Zafirakis, 2011). Across the globe, in 2014 about 370 gigawatts of electricity was generated from wind power providing 5% of the world's electricity demand (Wind, 2013). Concurrent with improved wind technology, its installation also increased in many countries.

Even though wind power can operate at almost zero level of greenhouse gas (GHG) emission, it has its own external costs in terms of visual disamenities, noise disturbance, and biodiversity loss. So far, the public perception and attitude towards wind power in Ethiopia are unexplored. Therefore, this paper seeks to assess and value the external costs of wind power through observing people's willingness-to-pay (WTP) to avoid the negative externalities of wind power. Quantification of the environmental costs of wind farms is important for the government in the process of deciding how to provide sustainable and quality electricity service.

2. Literature review

"As visual intrusion, noise and the impact on the ecosystem are effects which are non-rival and non- excludable at the local level, it could be argued that wind farms may be perceived to have public bad characteristics at the local scale"(Dimitropoulos & Kontoleon, 2009). Accordingly, few studies addressed issues related to environmental costs of wind power. They evaluated people's preferences concerning different attributes of renewable source of energies using mainly choice experiment.

Meyerhoff et al. (2010) assessed the negative externalities that would follow from expanding wind power generation in Germany and found using a choice experiment that further wind power development would result in a negative externality. They also showed that individual's choice is influenced by biodiversity loss and distance of wind farm from their vicinity. A similar research in Denmark by Ladenburg et al. (2013) points that number of turbines also influence individuals attitude towards wind power. More turbines in the local area lead to an increased negative attitude of respondents towards more onshore turbines. In their study, Ladenburg and Dubgaard (2007) found that middle and high-income individuals have a higher WTP for reduced visual amenities of offshore wind farms. Based on an economic concept, WTP for a good is positively correlated with income, a hypothesis stating higher household income results in higher WTP to avoid negative effects of wind power is formulated.

Navrud and Bråten (2007) using choice experiment examine people's preference and WTP for the different sized wind, hydropower, and natural gas plants. They found that Norwegian people prefer wind power plants from the choice between continued electricity from coal-fired power plants versus developing more hydropower plants, wind farms or gas-fired power plants. Even though people preferred development of few large wind farms, there was a NIMBY(not in my backyard) effect of wind farms. They also gave an insight that it is possible to make an economic optimal energy investment decision based on the relative external costs of different energy sources which can be inferred from observed WTPs.

Studies conducted so far to address this issues have taken place in developed countries. Taking this into account, this study will attempt to add to the existing literature in the field by having a developing country application. It will use a similar approach to value and assess the external cost of a wind farm in Ethiopia. It will also try to examine what factors determine people's WTP to avoid negative externalities of wind power.

From the social perspective as a whole, production is said to be at the efficient level when marginal benefits equal marginal production costs, which gives a maximized net benefit. But the market system does not always give a socially optimal result if environmental qualities are taken into account. In this case, while making a decision on which energy source to invest, Ethiopian electric power corporation (EEPCo), which is the main electricity provider in the country, mainly considers the construction and operation costs in order to keep the production cost as least as possible. However, there is another type of cost to the society, which is external to the producer and thus will not be included in the production cost. In order to be socially efficient, decisions about resource use must be taken into account both production costs and environmental costs: social costs=Private costs + external costs (Field & Field, 2017).

Recently, a study on household's defensive mechanism and WTP for improved electricity were conducted in the capital city of Ethiopia. Using a double-bounded dichotomous choice format the study found that consumers are willing to pay 19%-25% of their income for improved electricity service (Meles, 2017). Similarly, Carlsson and Martinsson (2007) used a contingent valuation method to elicit WTP to avoid different kinds of power outages. Their study concludes that duration of blackouts and socio economic variables influence WTP among the Swedish population. In this study, however, a different method, payment card approach to elicit peoples WTP to avoid blackouts in Northern Ethiopia is used.

3. Statement of the problem and Research question

The main target of this paper is to find peoples WTP to avoid blackouts and environmental costs of wind farms in Northern Ethiopia. It as well seeks to find factors affecting WTPs.

3.1 How much is households WTP to avoid blackouts?

The first objective of this study is to find the mean WTP of households for an improved electricity supply. An improved electricity supply in this study implies zero blackouts per year. Being aware of the preferences of the society helps the government in the process of providing public goods and services. Knowing how much people are willing to pay to avoid blackouts alarms the government to make improvements to the electricity sector.

3.2 What factors determine people's WTP to avoid blackouts?

This study assesses if the damages caused by blackouts, the number of blackouts per year, the average length of blackouts and duration of the longest blackouts play a role in the variation of WTP amounts. It is also interesting to check if recalling government unfulfilled promises affect WTPs. As it is common in Ethiopia to use alternative energy sources other than electricity, it is convenient to see if the number of those alternative energy sources affect WTPs.

As cited by Kristrom and Riera (1996), many empirical studies have shown that WTP is an increasing function of income. Theoretically, a WTP should increase with income for a normal good. Thus, it is important to see if income and other sociodemographic variables explain the variation in WTP to avoid blackouts.

3.3 How much is the external cost of wind power?

Besides the production costs of building wind power electricity plants, it is important to calculate the external costs of it and this is what this paper aims to answer. To my knowledge, there have been no studies on the valuation of the external costs of wind farms in Ethiopia.

3.4 What factors determine people's WTP to avoid the negative externalities (visual disamenities, noise disturbance, and biodiversity loss) of wind power?

Because wind power comes with a disadvantage for locals, residents may not want to have the wind farm in their vicinity. This is what we refer to a Not-In-My-Back-Yard (NIMBY) syndrome. Originally this situation was identified as a multi-person prisoner's dilemma, where a public good will not be provided even though all members of the society wants it to be provided(Wolsink, 2000). Wolsink (2000) argues, in cases where constructions and their siting is based on public support, the existence of a NIMBY syndrome can lead to suboptimal outcome. This study explores whether there exists a NIMBY syndrome, i.e respondents in Ashegoda have significantly higher willingness to pays for avoiding environmental costs of wind farm.

For those residing in the city, knowing someone who lives near a windfarm could positively affect their WTP to avoid the negative externalities. This is due to the fact that they can understand or feel the externalities better than other city-residents.

For those who are living in Ashegoda, the number of years they lived in that village expected to influence their WTP positively. It is assumed that the longer they live in the village the more attached they become emotionally. Therefor they could have a strong preference towards a cleaner environment in the place.

Disturbance due to the noise or visual intrusion associated with the wind farm expected to influence WTP positively. In principle, the more the respondents disturbed the more they should be willing.

The attitude towards the development of hydropower and wind power plants could also affect WTPs. We expect that preference over more hydropower production could affect WTP positively whereas preference over more wind power affects WTP negatively.

To sum up, this research question is inquiring if the above-explained variables and other sociodemographic factors explain the variation in WTP to avoid environmental costs of wind farms.

Table 1: Research questions and the underlying hypotheses

		Expected sign
Research question 1	**How much is households WTP to avoid blackouts?**	
H1	Mean WTP to avoid blackouts is positive	+
Research question 2	**What factors determine people's WTP to avoid blackouts?**	
H2	Wealth affects WTP positively	+
H3	Damages of BOs affect WTP positively	+
H4	Number of BOs affect WTP positively	+
H5	Length of the longest BOs affect WTP positively	+
H6	The average length of BOs affect WTP positively	+
H7	Remembering government unrealized promises will affect WTP negatively	-
H8	Age affects WTP first positively later negatively	+/-
H9	Sex of the respondent(female=1;male=0)	-
H10	Number of people in the household affects WTP positively	+
H11	Alternative energy sources affect WTP positively	+
Research question 3	**How much is the external cost of wind power?**	
H12	Mean WTP to avoid external costs of wind farms is positive	+

Research question 4	**What factors determine people's WTP to avoid the negative externalities (visual disamenities, noise disturbance, and biodiversity loss) of wind power?**	
H13	Living in Ashegoda affects WTP positively	+
H14	income affects WTP positively	+
H15	Knowing someone who lives near the wind farm affects WTP positively	+
H16	Number of people living in the house	+
H17	Sex of the respondent(female=1;male=0)	-
H18	Age affects WTP first positively then negatively	+/-
H19	Number of years lived in current place affects WTP positively	+
H20	Level of annoyance due to the wind farm affects WTP positively	+
H21	Preference over less hydropower development affects WTP negatively	-
H22	Preference over less wind power construction affects WTP positively	+

4. Theory

4.1 Nonmarket valuation

As it is stated by Milne (1991), in a public decision-making setting, it is vital to find a decision process that maximizes net benefit. Valuing environmental resources are essential to make this optimal decision reachable. To find the net benefits one should have all types of costs and benefits of a uniform unit, preferably monetary values. Part of these costs and benefits might not have monetary values or simply they are not traded in markets. To incorporate those non-traded goods and services, monetary values are placed on them using different techniques such as contingent valuation methods, hedonic pricing, travel cost method and dose-response models. Each of these techniques requires different types of data and they can be used in different scenarios (Milne, 1991).

The negative externalities or external costs of wind power: visual disamenities, noise disturbances and biodiversity losses particularly Birds hit by wind turbines are not covered by the market system since they do not have certain monetary values. Hence, non-market valuation techniques can be used to analyze how much impacts those environmental goods could have (Menegaki, 2008).

In environmental economics, we wish to estimate the utility change caused by an environmental change using monetary values, where we use Hicksian demand function instead of the normal uncompensated demand function, as we do not have the restrictive assumption of zero marginal utility of income in Hicksian demand function (Perman, 2003).

4.1.2 Hicksian Demand and Welfare changes

The two Hicksian monetary measures are compensating variation and equivalent variation, alternatively for quality or quantity changes compensating surplus and equivalent surplus (Freeman III, Herriges, & Kling, 2014).

Suppose an individual has an indirect utility function as a function of price, environmental quality and income as follows[1]:

$$v(p, q, m) \qquad 1$$

Let q_0 and q_1 denote the current environmental quality and the new environmental quality, respectively. In case of an improvement to the environment, if the individual has the property right over the new environmental quality, then they are entitled to the following indirect utility:

$$v(p, q_1, m) \qquad 2$$

[1] All notations and descriptions are based on (Kim, Kling, & Zhao, 2015), unless otherwise told.

Where we have to measure equivalent variation, i.e how much money the individual would accept to have the same utility as they are entitled to, in the absence of the improvement to the environment (q_1).

$$v(p, q_0, m + E(m)) = v(p, q_1, m) \qquad 3$$

Where E is the equivalent variation.

The equivalent variation is the willingness to accept (WTA) of the individual which is the minimum amount they would be willing to accept, for not having the change in the environment.

On the other hand, if the individual has property right for the degraded environment (q_0) , then they are entitled to the following indirect utility:

$$v(p, q_0, m) \qquad 4$$

Then the welfare measure is compensating variation which is measuring the reduction in income for the individual for a desired environmental change (q_1). The compensating variation is equivalent with the maximum willingness to pay of the individual to get the new environmental quality. This can be represented mathematically as follows:

$$v(p, q_0, m) = v(p, q_1, m - C(v)) \qquad 5$$

Where C is the compensation variation.

Theoretically compensation variation and equivalent variation or WTP and WTA should be the same, however, evidence from empirical studies show that there is a disparity between WTA and WTP values. Therefore, in contingent valuation studies, the choice between using WTP or WTA should be based on property rights (Perman, 2003)[2].

Table 2: appropriate welfare measures based on property rights and the environmental good to be valued[3].

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[2] Recommendation 7: Decision between WTA and WTP should be based on empirical and theoretical base (Johnston et al., 2017).
[3] The table is adopted from (Perman, 2003) and (Kim et al., 2015)

	Individuals entitled property right to an improved environment	Individuals entitled property right to a degraded environment
Environmental improvement	WTA compensation for not having the environmental improvement	WTP to have an improved environment
Environmental deterioration	WTA compensation for environmental deterioration	WTP to avoid the deterioration

Property rights were not the only reason for us to decide employing WTP, but the fact that WTA formats are undesirable to use in practice, for WTA studies are accompanied by many protest responses(Kim et al., 2015).

4.2 Contingent valuation

The empirical approach used in this study is contingent valuation method. A contingent valuation (CV) is a direct method of eliciting people's preferences by asking them the amount they would pay for a certain non-marketed good or service. A CV provides an economic value estimation for a proposed change of a non-marketed good or service from a certain base line (Johnston et al., 2017). One of its best attributes is its ability to capture non-use existence values. It employs a survey technique, which is carefully designed to elicit respondents WTP.

As stated by (Johnston et al., 2017), how respondents perceive the good to be valued, the study objective and the information content of valuation scenario should be the basis to choose between CV or choice experiment (CE) to explain the change to be valued[4]. The changes to be valued in our case (eliminating blackouts and avoiding environmental costs of wind farms) affect blackouts and wind farms as a whole. Respondents do not value the change in terms of attributes but as whole. To value such a fixed change as a whole, CV can be preferred. Moreover, CE is

[4] Recommendation 3: Decision, whether to use CV or CE, should base on the objective of the study, the complexity of valuation scenario and respondents perception towards the good (Johnston et al., 2017)

complex and unfamiliar for respondents compared to CV.

In the case of this study, respondents were asked the value they would put for an improved electricity service (for eliminating blackouts) if they were required to pay on the top of their electricity bill. Avoiding blackouts can be reached in two ways either by upgrading the existing hydropower or developing new wind farms. Building new wind farms cause new environmental costs in terms of noise disturbance, visual intrusion, and biodiversity loss whereas upgrading the existing hydropower dams do not cause such environmental costs. However, upgrading a hydropower plant is costly than building a new wind farm. This will be made known to the respondents and asked how much they would be willing to pay at most for upgrading hydropower plants instead of building new wind farms. The amount they would be willing to pay is then to avoid the negative externalities of wind power.

4.3 Critiques of contingent valuation

Like Milne (1991) described, contingent valuation method is often criticized for hypothetical bias that could arise from participants lack of experience or knowledge. The possible consequence of this is the inability of respondents to express willingness to pay values in a hypothetical market as accurately as they do in real markets.

This method is also susceptible to strategic bias. That is when respondents misstate their preference in order to free ride, guessing that others in the community will pay enough for the specified common good. Respondents may also understate their willingness to pay if they believe that they have to pay for real. On the other hand, they may overstate their WTP value if they believe that they do not actually have to pay but their stated amount affects the amount of good and service provided. Similarly for willingness to accept questions respondents may overstate WTAs to free ride (Milne, 1991).

Such biases can be minimized by careful CV survey design and implementation. For instance, an incentive compatible and consequential valuation question enhance valid WTP responses. To maximize validity this study follows the best-practices for SP studies recommended by Johnston et al. (2017).

5. Materials and Methods

In the previous chapter, a non-marketed valuation technique CV was discussed. In addition to this, it was argued that CV is the appropriate way to answer the research questions on hand. In this chapter, I continue discussing the tools, methods, and procedures used in this study. The roadmap of the chapter is as follows: the chapter begins by discussing the study population. Then the survey design and data collection procedures are discussed in detail. Finally, statistical models used for this are study are presented.

5.1 Population of Choice

One of the very first steps in CV method is deciding whose values is to count (Milne, 1991). Nowadays it is common to include both users and non-users in the valuation of an environmental good. To consider non-use values, it is necessary to include non-users in the survey. This study counts the values given by those who are directly affected and those who are indirectly affected when valuing the environmental costs of wind farms. Therefore, 150 sample respondents are drawn using cluster sampling and simple random sampling from Mekelle and 50 sample respondents were drawn from Ashegoda. The Ashegoda sample respondents were randomly drawn from the Dandera wereda. There is a 120 MW wind power in Ashegoda (see figure 2) and Dandera is the closest village to this wind farm. Thus, the Ashegoda respondents are those who are directly affected by the wind farm whereas sample respondents from Mekelle are those who are not directly affected by it. Taking part of the sample from Ashegoda will also help to see if a NIMBY effect makes a difference between their WTP to avoid the negative externalities of wind power. That is to find if living in an area with a wind farm increases the WTP of people to avoid the associated negative externalities.

The sample taken from Mekelle population was based on clustered sampling. There are 7 sub-cities in Mekelle. Out of the seven sub-cities, one was selected using simple random sampling. In the selected sub city there are 5 weredas. Out of the 5 weredas three were selected randomly. Finally. Respondents were selected randomly from the selected weredas. On the other hand, for the Ashegoda sample, respondents were randomly drawn from the village Dandera.

Figure 1: map of Mekelle and Dandera (source: (Geolocated, 2018))

Figure 2: Ashegoda windfarm to the right and residential houses in Dandera to the left (source: Own photos)

5.2 Survey Design and Data collection procedure

The survey design and the implementation process of this study was based on the contemporary guidance for stated preference studies published in 2017 with the goal of raising the quality of stated preference studies by Johnston et al. (2017). The main motive behind applying recommended best practices is to raise the validity and reliability of this study. Validity refers to maximizing accuracy in estimation while reliability refers to minimizing variability, a credible CV study incorporates both attributes (Bishop & Boyle, 2017).

A good survey design and implementation are vital if results of CV studies are to be replicated for a wider population. The basic steps to consider in designing and implementing a survey include: producing a survey instrument which clearly explains the status quo situations followed by a consequential valuation question[5], random sampling from the population of interest and employing an appropriate survey mode (Johnston et al., 2017).

An eight-page long questionnaire was developed. It was originally in English and then translated to Tigrigna[6]. The questionnaire begins with auxiliary questions concerning attitudes towards different energy sources and environmental activities[7]. The respondents presented with nine public goods and services including hydropower and wind power development. They were asked how important each of these public goods services are, given that the government is unable to provide the highest level of all kinds of goods and services because of a limited resource. They were also presented with a list of statements indicating their environmental friendliness. They were then asked to what extent they agree or disagree with each of the statements on a Likert scale. These questions were also responsible for familiarizing our subjects to the topic.

The second part of the questionnaire contains the willingness to pay questions. The respondents were presented with a hypothetical scenario where the government plans to eliminate blackouts by upgrading hydropower dams, building new wind farms and new transmission lines. They were told the project cost will be covered by the government, international donors, companies and the society collectively and the project will be implemented if these parties are able to cover the cost of the project. Then respondents were asked the most they would be willing to pay on the top of their electricity bill to fully avoid blackouts per year. The payment card includes values ranging from zero to 3600 birr[8] per year. Following these respondents were told that there are two ways to eliminate the blackout upgrading the existing hydropower dams or building new wind power plants. Upgrading existing hydropower dams will not have additional environmental costs but it is costly than developing a new wind farm. Building new wind farm has additional negative

[5] A consequential valuation question is a question that persuades respondents that their response is of importance for policy decision making; this type of consequentiality is known as policy consequentiality. Whereas a stronger consequentiality includes payment consequentiality where respondents surmise that they have to pay the amount they stated in valuation questions (Herriges, Kling, Liu, & Tobias, 2010).
[6] Tigrigna is a language spoken by inhabitants of Mekelle and Ashegoda.
[7] Recommendation 12: SP studies should contain supporting questions to enhance validity (Johnston et al., 2017).
[8] Birr is the currency of Ethiopia

externalities. Respondents were asked how much they would be willing to pay on the top of their electricity bill for upgrading hydropower dams instead of building new wind farms. Follow up questions were posed to identify “protestors” and “good cause” payers.

The questionnaire to Ashegoda sample respondents contains additional contextual questions related to access to electricity, relocation due to the construction of Ashegoda wind farm and compensations. Those who do not have access to electricity are excluded from the WTP questions.

Socio-demographic questions and a question about respondents perception towards the survey were the last part of the questionnaire. To avoid any disruptions income related questions were placed at the very end of the questionnaire.

5.2.1 Scenario description

The status quo, the proposed change and the mechanism of change should be described in a clear and understandable manner to subjects. Respondents should be able to figure out their expected gain or loss from a proposed change. A survey design procedure that ensures respondents understanding of the questions is as well required (Johnston et al., 2017)[9].

Consider the first valuation question format for eliciting respondents WTP to avoid blackouts:

> *The Government is now considering implementing a program to reduce the number of blackouts from the current level to eliminate the blackouts. The program includes upgrading old and building new electricity production plants and new transmission lines. The costs of this program will be covered by international donors, government, companies and the households. If the government sees that these interest groups are willing to pay more to avoid the blackouts than what it costs, they will implement the program, which will eliminate blackouts. Think about what it is worth to you to fully avoid the negative impacts you have experienced from blackouts the last 12 months. What is the most, if anything, your household certainly is willing to pay per year for 10 years on the top of your annual electricity bill (or on the top of your house rent, if you are not paying the electricity bill by yourself) to fully avoid blackouts? Remember that this payment will reduce your expenditure for other goods and services (see Appendix A3).*

[9] Recommendation 1

As it is clearly stated, the baseline scenario is the current level of blackouts the household experiencing. The proposed change in relative to the current level of blackouts is to eliminating blackouts. Therefore the change to be valued here is reducing a current number of blackouts to zero[10]. The last pilot survey we conducted verified that respondents understood the information provided.

To increase the information's credibility and acceptability by respondents we used a practical and sensible mechanism of change. We told our respondents that international donors, the government, companies, and households cover the cost of the proposed program. It was of importance to mention that international donors and companies are amongst the interest groups for two main reasons. First, to increase its acceptability. The presumption behind this thought is that few respondents might not trust the government given the current political unrest in the country. Second, it is consistent with the current practice in the country (i.e international donors and companies participate in similar development activities).

A binding and realistic decision rule is important (Johnston et al., 2017)[11]. Hence targeting the truth-telling behavior of respondents, we made it clear that the program will be implemented given that the interest groups are willing to pay more to avoid blackouts than what it costs. This will increase the likelihood of obtaining true WTP values from subjects. If a respondent state a higher WTP amount than what it really worth to fully avoid the negative impacts for them, then there is a higher probability that the program will be implemented and therefore the respondent will end up paying more than their true WTP. On the other hand, if a respondent states a lower WTP amount than what it really worth to fully avoid the negative impacts for them, then there is a lower probability that the program will be implemented and therefore they might not get the desired change. A rational respondent will then provide a true WTP value[12].

We clearly informed the payment type and process of the proposed change. We used a payment card approach in which respondents have to choose (from a list of amounts provided) their households certain maximum willingness to pay per year for 10 years on the top of their annual

[10] Based on our findings the average number of blackout is 160 times per year. Note that we do not have a uniform baseline for all the respondents as different households experience and recall different number of blackouts.
[11] Recommendation 10
[12] Recommendation 13: Design of an incentive compatible and consequential valuation questions are important for credibility of the study (Johnston et al., 2017).

electricity bill to fully avoid blackouts. A different payment vehicle, housing rent, was used for those who do not pay electricity bill themselves[13]. Using an electricity bill as a payment vehicle for such respondents would be absurd and may even stand as an excuse for respondents' payment-rejection[14].

We framed the valuation question for avoiding environmental costs of wind farms in a similar manner. Valuation questions were sequenced in a way that is sensible to respondents. In the first valuation they were asked to choose their maximum willingness to pay to avoid blackouts, then in the second valuation, they were informed about the two ways of avoiding blackouts amongst others. The methods were either constructing new wind farms or upgrading old hydropower plants. The status quo is that the new wind farms will be constructed. The new program (i.e the proposed change) is upgrading the existing hydropower plants instead of building new wind farms. The additional amount that respondents willing to pay for upgrading hydropower dams is equivalent to the environmental costs of wind farms for the household. The details concerning monetary costs and environmental costs of the power plants were described clearly for our subjects, as shown below.

> *Avoiding blackouts can be achieved by developing new wind power plants* ***or*** *by upgrading existing hydropower. Upgrading hydropower plants will be more costly than producing the amount of electricity needed from constructing new wind power plants. However, upgrading hydropower will cause no new negative environmental impacts, whereas new wind power plants will - in terms of noise, changing the view of the landscape, and cause disturbances to animal and bird life (e.g. birds hit by the wind turbine). Think about what it is worth to your households to avoid these negative impacts of noise disturbance, visual intrusion and biodiversity loss from wind power, and instead pay a higher electricity bill to cover the extra costs of upgrading existing hydropower plants instead. If households willingness to pay exceeds the extra costs of upgrading hydropower, the government will do this instead of building new windmill farms. What is the most, if anything, your household certainly is willing to pay per year for 10 years*

[13] This is the case where households rent a house and do not pay electricity bill directly.
[14] Recommendation 11: a realistic, credible and binding payment vehicle must be used (Johnston et al., 2017).

on the top of your annual electricity bill (or on the top of your house rent, if you are not paying the electricity bill by yourself) to avoid these negative environmental impacts from windmill farms? Remember that this payment will reduce your expenditure for other goods and services.

Choose the additional highest amount you would be willing to pay for this program (upgrading hydropower dams) (see appendix A3).

All the necessary information were provided to the respondents to secure valid responses however, this comes with cost. It is very likely for a respondent to be exhausted (which adversely affects the validity of the responses), as we increase the amount of information. A lengthy and very detailed information resists the cognitive abilities of respondents. Thus, it is very crucial to keep the questions clear and precise to achieve valid responses.

5.2.2 Survey pretesting

While designing the questionnaire for this study, consecutive pilot tests were conducted with the intent of developing an understandable and credible questionnaire for the respondents. There are two types of pretesting, qualitative and quantitative pretesting. Though time and budget limitation allow us to conduct only qualitative and quantitative pretesting, conducting post surveys was also favorable. As for Johnston et al. (2017) an ideal survey process includes both types of pretests and post-survey tests[15].

We conducted the first pilot in July 2017, where 10 people were interviewed. The interview constituted open-ended questions including the valuation questions. In addition to framing the auxiliary questions the responses gave an insight on what ranges of WTP amount to put in the payment card.

The second pilot was conducted in September. Questionnaires were sent to 20 respondents by email. Nine of them replied. The questions were focused on blackouts. The responses were helpful in shaping the questions in an understandable way.

Right before the main survey, the third pilot was conducted in January. There were no major changes in the questions after this survey but it helped us to see the pitfalls in the enumerators.

[15] Recommendation 2

Therefore, a training was given for the enumerators for the second time to ensure the quality of the survey.

5.2.3 Experimental design

Many researchers as cited by Johnston et al. (2017) advise that effective designs for CV questions should ensure monetary amounts which are credible to respondents and can give unbiased and consistent estimates[16]. Our CV design attempts to adhere to these features. The proposed change to be valued, previous studies and insights learned through pretesting influence the decision in experimental designs (Johnston et al., 2017). For this study, the amounts placed in the payment card were mostly based on the pilot testings' conducted.

5.2.4 Valuation question Response formats

There are multiple response formats in CV, each with their own advantages and disadvantage. Binary or dichotomous choice, iterative bidding, open-ended elicitation and payment card are among the common response formats. Dichotomous choice format is known to be the most incentive compatible format under certain conditions, nonetheless, the responses from such elicitation format provide a limited information about the respondent's preference (Carson & Groves, 2007). Similar to iterative bidding it is subject to yea-saying and initial biases. Payment card approach and open-ended elicitation, on the other hand, suffer from range bias and unrealistically high or zero responses, respectively. The bright side of payment card approach is that the range bias can be minimized using pilot tests. As mentioned earlier payment card approach was used for this study seeing that it is relatively unbiased and effective way of eliciting respondents' preference[17]. Amounts in the payment card were ranging from zero to 3600 birr per year. "Other" and "don't know" were included as an option in order not to constrain respondents to the amounts listed. Even though Johnston et al. (2017) points that SP studies need not necessarily include "don't know" or "no-answer" options, it is important to include them for CV studies to increase the validity of the WTP amounts elicited (Groothuis & Whitehead, 2002)[18]. CV studies and valuation questions as such are not familiar to respondents, therefore some respondents may

[16] Recommendation 4
[17] Recommendation 8: reasonable response format should be applied (Johnston et al., 2017)
[18] Recommendation 9

struggle in realizing their WTP for the good to be valued. In cases where there is no “Don’t know” option, they are forced to give a pseudo-WTP amount.

5.2.5 Ethics in data collection

As it is required to follow specific procedures in data collection concerning the rights and protections of respondents[19], this study adheres to the standard codes of ethics subscribed by the American Association for public opinion research (AAPOR)[20]. First and for most the interviews were voluntary and all respondents participated in the study were volunteers. Their responses are confidential, as we explicitly mentioned it to them in the very beginning of the interview. Before conducting the main survey, I have received a letter of permission from Mekelle University to inquire the necessary data for this study.

The issue in SP studies, however, is the use of deception in scenario description. As long as the deception is harmless, it is acceptable to use it. Ethics guidance does not disqualify such deceptions. Johnston et al. (2017) argues that the risk of using it should be evaluated against its benefits. It is risky to some degree to use deception however it is essential to answer some types of research questions which otherwise are impossible to answer.

5.2.6 Survey mode and sampling

The survey mode for this study was an interview. Interviews are the most appropriate survey mode for such a developing country like Ethiopia[21]. Other methods like telephone surveys and internet survey adversely affect the representativeness of the sample respondents. Nevertheless, interviews have their own disadvantage. For instance, interviewer bias. Therefore, to minimize unintended interviewer bias, we trained our enumerators and tested their performance prior to the data collection.

The survey took place in the first three weeks of January 2018. Three enumerators recruited for the data collection. The data were collected in a systematic random manner from a sample of 150

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[19] Recommendation 5: Survey procedure should avoid significant negative effects for respondents. Neither should it influence the validity of the study adversely (Johnston et al., 2017).
[20] See (American Association for Public Opinion Research, 2015)
[21] Recommendation 6: survey mode should be context specific (Johnston et al., 2017).

households in Hadenet, Mekelle. The remaining data were collected from 51 households in Ashegoda, Dandera village.

I and the enumerators went door to door to interview respondents. The choice of the village in Ashegoda was according to the closeness of the location to the wind turbines. The survey was conducted every day in a row, except 6th and 7th of January due to a public holiday.

The main limitation of this survey is that it has a small number of observations. Because of time and budget constraints, I was unable to increase the sample size to a larger size. In addition to this, there was high missing value in questions related to relocation due to the Ashegoda wind farm and compensation. This could be attributed to people who relocate due to the wind farm has moved to other places

5.2.7 Sample representativeness[22]

In Mekelle city female population accouts for 52% of the total popluation in year 2009. For the Mekelle sample 55% of the sample respondents were females which is quite representative of the population. However in the Ashegoda sample the female population was slightly over represented. In dandera village 64% of the inhabitants are female, but in the sample we have 84% of female respondents. potential explanation for this overrepresentation might be the relative availablity of females for an interview duiring the day.

Interms of age the Mekelle sample represents the population well as shown in the following table, unfortunately we were not able to compare the Ashegoda age distribition with its sample due to lack of data.

Table 3: age distribution of sample and population

Age range	**Mekelle sample (in percent)**	**Mekelle population aged between 20 and 74 (in percent)[23]**

[22] Recommendation 20: the generalizability and the sample representativeness of an SP study should be documented (Johnston et al., 2017).
[23] The calculation is based on the census conducted in 1994 by central statistical agency. Note that the percentage we provided are for the population aged between 20 and 74 in order to be able to compare it with the sample data (which ranges between 20 and 73)

20-29	33.8	34.8
30-39	23.4	25.8
40-49	19.3	15.2
50-59	12.4	12
60-74	11	11.9

The following table summarizes the major best practices recommended for SP studies in relation to this study's survey design and implementation process.

Table 4: summary of best practices in survey design and implementation

N*o*	Recommendations on survey design and implementation [24]	This study
1.	Scenario presentation: Clear presentation of baseline scenario, the proposed change to be valued, the mechanism of change and the payment vehicle	The status quo, the proposed change, the mechanism of change and the payment vehicles were clearly described for respondents for both valuation questions
	Scenario presentation: Evidence that respondents perception of the information provided	According to the last pretesting conducted, all respondents seem to understand the information provided by the interviewers.
2	Survey pretesting: Qualitative pretesting	The first and the second pilots were a qualitative type of pretesting focused on windfarms and blackouts respectively.
	Survey pretesting: Quantitative pretesting	A quantitative pretesting was conducted prior to the main survey
3	Attribute versus non-attribute approaches: Decision, whether to use CV or CE, should base on the objective of the study, the complexity of valuation scenario and respondents perception towards the good	The choice of CV for this study was based on a number of considerations i.e objectives of the study, respondents' perception towards the goods and simplicity of the CVM for respondents.

[24] Recommendations are retrieved from (Johnston et al., 2017).

4	Experimental design: CV questions should ensure credible monetary amounts that can give unbiased and consistent estimates.	Valuation questions and auxiliary questions were carefully designed based on pretesting and literatures.
5	Ethical considerations: Survey procedure should avoid significant negative effects for respondents. Neither should it influence the validity of the study adversely.	Standard procedures for data collection were obeyed while collecting the data.
6	Survey mode: survey mode should be context specific	Face to face interview was the most appropriate survey mode for our respondents.
	Sampling: random sampling from the population	Sample respondents were randomly selected from the population.
7	WTA versus WTP: decision between WTA and WTP should be based on empirical and theoretical base.	Decision for use of WTP was based on theory (see section 4)
8	Valuation question response format: reasonable response format should be applied	Payment card approach was used for it is relatively efficient
9	No answer options	"Don't know" options in the payment cards were provided to increase the validity of the responses.
10	Decision rule: a binding and credible decision rule should be selected	The decision rule was if the parties involved in the process including households can cover the cost of the program, then the propose program will be implemented.
11	Payment vehicle: a realistic, credible and binding payment vehicle must be used.	Payment vehicle was electricity bill for those who pay electricity bill. For those who do not pay electricity bill payment vehicle was house rent
12	Auxiliary questions: SP studies should contain supporting questions to enhance validity.	The questionnaire is composed of valuation question, supporting questions and sociodemographic questions.
13	Design of an incentive compatible and consequential valuation questions are important for credibility of the study.	Valuation questions were designed in a way that enhances consequentiality and truth full responses.

5.3 Statistical models

Using the CV design, we do not have the real maximum WTP responses but the observed values. The observed amount is a minimum indicator of the true maximum as stated by Voltaire (2015). It is assumed that the real WTPs lie between the observed value and the next highest amount in the payment card (Cameron & Huppert, 1989), thus we can take the average between the observed value and the next highest amount. This average value or mid-point is an approximation of the true unobserved WTP. It can be used while estimating an OLS. Alternatively, we can use an interval regression without calculating the mid points. In this case, the respondents real maximum WTP lies in between a lower boundary, equal to the amount the respondent picked and an upper boundary, less than the next highest amount. As we have a limited dependent variable, tobit model can also be used. Moreover, a logit model is used to explain what factors affect the decision to be willing to pay or not. In this case the dependent variable is a binary variable taking the value 0 and 1, denoting willing to pay nothing and willing to pay some positive amount respectively. Therefore, this study uses these four methods[25].

5.3.1 OLS

Let us begin with the most traditional estimation method. Consider the following population model adopted from Jeffrey M. Wooldridge (2009)[26] with a vector of variables and a normally distributed error term:

$$WTP = X\beta + u \qquad 6$$

For OLS to be consistent the error term necessarily should have a mean zero and should be uncorrelated with the independent variables. A sufficient condition is that the error term conditional on the explanatory variables has a zero mean.

$$E(u) = 0 \qquad 7$$

$$cov(u, x_j) = 0 \quad \textit{Where, j=1, 2…k} \qquad 8$$

$$E(u|x_1 x_2, \dots, x_j) = 0 \qquad 9$$

Under assumption (7) and (8), we have the population regression function:

$$E(WTP|x_1 x_2, \dots, x_j) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_j x_j \qquad 10$$

[25] Recommendation 14: Econometric estimator selection should base on the data type, the hypothesis to be tested and how the results will be used(Johnston et al., 2017).

[26] All the mathematical expressions are borrowed from Wooldridge(2002) and Wooldridge(2010), unless mentioned otherwise

The zero mean assumption holds as long as an intercept is included(Jeffrey M Wooldridge, 2010), however the zero covariance of the error term with the explanatory variables is of an issue to take care of. In the specified models below (23) and (24), we have no self-selection or decision variables as regressors, which secure as from possible correlation between explanatory variables and omitted variables (if any). Thus, we can say the models satisfy the zero covariance assumptions as we do not have a series problem of omitted variable bias, measurement error or simultaneity.

5.3.2 Interval regression

Consider the population function given in (1) again. Let $WTP_1 < WTP_2 < WTP_3 < \ldots < WTP_8$ denote the survey specified interval limits for WTP. We can estimate β and σ^2, and obtain the conditional probabilities under the normality assumption (Jeffrey M Wooldridge, 2010). According to the survey conducted, what we observe is:

$WTP^*=0$ if $WTP<WTP_1$ *11*

$WTP^*=WTP_1$ if $WTP_1 \leq WTP < WTP_2$

$WTP^*=WTP_2$ if $WTP_2 \leq WTP < WTP_3$

$WTP^*=WTP_3$ if $WTP_3 \leq WTP < WTP_4$

$WTP^*=WTP_4$ if $WTP_4 \leq WTP < WTP_5$

$WTP^*=WTP_5$ if $WTP_5 \leq WTP < WTP_6$

$WTP^*=WTP_6$ if $WTP_6 \leq WTP < WTP_7$

$WTP^*=WTP_7$ if $WTP_7 \leq WTP < WTP_8$

$WTP^*=WTP_8$ if $WTP_8=WTP$

The log likelihood for observation i is given below where ∅ denotes the standard normal CDF.

$$l_i(\beta,\sigma) = 1[WTP_i^* = 0]log\left\{\emptyset\left[{(WTP_1 - x_i\beta)}/{\sigma}\right]\right\} + 1[WTP_i^* = 1]log\left\{\emptyset\left[{(WTP_2 - x_i\beta)}/{\sigma}\right] - \emptyset\left[{(WTP_1 - x_i\beta)}/{\sigma}\right]\right\} + \cdots + 1[WTP_i^* = 8]log\left\{1 - \emptyset\left[{(WTP_8 - x_i\beta)}/{\sigma}\right]\right\} \quad 12$$

Given the assumption that the population distribution is homoscedastic and normal, the maximum likelihood estimators, $\hat{\beta}$ and $\hat{\sigma}$ are the interval regression estimators. Unlike ordered probit model the parameter β present the partial effects of interest and $\hat{\beta}$ can be interpreted as we had a normal regression. This is because with an interval regression the interval cut points are given in the data.

5.3.3 Logit

A logit model[27] is employed when we have a binary response outcome variable. In this case, our dependent variable would be whether a respondent is willing to pay or not. It takes to values, 0 and 1.

$$WTP = \begin{cases} 0 \ if \ no \\ 1 \ if \ yes \end{cases} \qquad 13$$

This model estimates the probability that y=1 as a function of the explanatory variables.

$$p = pr[y = 1|x] = G(X\beta) \qquad 14$$

Where X is a vector of independent variables and β *the associated variable coefficients.* $G(X\beta)$ is the cdf of the logistic distribution which is assumed to be between zero and unity.

$$G(X\beta) = \Lambda(X\beta) = \frac{e^{X\beta}}{1+e^{X\beta}} = \frac{exp(X\beta)}{1+exp(X\beta)} \qquad 15$$

It is only the sign of the coefficients which can be interpreted in a logit model setting. If x_j is continuous variable we can find the magnitude of the effect as follows:

$$\frac{\partial p(x)}{\partial x_j} = g(X\beta)\beta_j \qquad 16$$

$$where, \ g(z) \equiv \frac{dG}{dz}(z) = \frac{exp(Z)}{[1+exp(Z)]^2} \qquad 17$$

$$\frac{\partial p(x)}{\partial x_j} = \frac{exp(X\beta)}{[1+exp(X\beta)]^2}\beta_j \qquad 18$$

On the other hand if x_j is a dummy variable then the partial effect from changing x_j from zero to one would be:

[27] The mathematical expressions in this section are adopted from (Wooldrige,2010)

$$G(\beta_1 + \beta_2 x_2 + \cdots + \beta_{j-1} x_{j-1} + \beta_j) - G(\beta_1 + \beta_2 x_2 + \cdots + \beta_{j-1} x_{j-1}) \qquad 19$$

Similarly, if x_j is a categorical or discrete variables we can estimate the following expression to find the effect on the probability when x_j is increasing from c_j to c_{j+1}

$$G(\beta_1 + \beta_2 x_2 + \cdots + \beta_{j-1} x_{j-1} + \beta_j (c_j + 1)) - G(\beta_1 + \beta_2 x_2 + \cdots + \beta_{j-1} x_{j-1} + \beta_j c_j) \qquad 20$$

The log likelihood for observation i is:

$$l_i(\beta) = y_i log[G(x_i\beta)] + (1 - y_i) log[1 - G(x_i\beta)] \qquad 21$$

Then log likelihood for N observations would be:

$$L(\beta) = \sum_{i=1}^{N} l_i(\beta) \qquad 22$$

$\hat{\beta}$, the maximum likelihood estimator of β, maximizes the log likely hood. Then, $\hat{\beta}$ is a consistent and asymptotically normal estimator of β. Since, $G(x_i\beta)$ is a standard normal cdf in this case, $\hat{\beta}$ is called the logit estimator.

In this study, models are specified for both WTP to avoid blackouts and WTP to avoid environmental costs independently. These models would be:

$$WTP_{bo} = \beta_0 + \beta_1 income + \beta_2 bo\_damages + \beta_3 number\_bo + \beta_4 length\_longest\_bo + \beta_5 avg\_length\_bo + \beta_6 recall\_gov\_promise + \beta_7 age + \beta_8 age^2 + \beta_9 sex + \beta_{10} number\_ppl\_in\_hh + \beta_{11} alternative\_energy\_sources + e$$

23

$$WTP_{env\_cost} = \beta_0 + \beta_1 income + \beta_3 ashegoda + \beta_4 wind + \beta_5 hydro + \beta_6 age + \beta_7 age^2 + \beta_8 sex + \beta_9 number\_ppl\_in\_hh + e \quad 24$$

Abbreviation WTP_{bo} and WTP_{env_cost} stands for WTP to avoid blackouts and WTP to avoid environmental costs, respectively.

5.3.4 Tobit model

A tobit model can be applied for a nonnegative limited dependent variable with many zeros. There is a boundary in the dependent variables we have. For both WTP to avoid blackout and WTP to avoid environmental costs of wind farm, the value ranges between zero and 3600, and the observation hits this boundaries. Most importantly, we can estimate the marginal effects of variables on the dependent variable for the whole sample as well as for the truncated sample. For these purposes, we will also use Tobit model in addition to the above-explained models.

Let the WTP and WTP* be the observed and latent dependent variable respectively. Then the tobit model is given by[28]:

$$WTP^{*} = \beta_0 + X\beta + e, e|X \sim Normal(0, \sigma^2) \qquad 25$$

$$WTP = \begin{cases} = 0 \quad if \;\; WTP * < 0 \\ = WTP^{*} if \; 0 \leq WTP^{*} \leq 3600 \\ = 3600 \; if \; WTP^{*} > 3600 \end{cases} \qquad 26$$

Where zero is the lower boundary and 3600 is the upper boundary in this case.

6. Results and Discussion

This chapter provides the analysis conducted based on data gathered using the survey from both sample sets, namely Mekelle city and Ashegoda.

6.1 Sample summary

The raw data is set of continuous and categorical variables. Some variables were transformed to dummy variables. The variables transformed to dummy are: if respondents recall previous governmnet promises about eliminating blackouts, damage of blackouts, altternative energy sources otherthan electricity and level of annoyance due to the wind turbines. Table 5 provides the summary statistics for the sample data. The percentage distribution of catagorical variable is given in the appendix (see Appendix F). All the variables used in the models are summarized in this section.

A total of 201 households were interviewed. Among the respondents, 62% were female. For the combined sample, the average age was 38. Half of the respondents were between the age of 22 and 38, 5% were under the age of 22, 26% were between 38 and 50, the rest of the respondents were distributed above 50 and the maximum is 73.

Respondents were asked the highest attained education. 26% of the respondents had no schooling. 2% can only read and write. Those who attained vocational training, primary or secondary school

[28] All the mathematical expressions are based on Wooldridge(2002)

constituted about 39.5% of the sample respondents. The remaining 32.5 % had attained a diploma, bachelors or a masters degree.

54.5 % of the respondents had either a full time or part-time jobs. However for the Ashegoda sample respondents, more than half were females and most of them were housewives.

Around 54% of the respondents were married, 27% were single. The remaining were divorced and widowed. The average household size was approximately 4 and the average number of children in the household is 2. The largest family in the sample had 11 members.

Almost half of the respondents live in a rented house. Out of these respondents, 36% does not pay electricity in a rented house. Therefore those people were asked how much they would be willing to pay for the proposed program on the top of their monthly rent in the WTP part of the questionnaire. However, for other respondents, they were asked how much they would be willing to pay on the top of their electricity bill. Average electricity bill was 128 birr per month for those who are paying electricity bill. The average rent was 848 birr per month for those who do not pay electricity.

The average household income was 3700 birr per month but more than half of the respondents were not willing to reveal their income, therefore in the estimated models expenditure was used as a proxy variable for income. The average household expenditure was 3406 birr per month.

Respondents were asked how long they had been living in their current place. On average households had been living in their current place for 13 years. The logic behind this question was to find out if household who live longer in the area would pay more for environmental quality.

The average number of blackouts per year was 160 times with an average length of 3.9 hours. The mean length of the longest blackout per year was 89 hours.

Damages of blackout for the household includes inablity to cook, light, bake, iron, refrigate, to do laundary and so on. The percentage destribution and frequency of this variable from the initial data is provided in the appendix. For the analysis it was converted in to a dummy, where 0 denotes less than four damages and 1 denotes four or more damages to the household[29]. 56.5% of the

[29] we assumed that the damages have equal weight to the respondents

respondents experianced less than four damages where as the remaining respondents suffer from four or more damages.

The majority, 78 % of households use less than three alternative energy sources other than electricity for home making where as 22% had three or more alternative energy sources. The alternative energy sources include coal, gas, woodfire, dung and others. The percentage distribution of this variable is given in the appendix. For the analysis it was converted to a dummy variable.

Only 35.9% of respondents recall the government previous promises on eliminating blackouts, the remaining either don’t remember or don’t know.

From the Ashegoda sample, only 14.9% of respondents reported that they are annoyed by the turbine seen or the noise heard.

Table 5: Descriptive statistics

Variables	Mean	Std. Dev.	Min.	Max.	obs
Age	38.63	13.77	18	73	196
Number of Children	2.37	2.29	0	10	195
Number of People in the Household	3.97	2.13	1	11	200
Electricity bill per month in birr	128.3	111.55	1	550	140
Rent per month in birr	1363.7	1185.28	0	6500	91
Expenditure per month in birr	3406.47	2323.24	100	10000	132
Net Income per month in birr	3699.33	3438.48	0	25000	82
Number of years household lived in their current place	12.79	12.26	0.17	69	198
Number of blackouts per year	159.67	107.16	14	1080	176
Length of the length blackout per year in hour	89	232.44	1	2160	181
Average length of blackouts per year in hour	3.87	3.95	0.05	24	170
Amount of one time compensation (if any) in birr	18750	10307.76	5000	30000	4
Sex male=0 female=1	0.62	0.49	0	1	201
Recall government promise **1=yes, 0=otherwise**	0.36	0.48	0	1	198
Damage of blackouts **0= less than 4 damages** **1=4 or more damages**	0.43	0.50	0	1	200
Alternative energy sources	0.22	0.41	0	1	192

0= less than 3 alternative energy sources, 1= 3 or more alternative energy sources					
How annoyed respondents are due to the turbine seen or the noise heard 0=not annoyed, 1= annoyed	0.15	0.36	0	1	47

Respondents were asked their opinion on how important it is to improve the amount or quality of different goods and servises including hydro-power and wind-power development; on a scale of 0 to 4, 0 denoting very important and 4 denoting not important[30]. The following table provides the percentage distribution of respondents opinion on development of hydro-power and wind-power plants.

Table 6: percentage distribution of respondents opinion on development of hydro-power and wind-power plants

	0.Very Important	**1.Important**	**2.Moderately Important**	**3.Slightly Important**	**4.Not Important**	**5.don't know**
Hydro-power development	76.62	13.93	1.99	0.50	5.47	1.49
Wind-power development	67.16	15.92	5.97	1.00	1.00	1.49

6.1.1 Perception and attitude towards different energy sources and environmental friendly activities

As mentioned earlier respondents were provided with different public goods and services and asked how important those services were. The public goods and services were construction of primary and secondary schools, clinics and hospitals, hydropower plants, wind power plants, securing energy (avoiding blackouts) and clean water provision. The reason we provided mix of different public goods and services was to find how energy security and energy sources perceived by respondents compared to other basic public goods and services provision. As shown in table 6 hydropower and wind power plants were ranked at the bottom, still the overwhelming majority agrees that they are very important. Energy security on the other hand was one of the main

[30] See appendix A2, question number 2.

priorities for our respondents. Table 6 provides a short summary of respondents opinion towards energy security. For a detailed summary, see appendix G.

Table 7: information and attitude towards energy security and energy

	% perceived very important(rank)	% perceived not important	%don't knows
Primary and secondary schools	78.11(5)	0.00	2.99
Clinics and hospitals	91.04(3)	0.00	0.00
Hydro-power development	76.62(6)	5.47	1.49
Wind-power development	67.16(7)	1.00	1.49
Roads	91.54(2)	0.00	0.00
Energy security(avoid blackouts)	86.50(4)	4.00	0.50
Clean water supply	96.02(1)	0.00	0.00

Similarly, respondents were asked if they agree or disagree to a number of statements to explore the opinion of our respondents over different environmental friendly activities. For majority of the statements more than half of the respondents agreed, implying a positive attitude towards environmental friendly activities. The sentence "I do like to see more diesel power generation plants built in my country" was placed purposefully to detect yea saying for this group of questions and 46 percent of the respondents agreed to this sentence i.e they would like to more diesel power generation plants. This indicates either respondents environmental unfriendliness or respondents "yea" saying.

Table 8: opinion towards environmental friendly activities

	% agrees to the proposed statements(rank)	% disagrees to the proposed statements
I use energy saving light bulbs	62.69(6)	24.88
I turn off the lights when I am not using them	85.57(3)	3.98

I keep my home and my car smoke-free	46.27(9)	12.93
I plant trees and native plants	56.71(7)	21.39
I reduce my use of chemicals	43.72(10)	5.03
I dispose waste properly	89.95(2)	4.53
I buy bonds in order to support the development of renewable resources	31.24(12)	31.85
I recycle	31.84(11)	47.26
I volunteer, give time or some cash to environmental activities	68.84(5)	19.60
I use water sparsely	92.00(1)	3.00
I teach the young the importance of treating our environment with care	70.95(4)	5.59
I do like to see more diesel power generation plants built in my country	46.00(8)	23.00

6.2 WTP to avoid blackouts

As shown in table 8, the mean WTP to avoid the blackouts is positive. On average respondents were willing to pay 366.5 birr every year for ten consecutive years. With the mid points calculated, the mean WTP grows to 499 birr per year, with the median being 210. The maximum WTP values was 3600 birr whereas zero is the minimum. 19 % of the respondents had zero willingness to pay and 8% answered "don't know". Out of all the zero responses, 17.4% were protest zeros. Mean WTP values were calculated with and without protest zeros. The mean WTPs calculated without excluding the protest zeros are provided in table 9. The main reason behind excluding protest zeros from any calculations is that those zeros are not true. In other words, if respondents were not protesting they could have been willing to pay something. Respondents have values for the good and service but we cannot observe it as they are protesting. In this case, all respondents who were willing to pay nothing were asked their reason for willing to pay nothing. Observations were considered protest zeros if their reason for not willing to pay something for the program lies in the following category: if they do not think the program would be effective, if they do not think they should pay for the proposed program, if they do not support new government programs or if they don't trust the government.

Table 9: willingness to pay for improved electricity supply without protest zeros

WTP to avoid blackouts	Mean	Median	Standard deviation	Minimum	maximum	sum	Number of observations
With raw data	366.55	120	496.64	0	3600	63780	174
With mid points calculated	499.14	210	578.68	0	3600	86850	174

Table 10: willingness to pay for improved electricity service with protest zeros

WTP to avoid blackouts	Mean	Median	Standard deviation	Minimum	maximum	sum	Number of observations
With raw data	350.44	120	491.35	0	3600	63780	182
With mid points calculated	477.20	210	574.98	0	3600	86850	182

Table 10 summarizes the WTP to avoid blackouts based on location. The Ashegoda sample respondents are willing to pay 321.9 birr per year for the following 10 years where as the city sample (Mekelle) respondents are willing to pay 547 birr. Though the average WTP values varies between the samples, the median was the same. The maximum WTP for the Ashegoda sample was only 1500 birr per year.

Table 11: WTP/household/year (for 10 years) to avoid blackouts for the Ashegoda and Mekelle city samples

Sample type		Mean	Median	Standard deviation	Minimum	maximum	sum	Number of observations
Ashegoda sample	With raw data	230.27	120	299.50	0	1200	8520	37
	With mid points calculated	321.89	210	392.79	0	1500	11910	37
Mekelle City sample	With raw data	403.36	120	532.53	0	3600	55260	137
	With mid points calculated	547.01	210	611.78	0	3600	74940	137

The estimated WTP value was 1.2%[31] of mean annual net income and 32% of mean annual electricity bill implying that people are willing to pay 1.2 % of their income and 32% of their electricity bill.

The core finding here is therefore: the estimated WTP/household to eliminate blackouts is 499 birr per year[32].

6.3 Determinants of WTP to avoid blackouts

Results from the estimations show that, Household expenditure (proxy for income) affects WTP significantly. The higher the income is, the higher the WTP. This is in line with the economic theory that a higher household income will result in a higher WTP. Previous studies also obtained a similar result. A study for Ghanaian households WTP for improved electricity supply found out that income affects respondents WTP positively (Twerefou, 2014). Carlsson and Martinsson (2007) found that a 10 % increase in income will increase a WTP by 2%. As shown in the table

[31] The same for mean annual expenditure
[32] 499 birr is equivalent with 18.09 US Dollars (converting exchange rate 1 birr = 0.036 US Dollar)

11, a 100-birr increase in income will increase WTP for improved electricity service by 13.6 birr, Ceteris paribus.

Households reported that on average they experience 160 blackouts per year with an average length of 4 hours. In the estimated models, number of blackouts affects WTP significantly. Keeping other things constant, one more blackout in a household, leads to a 1.2 up to 1.4 birr increase in WTP to avoid blackouts. Average length of blackout also appears to influence WTP positively and significantly. According to the OLS estimation, an hour increase in the average length of blackouts happens to increase WTP to avoid blackout by 37 birr, other factors being equal. This confirms the Swedish study by Carlsson and Martinsson (2007) that duration of blackouts significantly affects WTP amounts.

In line with the findings of Twerefou (2014), a male respondent is willing to pay a higher amount than a female respondent. Other things being equal, a male respondent is willing to pay 356 up to 400 birr more than a female respondent. Carlsson and Martinsson (2007) also shows that male respondents have a higher WTPs.

Table 12: Estimated Models for WTP to avoid blackouts (OLS and Interval regression)

	OLS	interval regression
Expenditure per month	0.136^{***}	0.114^{***}
	(0.0306)	(0.0260)
number of damages the household face due to the power outage	168.9	115.1
	(134.0)	(114.0)
number of blackouts the household experienced for the last 12 months	1.361^{**}	1.237^{**}
	(0.480)	(0.408)
length of the longest blackout for the past 12 months per hour	0.0434	-0.0155
	(0.476)	(0.405)
average length of	37.26^{*}	31.61^{*}

blackouts for the past 12 months		
	(16.50)	(14.04)
if the respondent can recall the government making promise to diminish blackouts	155.7	161.9
	(121.2)	(103.1)
age	6.109	12.92
	(28.59)	(24.32)
age2	-0.118	-0.198
	(0.323)	(0.275)
male=0 female=1	-399.6**	-356.1**
	(130.5)	(111.0)
total number of people in the household	39.01	47.09
	(34.33)	(29.20)
number of other energy sources the household use	169.7	169.8
	(211.2)	(179.7)
Constant	-315.0	-519.0
	(637.6)	(542.3)
lnsigma		
Constant		6.118***
		(0.0737)
Observations	92	92
Adjusted R^2	0.387	
AIC	1427.8	1412.9
BIC	1458.1	1445.7

Standard errors in parentheses
* $p < 0.05$ (the coefficients are significant at the 5% level)
** $p < 0.01$ (the coefficients are significant at the 1% level)
*** $p < 0.001$ (the coefficients are significant at the 0.1% level)

Damages of blackout to the household, length of the longest blackout, recalling government promise, age, household size and number of alternative energy sources were insignificant and thus they have no explanatory power over the variation of WTP to avoid blackouts. As it can be inferred from Appendix E1, a reduced model was formulated to see the stability of the results, as the reduced model has higher number of observation than the full model. All the variables (expenditure, number of blackouts, average length of blackout and gender) were significant in the reduced model. In addition to this, the F test shows that these variables were jointly significant.

A variance inflation factor (VIF) was conducted to detect for multicollinearity. The test result shows no evidence for multicollinearity.

To explore what factors affect whether to be willing to pay or not, we have estimated a logit model (see appendix B1). The significant variables were expenditure, number of blackouts and gender. A male respondent is more likely to have a positive WTP amount. As expenditure increases the probability of being willing to pay increases. An increase in number of blackout increases the probability of being willing to pay to avoid blackouts. What we can learn from this result is average length of blackouts does not affect the decision between whether to pay or not. However, once the respondents decide to pay, average length of blackout significantly affects the amount.

Based on the tobit model (see appendix B2), the variation in the WTP value (for those who has positive WTP) is explained by expenditure, number of blackouts, average length of blackouts and gender.

Table 13: Summary of hypotheses and findings on determinants of WTP to avoid blackouts (BO)

	Hypotheses under factors affecting WTP to avoid BO	**Expected sign**	**Findings**
H2	Wealth affects WTP positively	+	True
H3	Damages of BOs affect WTP positively	+	false
H4	Number of BOs affect WTP positively	+	True
H5	Length of the longest BOs affect WTP positively	+	false
H6	The average length of BOs affect WTP positively	+	True
H7	Remembering government unrealized promises will affect WTP negatively	-	false
H8	Age affects WTP first positively later negatively	+/-	false
H9	Sex of the respondent(female=1;male=0)	-	True

H10	Number of people in the household affects WTP positively	+	False
H11	Alternative energy sources affect WTP positively	+	False

6.4 WTP to avoid environmental costs of wind farms

The mean WTP for avoiding environmental costs from wind farms is 374 birr per year for ten consecutive years. Explicitly speaking, households are willing to pay a positive amount to cover the extra costs of upgrading existing hydropower plants instead of building new wind farms. As depicted in table 15, this value is calculated excluding protest zero and “good cause” payments. The maximum WTP values was 2700 birr whereas zero is the minimum. 34.9 % of the respondents had zero willingness to pay and 9.2 % replied “don’t know”. Out of all the zero responses 17.4% were protest zeros and out of all the positive WTP responses 18.3% were “good cause” payments. It is not possible to observe real WTP if respondents are paying something just to contribute for a good cause. They are willing to pay something not because it is worthy for them to avoid the environmental costs but to just contribute for something good. Table 13 and 14 show the estimated WTP with the initial data and with only protest zeros removed, respectively.

Table 14: willingness to pay to avoid environmental costs of wind farms (including protest zeros and good cause payments)

WTP to avoid environmental costs of wind farms	**Mean**	**Median**	**Standard deviation**	**Minimum**	**maximum**	**Sum**	**Number of observations**
With raw data	265.76	120	390.19	0	2400	47040	177
With mid points calculated	375.93	210	490.71	0	2700	66540	177

Table 15: mean WTPs with Protest zeros excluded

WTP to avoid environmenta	**Mean**	**Median**	**Standard**	**Minimum**	**maximum**	**sum**	**Number of observations**

l costs of wind farms			deviation				
With raw data	280.99	120	393.58	0	2400	45240	161
With mid points calculated	398.38	210	492.34	0	2700	64140	161

Table 16: mean WTPs to avoid environmental costs of BOs (Protest zeros and good cause payments excluded)

WTP to avoid environmental costs of wind farms	**Mean**	**Median**	**Standard deviation**	**Minimum**	**maximum**	**sum**	**Number of observations**
With raw data	264.68	120	399.28	0	2400	37320	141
With mid points calculated	374.25	210	497.08	0	2700	52770	141

The sign of the estimated WTP confirms the hypothesis that Mean WTP per household to avoid external costs of wind farms is positive. This finding agrees with previous studies. As Mattmann et al (2016) mentioned in their meta-analysis, except two all the WTP estimations obtained in previous studies were positive. For instance, a study conducted in Denmark has shown that the Danish population is willing to pay a positive amount for visual disamenity reduction in future offshore wind farm constructions. Households were willing to pay 33, 94 and 107 euros per year for locating future wind farms 12, 18 and 50 km offshore, respectively (Ladenburg & Dubgaard, 2007).

Table 16, shows the summary of estimated WTPs by location. The average WTP values were higher among the city sample i.e the mean WTP for the Ashegoda sample is 152 birr per year and the mean WTP for the city sample is 434 birr. Another important point to notice is that the median for the Ashegoda sample respondent is zero. For the city sample the median WTP is 210 birr.

Table 17: WTP to avoid environmental costs for the Ashegoda and city sample sets

Sample type		Mean	Median	Standard deviation	Min	max	sum	Number of observations
Ashegoda sample	With raw data	104	0	171.11	0	600	3120	30
	With mid points calculated	152	0	248.00	0	900	4560	30
City sample	With raw data	308.10	120	431.56	0	2400	34200	111
	With mid points calculated	434.32	210	530.24	0	2700	48210	111

As presented in the below in the table, the city sample respondents were willing to pay 0.9% of their annual expenditure and the Ashegoda sample respondents were willing to pay 1.2 % of their expenditure. In total, respondents are willing to pay 0.9 % of their annual net income (expenditure). Likewise, the estimated WTP is 24 % of the mean annual electricity bill.

Table 18: WTP to avoid environmental costs as a percentage of income, expenditure and electricity bill

Sample type (number of observation)	**WTP as percentage of annual income**	**WTP as percentage of annual expenditure**	**WTP as percentage of annual electricity bill**
Ashegoda (30)	0.9	1.2	31.8
Mekelle (111)	0.9	0.9	21.9
Total (141)	0.9	0.9	24.1

The main finding here is the environmental cost of wind farm per household in monetary terms is 374 birr per year[33].

[33] 374 birr is equivalent with 13.56 US Dollars (converting exchange rate 1 birr = 0.036 US Dollar)

6.5 Determinants of WTP to avoid environmental costs of wind farms

Expenditure (proxy for income) affects WTP to avoid environmental costs positively. This agrees with the hypothesis that income affects WTP to avoid environmental costs of wind farms positively. Many studies from different countries also found that income has a positive effect on WTPs, as the economic theory suggests. For instance, a Danish study proved that middle and high-income households have a higher WTP for reduced disamenities than low-income households (Ladenburg & Dubgaard, 2007). Based on the estimated WTP functions, a 100 birr increase in monthly income will result in a 10 birr increase in the WTP to avoid environmental impacts of wind farm, ceteris paribus.

Men have a higher willingness to pay. All other factors being equal, a male respondent is willing to pay 383 to 417 birr more than females. Total number of people in the household positively influences WTP. Keeping other factors constant, having one more person in the household increases WTP by 48 birr based on the OLS result.

Ceteris paribus, respondents who perceive wind power developments as a less important public good provision are willing to pay more to avoid environmental costs of wind farms. A parallel result was recorded by Koundouri et al (2009) in there estimation of WTP for construction of wind farms in Greece. They showed that support for construction of wind farm significantly positively affects their WTP to its construction. That means individuals who do not support development of windfarms will have a lower WTP for its construction in general. On the other hand, perception of hydropower development as a less important public good does not explain the variation in WTP.

In all estimated models, the variable "Ashegoda" happens to be insignificant implying that the result does not support the presence of a NIMBY effect. Living in Ashegoda does not explain the variation in WTP to avoid environmental costs of wind farm.

As can be inferred from Appendix D, separate estimations for the Ashegoda and Mekelle sample were conducted. In the Mekelle (city) sample, knowing someone who lives near a wind farm was included as a variable, but results show that it is insignificant. Thus, knowing someone who lives near a wind farm does not affect the WTP for city sample respondents.

From the separate model estimated for Ashegoda sample respondents only (see Appendix D), the number of years the household had lived in the area significantly influences WTP. However, the expected signs did not hold. Level of disturbance due to the noise heard or the turbines seen by respondents does not have a significant effect on WTP.

Table 19: Estimated models for WTP to avoid environmental costs of Wind farms (OLS and Interval regression)[34]

	OLS	interval regression
expenditure per month	0.104***	0.0999***
	(0.0240)	(0.0210)
1=Ashegoda 0=otherwise	138.0	148.1
	(158.2)	(134.3)
age	-4.682	-5.643
	(21.86)	(18.80)
age2	0.0270	0.0446
	(0.245)	(0.211)
male=0 female=1	-417.4***	-383.3***
	(96.30)	(82.23)
total number of people in the household	43.60	39.04+
	(26.86)	(23.07)
Hydro-power development[35]: VI=0 I=1 MI=2 SI=3 NI=4 DK=5=0	0	0
	(.)	(.)
Hydro-power development : VI=0 I=1 MI=2 SI=3 NI=4 DK=5=1	44.38	32.64
	(137.1)	(116.1)
Hydro-power development : VI=0 I=1 MI=2 SI=3 NI=4	16.37	15.55
	(330.3)	(287.9)

[34] The F test conducted proved that variable expenditure, gender, number of people in the household and prior attitude towards wind farm are jointly significant.

[35] "Hydro-power development" and "wind-power development" here are categorical variables denoting respondents' opinion towards the development of hydropower plants and wind power plants, respectively. Very important (VI), important (I), moderately important (MI), slightly important (SI), not important (NI) and don't know (DK) are the categories' where VI is the base category.

DK=5=2		
Hydro-power development : VI=0 I=1 MI=2 SI=3 NI=4 DK=5=5	-259.6 (283.1)	-212.1 (237.5)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=0	0 (.)	0 (.)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=1	26.56 (121.7)	20.36 (103.7)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=2	399.1^{+} (204.3)	364.5* (171.0)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=3	2027.6*** (544.9)	2007.7*** (494.2)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=4	615.0 (436.2)	614.7 (404.6)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=5	232.0 (206.6)	191.1 (177.1)
Constant	196.8 (476.4)	223.3 (408.8)
lnsigma		
Constant		5.839*** (0.0777)
Observations	100	100
R^2	0.496	
Adjusted R^2	0.413	

Standard errors in parentheses
+ $p < 0.10$ (the coefficients are significant at the 10%level)
* $p < 0.05$ (the coefficients are significant at the 5% level)
** $p < 0.01$ (the coefficients are significant at the 1% level)
*** $p < 0.001$ (the coefficients are significant at the 0.1% level)

In the logit model (see Appendix C1), expenditure, gender and number of people in the household significantly affects the decision between whether to pay something to avoid environmental costs or not. Results from Tobit model is quite similar with the interval regression and the OLS, except in the OLS number of people in the household is insignificant.

Table 20: summery of hypotheses and findings on the determinants of WTP to avoid environmental costs of wind farms

	Hypotheses under factors affecting WTP to avoid environmental costs of wind farms	**Expected sign**	**Findings**
H13	Living in Ashegoda affects WTP positively	+	False
H14	income affects WTP positively	+	True
H15	Knowing someone who lives near the wind farm affects WTP positively	+	False
H16	Number of people living in the house	+	True
H17	Sex of the respondent(female=1;male=0)	-	True
H18	Age affects WTP first positively then negatively	+/-	False
H19	Number of years lived in current place affects WTP positively	+	Affects WTP negatively
H20	Level of annoyance due to the wind farm affects WTP positively	+	False
H21	Preference over less hydropower development affects WTP negatively	-	False

H22	Preference over less wind power construction affects WTP positively	+	True

6.6 Validity of the study[36]

As defined by Johnston et al. (2017), content validity refers to the appropriateness of the survey design and implementation process, the contents in the survey instrument, the data analysis and study reporting. In this study, the survey design and implementation procedure, the questions and descriptions in the survey instrument, the analysis and the study reporting were in accordance with the best-practices proposed by Johnston et al. (2017).

Construct validity refers to whether the results of the study satisfies the hypothesis tests based on prior expectations (Johnston et al., 2017). In this study, the results show that WTP increases with income, which is in line with the economic theory. Part of the hypotheses were true and in agreement with previous studies.

Criterion validity on the other hand requires comparison of SP estimates with presumed true value (i.e experimental research and voting comparison studies). Because of lack of such studies a criterion validity test was not carried out.

6.7 Limitation of the study

Even though face-to-face interview was the best way to collect the appropriate data for our study, it comes with a disadvantage. With the time and budget limitation it is almost impossible to have more than 200 observations. Thus having a small number of observation is the first limitation of this study. Second, some of the variables have many missing values to the extent that they cannot be used in the analysis. For instance, the variables "relocation" and "compensation" denoting " if respondents relocated due to the Ashegoda wind farm construction" and "if respondents received any compensation" were not used in the analysis as a result of very many missing values. Third, because of time limitation, most of the interviews were conducted in working days and working hours. This could have a significant influence on the sample representativeness, as busy (working) respondents would be unavailable for the interview. Fourth, Johnston et al. (2017) suggests that

[36] Recommendation 21: in SP studies analysis should include a validity assessments(Johnston et al., 2017)

SP studies should include both observed and unobserved heterogeneity in their modellings[37] but in the econometric analysis unobserved preference heterogeneities were not modeled. Fifth, conducting a scope test, transitivity test or any other behavioral axioms tests would be ideal, but such type of tests were not conducted in this study. Last of all, it is recommended that an ideal SP study should include both parsimonious and more complex models in its analysis (Johnston et al., 2017)[38]. If it was possible to devote even more time on the data analysis, a greater insight could have been grasped from the data.

7 Conclusion and implications

Electricity blackouts is among the major problems in Ethiopia, and thus it is important to study households willingness to pay to avoid blackouts. On average households face 160 blackouts per year and with an average length of four hours. In this study, CVM was employed to explore households´ WTP to avoid blackouts. Results show that households are willing to pay an additional 32% of their annual electricity bill to eliminate blackouts. This could justify larger investments by the government (particularly the Ethiopian electric power corporation (EEPCo)) to reduce blackouts. Household WTP to avoid blackout increased significantly with increasing wealth, number of blackouts and average length of blackouts. Male respondents have significantly higher WTP. We anticipate that this finding will have a significant role in future cost benefit analysis as well as policy decision-makings. This study focused only on households WTP to avoid blackouts hence future research should have a broader look on the external cost of blackouts.

The expansion of wind farm developments and its corresponding external costs led to the valuation of environmental costs of wind farm. The contingent valuation study that we conducted shows that respondents are willing to pay 374 birr per year (for 10 years), that is 24% of their current annual electricity bill. Household WTP to avoid external effects of wind power increased significantly with increasing wealth and number of people in the household; and decreasing preference over windfarm construction. Male respondents have significantly higher WTP to avoid external effects of wind farm.

Based on the results it is suggested that the government (or EEPCO):

[37] Recommendation 15
[38] Recommendation 16

i. Invest more in the power sector to eliminate blackouts.
ii. Compensate local residents who live near windfarms. The compensation could be in a form of improved power supply, creation of job opportunities and infrastructure development for the community.
iii. Create habitat to compensate for the biodiversity loss by the wind farm.

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Appendix

A. Questionnaire

A1. External cost of wind farms in Ethiopia: Assessment and valuation

Dear respondent, this is a survey on people’s experience and attitudes towards energy use. It is conducted in partial fulfillment of master’s degree program. I would be most grateful if you could take about 30 minutes of your time to complete this interview. There are no right or wrong answers. We would just like you to answer this as best as you can. Responses are confidential, so feel free to give your honest opinion.

Thank you in advance for your cooperation

Name of interviewer______________

Date ______

Time interview started ___________________________

Time interview ended ________________________

Subcity__________________

Tabia _________________

A2. Part I: perception and attitude towards different energy sources

1. How many years have your household lived where you live now? ____________years
2. Resources and budgets are limited and hence a country cannot provide the highest level of all services to its citizens. Some goods and services are more important than other goods and services. In your opinion, how important is it to improve the amount or quality of the following goods and services

For interviewer: Rotate the order of the public goods and services for each respondent

	0.Very Important	1.Somewhat Important	2.Moderately Important	3.Slightly Important	4.Not Important	5.don't know
Primary and secondary schools						
Clinics and hospitals						
Hydro-power development						
Wind-power development						
Roads						
Energy security(avoid blackouts)						
Clean water supply						

3. Please indicate whether you agree or disagree with each of the following statements

	0.Strongly agree	1.agree	2.neutral	3.disagree	4.Strongly disagree	5.Don't know	6.Not applicable
I use energy saving light bulbs							
I turn off the lights when I am not using them							
I keep my home and my car smoke-free							
I plant trees and native plants							
I reduce my use of chemicals							
I dispose waste properly							
I buy bonds in order to support the development of renewable resources							
I recycle							
I volunteer, give time or some cash to environmental activities							
I use water sparsely							

I teach the young the importance of treating our environment with care							
I do like to see more diesel power generation plants built in my country							

4. Do you know someone who lives near a windmills farm?_ 0. No____1. Yes____

A3. Part II: Willingness to pay questions

5. For which of the following purposes do you use electricity

☐0. Cooking

☐ 1. Light

☐ 2. Baking

☐ 3. Ironing

☐4. Refrigerating

☐5. Laundry

☐ 6. Other (please specify)______________________

☐ 7. I do not use electricity

6. What other energy sources do you use for heating, light, and cooking?

☐ 0. Coal

☐ 1. Gas

☐ 2. Wood fire

☐ 3. Dung

□ 4. Other, please specify:___________________________

□ 5. I do not use any other sources

7. Approximately how many blackouts approximately did your household experience the last 12 months ?____________blackouts
8. Approximately how long did the longest blackout last that your household experienced the last 12 months ?__

Reply in number of ___________hours OR__________days

9. What is the average length of most blackouts you have experienced during the last year?____________hours
10. What kind of negative impacts does blackouts have on you and your household?

□0.Unable to cook with electric appliances

□1.Unable to refrigerate food

□2. Unable to use bank services and ATM

□3. Negative entertainment effects (i.e television and radio do not function)

□4. Vulnerable to robbers in a dark night

□5. Not able to read or study

□6. others please specify
____
____
____
____
____

11. The Government is now considering implementing a program to reduce the number of blackouts from the current level to eliminate the blackouts. The program includes upgrading old and building new electricity production plants and new transmission lines. The costs of this program will be covered by international donors, government, companies and the households. If the government sees that these interest groups are willing to pay more to avoid the blackouts than what it costs, they will implement the program, which will eliminate blackouts. Think about what it is worth to you to fully avoid the negative impacts you have

experienced from blackouts the last 12 months. What is the most, if anything, your household certainly is willing to pay per year for 10 years on the top of your annual electricity bill (or on the top of your house rent, if you are not paying the electricity bill by yourself) to fully avoid blackouts? Remember that this payment will reduce your expenditure for other goods and services

0birr per month (0 birr per year)For 10 years	10 birr per month (120 birr per year) For 10 years	25 birr per month (300 birr per year) For 10 years	50birr per month (600 birr per year) For 10 years	100birr per month (1200 birr per year) For 10 years	150birr per month (1800 birr per year) For 10 years	200birr per month (2400 birr per year) For 10 years	250birr per month (3000 birr per year) For 10 years	300birr per month (3600 birr per year) For 10 years	other (please specify)_______	Don't know

If your answer to #11 was zero or don't know, please respond to question #12; otherwise, skip #12and answer #13

12. Why are you not willing to pay anything for the program which will eliminate blackouts, or don't know what you are willing to pay? Please choose the **one** most important reason.

□ 0. I do not experience any blackouts

□ 1. I cannot afford to pay

□ 2. I do not think that this program would be effective.

□ 3. I do not think that I should pay for this program.

□ 4. I do not support any new government programs.

□ 5. I do not trust the government

□ 6. This program is not important to me

□ 7. Other, please specify: ____

13. What is the most important reason for you being willing to pay something to eliminate blackouts?

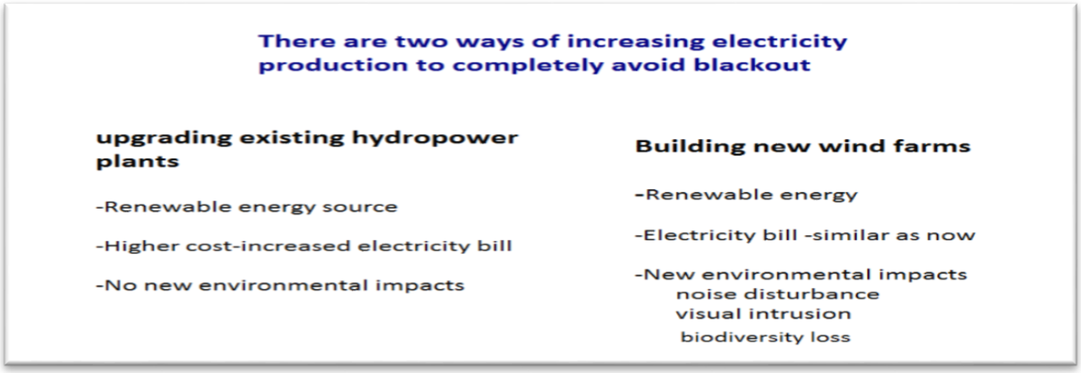
____

______

14. Avoiding blackouts can be achieved by developing new wind power plants **or** by upgrading existing hydropower. Upgrading hydropower plants by installing new turbines will be more costly than producing the amount of electricity needed from constructing new wind power plants. However, the upgrading of hydro will cause no new negative environmental impacts, whereas new windpower plants will - in terms of noise, changing the view of the landscape, and cause disturbances to animal and bird life (e.g. birds hit by the wind turbine) – see the card below. Think about what it is worth to your households to avoid these negative impacts of noise disturbance, visual intrusion and biodiversity loss from windpower, and instead pay a higher electricity bill to cover the extra costs of upgrading existing hydropower plants instead. IF households´ willingness-to –pay exceeds the extra costs of upgrading hydropower, the government will do this instead of building new windmill farms. What is the most, if anything, your household certainly is willing to pay per year for 10 years on the top of your annual electricity bill (or on the top of your house rent, if you are not paying the electricity bill by yourself) to avoid these negative environmental impacts from windmill farms? Remember that this payment will reduce your expenditure for other goods and services.

    Choose the additional highest amount you would be willing to pay for this program (upgrading hydropower dams).

For interviewer: *show the card to the respondent.*



0birr per month (0 birrs per year)For 10 years	10 birr per month (120 birrs per year) For 10 years	25 birr per month (300 birrs per year) For 10 years	50birr per month (600 birrs per year) For 10 years	100birr per month (1200 birr per year) For 10 years	150birr per month (1800 birr per year) For 10 years	200birr per month (2400 birr per year) For 10 years	250birr per month (3000 birrs per year) For 10 years	300birr per month (3600 birrs per year) For 10 years	other (please specify)___ ____	Don't know

If your answer to #14 was zero or don't know, please respond to question #15; otherwise, skip #15 and answer #16 and #17.

15. What is the most important reason for you not being willing to pay anything, or that you don't know what you are willing to pay, to upgrade hydropower plants and avoid new wind power plants with its negative environmental impacts? Please choose the **one** most important reason.

☐ 0. The government should build and pay for upgrading hydropower plants

☐ 1. I cannot afford to pay anything

☐ 2. I do not think that it is feasible to upgrade hydro power plants to produce the electricity needed to eliminate blackouts

□ 3. I do not think that I should pay for the upgrading of hydropower plants

□ 4. I do not support any new government programs.

□ 5. I do not trust the government

□ 6. Avoiding the negative environmental impacts from wind power is not important to me

□ 7. I would rather have the windmill farms because they have positive impacts on employment etc

□ 8. Other reasons, please specify ____

16. Why are you willing to pay something to upgrade existing hydropower plants, and avoid the negative environmental impacts from windmill farms?

□0. Avoiding the negative environmental impacts from windmill farms is important to me and my household.

□1. I think it is our responsibility to protect our environment for future generations

□2. I want to contribute to a good cause.

□3. Other: ____

17. Which form of payment do you then prefer?

□0. Voluntary payment

□ 1. Increased Income tax

□ 2.Increase in electricity bill

□ 3.Indifferent

18. Do you remember the government making a promise to diminish blackouts?

□ 0. no

□ 1.yes

□ 2. Don't know

A4. Part III: for Ashegoda sample respondents

The following questions are only for Ashegoda sample respondents

19. Do you get electricity? 0. No____1. Yes____
20. Do you do any farming activities adjacent to the Ashegoda wind farm? 0. No____1. Yes____
21. How did you get introduced to this wind farm construction?

____

____

22. Did you have to relocate because of this wind farm construction?

0. No____1. Yes____2. Don´t know If yes please answer question #23, otherwise proceed to question #24

23. How long did you live in the area before relocation?_______years
24. Did you get any compensation?

0. No____ 1. Yes____ 2. Don´t know

If yes please answer the question from #25 to #29 , otherwise proceed to question # 30

25. What type of compensation did you receive?
    - □0. One-time monetary compensation
    - □1. Annual monetary compensation
    - □2. Non-monetary compensation
26. If you get a one-time monetary compensation, how much was the compensation for your household? __________Birr
27. If you get an annual monetary compensation, how much was the compensation for you household per year?_____Birr and for how many years?___years
28. If you get a non-monetary compensation; what was it?___________
29. How satisfied or dissatisfied are you with the compensation given to you?

□0. Very satisfied □1. Fairly satisfied □2. Neither satisfied nor dissatisfied

□3. Fairly dissatisfied □4. Very dissatisfied □5. Don´t know

30 How many wind turbines do you see from where you live now? _____# wind turbines

31 How annoyed are you by the wind turbines you see and/or hear?

□0. Extremely annoyed

□1. Very Annoyed

□2. Somewhat annoyed

□3. Little annoyed

□4. Not annoyed at all

□5. Don´t Know

A5. Part IV: Socio-demographic Characteristics

32. age ____

33. Sex □ male □ female

34. Which is the highest level of education that you have completed?

□0.No schooling □1.reading and writing only(keshi or medrsa)

□2.primary school □3.high school

□4.Vocational training □5.diploma □6.bachelor's degree

□7.Masters degree □8.doctorate degree □9.Other (please specify)______

35. Employment status □0.full-time job □1.part-time job □2.unemployed

□3.Pensioner □ 4.student □ 5.farmer

□6.Housewife

□7.Other (please specify)______

36. marital statuses □ 0.married □ 1. unmarried □2. divorced

□3.Widowed

37. Number of children (if any)____

38. Number of people in your household (including yourself):_________

39. Type of home ownership □

0. own house □1. rent □2.other(please specify)____________

40. If you rent the house you are currently living in, do you pay electricity yourself? 0. No 1.Yes
    If no, skip question #41
41. How much does your household pay approximately per month in electricity bill?______birr per month
42. How much do you pay for rent?______birr per month
43. Approximately how much money does your household spend per month on average for goods and services?__________birr per month
44. How much is your monthly net household income (after taxes) ______birr per month
45. Do you have any comments on this survey? Feel free to state anything which could help us improve the questionnaire.____

    Thank you for your time and help!

B. Results from logit and tobit (WTP to avoid balckout)

B1. Logit model for WTP to avoid blackout

Table 21: Results- Logit model for WTP to avoid blackout

	logit	mariginal effects
WTP for sustainable energy per year expenditure per month	0.00109*	0.000587*
	(0.000484)	(0.000291)
number of damages the household face due to the power outage	1.378	1.418
	(1.054)	(0.938)
number of blackouts the household experianced for the last 12 months	0.0145*	0.00685
	(0.00724)	(0.00600)
length of the longest blackout for the past 12 months per hour	-0.000685	0.00137
	(0.00280)	(0.00236)
average length of blackouts for the past 12 months	0.00970	-0.0109
	(0.108)	(0.0966)

if the respondent can recall the government making promise to diminish blackouts	-0.436	-0.232
	(0.870)	(0.738)
age	-0.427	-0.353
	(0.258)	(0.225)
age2	0.00430	0.00386
	(0.00294)	(0.00266)
male=0 female=1	-3.999*	-1.727
	(1.590)	(0.965)
total number of people in the household	0.232	0.0854
	(0.246)	(0.212)
number of other energy sources the household use	1.962	
	(1.223)	
Constant	8.179	7.060
	(5.134)	(4.345)
Observations	99	104
Pseudo R^2	0.397	0.305
AIC	74.81	84.09
BIC	106.0	113.2

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

B2. Tobit model for WTP to avoid blackouts

Table 22: Results- Tobit model for WTP to avoid blackouts

	tobit	marginal effect for truncated sample	marginal effect for censored sample
model			
expenditure per month	0.158***	0.158***	0.158***
	(0.0328)	(0.0328)	(0.0328)
number of damages the household face due to the power outage	243.4	243.4	243.4

	(144.2)	(144.2)	(144.2)
number of blackouts the household experianced for the last 12 months	1.514**	1.514**	1.514**
	(0.509)	(0.509)	(0.509)
length of the longest blackout for the past 12 months per hour	0.221	0.221	0.221
	(0.527)	(0.527)	(0.527)
average length of blackouts for the past 12 months	38.46*	38.46*	38.46*
	(17.77)	(17.77)	(17.77)
number of other energy sources the household use	137.9	137.9	137.9
	(237.7)	(237.7)	(237.7)
if the respondent can recall the government making promise to diminish blackouts	162.6	162.6	162.6
	(130.0)	(130.0)	(130.0)
age	-4.554	-4.554	-4.554
	(30.54)	(30.54)	(30.54)
age2	-0.0123	-0.0123	-0.0123
	(0.345)	(0.345)	(0.345)
male=0 female=1	-467.1**	-467.1**	-467.1**
	(139.7)	(139.7)	(139.7)
total number of people in the household	40.66	40.66	40.66
	(37.10)	(37.10)	(37.10)
Constant	-257.1	-257.1	-257.1
	(680.6)	(680.6)	(680.6)
sigma			
Constant	560.4***	560.4***	560.4***
	(46.08)	(46.08)	(46.08)

Observations	92	92	92
Adjusted R^2			
Pseudo R^2	0.046	0.046	0.046
AIC	1242.7	1242.7	1242.7
BIC	1275.5	1275.5	1275.5

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

C. Results from logit and tobit (WTP to avoid environmental costs of wind farm)

C1. Logit

Table 23: Results- WTP to avoid environmental costs of wind farm (Logit)

	logit	logit_mar
WTP for upgrading hydro per year		
expenditure per month	0.000365*	0.000365*
	(0.000175)	(0.000175)
1=ahegoda 0=otherwise	-1.673	-1.673
	(0.943)	(0.943)
age	-0.115	-0.115
	(0.130)	(0.130)
age2	0.0000981	0.0000981
	(0.00141)	(0.00141)
male=0 female=1	-1.900**	-1.900**
	(0.632)	(0.632)
total number of people in the household	0.466*	0.466*
	(0.189)	(0.189)
Constant	3.559	3.559
	(2.848)	(2.848)
Observations	100	100
Pseudo R^2	0.284	0.284
AIC	107.6	107.6
BIC	125.8	125.8

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

C2. Tobit

Table 24: Results- WTP to avoid environmental costs of wind farm(Tobit)

	tobit	marginal effect for the censored sample	mariginal effect for the truncated sample
model			
expenditure per month	0.128^{***} (0.0314)	0.128^{***} (0.0314)	0.128^{***} (0.0314)
1=ahegoda 0=otherwise	-1.495 (238.1)	-1.495 (238.1)	-1.495 (238.1)
age	-11.47 (30.67)	-11.47 (30.67)	-11.47 (30.67)
age2	0.0284 (0.341)	0.0284 (0.341)	0.0284 (0.341)
male=0 female=1	-605.6^{***} (130.6)	-605.6^{***} (130.6)	-605.6^{***} (130.6)
total number of people in the household	69.18^{+} (37.19)	69.18^{+} (37.19)	69.18^{+} (37.19)
Hydro-power development : VI=0 I=1 MI=2 SI=3 NI=4 DK=5=0	0 (.)	0 (.)	0 (.)
Hydro-power development : VI=0 I=1 MI=2 SI=3 NI=4 DK=5=1	32.54 (181.7)	32.54 (181.7)	32.54 (181.7)
Hydro-power development : VI=0 I=1 MI=2 SI=3 NI=4 DK=5=2	114.1 (414.9)	114.1 (414.9)	114.1 (414.9)
Hydro-power development : VI=0 I=1 MI=2 SI=3 NI=4 DK=5=5	-3273.6 (.)	-3273.6 (.)	-3273.6 (.)
Wind-power	0	0	0

development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=0	(.)	(.)	(.)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=1	75.45 (163.3)	75.45 (163.3)	75.45 (163.3)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=2	539.0* (256.6)	539.0* (256.6)	539.0* (256.6)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=3	2117.0** (682.6)	2117.0** (682.6)	2117.0** (682.6)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=4	682.4 (543.7)	682.4 (543.7)	682.4 (543.7)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=5	374.9 (291.8)	374.9 (291.8)	374.9 (291.8)
Constant	229.7 (666.1)	229.7 (666.1)	229.7 (666.1)
sigma			
Constant	518.5*** (48.05)	518.5*** (48.05)	518.5*** (48.05)
Observations	100	100	100
Pseudo R^2	0.062	0.062	0.062
AIC	1053.6	1053.6	1053.6
BIC	1092.6	1092.6	1092.6

Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

D. Regression results for separate samples (i.e Mekelle sample and Ashegoda sample)

Table 25: Results- separate estimation results for Mekelle and Ashegoda (OLS)

	OLS for the city sample	ols for Ashegoda sample

expenditure per month	0.103[***]	-0.0489
	(0.0260)	(0.0424)
male=0 female=1	-357.1[**]	-842.0[***]
	(111.4)	(56.65)
total number of people in the household	43.67	-20.47[+]
	(28.77)	(10.05)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=0	0	0
	(.)	(.)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=1	9.376	136.2[**]
	(129.3)	(38.40)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=2	440.1[*]	
	(215.2)	
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=3	2042.4[***]	
	(468.5)	
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=4	744.0	
	(493.2)	
Wind-power Development: VI=0 I=1 MI=2 SI=3 NI=4 DK=5=5	239.5	27.66
	(281.2)	(55.10)
if the respondent know someone who live near the windmills farm: no=0 yes=1	-68.26	
	(160.0)	
number of years the household lived in their		-3.327[+]
		(1.666)

current place		
level of dissatisfaction (how annoyed the respondent is due to the turbines he/she		-44.31
		(27.20)
Constant	33.78	1215.8***
	(132.3)	(206.6)
Observations	82	18
R^2	0.444	0.976
Adjusted R^2	0.374	0.959

Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

E. Reduced models

E1. Reduced model for WTP to avoid blackouts

Table 26: Results for the reduced model for WTP to avoid blackouts (OLS and Interval regression)

	OLS	interval regression
main		
expenditure per month	0.146***	0.147***
	(0.0245)	(0.0238)
number of blackouts the household experienced for the last 12 months	1.122*	1.083*
	(0.452)	(0.444)
average length of blackouts for the past 12 months	37.39*	37.25*
	(15.91)	(15.45)
male=0 female=1	-331.4**	-319.0**
	(110.2)	(106.2)
Constant	2.137	-2.947
	(163.3)	(157.7)
lnsigma		
Constant		6.204***
		(0.0761)
Observations	99	99
R^2	0.401	
Adjusted R^2	0.375	

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

E2. Reduced model for WTP to avoid environmental costs of wind farm

Table 27: Results for reduced model for WTP to avoid environmental costs (OLS and Interval regression)

	OLS	interval regression
main		
expenditure per month	0.0918***	0.0858***
	(0.0188)	(0.0170)
male=0 female=1	-377.9***	-343.3***
	(90.47)	(79.60)
total number of people in the household	47.20*	44.44*
	(21.69)	(19.13)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=0	0	0
	(.)	(.)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=1	48.70	38.07
	(103.7)	(90.66)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=2	427.2*	382.8*
	(192.9)	(166.9)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=3	2027.3***	1995.6***
	(418.8)	(401.7)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=4	635.7	627.1
	(421.3)	(403.9)
Wind-power development:VI=0 I=1 MI=2 SI=3 NI=4 DK=5=5	161.6	136.6
	(170.3)	(149.1)

Constant	78.06	97.71
	(110.6)	(96.89)
lnsigma		
Constant		5.859^{***}
		(0.0767)
Observations	102	102
R^2	0.471	
Adjusted R^2	0.426	

Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

F. Summary table for categorical variables

Table 28: purposes of electricity for the household

purpose of electricity for the household	Freq.	Percent	Cum.
0 cooking	10	4.98	4.98
1 lighting	15	7.46	12.44
2 baking	33	16.42	28.86
3 ironing	63	31.34	60.20
4 refrigerating	50	24.88	85.07
5 laundry	13	6.47	91.54
6 other	12	5.97	97.51
7 do not use electricity	4	1.99	99.50
.	1	0.50	100.00
Total	201	100.00	

Table 29: alternative energy sources

number of other energy sources the household use	Freq.	Percent	Cum.
0 coal	10	4.98	4.98
1 gas	85	42.29	47.26
2 wood fire	55	27.36	74.63
3 dung	35	17.41	92.04
4 other	7	3.48	95.52
.	9	4.48	100.00
Total	201	100.00	

Table 30: damage of blackouts for the households

number of damages the household face due to the power outage	Freq.	Percent	Cum.
0 unable to cook with electric appliances	20	9.95	9.95

1 unable to refrigerate food	19	9.45	19.40
2 unable to use bank services and ATM	28	13.93	33.33
3 negative entertainment effects	46	22.89	56.22
4 vulnerable to robbers in a dark night	41	20.40	76.62
5 not able to read or study	33	16.42	93.03
6 others	13	6.47	99.50
.	1	0.50	100.00
Total	201	100.00	

Table 31: reason for not willing to pay to avoid blackouts

Main reason for not willing to pay for sustainable energy :	Freq.	Percent	Cum.
0 do not experience BOs	1	0.50	0.50
1 cannot afford to pay	32	15.92	16.42
3 I do not think I should pay for the program	7	3.48	19.90
4 do not support any new government programs	1	0.50	20.40
5 I do not trust the government	3	1.49	21.89
6 this program is not important to me	2	1.00	22.89
7 other	8	3.98	26.87
.	147	73.13	100.00
Total	201	100.00	

Table 32: reason for being willing to pay something to avoid blackouts

main reason for willing to pay something for sustainable energy	Freq.	Percent	Cum.
0 because it's my responsibility as a citizen	4	1.99	1.99
1 because I believe that this matter is important	12	5.97	7.96
2 because it is important for development	19	9.45	17.41
3 because I believe that I (and my household) will be the beneficiary	70	34.83	52.24
4 to be able to receive a sustainable(and full) service	12	5.97	58.21
5 because I would like to see the problem been solved	29	14.43	72.64
6 to save time, energy and	2	1.00	73.63

money(the money spent for other sources)			
.	53	26.37	100.00
Total	201	100.00	

Table 33: reason for not willing to pay something to avoid environmental costs of wind farm

Main reason for not willing to pay to avoid environmental costs of windfarms	**Freq.**	**Percent**	**Cum.**
0 the government should build and pay for the programs	1	0.50	0.50
1 I can afford to pay anything	36	17.91	18.41
2 I do not think that it is feasible to upgrade hydropower plants to reduce the electricity needed to eliminate blackouts	2	1.00	19.40
3 I do not think I should pay for this program	5	2.49	21.89
5 I do not trust the government	4	1.99	23.88
6 avoiding the negative environmental impacts from wind power is not important to me	5	2.49	26.37
7 I would rather have the windmill farms because they have positive impacts on employment	5	2.49	28.86
8 other	20	9.95	38.81
.	123	61.19	100.00
Total	201	100.00	

Table 34: reason for willing to pay something to avoid environmental costs of wind farm

Main reason for paying something to avoid environmental costs of wind farm	**Freq.**	**Percent**	**Cum.**
0 avoiding the negative environmental impacts from windmill farms is important to me and my household	20	9.95	9.95
1 I think its our responsibility to protect our environment	73	36.32	46.27
2 I want to contribute to a good cause	21	10.45	56.72
3 other	3	1.49	58.21
.	84	41.79	100.00
Total	201	100.00	

Table 35: preferred form of payment

Preferred form of payment	Freq.	Percent	Cum.
0 voluntary payment	84	41.79	41.79
1 increased income tax	15	7.46	49.25
2 increased electricity bill	25	12.44	61.69
3 indifferent	13	6.47	68.16
.	64	31.84	100.00
Total	201	100.00	

Table 36: if respondents recall government promising to diminish blackouts

If respondent can recall the government making promise to diminish blackouts	Freq.	Percent	Cum.
0 no	39	19.40	19.40
1 yes	71	35.32	54.73
2 don’t know	88	43.78	98.51
.	3	1.49	100.00
Total	201	100.00	

Table 37: if respondents in Ashegoda get electricity

Ashegoda: if they get electricity : no=0 yes=1 don’t know=2	Freq.	Percent	Cum.
0	10	4.98	4.98
1	41	20.40	25.37
.	150	74.63	100.00
Total	201	100.00	

Table 38: farming in Ashegoda

Ashegoda: do any farming activities adjacent to the Ashegoda wind farm:no=0 yes	Freq.	Percent	Cum.
0	41	20.40	20.40
1	10	4.98	25.37
.	150	74.63	100.00
Total	201	100.00	

Table 39: how they introduced to the wind farm at first

How they get introduced to this wind farm construction	Freq.	Percent	Cum.
0 there was no introduction	21	10.45	10.45
1 introduction was given(what it is and how it works)	7	3.48	13.93
2 they told us that an electricity producing plant which uses sun will be planted	2	1.00	14.93

3 don't know	5	2.49	17.41
4 at that time I was not here	5	2.49	19.90
5 told us that it is good for the country (through export)	1	0.50	20.40
6 don't remember	7	3.48	23.88
.	153	76.12	100.00
Total	201	100.00	

Table 40: relocate

if they relocate because of the Ashegoda wind farm construction: no=0 yes=1 don't know	**Freq.**	**Percent**	**Cum.**
0	44	21.89	21.89
1	4	1.99	23.88
.	153	76.12	100.00
Total	201	100.00	

Table 41: number of years before relocation

number of years the household lived in the area before relocation	**Freq.**	**Percent**	**Cum.**
4	1	0.50	0.50
5	1	0.50	1.00
7	1	0.50	1.49
50	1	0.50	1.99
.	197	98.01	100.00
Total	201	100.00	

Table 42: compensation

if they get any compensation: no=0 yes=1 don't know=2	**Freq.**	**Percent**	**Cum.**
0	3	1.49	1.49
1	4	1.99	3.48
.	194	96.52	100.00
Total	201	100.00	

Table 43: compensation type

type of compensation did you receive: one time monetary=0 annual monetary=1	Freq.	Percent	Cum.
0	4	1.99	1.99
.	197	98.01	100.00
Total	201	100.00	

Table 44: amount of one time compensation

amount of one time compensation	Freq.	Percent	Cum.
5000	1	0.50	0.50
20000	2	1.00	1.49
30000	1	0.50	1.99
.	197	98.01	100.00
Total	201	100.00	

Table 45: Level of satisfaction for the given compensation

Level of satisfaction : very satisfied=0 fairly satisfied=1 neither=2 fairly dissatisfied=3 very dissatisfied=4 Don't Know=5	Freq.	Percent	Cum.
1	1	0.50	0.50
2	1	0.50	1.00
4	1	0.50	1.49
5	1	0.50	1.99
.	197	98.01	100.00
Total	201	100.00	

Table 46: Number of turbines

number of turbines the respondent can see from his/her place none=0 few(less than 10)=1 many(11-80)=2 don't know=3	Freq.	Percent	Cum.
0	4	1.99	1.99
1	9	4.48	6.47
2	32	15.92	22.39
3	1	0.50	22.89
.	155	77.11	100.00
Total	201	100.00	

Table 47: level of dissatisfaction

level of dissatisfaction on (how annoyed the respondent is due to the turbines he/she	Freq.	Percent	Cum.
1	1	0.50	0.50
2	4	1.99	2.49
3	2	1.00	3.48
4	40	19.90	23.38
5	3	1.49	24.88
.	151	75.12	100.00
Total	201	100.00	

Table 48: Gender

male=0 female=1	Freq.	Percent	Cum.
0	76	37.81	37.81
1	125	62.19	100.00
Total	201	100.00	

Table 49: Education

no schooling=0 read and write only(keshi or merdsa)=1 primary=2 high=3 vocational training 4=diploma 5=bachelor's degree 6=master's degree 7=doctorate degree 9=other	Freq.	Percent	Cum.
0	52	25.87	25.87
1	4	1.99	27.86
2	38	18.91	46.77
3	36	17.91	64.68
4	5	2.49	67.16
5	34	16.92	84.08
6	26	12.94	97.01
7	5	2.49	99.50
.	1	0.50	100.00
Total	201	100.00	

Table 50: employment

full time=0 part time=1 unemployed=2 pensioner=3 student=4 farmer=5 housewife=6	Freq.	Percent	Cum.
0	73	36.32	36.32
1	36	17.91	54.23
2	10	4.98	59.20
3	5	2.49	61.69
4	7	3.48	65.17
5	7	3.48	68.66
6	46	22.89	91.54
7	16	7.96	99.50
.	1	0.50	100.00
Total	201	100.00	

Table 51: Marital status

married=0 unmarried=1 divorced=2 widowed=3	Freq.	Percent	Cum.

0	107	53.23	53.23
1	55	27.36	80.60
2	10	4.98	85.57
3	26	12.94	98.51
.	3	1.49	100.00
Total	201	100.00	

Table 52: Home type

type of home ownership: own house=0 rent=1 government housing =2	Freq.	Percent	Cum.
0	99	49.25	49.25
1	95	47.26	96.52
2	6	2.99	99.50
.	1	0.50	100.00
Total	201	100.00	

Table 53: If respondents pay electricity in a rented house

if they pay electricity bill (for those living in a rented house): no=0 yes=1	**Freq.**	**Percent**	**Cum.**
0	34	16.92	16.92
1	61	30.35	47.26
.	106	52.74	100.00
Total	201	100.00	

G. Other informative tables

Table 54: Percentage distribution: Respondents' opinion on importance of different public goods and services

	0.Very Important	**1.Important**	**2.Moderately Important**	**3.Slightly Important**	**4.Not Important**	**5.don't know**
Primary and secondary schools	78.11	16.42	2.49	0.00	0.00	2.99
Clinics and hospitals	91.04	7.96	0.50	0.50	0.00	0.00
Hydro-power development	76.62	13.93	1.99	0.50	5.47	1.49
Wind-power development	67.16	15.92	5.97	1.00	1.00	1.49
Roads	91.54	7.46	0.50	0.50	0.00	0.00

Energy security(avoid blackouts)	86.5	6.50	1.00	1.50	4.00	0.50
Clean water supply	96.02	3.48	0.50	0.00	0.00	0.00

Table 55: percentage distribution of respondents opinion towards environmental friendly activities

	0.Strongly agree	**1.agree**	**2.neutral**	**3.disagree**	**4.Strongly disagree**	**5.Don't know**	**6.Not applicable**
I use energy saving light bulbs	40.8	21.89	4.98	20.40	4.48	2.99	4.48
I turn off the lights when I am not using them	59.7	25.87	5.97	1.99	1.99	0.00	4.48
I keep my home and my car smoke-free	39.3	6.97	7.96	3.48	9.45	2.99	29.85
I plant trees and native plants	33.33	23.38	19.90	15.42	5.97	1.00	1.00
I reduce my use of chemicals	40.20	3.52	2.01	2.01	3.02	32.66	16.18
I dispose waste properly	77.39	12.56	5.03	3.52	1.01	0.00	0.50
I buy bonds in order to support the development of renewable resources	23.28	7.96	15.92	24.88	6.97	14.43	6.47
I recycle	23.88	8.46	9.45	29.85	17.41	6.97	3.98
I volunteer, give time or some cash to environmental activities	46.23	22.61	8.04	16.58	3.02	1.01	2.51
I use water sparsely	83.00	9.00	4.50	1.00	2.00	0.00	0.50

I teach the young the importance of treating our environment with care	47.49	23.46	8.94	5.59	0.00	1.12	86.59
I do like to see more diesel power generation plants built in my country	28.00	18.00	11.00	11.50	10.50	17.00	4.00

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