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- A contingent valuation experiment

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Abstract

To limit climatic change, humans must achieve a reduction in greenhouse gas emissions. India, as a large emerging economy, could substantially contribute towards this goal by transforming its energy system. Based on a double-bounded dichotomous choice contingent valuation survey of 260 enterprises in and around Hyderabad, India, this paper provides willingness to pay (WTP) estimates of small and medium-sized firms for electricity generated from renewable sources. The estimated average additional willingness to pay was 1.08 Indian Rupees per kilowatt hour which constituted approximately 23% of the average tariff rate paid by the sector at the time of the study. The findings further suggest that WTP is driven by not only pure economic considerations but also managers' attitudes – implying altruistic motives which might particularly be important in small firms. As a robustness check, the Heckman model was used to control for selection bias and protest responses. Additionally, the single-bounded probit model was employed to assess statistical efficiency gains from the second equation in the bivariate probit model. The estimated WTP suggests a market potential for additional private investments in renewable energy sources which, in combination with an effective tariff, could increase voluntary adoption rates of green energy tariffs.

Contents

Acronym

DBDC	Double bounded dichotomous choice
GE	Green energy
IINDC	India's intended Nationally Determined Contribution
INR	Indian Rupee
RE	Renewable energy
MSMEs	Micro, small and medium-sized enterprises
Mtoe	Million tons of oil equivalent
SME	Small and medium-sized enterprise
UNFCCC	United Nations Framework Convention on Climate Change
WTP	Willingness to Pay

Note from the author:
The use of "we" and "our" and any other similar terminologies is intended for writing style purposes only. I am the sole person responsible for and author of the current thesis.

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1. Introduction

Since the Industrial Revolution, human activity has been contributing to the emission of greenhouse gases – mainly Carbon Dioxide – causing the rise in the average temperature of the earth's climate system. The Carbon footprint of a country depends mainly on its level of development and the carbon intensity of the economy. As such, on a per capita basis, India's emission trail is one of the lowest in the world. In contrast, being mainly coal-dependent for energy production, India is the third-largest country in volume terms of CO_2 emissions in the world, preceded by only China and the United States (International Energy Agency, 2015). According to a report by Ministry of Environment, forest and climate change (2015), the energy sector of India takes the lion share contributing up to 71% of the total greenhouse gas emission of the country. Fueled by fast economic progress and large population growth, India´s energy demand will double and reach 1,900 million tons of oil equivalent (Mtoe) by 2040, making India the largest source of growth in global coal demand (International Energy Agency, 2015). In this regard, the Indian micro, small and medium-sized enterprises (MSME[1]) use about 50 Mtoe annually, representing 20 to 25% of the energy demand by large industries with the expected annual growth rate of six percent (Bureau of Energy Efficiency, 2018). This signifies the fact that India's developmental pattern will inevitably have a significant influence on the global environment.

Cognizant to this, stakeholders, such as the Intergovernmental Panel on Climate Change (IPCC) have long been advocating the adoption of renewable energy as a major mitigation strategy (IPCC, 2014). Accordingly, the government of India has proposed various initiatives and issued legislations to ensure their implementation. On the international front, the government submitted "India's Intended Nationally Determined Contribution (IINDC)" to the UNFCCC[2] on 2015 pledging to reduce the emissions intensity of its GDP by 33 to 35 percent by 2030 from the 2005 levels (UNFCCC, 2015, p.8). One of the most important initiatives indicated in IINDC regarding MSMEs is the "Zero Effect, Zero Defect" (ZED) scheme. The scheme, in addition to other energy efficiency objectives, envisages promotion of renewable energy use among Small & Medium scale Industries. Among the locally focused regulatory frameworks, the National Action Plan on Climate Change is another significant milestone implemented in 2008. Supplementing other provisions, it recommends a minimum share of renewable energy in the national grid of 5% in 2010 to be increased subsequently by 1% every year to reach 15%[3] by 2020 (NAPCC, 2008). The National Electricity Policy (2005) and The Electricity Act (2003) are also vital legislations favoring renewable energy development in the country. While the former stipulates the need to progressively increase the share of electricity from non-conventional sources, the later requires the purchase of a specified percentage of the

[1]The Indian micro, small and medium-sized enterprises (MSME) forms the backbone of India's industrial sector. It contributes to about 8% of India's GDP and more than 45% of the overall industrial output.
[2]United Nations framework convention on climate change. The objective of the Convention is to stabilize greenhouse gas concentrations "at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system."

[3]The share of renewable target for 2020 is increased to 21% as per order no. 23/03/2016-R&R issued by The Ministry of Power dated 14 June 2018.

power procurement by distribution utilities from renewable energy sources through renewable purchase obligation mechanisms.

While the cost of renewable energy in India is still more expensive than fossil-based energy at a levelized cost basis, the steady decline observed in recent years signals a near future paradigm shift in its competitiveness (IRENA, 2017). On the other hand, despite the supportive policy environment, the financial and operational constraints mainly attributed to high integration cost faced by utility companies have led to a lower level of capital investment in renewable power generation (Amrutha et al., 2017). Funding a program to support renewable energy adoption through economic instruments, therefore, necessitates a thorough analysis of knowing whether consumers are willing to carry some portion of the financial burden. Although many studies were conducted on consumers' willingness to pay for renewable energy, most of the empirical and theoretical literature was limited to analyzing the issue only from a household consumer perspective and are narrow in scope by concentrating on a developed country context (eg., Oerlemans et al., 2016; Soon and Ahmad, 2015; Sundt and Rehdanz, 2015). No prior research has addressed the issue from MSMEs perspective in a developing country context.

Using a data collected in a double-bounded dichotomous choice contingent valuation experiment from 260 MSMEs in Hyderabad, – India's sixth largest city and a major hub for the country's pharmaceutical industry – this study estimates a willingness to pay (WTP) of INR 1.08 for a sample of MSMEs for an increased share of electricity generated from renewable sources in their energy mix. The amount accounts for around 23% of the average tariff rate paid by the firms at the time of the survey. It further investigated and identified factors which might affect the willingness to pay decision process of small-scale firms. The result shows that there is a potential for engaging MSMEs in climate change mitigation and environmental initiatives.

1.1 Research problem and objectives

The proliferation of studies in the area of economic valuation of non-marketed good in general and renewable energy in particular, has been quite significant. However, there exists a huge gap in the existing literature pertaining to geographical coverage and consumer type. Filling the existing gap is the major purpose of this study.
As mentioned above, energy use – and related emissions – of MSMEs from India's and the global[4] perspective is substantial. Hence, the need to identify the existence and extent of small and medium scale firms' willingness to pay for cleaner energy is vital to implement climate change mitigation initiatives effectively and efficiently. Furthermore, considering the large economic role being played by the sector reinforces the idea that a focused analysis of the sector is well deserved.

Accordingly, this study will mainly investigate the following question:

- What is the willingness to pay for energy generated from renewable sources by India's MSMEs?

Furthermore, factors influencing WTP will be analyzed to identify and capture the complete aspect of the valuation decision process. The following factors are assumed to affect the willingness to pay decision:

[4]While in the United Kingdom SMEs's energy demand represent around 45% of total business energy use, half of total final industrial energy demand in the United States is consumed by the sector (IEA, 2015).

- Firm size measured in terms of annual turnover and number of employees;
- Prior experience with CO_2 reduction indicated either through current utilization of RE or energy efficiency measures taken by the firm;
- Entrepreneur-owner's awareness of renewable energy;
- Nature of the firm with regard to its energy cost share as compared to annual turnover;
- Information asymmetry on a current price of RE reflected through perception level of price expensiveness;
- Additionally, an entrepreneur's environmental affinity is also assumed to be another factor influencing the WTP decision-making process of renewable energy adoption.

Thus, this study has the general objective of providing an estimate for WTP of the Indian small and medium enterprises for a fifteen percent increase in electricity supplied from renewable energy sources. Furthermore, identifying factors affecting WTP to investigate whether the observed differences can be explained by the attitudinal and socio-economic characteristics of the respondent (e.g. MSMEs size) is also considered a specific objective.

From a practical perspective, the results could provide an indicative demand of India's MSMEs for renewable energy and can serve as an input for a cost-effective policy design. Utility providers can also gain an insight for an investment potential on renewable energy capacity. Furthermore, the insights and the conceptual framework developed to accommodate the theory of the firm in the WTP context is hoped to serve as an empirical reference for future similar studies.

The foregoing Chapter has presented the introduction of the study. The remainder of the thesis is organized as follows. Chapter 2 will present a literature review. The review will cover both the theoretical aspects and empirical studies of contingent valuation. Chapter 3 presents the methodology. It discusses the conceptual framework and econometric model formulation. The applied models are also discussed. Data source and valuation scenario are presented in Chapter 4. Chapter 5 presents the estimation results and robustness checks. Chapter 6 presents a discussion of the result and limitation. Finally, Chapter 7 draws some conclusions and discusses insight gained from the study.

2. Literature review

This chapter reviews valuation techniques and studies related to firms' and households' WTP for electricity from renewables and environmental goods. One study focusing on WTP for electricity supply is also included as it is relevant to shade light with regard to characteristics of smaller firms which are relevant to energy-related decision making. Although the current study is concerned with MSME's RE adoption, additional review on determinates of WTP decision of individual consumers is assumed to enrich the understanding of how Entrepreneurs of MSMEs would make energy-related choices. Furthermore, as suggested by Rahbauer et al. (2012) realizing the similarity of the decision-making process between individual consumers and MSMEs – usually made by single person or owner – makes the expanded review of households worthwhile.

2.1 Valuation Techniques and Theoretical Concepts

Owing to the inherent nature of environmental public goods (non-rivalry and non-excludability), economists have developed a range of methods in order to estimate the value of such type of goods. A typical example of such a practice is the valuation of biodiversity or ecosystem services. In a nutshell, valuation methods for such goods can be categorized under the revealed or stated preference techniques.

Revealed preference methods use actual purchase behavior reflecting utility maximization subject to constraints (Freeman et al., 2014). The method exploits information from markets that are associated with the non-marketed good under evaluation. If information on WTP can be inferred from individuals' actual decisions, the technique might be more appealing (Bateman et al., 2002). There are quite a few methods at the disposal of the researcher under the revealed preference approach. Harrison (2013) noted that the most popular method among revealed preference approaches is the travel cost method, which uses the travel costs incurred to enjoy a natural amenity and infer the value that visitors attach to the recreational experiences it offers. Another technique is hedonic regression which estimates price for characteristics of a good or service. For instance, air quality, proximity to a lake or forest as a component of real estate prices can be used to estimate demand for environmental public goods.

Under the stated preference valuation domain, the most widely used method to derive WTP for environmental goods in general and renewable energy, in particular, is contingent valuation (CV) followed by discrete choice experiments (Soon and Ahmad, 2015). Historically the prominence of the CV methodology can be traced back to its application on the Exxon Valdez oil spill incident in 1989. Because of damage estimates resulted from the contingent valuation, a debate was initiated about whether values can translate to valid economic measures of environmental goods. The particular issue was the validity of the non-use value of environmental goods (Carson, 1996). As a result, the National Oceanographic and Atmospheric Administration (NOAA) convened a panel of leading economists to assess the reliability of contingent valuations. The findings of the NOAA panel – although did not provide pass a verdict on the issue – gave support to the use of CV in valuing environmental damages and recommended a set of guidelines to be utilized (Arrow et al., 1993).

Despite its wide application in academic literature, CV remained controversial due to the potential hypothetical bias inherent to stated preference methods and the validity of non-use value. However, with a proper design, CV can be appealing in overcoming most practical challenges associated with the valuation of non-marketed goods. A similar stance is taken by Carson et al., (2000) who concluded that inconsistency claims with CV results are not empirically supported and hence a careful study design and implementation can mitigate many of the alleged problems.

Another important feature of the CV method is the flexibility it extends to elicit respondent's valuations of the non-marketed good in question. The most widely used elicitation formats in contingent valuation surveys are: i) an open-ended format: respondents are asked to state the maximum amount that she would be willing to pay in order to secure the provision of some hypothetical product, ii) a payment card format: respondents are asked to choose a willingness to pay point estimate (or a range of estimates) from a list of values predetermined by the surveyors, and iii) a dichotomous choice or referendum format: respondents are asked one (single-bounded), two (double-bounded) or more questions to accept or reject a good or program at a stated price (Freeman et al., 2014; Haab and McConnell, 2002). The current study will be based on data collected through a double-bounded dichotomous choice format.

2.2 Empirical literature review

Despite a large number of studies published over the last decade examining willingness to pay for renewable energy, only few have tried to investigate the issue from a developing country perspective and no research gave an exclusive focus on the small and medium scale firms. Soon and Ahmad (2015) noted that, despite a marked increase of publications on WTP for green energy, most of the literature stems from the US and Europe. This uneven concentration towards a developed country context might be attributed to the perceived level of low demand for green energy in the developing world. Another area characterizing the existing literature is that more emphasis has been made on analyzing the preference and thereby the willingness to pay for renewable energy by individual consumers – who sometimes are referred as residential customers (Sundt and Rehdanz, 2015).

The decision to adopt renewable energy is influenced by behavioral and socio-economic characteristics of the decision maker. Hence, firm managers' attitude and motivation play a vital role in the decision to purchase renewable energy. One of the attempts (Wiser et al., 2001) made addressing firms and the motivation behind adopting green energy (GE) is a survey made on 1,800 non-residential US customers of GE utility companies. Its key finding is rather intriguing since altruistic factors and a desire to build employee morale were identified as important motives in the adoption decision. The study claimed that the motivation for adopting a green energy for smaller firms was an environmental quality criterion (altruism value), while the price of GE was the most important factor for larger firms. The simple regression of 464 completed responses is, however, considered a rather low response rate as compared to the initial survey participants which might affect the resulting validity. Although the study is an ex-post analysis of consumers who have already adopted the product, the finding was instrumental by indicating that altruism might be an important motivation for green energy adoption in small-scale enterprises. This further validates the relevance of the CV method used in the current study since it captures the non-use value aspect of RE which might be highly linked to the MSMEs manager's pro-environmental attitude.

Also, Ghosh et al. (2017) investigated MSME's preferences and factors affecting WTP, albeit with a focus on power interruptions. Using a double-bounded dichotomous choice contingent valuation experiment, and a bivariate probit econometric model to estimate WTP, they found that MSME's in the study area are willing to pay approximately 20% more than the prevailing tariffs for reliable power supply. It is also reported that WTP is heterogeneous depending on industry type. Accordingly, the study observed that the WTP is the highest for the pharmaceutical firms followed by the food and chemical firms respectively. As their analysis is based on the same sample of MSMEs of this study, the findings and employed methodologies are found to be instrumental in getting insight on econometric model derivation and important characteristics of the target consumer.

Harajli and Gordon (2015) examined the willingness to pay for renewable energy for the commercial sector in Lebanon and identified that WTP increases with the reliability of renewable sources in replacing diesel generators. The authors used a variant of a discrete choice experiment in which they provided the consumer with five different attributes for the proposed renewable energy package. Tobit regression was used to allow and accommodate for zero value bids from respondents. Number of employees, office ownership, and the amount of money paid were the factors which influenced the WTP positively. Although the paper addresses determinants of RE adoption focusing on characteristics of the firm, it seems to ignore the influence of attitudinal and behavioral characteristics of firm managers which might be significant particularly in a decision-making process of smaller firms. Notwithstanding methodological differences, their paper is found to be relevant to the current study, since it provides the only close reference for comparison of determinants of WTP for renewable energy in the context of firms.

The socio-economic structures affecting attitude and decision towards the WTP for RE prove to be quite different among countries depending on the developmental stage reached. Consequently, the demand for renewable energy in different countries and characteristics of consumers might be heterogeneous. As such, for a Chilean household, WTP increases with the level of education, income, and knowledge of the current source of electricity generation (Aravena et al., 2011). Abdullah and Jeanty (2011), in contrast, suggest that households in Kenya are willing to pay more for grid electricity than photovoltaic (solar energy) electricity. By applying an interval data logit regression model, they identified that income, educational level, and homeownership are statistically and positively impact WTP for green energy. On the other hand, Greek consumers with better awareness about energy and climate change are found to have a higher WTP for green energy (Zografakis et al., 2010). With respect to determinates of green energy adoption by firms, Vazquez-Brust and Sarkis (2010) suggested that existing energy policies, culture, average firm size, and environmental concern correlates with the attitude of European SMEs towards renewable energy.

As stated earlier, the literature investigating MSME's WTP for RE and factors affecting renewable energy purchase behavior is rather limited. However, the peculiar nature of small-scale industries both in capacity (turnover, number of employees) and the decision-making process warrants a focused assessment. It is also interesting to note that the decision-making process in small-scale firms and households share similarity as decisions in such type of firms would usually be made in a small group or owner-managers her/himself. Trianni and Cango (2012) support this view that small-scale firms are usually organized in a way that the decision falls within the responsibilities of a single decision maker (usually, the entrepreneur him/herself). In conclusion, there is no econometric literature of a CV experiment conducted to characterize the willingness to pay for power generated from renewable energy exclusively on small-scale firms landscape.

3. Methodology

This section examines the conceptual framework of the contingent valuation experiment within which the current study operates and outlines the approach taken in the econometric model derivation.

3.1 Conceptual framework

The underlying theory of a contingent valuation experiment constitutes the assumption for the existence of a well-behaved preference among alternative bundles of goods for a utility-maximizing consumer. Furthermore, these preferences have the property of substitutability among marketed and non-marketed goods. Freeman et al. (2014, p.8) state that the resultant tradeoffs that a utility maximizing consumer makes as he or she chooses less of one good and substitute more of some other good reveal the values placed by that consumer. Hence, the purpose of a CV experiment is to provide the monetary amount of a rational consumer's willingness to pay while keeping the consumer's utility constant when facing alternative scenarios. Thus, the valuation of non-marketed goods using CV is based on microeconomic theory and welfare economics fundamentals. It builds upon analyzing the impact of a change in the provision of a good – for instance by means of a policy initiative – which has a potential to impact the consumer's welfare. The impacts can either be categorized as benefit or cost depending on the background and context of standing. But, according to Bateman et al. (2002) benefits and costs are defined in terms of consumer preference. To measure how large that benefit is, therefore, to measure how much the consumer is willing to give up or willing to pay to get it. In welfare economics, this notion is called compensating variation for securing the benefit.

However, the concept of compensating variation has been exclusively developed on welfare consideration of a utility maximizing household. Since small-scale firms are the focus of this study, further assumptions will be made before derivation of the econometric model in order to accommodate the theory of the firm with the random utility concept of the WTP framework.

3.2 Theoretical model

Following Haab and McConnell (2002), the theoretical model can be formulated by assuming a hypothetical policy choice offered to a consumer which resulted in securing a change in the provision of a non-market good from its present level of Q_0 to a greater level Q_1.
By further assuming that the agent's utility depends on other demographic, product attribute and socio-economic factors denoted by S; the indirect utility function V (.) can be characterized as:

$$v = V(P, I, Q, S) \quad (1)$$

Where: P represent prices, I is income, Q is the quantity or quality of the non-marketed good.

As proposed by Bateman et al. (2002), the utility difference can be expressed as:

$$V\ (I, P, S, Q_0) < V\ (I, P, S, Q_1) \quad (2)$$

Where:

$$\frac{\partial V}{\partial Q} \geq 0 \quad (3)$$

It follows that a utility maximizing consumer (household) would prefer a higher utility which can be achieved at Q_1, he/she will be induced to sacrifices some part of his/her income to compensate for the provision of the non-marketed good. The maximum sacrifice of the income or the maximum payment for an improvement in welfare from the provision of the good is what we call compensating variation and its monetary measure is the maximum willingness to pay (Bateman et al., 2002). Continuing our mathematical formulation, we can define this amount denoted here by *cv*, as follows;

$$V\ (I, P, S, Q_0) = V\ (I - cv, P, S, Q_1) \quad (4)$$

From equation (1), (2) and (4) we can rewrite the utility difference (i.e. WTP amount) as a function of the other parameters and variable.

$$cv = WTP = W\ (Q_0, Q_1, I, P, S) \quad (5)$$

Having this basic relationship, we can now proceed to adapt the WTP calculation based on the utility difference concept in the context of a profit-maximizing firm. However, as a point of departure from the conventional derivation of household's WTP based solely on random utility theory and being a critical component of our conceptual framework, a setup of a *single owner–entrepreneur*[5]is assumed throughout this study. This is, in fact, plausible in the standard notion and organizational structure of a small-scale firm.

Define now the maximized attainable profit of the firm as:

$$\pi_i^* = \pi(P_i, S_i, Q_i) \quad (6)$$

Where $\pi_i^*(\,.\,)$ is the maximized profit of a representative firm for a given output price P_i, firm's characteristics S_i and optimal level of the non-market good Q_i. On the other hand, realizing that the income component for the single owner-entrepreneur in equation (1) and (4) can be decomposed in to two components of labor and non-labor income (e.g. of non-labor income in the form of capital gains or dividends) is also another important consideration for the way forward. Assuming further that non-labor income here denoted by *m* depends solely on profit and following Zapata and Carpio (2012), *m* can be expressed as a function of the maximized profit defined in equation (6). Thus, it can be written as:

$$m = m\big(\pi(P_i, S_i, Q_i)\big) \quad (7)$$

Such that: $\frac{\partial m}{\partial \pi} > 0$. It is straightforward to see that *m* is increasing in profit.

Using equation (4), (6) and (7), the compensating variation discussed in the conceptual framework i.e. the maximum amount the firm is willing to pay to attain the benefit or utility (here denoted by $\boldsymbol{v}$) from an increase in non-marketed good can be expressed as:

$$v(m\big(\pi(P_i, S_i, Q_0)\big) = v(m\big(\pi(P_i, S_i, Q_1)\big) - cv) \quad (8)$$

[5] Manager, entrepreneur and owner are used interchangeably throughout this study referring the same decision maker in a firm.

In equation (8), analogous to equation (4), *cv* represents the maximum amount the firm owner-entrepreneur is willing pay to increase the non-marketed good initial quantity of Q_0 to a higher level of Q_1. Then, adapting from Zapata and Carpio (2012) and following from expression in equation (8), the *cv* measure is given by *variation function* or firm's willingness to pay function as:

$$cv = wtp = m(\pi^*(P_i, S_i, Q_1)) - m(\pi^*(P_i, S_i, Q_0)) \quad (9)$$

Since we earlier assumed the non-labor income to only has profit in its argument and under the assumption of a linear relationship, the above expression can be reduced to:

$$WTP = \pi^*(P_i, S_i, Q_1) - \pi^*(P_i, S_i, Q_0)$$
(10)

Hence, the maximum WTP for the firm is just the difference between the *ex-post* and *ex-ante* profit levels generated from the two levels of Q_i Where i = 0,1 (i.e., before and after adopting the non-marked good).

Consequently, it can be noted that making the single owner-entrepreneur setup of a representative small-scale firm allowed us to link the notion of a profit-maximizing firm with that of the conventional WTP concept. The single owner-entrepreneur assumption will also be critical in understanding how both firm and individual specific characteristics affect the decision-making process in small firms.

3.3 Interpretation of Dichotomous choice data

Dichotomous choice (DC) elicitation formats are believed to provide better estimates of respondent WTP by simplifying the cognitive task faced by respondents in the hypothetical markets scenario (Bateman et al., 2002; Hanemann et al., 1991). Through this type of format, respondents are offered a bid (and or an additional follow up bid in case of the double-bounded dichotomous format) for the increase of electricity from renewable sources. Accordingly, the response (a 'yes' or 'no' answer) results in a binary data type indicating whether the respondent's WTP is greater or lower than the offered bid value. Hence, for a rational wellbeing maximizing agent and consistent with the theoretical model presented above, the offered bids will only be accepted by the agent if the new state provides an improvement as compared to the status quo. Hence, if accepted, the bid value must have been less than or equal to the maximum WTP for the renewable energy. In contrast to open-bid format, DC valuation items do not provide direct measures of WTP but rather define the boundary of a range within which actual but unobservable WTP must lie. As a result, the DC question format treats this unobserved true WTP amounts as latent variables and transform them to a probabilistic specification using binary responses. Finally, this distributional specification of WTP will be used in the calculus of probabilities that the responses fall within the specified bounds.

3.4 Empirical Model specification

Generally, willingness to pay from dichotomous choice response data can be estimated either using parametric econometric models (e.g., Bateman et al., 2002; Haab and McConnell, 2002; Carson and Hanemann, 2005) or non-parametric approach (e.g., Kristrom, 1990; Carson et al., 1994). In the current study, parametric models are adopted since we want to allow for the inclusion of covariates, such characteristic of the firm, which would have been impossible in case of non-parametric models. Based on the data collected through DBDC elicitation format, the Bivariate probit model is employed to estimate the parameters which are used in the computation of the mean WTP value. Additionally, probit and probit with sample selection (Heckman) models were used to evaluate efficiency gain and check for the threat of sample selection bias respectively.

Following Gosh et al. (2017) and adapting from Zapata and Carpio (2012), we continue the derivation of the empirical model by reiterating the maximized profit function defined in equation (10).

$$WTP = \pi^*(P_i, S_i, Q_1) - \pi^*(P_i, S_i, Q_0) \quad (10')$$

Again, we assume that P_i *and* S_i are fixed, and profit is non-decreasing in the provision of electricity from renewable sources. i.e.: $\frac{\partial \pi}{Q_i} \geq 0$.

With this setup, the monetary amount of welfare change that would make the firm at least as well off as the initial profit level can be calculated as the difference between the maximized profits before and after the provision of the renewable energy. In this study, the valuation scenario presented is an increase in the share of renewable energy in the overall electricity supply to 15% which is similar to the level the "National Action Plan on Climate Change" envisaged for the year 2020 (NAPCC, 2008). Unlike the open-ended format which asks respondents how much they would be willing to pay, in the DC format adopted in this paper, WTP defined above cannot be estimated directly but can be observed if the firm's willingness to pay is larger or smaller than a bid amount denoted here as ***T***. So, for an affirmative response to the bid offer T (i.e., a 'Yes' response) for the increase in renewable energy in the energy mix we have:

$$\pi^* (P_i, S_i, Q_1) - \pi^* (P_i, S_i, Q_0) + T = \Delta\pi > 0 \quad (11)$$

Hence, the profit difference i.e., $\Delta\pi$ as a function of the other parameters is given by:

$$\Delta\pi = \Delta\pi (P_i, S_i, Q_1, Q_0, T) > 0 \quad (12)$$

Where:

$\Delta \pi$ represents a profit difference resulted from the provision of renewable energy, Q_0 and Q_1 represent the initial and final level of the renewable energy provision respectively and T is the bid amount. For a linear functional form after dropping the price P_i and introducing the random and unobservable element, the function becomes;

$$\Delta \pi = \alpha + \beta S_i + \lambda T + \varepsilon \quad (13)$$

Where α, β and $\boldsymbol{\lambda}$ are parameters to be estimated and it follows that from equation (11) and (13) the willingness to pay formula can be derived as:

$$WTP_i = -\frac{(\alpha + \beta S_i)}{\lambda} \quad (14)$$

Here the term $\alpha + \beta$ represents the difference in profit function from the provision of renewable energy and $\boldsymbol{\lambda}$ represents the shadow price or specifically the opportunity cost for the forgone opportunity to invest elsewhere. Assuming a normal distribution of the stochastic term, the likelihood functions used to recover the parameters of equation (13) for the probit and bivariate probit models are presented in the next subsection.

3.4.1 Single bounded probit model

For the single bounded probit model, if the bid offer for the provision of green energy is rejected, the probability of a 'no response' is given by:

$$\Pr(Q_0) = \Pr(\alpha + \beta S_i + \lambda T + \varepsilon < 0) = \Pr(\varepsilon > \alpha + \beta S_i + \lambda T) \quad (15)$$

Also, exploiting the property of symmetry, the probability of a 'yes' response becomes:

$$\Pr(Q_1) = 1 - \Pr(Q_0) \quad (16)$$

$$= 1 - \Pr(\varepsilon > \alpha + \beta S_i + \lambda T) \quad (17)$$

After rearranging and maintaining the functional form of our derivation, the cumulative distribution function for the rejection of the bid offer for the green electricity, i.e., a 'no' response becomes:

$$\Pr(Q_0) = \Phi(\alpha + \beta S_i + \lambda T) \quad (18)$$

Where, $\Phi(\,.\,)$ is the cumulative density function (CDF) of the standard normal distribution.

The Heckman selection (which sometimes called as probit with sample selection) model can be derived easily in a similar manner; hence the derivation is not included in this section.

3.4.2 Double bounded dichotomous choice(DBDC) – Bivariate Probit Model

The DBDC model, i.e., the bivariate probit model, is chosen in this study for the efficiency gain it offers compared to a single-bound probit model by allowing utilization of the response from the follow-up question. We start here based on the discussion made by Haab and McConnell (2002) using the following general form of WTP.

$$WTP_{ij} = \mu_i + \varepsilon_{ij} \quad (19)$$

Where:
WTP_{ij} is j^{th} respondent's unobserved true willingness to pay and i=1,2 are responses to initial and follow up bids respectively.
μ_1 , μ_2 = the mean of the first and the second response.
ε_{ij} = the error terms or the unobservable part of the true WTP of the firm.
Assuming that μ_i depends on characteristics of the firm S_i such that: $\mu = \beta S_i$, the bivariate normal distribution estimated by this model takes the following form:

$$Y_{1j}^{*} = \beta_i S_i + +\varepsilon_{1j}$$
(20)
$$Y_{2j}^{*} = \beta_i S_i + +\varepsilon_{2j}$$

Where, the covariance between the error terms is denoted by the correlation coefficient ρ ($corr[\varepsilon_{1j},\varepsilon_{2j}] = \rho$). Y_{1j}* *and* Y_{2j}* are latent variable denoting firm's unobserved true willingness to pay when the respective bids are offered successively. While S_i represents the vector of transposed covariates and β_i is the corresponding vectors of coefficients in the first and second bid. The binary variable representing this latent variable will be equal to 1, (i.e. the firm will respond 'yes') if and only of the value if this latent term is greater or equal to the respective bids. The related and observed binary variable of the dichotomous question response representing the latent variables can be formulated as:

$$y_j = \begin{cases} 1\ if\ y_j^{*} > 0 \\ 0\ if y_j^{*} \leq 0 \end{cases} \quad (21)$$

In this format, the iterative process generates four sets of responses which can be represented as – (yes, yes), (no, yes), (yes, no) and (no, no). This would result in a tighter bound than the single DC format, hence demonstrating the efficiency of the Bivariate model, other things being equal. Here responses are in strict order, i.e., first the initial bid is asked then the follow up will proceed either as a higher amount or lower depending on the response given to the initial bid. Following Haab and McConnell (2002) and letting t^1 be the first bid price and t^2 be the second, four sets of responses result in the following upper and lower bounds on the respondent's WTP.

1. $WTP > t^2$ for the yes –yes response

2. $t^1 \leq WTP < t^2$ for the yes –no response

3. $t^1 > WTP \geq t^2$ for the no-yes response

4. $WTP < t^2$ for the no–no response

The jth contribution to the likelihood function in equation (20) which can be estimated by the maximum likelihood method is given by:

$$l(\mu / t) = \Pr(\mu_1 + \varepsilon_{1j} \geq t^1, \mu_2 + \varepsilon_{2j} < t^2)^{YN} \times \Pr(\mu_1 + \varepsilon_{1j} \geq t^1, \mu_2 + \varepsilon_{2j} > t^2)^{YY}$$
(22)
$$\times \Pr(\mu_1 + \varepsilon_{1j} < t^1, \mu_2 + \varepsilon_{2j} < t^2)^{NN} \times \Pr(\mu_1 + \varepsilon_{1j} < t^1, \mu_2 + \varepsilon_{2j} \geq t^2)^{NY}$$

Where:
YN=1 for a yes-no answer 0 otherwise; *YY*=1 for a yes-yes answer, 0 otherwise; *NY*=1 for a no-yes answer, 0 otherwise; and *NN*=1 for a no-no answer, 0 otherwise.

With the assumption that error terms have a standard normal distribution with means 0 and variances of σ^1 and σ^2, then the unobserved willingness to pay values WTP_{1j} and WTP_{2j} will have a bivariate normal distribution with mean μ_1 and μ_2; variances σ^1 and σ^2 and correlation coefficient ρ. The parameters estimated from the corresponding cumulative distribution function using maximum likelihood method will be used to calculate the WTP.

4 Data and valuation scenario

This section covers the valuation scenario, data description, summary statistics, variable definition, and preliminary analysis. It concludes with an estimation strategy adopted in this study.

4.1 Valuation scenario

The data used in this study is collected from 260 small-scale firms in Hyderabad – the joint capital of the Indian states of Andhra Pradesh and Telangana. The survey was conducted during September- December 2010 for a dual-purpose study by Humboldt-Universität Berlin and The Energy Resource Institute (TERI) in Delhi. The first part of the study focuses on the current situation of the power supply and was motivated by addressing power outage issues of MSMEs in the region (Ghosh et al., 2017). The second part – which is the focus of this study – deals with prospects of MSMEs' demand for renewable energy. Accordingly, information on firm characteristics, energy supply, power outages, and attitudinal characteristics of firm's manager for the valuation scenario was collected.

An important issue in administering CV surveys especially the in DBDC format is the choice on the optimal bid design. The relevant information for the designing process might emanate from a focus group discussion, pretests or previous studies (Haab and McConnell, 2002). This stage is crucial because in most CV studies – as the proposed good would usually be novel or unfamiliar to respondents – a poor design might result in a very high or low unrealistic WTP values. The bid vector on this study was constructed based on a WTP value from a previous study (Hanisch et al., 2010) and pretest assessment. Accordingly, the bid vector which resulted in five bid levels of 0.20, 0.40, 0.70, 1.00, and 1.40 Indian rupees (INR) were used in the survey instrument. Three different initial bids of 0.40, 0.70 and 1.00 were randomly allocated to the respondents. Depending on the response to the initial bid (a 'yes' or 'no'), a higher or a lower amount from the bid vector was offered in the follow-up question. For example, if the initial bid of 0.40 INR is rejected, i.e., the response was a 'no', a lower follow-up bid of 0.20 INR was offered. Moreover, prior to offering the bid values, respondents were asked if they are in principle generally willing to pay for such a program. A follow-up question is also presented to those who responded 'No' in order to identify the reasons. The follow-up question is used to get a better idea as to whether survey participants does actually have a zero valuation for the proposed good. As a result, only those who responded yes to the general WTP question were offered the valuation bids in the subsequent survey steps.

4.2 Variable definition

Based on the conceptual framework and theoretical consideration established earlier, the following dependent and independent variables are defined.

Dependent variables:

*General willing to pay (**generalWTP**):* This variable represents the participation decision equation or the general willingness to pay response for the renewable energy proposed.

*Response to bid 1&2. (**RES_BID1 & RES_BID2**):* As explained in the preceding sections these are dependent binary choice variables measuring the willing to pay value for the proposed increased supply of electricity from a renewable source. Its value takes 1 for the "yes" answer to the respective bid offers, zero otherwise.

Explanatory variables:

In addition to the bid variables *(**BID1 & BID2**)*, the explanatory variables included in this study comprises of characteristics peculiar to the firm as an entity and attitudinal attributes specific to owner-entrepreneur. The Bid variables are expected to have a negative sign.

*Annual turnover (**TURNOVER**):* This variable represents the yearly turnover in million(INR). It is expected to influence the WTP positively since annual turnover is one attribute to depicting firm size and capacity in investment decision making.

*Number of employees (**EMPLOY**):* This variable represents number of permanent and contract employees of the firm at the time of the survey. Like annual turnover, number of employees is expected to influence the WTP decision positively. It is expected that the more employees the firm has, the more likely it would have a staff dedicated for energy-related decision making.

*Energy-turnover ratio (**ENERGYT**):* This variable represents the ratio of electricity expenditure per year divided by annual turnover. It is calculated by taking the firm's contracted demand or sanction load (kW) expense for one year. The heterogeneity in working hour, working days and applied tariffs among firms are taken into consideration in the calculation. It is included to capture the energy intensity of the firm's activity. It is expected to have a negative relationship with WTP for renewable energy. The more energy intensive process a firm has, the more sensitive it would be for an additional price premium needed to be paid for renewable energy.

*Efficiency measure (**EFFICIENCY**):* This variable is an indicator variable representing whether the firm has adopted energy efficiency measures in its production process. It is expected to have either a positive or negative impact on WTP decision depending on the initial purpose of energy efficiency measure. On one hand, energy efficiency can be motivated by reducing the firm's carbon footprint. In this regard, it can be assumed that the practice would influence additional carbon reduction measures such as renewable energy adoption. On the other hand, if efficiency measures are mainly done for cost-saving motives, the observed experience might result in a negative relationship with WTP for RE.

*Environmental affinity (**ENVPRO**):* This variable represents the environmental affinity (a pro-environmental attitude towards lessening the impact of electricity production on the environment) level expressed by the respondent. It is measured on three-point[6] scales: *Agree, Indifferent, Disagree*. Even though many people seem to have a concern about the environment, this pro-environmental sentiment might not necessarily lead to green purchasing (Joshi, 2015). Moreover, a recent study (Ferraz, 2017) also suggests that the final purchasing decision on green products will usually be based on other attributes such as price and quality. It has also been argued that households often express strong support for the idea of green electricity, but these same attitudes are seldom reflected in actual behavior (Berglund and Matti, 2006). Hence, it is assumed that the influence of this variable would only be on the participation stage, i.e., on the general willingness to pay equation. As a result, it is only used in the Heckman probit model as an exclusion restriction. It is assumed to have a positive effect.

[6] In the survey instrument it was designed to have 6-point scales. However, since it was found that the "strongly disagree" and "I don't know" options have very few respondents and for ease of interpretation the scale was revised to have three levels (details can be referred from Appendix A. Table 1).

Awareness of renewable energy ***(AWARE):*** This is a binary variable indicating whether or not the manager of the firm has awareness with regard to the type and sources of renewable energy. Awareness of and belief towards the benefits to be gained from the product is likely to affect WTP renewable energy
(Harrison, 2013). A positive relationship is expected.

Price perception ***(PR_PERCP):*** This is a binary variable indicating whether or not respondents perceive energy from renewable sources is expensive. In line with the standard economic theory, for a higher price premium perception, a negative relationship is expected.

4.3 Summary statistics and preliminary analysis

Out of the total sample firms, more than half of the respondents did not accept the general willingness to pay question (participation question) and gave a 'no' response for the proposed valuation scenario (Table 4.1). The dominant reasons given for the negative response are unaffordability which accounts for around 57% and the sentiment that "emission reduction should be the government's responsibility", which constitutes 37% of the responses (see details from Appendix A. Table.2).

Table 4.1: Distribution of willing (participants) and non -willing respondents

General WTP	Frequency	Percent (%)
Willing	124	47.69
Non-willing	134	52.31
Total	260	100

Respondents were also asked to express their level of environmental affinity by indicating their agreement, indifference, or disagreement with the idea that "effort should be made to reduce the impact of electricity production on the environment" (Details of the exact wording of this item can be referred from Appendix C. Section III). It is revealed that most respondent who chose the agree option to the question also belonged to the group who responded yes to the general WTP question (Table 4.2). While 120 (65%) respondents from 'the participant category' express their agreement, 66 (35%) respondents from of the non-willing group also chose the 'agree' option to the scenario presented.

Table 4.2: Environmental affinity comparison

	Agree		Disagree		Indifferent	
	N	%[a]	N	%	N	%
Non-willing	66	35	16	84	54	98
Willing	120	65	3	16	1	2
Total	186		19		55	

[a] % represent column frequency of the two groups under the three option responses (agree, disagree and indifferent) of environmental affinity

Furthermore, it is noted that a higher percentage of the participant category (97% out of 124) gave a confirming answer to the environmental affinity self-assessment. This might be an implication that pro-environmental attitude has a major influence on the participation decision. On the contrary, more than half of the non-willing respondents fall into the categories of either disagree or indifferent, the latter being the highest (Table 4.2).

We also conducted a rank-sum test on characteristics of the two groups to see if there is a systematic difference between firms that are generally willing to pay (participants) and those who are not (non-participant). Accordingly, the test statistics indicate we had to reject the null hypotheses that the there is no significant difference between means of the two groups. It is also noted that the test result might be an early warning for a potential sample selection bias if an ad hock approach of ignoring non-participants is adopted for subsequent analysis (for test detail see Appendix A. Table 3).

Table 4. 3 summarize variables used in this study as covariates which are expected to influence WTP of firms for an increase in renewable energy.

Table 4.3: Summary statistics

Characteristic	Description	N	Mean	Std.Dev.	Expected sign
TURNOVER	Annual turnover in millions INR	257	51.44	104.6	+
ENERGYT	The ratio of energy expenditure to annual turn over	245	0.626	7.493	-
EMPLOY	Number of employees	260	35.46	42.23	+
AWARE	= 1 if aware of RE, 0 otherwise	260	0.508	0.501	+
EFFICIENCY	= 1 if energy efficiency measure is employed, 0 otherwise	256	0.656	0.476	+/-
PR_PERCEP	= 1 if RE price is perceived expensive, 0 otherwise	260	0.858	0.350	-

Source: Own calculation

The average turnover of the sample MSMEs is around 51 (million INR) but varies greatly with the standard deviation of almost 105 (million INR). The average energy expenditure to turnover ratio of firms is 0.62 with a standard deviation of 7.4. Firms in the sample on average have 35 employees. While half of the firms claimed to have awareness about renewable energy, nearly 86% have a perception that renewable energy is more expensive. Almost two-thirds of the firms covered in the study employ some type of energy efficiency measure.

4.4 Model estimation strategy

The preliminary assessment revealed that more than half of the firms in the sample are found to be non-willing. However, proceeding to the estimation of the parameters with the sub-sample belonging only to the participant group may induce a sample selection bias. The most widely used approach to handle such a hiccup is to differentiate the response of non-willing respondents as a ‘protest’ or ‘true’ zero values of WTP based on debriefing questions[7] and

[7] Debriefing questions used to determine true and protest zeros can be referred from section C of the survey questioner (Appendix C).

conduct the estimation by including observations with true zeros (Bateman et al., 2002). The problem with this approach is that the discrimination between the two types of zeros is based on an arbitrary criterion. Accordingly, we chose a strategy of dropping all zeros from the analysis and resort to begin the estimation using the Heckman sample selection model as a robustness check for the potential sample selectivity bias. Based on the result of this model, the Bivariate probit model discussed in the methodology section will then be employed for the main analysis. The single probit model estimation will also be included to compare the efficiency gained by the bivariate probit model.

Finally, prior to conducting the econometric regressions, covariates were tested for the presence of multicollinearity. Accordingly, the Variance inflation factor (VIF) which is less than two for all variables suggests that there is no multicollinearity problem. Moreover, a model specification test using *linktest* command for single-equation models was conducted after running the probit model. The test result indicates specification error is not a problem for the single equation probit model (see Appendix A. Table 4 and 5). All model estimations and computation were made using Stata.13 package.

5 Estimation results

In the fitted Heckman model, all the explanatory variables representing sample characteristics are incorporated in the General willingness to pay equation. However, the ENVPRO variable is not included in the WTP amount equation (Table 5.1). This is done because the Heckman model should include at least one variable – which is called exclusion restriction – in the first stage that is different from the variables included in the second stage of WTP amount valuation equation involving only participants (Heckman, 1979; Sartori, 2003).

Table 5.1: Result from Heckman Sample selection model

VARIABLES	*Equation 1* General willingness to pay	*Equation 2* Amount WTP
TURNOVER	0.00102	-0.00134
	(0.00126)	(0.00185)
EMPLOY	-0.00135	0.00528
	(0.00257)	(0.00533)
ENERGYT	-0.686	-1.386
	(0.453)	(0.888)
AWARE	0.426**	-0.0852
	(0.193)	(0.350)
EFFICIENCY	0.173	-0.931**
	(0.214)	(0.438)
PR_PERCEP	-0.728**	-0.325
	(0.292)	(0.513)
ENVPRO		
Agree[a]	2.147***	
	(0.427)	
Disagree	0.914	
	(0.562)	
BID1		-0.00819
		(0.00610)
Constant	-1.444***	2.654***
	(0.507)	(0.755)
N	243	117
LR test of indep. eqns. (rho = 0): chi2(1) = 0.05 Prob> chi2 = 0.8996		

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

[a]- Indifferent is the base category for the ENVPRO

However, it is noted from the Likelihood ratio test that the null hypothesis of independent equations could not be rejected (Prob > χ^2 = 0.8996). This implies the two equations can be estimated as two independent probit models representing the participation (the general willingness to pay equation) and the amount valuation equation separately. Moreover, the test for overall model significance indicate the Heckman model does not seem to have much explanatory power (χ^2 (7) = 8.68, Prob > χ^2 = 0.2767). Nevertheless, the result suggests while environmental affinity and awareness for renewable energy significantly and positively affect firms' willingness to participate in the valuation experiment, the perception on price was found to be a deterrent.

On the WTP amount valuation equation, only the EFFICIENCY variable was found to be significant at the 5% level and has a negative sign. Furthermore, although the bid variable has the expected negative sign it was not significant (full regression result can be referred from Appendix B. table 9). Accordingly, based on the Likelihood ratio test, we identified that sample selection bias is not a threat. We, therefore, proceeded our estimation on the sub-sample (participants) using the bivariate probit model adopted for this study.

Table 5.2 presents the main regression result of parameters used to compute the WTP value. Additionally, since the test for the null hypotheses that means (β_{1j} and β_{2j}) are equal across the two equations[8] could not be rejected ($\chi2$ (8) =12.11; Prob > $\chi2$ = 0.1462), we estimated the model after imposing the cross-equation constraint on the means and dispersion parameters to be identical (details of the test and steps taken can be referred from Appendix B. Table 7.a, b & c). Estimated parameters from the single bounded probit model are also included to compare the efficiency gain.

Table 5.2: Estimation result: Probit and Bivariate Probit Model

VARIABLES	(Model 1) Probit	(Model 2) Bivariate Probit
BID	-0.00796	-0.0113***
	(0.00607)	(0.00310)
TURNOVER	-0.00126	0.00169
	(0.00183)	(0.00127)
EMPLOY	0.00518	-0.00339
	(0.00534)	(0.00233)
ENERGYT	-1.449*	-0.726
	(0.831)	(0.507)
AWARE	-0.0488	0.436***
	(0.311)	(0.162)
EFFICIENCY	-0.919**	-0.955***
	(0.439)	(0.240)
PR_PERCEP	-0.384	-0.588**
	(0.438)	(0.245)
Constant	2.576***	2.612***
	(0.696)	(0.441)
ρ		-0.784***
		(0.111)
$\chi^2(7)$	11.86	38.7
N	117	117
Wald test for $\rho=0$ $\chi2(1)=13.3$ Prob> $\chi2=0.0003$		

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

[8]Note: the two equations here represent the responses for the initial and follow up bids.

The result from the Bivariate probit regression indicates the coefficient of correlation (ρ) between the error terms of the two equations is statistically and significantly different from zero at 1% level. The fact that it is less than unity also implies the correlation between the error terms of the fist and follow up equation is not perfect. Furthermore, the Wald test for independence ($\rho=0$, $\chi^2(1)=13.3$, Prob > χ^2 = 0.0003) shows the null hypotheses that there is no correlation between the error terms of the two equations had to be rejected. This justifies that estimation using the bivariate rather than two independent probits is appropriate.

The probit model performed rather poorly (χ^2=11.86, Prob > χ^2=0.1052) and only two variables; ENERGYT and EFFICIENCY were found to be significant. On the other hand, the Bivariate probit model fits the data well as compared to the probit and it is highly significant (χ^2=38.7, Prob > χ^2 = 0000) implying the joint null hypothesis of coefficients of all explanatory variables included in the bivariate model were zero should be rejected. Moreover, four variables estimated by the Bivariate model; (i) BID (ii) AWARE, (iii) EFFICIENCY, and (iv) PR_PERCEPT were significant at least at 5% level. This might be due to the efficiency gain inherent to the model by incorporating information on the follow-up bid (Haab and McConnell, 2002). However, none of the other variables assigned to capture firm characteristics were significant. Finally, except for the EMPLOY variable coefficients on firm characteristics exhibited the hypothesized sign.

The computation of WTP value and the 95% confidence interval construction are done using the Krinsky and Robb procedure and via a user-developed *wtpcikr* command (Jeanty, 2007). Accordingly, the mean WTP is found to be 1.08 INR[9] per kilowatt hour (Table 5.3).

Table 5.3: WTP estimation result

	Mean WTP[10]	Lower bound	Upper bound
Bivariate probit	1.08***	0.617	1.91
Probit	1.05	-3.77	6.34

****** p<0.01, ** p<0.05, * p<0.1***

The result depicts that the mean WTP estimate from the Bivariate probit is significant and provides a narrower confidence interval around the mean WTP as compared to the probit model. This again demonstrates the utilization of the bivariate model has actually induced an efficiency gain relative to estimating independent probits. The estimated WTP amount represents around 23% of the average tariff paid[11] by the surveyed firms. If one takes a conservative approach and use the lower bound of the confidence interval, it accounts for 13% of the average tariff. However, as explained in section 4.1, it should also be noted that more than half of the sample firms were not willing to pay for the hypothetical program.

[9] 1USD was equivalent to INR 44.34. Currently (as of August,2018),1USD is around 68.63.

[10] Mean and median values for a linear functional form are equal due to symmetrical probability distribution function of probit models.

[11] Sample average tariff at the time of the survey was INR4.654.

5.1 Robustness check

One of the major threats inherent to CV experiments is the presence of missing observations or having a large number of zero values on the dependent variable. This can lead to bias estimates if welfare measures are computed exclusively on the positive segment of the WTP distribution. In this regard, we tried to check and mitigate the potential sample selection bias by initially employing the Heckman sample selection model which controls for such internal validity issues.

However, WTP estimates might also be sensitive to the functional form assumed. Haab and McConnell (2002) demonstrated that mean and median WTP can be highly sensitive to distributional assumptions and functional form employed in the estimation procedure. Hence, we re-estimated the parameters using the exponential functional form of WTP equation and calculated the required Mean and median WTP. Following Jeanty (2007), the WTP equation in its exponential form can be written as:

$$WTP = exp^{\left(\frac{\beta' x}{\beta_b}\right)} \quad (23)$$

Where:
β' represent a column vector of estimated coefficients;
x represents the respondent's characteristics;
β_b denotes coefficients on the bid variables.

Table 5.4 presents the mean and median values of willingness to pay and the 95% confidence interval for the exponential functional form. It is found that parameter estimates of the explanatory variables are almost identical in sign and significance level with the linear counterpart. Hence, the regression result is not presented here and can be referred from Table 8 of Appendix B.

Table 5.4. Estimates of the Exponential functional form

	Value	Lower bound	Upper bound
Median	1.06^{***}	0.59	2.89
Mean	1.96^{***}	0.94	31.45

****** p<0.01, ** p<0.05, * p<0.1***

It is noted that the median WTP estimate falls within the confidence interval of the linear form computed in the preceding section. However, the mean WTP of the exponential functional form exhibited a deviation and has a very wide confidence interval indicating that the estimates might be sensitive to the functional form assumption. Hence, results might call for a cautious interpretation and utilization of the estimated value might need to follow a conservative approach.

6 Discussion

This section presents the discussion on the estimated value of the mean willingness to pay and comments on the results of significant explanatory variables estimated by the Bivariate probit model. It concluded with the limitations identified.

The WTP estimate of INR 1.08 calculated in this valuation experiment was found to be slightly higher than expected as it is almost similar with the study of Ghosh et al. (2017) which estimated a WTP value of INR 1.22 for an uninterrupted electricity supply for the same sample of MSMEs. Although the estimate of the current study is a little lower in absolute terms, considering the level of importance between the two aspects of a single commodity valuation – one being its supply and the other being its quality – a moderate difference was expected. Moreover, considering the high elasticity of MSME's production on power supply and the power outage prevalence in the studied area, the current estimate may seem overstated. However, two competing explanations can be considered. One possible justification can be the dominance of altruistic motives – which are highly related to entrepreneur attitude – over economic objectives among the sample MSMEs. Actually, this might not be implausible as it is corroborated by a study (Wiser et al., 2001) on non-residential green energy adopters in the USA. They identified that altruism is a much more influential motivator for green energy adoption than other factors among smaller organizations. It is also suggested that small-scale firms in Germany are engaged in energy management mainly motivated by the decision maker's concern for the environment (Kannan and Boie, 2001). Yet, the comparability of these studies with the current result might be questionable since both studies were conducted in a more developed country setting where the market for green energy is well established and with a different socio-economic dynamics.

The other alternative – and probably more credible – explanation might be related to the unintended flaw in the survey administration of this study which might deepen the hypothetical bias inherent to CV experiments. As it is explained in preceding sections, the contingent valuation study was done to investigate two related but different aspects of electricity demand by the sample MSMEs. Consequently, the survey design and administration were done on two different dimensions of the same product – the quantity (uninterrupted power supply) and the quality (the "green" energy). However, administering the survey simultaneously on the same sample (even though a reminder to respondents was included to control this issue[12]), might have intensified the cognitive burden of respondents to effectively differentiate the two valuations as separate dimensions. Consequently, this might have induced an upward bias on the estimated value. Unfortunately, no other study was found to compare the WTP estimate further. Therefore, the result should be interpreted cautiously, and utilization of estimates might need to follow a conservative approach of using the lower bound of the confidence interval. On the other hand, estimated coefficients of the bivariate model indicate firm's willingness to pay for RE is highly likely to be influenced by (a) the offered bid, (b) owner-manager's awareness, (c) whether or not the firm has an energy efficiency measure and, (d) perception towards renewable energy price.

Thus, the coefficient on the bid variables is negative as expected and significant implying that the higher the premium on the price for RE, the less likely firms would be willing to pay for electricity generated from renewable sources. The result is in line with economic theory and consistent with virtually all reviewed studies conducted on consumer willingness to pay for

[12] The wording used to control this "hypothetical bias" can be referred from section 3 of Appendix C.

renewable energy (e.g., Aravena et al., 2011; Abdullah and Jeanty, 2011; Arega and Tadesse, 2017).

Likewise, firms who have implemented energy efficiency measure are less likely to be willing to pay for the RE. This variable was hypothesized to have either a positive or a negative sign depending on the dominant motive for the efficiency measure. If efficiency measures or energy management are mainly guided by entrepreneur's environmental concern as discussed by Kannan and Boie (2001), it is expected to influence the WTP positively since renewable energy would just be considered as an additional option for the firm to attain its environmental objective. On the flip side, however, if efficiency measures prioritize pure economic motives, the required substantial initial investment (e.g. purchase requirement for energy efficient machinery) had to compete with the objective of environmental protection. Similar conflicting outcomes were observed by a choice experiment study (Harajli and Gordon, 2015) on WTP for green energy among the Lebanon commercial industries. Considering the financial and operational constraints of MSMEs in a developing nation, it can be argued that the opportunity cost of WTP for renewable energy would be much higher. Hence, the negative relationship is justifiable.

Awareness of mangers, as expected, has a positive and significant impact on WTP for renewable energy. This result is consistent with findings of other studies conducted on households WTP for green energy. Studies by Zografakis et al. (2010) in Greece and Aravena et al. (2011) in Chili, found a positive and significant relationship between knowledge/awareness of RE and the Willingness to pay for it. On the contrary, Bollino (2009) obtained a negative relationship between mean WTP and "general knowledge" for electricity from renewable sources among Italian consumers. His finding, however, was a result of a more refined distinction between the level of Green energy knowledge: general and deep knowledge.

The coefficient of price perception variable was found to be significant and negatively influences the willingness to pay decision of MSMEs. This is expected since, for a commodity with a positive price attached to it, the probability of willingness to pay will decrease with an upwardly biased price perception. Arkesteijn and Oerlemans (2005) found a similar result for the Dutch renewable energy market. They further concluded that price perception was a stronger determinant of green energy adoption than income for residential users. Despite the difference in the socio-economic set up of the sample on which their study is based on, the negative relationship between demand and price (either perceived or observed) is rather a global phenomenon; hence the result in this study is justifiable.

6.1 Limitations

As a natural next step after estimating the WTP for the small and medium industries sample in general, it would have been ideal to evaluate the heterogeneity of WTP that might exist between firms belonging to different sectors. However, this could not be done since the size of the subsample – which the bivariate models are fitted on – is found to be too small and lacks variability within some sectors. For example, we only have one firm from the textile industry category in the subsample. One option could have been to consider a standard category based on firm characteristics assigned by the government of India for MSME classification. However, since this study considers attitudinal variables of owner-entrepreneur in addition to firm-specific characteristics of the standard category, we refrain from performing this task.

Considered another limitation in this valuation study is the small sample size (only 117 observations were qualified for the final bivariate probit analysis) which might have a bearing on estimated parameters and the calculated welfare measures. The fact that some coefficients of economic characteristics like annual turnover were not significant might be due to the small sample size.

Finally, a comprehensive comparison of the estimated WTP value could not be performed due to the lack of existing study conducted with a similar context.

7 Conclusion

The objective of this study was to estimate the value of WTP of Indian Small and medium scale firms for electricity generated from renewable sources. We also identified factors affecting the WTP decision in the context of small and medium scale firms. In order to achieve this, a survey data collected using double bounded CV format from 260 small and medium scale firms in Hyderabad, India was used. Exploiting the properties of the Bivariate probit model, this study identified that there exists a positive willingness to pay amounting to INR 1.08/kWh among the subsample of participant firms. Heckman sample selection model was utilized as a robustness check for the potential sample selection bias. The estimated WTP amount is around 23% of the average tariff per kWh paid by the sample MSMEs during the study period. Unfortunately, comprehensive comparison could not be made since studies relevant to the issue and with a specific context of firms were lacking. Moreover, regression results performed to identify significant factors affecting the willingness to pay decision suggest that attitudinal and behavioral characteristic of managers dominate firm-specific characteristics.

Save for the comments and limitations provided in the preceding sections, the result of this study can be instrumental in filling the existing literature gap in the area and provide an indicative value of the demand for renewable energy among MSMEs. It also offers an insight into how to characterize the peculiar nature of smaller firms in order to better understand relevant adoption factors. Furthermore, taking the current feed-in tariff of INR 4.25 (Andhra Pradesh Electricity Regulatory Commission,[13] 2017) applicable to wind farms as a benchmark, the estimated value of INR 1.08/kWh above the existing tariff suggests a feasible and voluntary purchase arrangement can be implemented for financing renewable energy generation projects or attracting investors in the sector.

Moreover, the influential characteristics identified could particularly be vital in facilitating the implementation of ‘green’ initiatives. One such avenue that could be considered is enabling MSMEs to access updated information on the current developments and price of renewable energy so that informed energy-related decisions are made. Likewise, implementation of national initiatives targeting small-scale firms – such as the ZED scheme – need to consider a synergy approach between energy efficiency (conservation) activities and renewable energy adoption.

[13] The commission is a state regulatory body in study area of the state of Andhra Pradesh.

Appendices

Appendix A.

Categorization of the ENVPRO variable (measuring the environmental affinity of managers)

The adjustment undertaken for the attitudinal variable of ENVPOR which represents environmental attitude is presented below. As can be noted from Table 1 the two affirmative responses (Strongly agree and Agree) for the question "..Efforts should be made to lessen the environmental impacts of electricity production.." are aggregated in the Agree category. The classification of the remaining two has also been made in a similar way.

Table 1. Environmental Affinity distribution

Original 6 Category - Likert scale	***Freq.***	***Percent***	***New 3 category Likert scale***	***Freq.***	***Percent***
Strongly agree	48	18.46			
Agree	138	53.08	**Agree**	**186**	**72%**
Don't know/refuse	7	2.69			
Neither agree nor disagree	48	18.46	**Indifferent**	**55**	**21%**
Disagree	16	6.15			
Strongly disagree	3	1.15	**Disagree**	**19**	**7%**
Total	260	100.00		**260***	**100%**

- ***Note that the category is for the whole sample***

Table 2. Frequency of protest reason for non-participant group

protestreason	Freq.	Percent	Cum.
Cannot afford to pay	77	56.62	56.62
Do Not believe we would get renewable..	4	2.94	59.56
No benefit from renewable energy	4	2.94	62.50
Others	2	1.47	63.97
The Govt is responsible for emission ..	49	36.03	100.00
Total	136	100.00	

Test for mean difference between the non-participant and participants group

Table.3. presents the details of the rank-sum test conducted for the null hypothesis that there is no significant mean difference between the non-participant and participants groups. Note that *gneneralwtp = 1if participant, 0 otherwise*. This is a non-parametric test similar to the customary paired t-test. It is preferred for this study since the explanatory variables are not normally distributed. In general, the Mann–Whitney (rank-sum) test "tests the hypothesis that two independent samples (that is, unmatched data) are from populations with the same distribution by using the Wilcoxon rank-sum test, which is also known as the Mann-Whitney two-sample statistic" (Wilcoxon, 1945; Mann and Whitney, 1947).

Table 3. Mann–Whitney (rank-sum) test

```
Two-sample Wilcoxon rank-sum (Mann-Whitney) test

  generalwtp |      obs    rank sum    expected
-------------+---------------------------------
           0 |      133       15723       17157
           1 |      124       17430       15996
-------------+---------------------------------
    combined |      257       33153       33153

unadjusted variance   354578.00
adjustment for ties     -1118.86
                     ----------
adjusted variance     353459.14

Ho: turnover(genera~p==0) = turnover(genera~p==1)
             z =  -2.412
    Prob > |z| =   0.0159

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

  generalwtp |      obs    rank sum    expected
-------------+---------------------------------
           0 |      136     16021.5       17748
           1 |      124     17908.5       16182
-------------+---------------------------------
    combined |      260       33930       33930

unadjusted variance   366792.00
adjustment for ties      -649.99
                     ----------
adjusted variance     366142.01

Ho: employ(genera~p==0) = employ(genera~p==1)
             z =  -2.853
    Prob > |z| =   0.0043

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

  generalwtp |      obs    rank sum    expected
-------------+---------------------------------
           0 |      128     16630.5       15744
           1 |      117     13504.5       14391
-------------+---------------------------------
    combined |      245       30135       30135

unadjusted variance   307008.00
adjustment for ties        -4.13
                     ----------
adjusted variance     307003.87

Ho: energyt(genera~p==0) = energyt(genera~p==1)
             z =   1.600
    Prob > |z| =   0.1096
```

```
Two-sample Wilcoxon rank-sum (Mann-Whitney) test

  generalwtp |      obs    rank sum    expected
-------------+---------------------------------
           0 |      136       15532       17748
           1 |      124       18398       16182
-------------+---------------------------------
    combined |      260       33930       33930

unadjusted variance   366792.00
adjustment for ties   -91759.04
                     ----------
adjusted variance     275032.96

Ho: aware(genera~p==0) = aware(genera~p==1)
             z =  -4.225
    Prob > |z| =   0.0000

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

  generalwtp |      obs    rank sum    expected
-------------+---------------------------------
           0 |      133     16286.5     17090.5
           1 |      123     16609.5     15805.5
-------------+---------------------------------
    combined |      256       32896       32896

unadjusted variance   350355.25
adjustment for ties  -113245.98
                     ----------
adjusted variance     237109.27

Ho: effici~y(genera~p==0) = effici~y(genera~p==1)
             z =  -1.651
    Prob > |z| =   0.0987

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

  generalwtp |      obs    rank sum    expected
-------------+---------------------------------
           0 |      136       19224       17748
           1 |      124       14706       16182
-------------+---------------------------------
    combined |      260       33930       33930

unadjusted variance   366792.00
adjustment for ties  -232482.29
                     ----------
adjusted variance     134309.71

Ho: pr_per~p(genera~p==0) = pr_per~p(genera~p==1)
             z =   4.027
    Prob > |z| =   0.0001
```

***Note that the testing of variables is done with the following sequence (Turnover, employee, energy, aware, efficiency, and pr_percp)**

Probit model specification test.

Table 4. presents the specification test allowed in stata for a single equation model. *Linktest* performs a test of specification of the dependent variable (StataCorp, 2013).

The assumption is if the model is really specified correctly, then the prediction squared(*_hatsq*)will not be significant and have no explanatory power.

Table 4: Specification test for single equation probit model

```
Probit regression                                 Number of obs   =        117
                                                  LR chi2(2)      =      12.17
                                                  Prob > chi2     =     0.0023
Log likelihood = -47.426298                       Pseudo R2       =     0.1137
```

response_bid1	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_hat	.4779352	1.002475	0.48	0.634	-1.486879	2.442749
_hatsq	.264104	.4915735	0.54	0.591	-.6993623	1.22757
_cons	.2057232	.489371	0.42	0.674	-.7534264	1.164873

(Note that _hatsq – which represents the prediction squared – is not significant for the probit model of this study, implying that specification error is not a threat in the probit model)

Multicollinearity test

Table 5 presents multicollinearity test conducted in this study. VIFs are used to detect collinearity (also called multicollinearity) among predictors. High VIFs reflect an increase in the variances of coefficients due to collinearity among explanatory variables.

Table 5. Variance Inflation factor- multicollinearity test

Variable	VIF*	1/VIF
TURNOVER	1.92	0.520513
EMPLOY	1.83	0.546769
PR_PERCEP	1.2	0.832241
EFFICIENCY	1.18	0.847178
ENERGYT	1.11	0.900013
AWARE	1.06	0.941982

****Note the value of VIF for all covariates is below two, implying multicollinearity is not a threat (Gorss, 2003).***

Appendix B.

Steps taken in estimation of Bivariate probit Models

Tabel 7.a, b, and c presents the steps followed for imposing equality constraint on means and dispersion parameters across the two equations representing the latent WTP equations described on the methodology section.

Hence, after estimating the parameters using the unconstrained standard Biprobit model (Table 7a) – where the two set of parameters of the two equations takes different values similar to Cameron and Quiggin (1994) approach – we conducted a Wald test (Table 7b) to check if coefficients are significantly different across the two underlying WTP equations.

Tabel 7a .Result of the unconstrained standard bivariate probit model

```
Seemingly unrelated bivariate probit            Number of obs     =        117
                                                Wald chi2(14)     =      37.53
Log likelihood = -88.037593                     Prob > chi2       =     0.0006
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
response_bid1						
bid1	-.0084264	.0058761	-1.43	0.152	-.0199435	.0030906
turnover	-.0012364	.0018243	-0.68	0.498	-.0048119	.002339
employ	.0048445	.005252	0.92	0.356	-.0054493	.0151383
energyt	-1.349463	.8339522	-1.62	0.106	-2.983979	.2850529
aware	-.0340931	.3096366	-0.11	0.912	-.6409697	.5727835
efficiency	-.9152476	.4292308	-2.13	0.033	-1.756525	-.0739706
pr_percep	-.4519892	.4298603	-1.05	0.293	-1.2945	.3905214
_cons	2.637113	.6793116	3.88	0.000	1.305686	3.968539
response_bid2						
bid2	-.0132925	.0059607	-2.23	0.026	-.0249753	-.0016097
turnover	.0067716	.0031744	2.13	0.033	.0005499	.0129932
employ	-.0128296	.0052587	-2.44	0.015	-.0231364	-.0025228
energyt	.042889	1.261009	0.03	0.973	-2.428643	2.514421
aware	.9970607	.3174263	3.14	0.002	.3749166	1.619205
efficiency	-1.248976	.4094573	-3.05	0.002	-2.051498	-.4464548
pr_percep	-.7118038	.4236172	-1.68	0.093	-1.542078	.1184707
_cons	2.710188	.8059677	3.36	0.001	1.13052	4.289856
/athrho	-.851775	.3446732	-2.47	0.013	-1.527322	-.176228
rho	-.6919957	.1796237			-.9099652	-.174426

```
LR test of rho=0: chi2(1) = 6.13956                       Prob > chi2 = 0.0132
```

However, as it can be seen from the stata output of χ2 statistics (Table. 7.b), the null hypothesis that the means and dispersion parameters across the two equations (Response Bid1 and Response Bid2') are equal cannot be rejected (*χ2=12.11, Prob > χ2 = 0.1462*).

Table 7.b. Test result for equality of means and dispersion parameters

```
 ( 1)  [response_bid1]_cons - [response_bid2]_cons = 0
 ( 2)  [response_bid1]bid1 - [response_bid2]bid2 = 0
 ( 3)  [response_bid1]turnover - [response_bid2]turnover = 0
 ( 4)  [response_bid1]employ - [response_bid2]employ = 0
 ( 5)  [response_bid1]energyt - [response_bid2]energyt = 0
 ( 6)  [response_bid1]aware - [response_bid2]aware = 0
 ( 7)  [response_bid1]efficiency - [response_bid2]efficiency = 0
 ( 8)  [response_bid1]pr_percep - [response_bid2]pr_percep = 0

           chi2(  8) =   12.11
         Prob > chi2 =    0.1462
```

Hence, as noted in the result section of this paper, estimation for the main analysis is done after imposing equality constraint of the means(β) and dispersion(σ) parameters of the two WTP equations but allowing the correlation coefficient of the error terms(ρ) to be determined through the regression process. This approach of utilizing results after constraining the means of WTP of each response to be identical (e.g. $\beta_{1 \text{ of equation1}} = \beta_{1 \text{ of equation 2}}$) was pioneered by Alberini (1995) and has been applied by empirical studies for its robustness (eg., Jakus et al.,1997; Jeanty, 2007; Ghosh et al.,2017). Furthermore, the approach has a superior advantage of effectively removing the difficulty of interpretation and estimation by offering a single vector for the parameter estimates instead of two sets of parameters for each response.

Finally, both the Akaike's information criterion –AIC and Bayesian information criterion -BIC (Table 7c) indicate that the constrained model adopted in the result section is a better fit for the data.

Table 7.c. Akaike’s information criterion and Bayesian information criterion

Model variant	DF	AIC	BIC
*Constrained	9	207.8095	232.6691
Unconstrained	17	210.0752	257.0321

- ***Note Constrained Model variant adopted in the result section has lesser values of both criterions***

Table 8. presents the regression result of the exponential form of the bivariate probit model. In simple terms, the regression is done after performing a logarithmic transformation on the Bid variables.

Table 8. Biprobit exponential functional form Estimation result

VARIABLES	Response to Bids
lnbid	**-0.903***** (0.241)
turnover	0.00175 (0.00124)
employ	-0.00326 (0.00228)
energyt	-0.706 (0.511)
aware	**0.429***** (0.161)
efficiency	**-0.942***** (0.238)
pr_percep	-0.581** (0.243)
ρ	**-.808083****
Constant	5.578*** (1.127)
Observations	117

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

[14]Wald chi2(7) = 39.36 Prob > chi2 = 0.0000

Similar to the linear functional form: lnbid, efficiency, and pr_percerp variables affect the WTP decision negatively and significantly. Again, parallel to its linear counterpart, the aware variable in this model has a positive significant influence on WTP. Furthermore, the model is statistically significant as indicated by the χ^2 test of 39.36. Moreover, the correlation coefficient between the error terms of the two equations (ρ), is also significant implying that estimating the two equations together was appropriate.

[14] Test for overall model significance

Table 9. Heckman sample selection model regression result

```
Probit model with sample selection              Number of obs      =        243
                                                Censored obs       =        126
                                                Uncensored obs     =        117

                                                Wald chi2(7)       =       8.68
Log likelihood = -166.2107                      Prob > chi2        =     0.2767
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
response_bid1						
bid1	-.0081854	.0060961	-1.34	0.179	-.0201336	.0037628
turnover	-.0013396	.0018491	-0.72	0.469	-.0049637	.0022845
employ	.0052807	.0053278	0.99	0.322	-.0051615	.015723
energyt	-1.386015	.8883979	-1.56	0.119	-3.127243	.355213
aware	-.0851725	.350039	-0.24	0.808	-.7712363	.6008913
efficiency	-.9311123	.4378746	-2.13	0.033	-1.789331	-.0728939
pr_percep	-.3246483	.5134049	-0.63	0.527	-1.330903	.6816068
_cons	2.654381	.7553342	3.51	0.000	1.173953	4.134808
generalwtp						
turnover	.0010155	.0012624	0.80	0.421	-.0014587	.0034898
employ	-.0013517	.0025718	-0.53	0.599	-.0063924	.0036891
energyt	-.6855058	.4532068	-1.51	0.130	-1.573775	.2027632
aware	.4255432	.1934868	2.20	0.028	.046316	.8047703
efficiency	.1729538	.2136303	0.81	0.418	-.2457538	.5916615
pr_percep	-.7277836	.2921526	-2.49	0.013	-1.300392	-.155175
Agree	2.147176	.4270755	5.03	0.000	1.310123	2.984229
disagree	.9138005	.5617032	1.63	0.104	-.1871176	2.014719
_cons	-1.444402	.5072087	-2.85	0.004	-2.438513	-.4502911
/athrho	-.1545526	.7138171	-0.22	0.829	-1.553608	1.244503
rho	-.1533337	.6970344			-.9143789	.846735

```
LR test of indep. eqns. (rho = 0):   chi2(1) =      0.05   Prob > chi2 = 0.8296
```

Appendix C.

Survey on energy resources and electricity in industries

Survey on energy resources and electricity in industries

Survey No. 9

Panel Identification

Code: _______________ Investigator: ________________Date: ________Start time: _____

Supervisor: _______________ District: ____________________End Time: _________

Objective of the survey

Hello, my name is .... I am from Hyderabad. I am working for the Project "Sustainable Hyderabad" which is concerned with climate change and energy. This project is funded by the Government of Germany. The aim of the project is to make Hyderabad a low emission city by 2030. As a partner to Department of Resource Economics (RESS), Humboldt University, Berlin in the Megacities Research Consortium, The Energy and Resources Institute (TERI) is undertaking a study to analyse energy consumption pattern of industries in Hyderabad. Please kindly provide necessary information on your consumer behaviour and your attitudes. The information you may give us, will help us to identify certain problems and consumption patterns related to energy and electricity supply. The results of the entire survey build the basis for the development of strategies for making Hyderabad an environmentally sustainable city.

Of course, we will treat your information confidential and it will not be shared with other people. The data will only be used in aggregate and your name will not be mentioned in any stage of the study.

If there are any problems or clarification issues, please contact *Mr. Philip Kumar* (mobile no. 9701222352) If there are any other questions, we would very much appreciate if we can come back to you.

A: Industry/Company Information:

1. Name of company: ____
2. Main interviewee's name: ____
3. Designation: ____
4. Address: ____
5. District: ________________________________ Pin: | | | | | | |
6. Telephone number: ____________________________ Fax: ______________________
7. Email:______________________________________
8. Product Portfolio
   a) Main Products:
      i) ________________________________
      ii) _____________________________
      iii) _______________________________________

9. Do you produce 24 hours per day? Yes □ / No □

If No, how many hours/ day_______________

10. Do you produce every day per week? Yes □ / No □

If No, how many days/week_________

11. For how many months does your manufacturing have peak production? ____________

Please specify these months: _____________

12. What is the average tariff for electricity that you pay in your manufacturing unit? ______________Rs/Kwh

13. What is the number of employees at your the manufacturing unit?

- Permanent employees____________
- Contract staff_______________

Interviewer instruction: (for Question 13 &14): Ask information for 2009-10 or any latest year for which data is available

14. Could you please provide us the details of your manufacturing unit production profile?

Main Product	**Duration of one production cycle**	**Annual Turnover (Rs)**	**Annual Production**		**Annual Cost of production (Rs)**
			Amount (Number)	**Units**	
Total					
I.					
II.					
III.					

B: Energy consumption pattern (Manufacturing/Production Only)

1. Fuel wise yearly consumption (volume and cost)   Year ______________
2. What have been the reasons for the changes in the consumption of fuels in your manufacturing units?

Fuel Type	**Yearly consumption**	**Units**	**Yearly Expenditure (Rs. Lakh)**	**% change in the last five years**	**Increase/Decrease (-)/(+)**	**If (-), has there been any shift to some other fuel (please specify the same)**
Electricity at Manufacturing unit						
Coal						
Natural Gas						
Naptha						
Coke						
Lignite						
Petrol						
High Speed Diesel						
Light Diesel Oil						
SKO (Kerosene)						
Fuel Oil/Furnace Oil						
Biomass						
Charcoal						
Any other (Please Specify)						

Shift from: **(Fuel Type)**	**Shift to:** **(Fuel Type)**	**Reason for the Change in Consumption of Fuel**							
		Due to Increase in price	**Due to unavailability**	**Due to changes in process/** **production technology**	**Due to efforts towards energy efficiency**	**Due to efforts towards use of cleaner fuels**	**Due to introduction of a new product**	**Due to change in scale of operation**	**Any other(Please specify)**
Electricity at Manufacturing unit									
Coal									
Natural Gas									
Naptha									
Coke									
Lignite									
Petrol									
High Speed Diesel									
Light Diesel Oil									
SKO (Kerosene)									
Fuel Oil/Furnace Oil									
Biomass									
Charcoal									
Any other (Please Specify)									

3. What is your electricity sanctioned load/contracted demand from electricity distribution manufacturing unit?___________ ___

4. How many hours/days of unscheduled outages do you face on average during a production day?

Summer _______ hrs/day, Winter ________hrs/day, Monsoon_______hrs/day?

Or

Summer _______ days/week, Winter ________days/week, Monsoon_______days/week?

5. How many hours/days of scheduled outages do you face on average during a production day?

Summer ___ __ hrs/day, Winter _________hrs/day, Monsoon_______hrs/day?

Or

Summer _______ days/week, Winter ________ days/week, Monsoon_______ days/week?

6. What is the specific time in a day when an outage hurts your production process the most?

________________________________ ___ ___

7. Did the number of outages change in the last three years?

Scheduled increased □/ decreased □ / no change □

Unscheduled increased □/ decreased □ / no change □

8. What are the problems you experience with the electricity supplied by your electricity company:

Please rank each problem from 1-5 (1 is very mild and 5 is very serious) or NA in case the problem has not been experienced

Code	**Problem of Supply**	**Rank**
01	Voltage Fluctuation	
02	Scheduled Outages	
03	Unscheduled Outages	
04	There is no response to complaints	
05	Unofficial payments are required for repairs	
06	Getting a new connection from the grid is very difficult	
07	Getting additional load from the grid is very difficult	
08	Others (Specify)	

9. Does your manufacturing units have captive facility? Yes □/ No □/

a. If No, are you planning to set up a captive facility in the near future? Yes □/ No □/

b. If yes, please answer the following questions:

i) What is the capacity of the captive facility? ____________ kW

ii) What fuel/s is used in the captive facility? (Please tick from the options below)

Coal	Natural gas	Diesel	Renewable based (biomass, solar, wind)	Any other please specify

iii) In your peak production months, What is the average daily usage of captive facility?_________________ hrs

iv) What is the operating cost of power generation from the captive facility?______________ (Rs/kwh)

v) Is the captive facility used as a supplement to the grid power or only in case of outage as backup? Supplement □/Backup □

vi) Do you sell power to any third user from your captive facility? Yes □ / No□

vii) Do you use renewable energy sources for your captive facility? Yes □ / No□

Small hydro □ biomass □ solar PV □ wind □ Any other ____________

If yes,

- Does all your captive power requirement come from renewable source? Yes □/ No □

viii) Is it located at manufacturing site □ or offsite □?

10. In case of outages/load shedding, do you mainly (specify only one option)

a. Continue to work on processes that do not require electricity □

b. Stop the entire manufacturing process altogether □

c. Delay the process and complete the cycle once electricity is restored □

d. Use a genset as backup □ Please specify the fuel ________________________

e. Use inverter as backup □

f. Use captive as backup □

g. Use cooperative arrangement □

h. Any other alternative □

   - Please specify ____

11. What is the production loss suffered in terms of value (Rs) on account of one hour electricity outage : __________(Rs)

12. Does your manufacturing unit have facility for cogeneration/ waste heat recovery? Yes □ / No □

C: Willingness to Pay (WTP)

1. Renewable Energy

1.1. Knowledge on Renewable energy

1.1.1. Are you aware of renewable energy? Yes ☐/ No ☐

1.1.2. Please specify the sources of renewable energy known to you

a. ____________________________

b. ____________________________

c. ____________________________

Interviewer instruction: If the respondent says No, please briefly explain the concept of renewable energy

1.2. WTP for Renewable Energy (Read out text)

"It is possible to provide some of the electricity using renewable energy sources such as solar, wind, biomass, etc. Increasing the supply using such renewable energy sources would have the advantage to reduce emissions and climate change. It may also improve the environment around the electricity generating plants. At the moment, the share of renewable energy in your electricity mix is around two percent.

We do not yet know exactly how much this investment would cost, but I would like to know if you agree in principle with paying for an increase of renewable energy in the energy mix? Please do not agree to pay if your company cannot afford it or if you feel there are other things that are more important for you to spend money on."

☐ Yes IF YES, GO TO QUESTION 1.3

☐ No IF NO, GO TO THE NEXT QUESTION AND THEN TO QUESTION 2

1.2.1. Please could you give us the main reason why you are not willing to pay for renewable energy? (Tick only ONE option!)

Code	Mark a tick	Reason
01		The government is responsible for emission reductions
02		Do not believe we would get renewable energy supply (lack of trust)
03		Cannot afford to pay
04		No benefit from renewable energy
05		Other (please specify)

1.3. DC Contingent Valuation for Renewable Energy (Read out text and explain that this and the following question are hypothetical)

"Now I am going to offer you an increase in the share of renewable energy in the overall electricity supply to 15%. Currently this share is 2%. This means that in the hypothetical question 15% of ALL energy produced in Andhra Pradesh will be generated from renewable energy sources.

The increased share of renewable energy will NOT reduce the number of outages or guarantee a more stable supply for your company. It will, however, reduce emissions of green house gases and can thus slow down global warming. Please do not agree to pay if your company cannot afford it or if you feel there are other things that are more important for you to spend money on."

1.3.1. Would you pay 100 Paise in ADDITION per Unit (kWh) for receiving 15 % renewable energy supply?

☐ Yes (If Yes go to Question 1.3.2)

☐ No (If No go to Question 1.3.3)

1.3.2. Would you pay 140 Paise in ADDITION per Unit (kWh) for receiving 15 % renewable energy supply?

☐ Yes

☐ No

1.3.3. Would you pay 70 Paise in ADDITION per Unit (kWh) for receiving 15 % renewable energy supply?

☐ Yes

☐ No

1.4. Open Bid for Renewable Energy

Please state the maximum amount you would be willing to pay in ADDITION per unit (kWh) for increasing the share of renewable energy in AP to 15 %: ____________________ Paise/KWh!

2. Reduction of Outages (Read out text)

"As you are aware, many businesses in this state face problems of power supply. While some companies continue to depend only on the transmission grid, others rely partly or wholly on captive generation. Currently, you pay for grid supply as well as paying for any damage due to voltage fluctuations and interruptions of supply. You may also pay for stand-by or captive generation. An improved quantity and quality of electricity supply may increase your company's productivity. However, if output is to be increased, significant new investment in generation, transmission and distribution will be required and the additional cost would have to be recovered through the electricity tariff."

2.1. WTP for Reduction of Outages (Read out text)

"We do not yet know exactly how much this investment would cost, but I would like to know if you agree in principle with paying for a reduction of outages to zero? Please do not agree to pay if your company cannot afford it or if you feel there are other things that are more important for you to spend money on."

☐ Yes IF YES, GO TO QUESTION 2.2

☐ No IF NO, GO TO NEXT QUESTION AND THEN TO SECTION D

2.1.1. Please could you give the main reason why you are not willing to pay for a reduction of outages? (Tick only ONE option!)

Code	Mark a tick	Reason
01		The government is responsible for a stable energy supply
02		Do not believe we would get improved supply (lack of trust)
03		Cannot afford to pay
04		Believe the current tariff is already too high
05		Outages do not affect business operations
06		Demand is already met from self-generation
07		Other (please specify)

2.2. DC Contingent Valuation for a Reduction of Outages to Zero (Read out text and explain that this and the following question are hypothetical)

"Now I am going to offer you stable electricity supply. This will reduce the number of outages to zero and guarantee a stable supply for your company. You would not need any back-up systems or captive generation. How much would you pay in ADDITION to the current tariff? Please tell me if you would be willing to pay this amount for the improved service. Note that the reduction of outages is valid for your company only. Other customers are not affected by your choice. Please do not agree to pay if your company cannot afford it or if you feel there are other things that are more important for you to spend money on."

2.2.1. Would you pay 180 Paise in ADDITION per unit (kWh) for a reduction of outages to zero?

☐ Yes (If Yes go to Question 2.2.2)

☐ No (If No go to Question 2.2.3)

2.2.2. Would you pay 250 Paise in ADDITION per unit (kWh) for a reduction of outages to zero?

☐ Yes

☐ No

2.2.3. Would you pay 120 Paise in ADDITION per unit (kWh) for a reduction of outages to zero?

☐ Yes

☐ No

2.3. Open bid for Reduction of Outages to Zero

Please state the maximum amount you are willing to pay in ADDITION for a reduction of outages to zero: _________________________ Paise/KWh!

D: Attitudes, Perceptions, Awareness

I. Energy Efficiency and load management

Time of Day (ToD) tariff

1. Are you aware of Time of Day tariffs for industry?

Yes □/No □

Interviewer instructions: If response is Yes, then go to Q 2 else go to Q 3.

2. Would you want the government to introduce Time of Day tariffs in the state?

Yes □/No □

If no, why not____

Energy Efficiency

3. Are you aware of the Bureau of Energy Efficiency's (BEE)/Non-Conventional Energy Development Corporation of Andhra Pradesh (NEDCAP)'s initiatives/programme in the field of energy efficiency/energy conservation? Yes □/No □

4. Do you get energy audit conducted at regular intervals? Yes □/No □

5. Is energy audit mandatory for your industry by NEDCAP? Yes □/No □

6. Have you taken measures for energy efficiency in your manufacturing units? Yes □/No □

(i) If yes, does this include? (You can have multiple options)

   a. Use of energy efficient appliances/devices □

   b. Use of cleaner and efficient fuels □

   c. Others (Please specify) ____

Is there scope for undertaking more energy efficiency measures? Yes/No

(ii) If No, then why?

Reasons	**Strongly Disagree**	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly Agree**	**Don't know/ Refuse**
Investment is much more than returns						
We are not concerned about these issues						
We don't know how to undertake measures for energy efficiency						
Financing of energy efficiency is difficult						
Any other reasons						

II. Cleaner and efficient fuels

7. Are you planning to replace consumption of coal/diesel consumption with fuels like natural gas? Yes □/No □/ We do not use coal or diesel at the manufacturing unit □

If Yes, why? ______________________________

If not, why? (Multiple choices possible):

Reasons	**Strongly Disagree**	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly Agree**	**Don't know/Refuse**
There is uncertainty of availability of cleaner fuels						
Cleaner Fuels are more expensive						
There is too much variation in their prices						
Substitutability of fuels is an issue						
Cleaner fuels have lesser efficiency						
Any other						

III. Renewable energy

8. Do you think that power supply from renewable sources is more expensive than power supply from conventional sources? Yes □/ No □

9. Please indicate whether you agree or disagree with the following statement: "Efforts should be made to lessen the environmental impacts of electricity production, even if this would result in increased electricity prices for you". (Please tick from options below)

Strongly Disagree	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly Agree**	**Don't know/ Refuse**

10. Would you be willing to buy renewable energy to meet your electricity requirements?

Yes □/ No□

If yes, please indicate your choice from the following options:

a. Direct purchase from renewable energy producer □

b. Electricity supply by APCPDCL based on renewable sources □

c. both are ok □

Indicate the reasons for not choosing option a or b

Reasons	**a**	**b**
It is too expensive		
Govt. policy is not favourable enough		
Credibility of the institutional arrangement		
Availability of renewable source is a concern		
Connectivity is an issue		
Electricity supply will not be reliable		
Any other		

If No, please specify the reasons:

Reasons							
It is too expensive	Availability of renewable sources of energy is uncertain	Environment is not my concern	Electricity generated from renewable sources is not sufficient	Electricity generated from renewable sources is not reliable	I am not aware of such facility	Govt. policy is not favourable enough	Production process is not compatible with renewable based captive facility

Please specify if there are any other reasons in addition to the reasons listed above:

___

11. Would you be interested in setting up a cooperative captive facility with your neighbouring units?

Yes □/No □

12. Preferences on Organizations

"The electricity can be provided by different kinds of suppliers. It can be supplied by a government owned company (APCPDCL), by a private company, or by a cooperative. At the moment, you receive your electricity from a government-owned company, which is APCPDCL. But in future it may be possible that you can choose your supplier. A cooperative means that electricity consumers are owners of their supplier, while a private company is a profit-oriented arrangement like Reliance or Lanco."

Do you have any preference for the power supplier?

☐ Government owned company (APCPDCL)

☐ Private company

☐ Cooperative

☐ Any other (specify) ______________________________

☐ I don't care

END OF SECTION

Please take a copy of the annual report or the balance sheet, whichever is available?

Please also specify which day of the week is a holiday for your company?

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