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ABSTRACT

This study undertakes a contingent valuation survey using a stratified random sample of 2083 households in rural Madhya Pradesh, India, with the objective of estimating the benefits of an improved electricity supply to rural households. Willingness to Pay (WTP) estimates using a bidding game and dichotomous choice elicitations formats, show that benefits adequately justify the investments on feeder separation and rural electricity service improvements. Results of this study support similar investments in other states in India with similar electricity services and socio-economic characteristics. The estimated income elasticity of WTP indicates the possibility of progressive tariff increases as household income increases. Simulations using the estimated WTP function show that block and flat tariff exhibit similar impacts on revenue generation; however block tariffs have the ability to induce energy conservation at the household level. Although not entirely conclusive, the study casts doubts about the rationale for subsidies for the poorest households.

ABBREVIATIONS

ADB	–	Asian Development Bank
BPL	–	Below Poverty Line
CV	–	Contingent Valuation
CVM	–	Contingent Valuation Method
DISCOM	–	District Distribution Company
EIRR	–	Economic Internal Rate of Return
FGD	–	Focus Group Discussion
GP	–	Gram Panchayat
MP	–	Madhya Pradesh
NOAA	–	National Oceanic and Atmospheric Administration
SCT	–	Scheduled Castes
SLP	–	Single Light Point
WTP	–	Willingness To Pay

I. INTRODUCTION

1. Access to adequate and good quality electricity remains one of the biggest development challenges in rural India; about 400 million people do not have access to electricity. In addition to direct improvements in the standard of living, electricity indirectly improves incomes and well-being through increasing agricultural productivity, enhanced business opportunities, job creation, and industrialization in rural areas. Like most of India, the State of Madhya Pradesh (MP) is an agrarian state with its rural population forming 70% of the total population. Inadequate power supply in rural areas is one of the major obstacles affecting the economic development of this state. Out of 52,074 villages in MP, 15% are without electricity. Given that electricity supply to major public office buildings such as hospitals and schools qualify a village as being electrified, village electrification data is not a good indicator for households' access to electricity. Even those who have access to electricity receive very poor services, in rural areas of MP poor electricity services are the norm, with supply consisting of just six to eight hours per day.

2. Un-metered and subsidized power to agricultural water pumping, which prevents cost recovery for power distribution companies, has been a major obstacle in expanding power supply to rural households. Excessive power use by agricultural consumers creates low voltage for households and other system imbalances. The government of MP has set up an ambitious target of 24-hour quality power supply to all rural households while ensuring an 8-hour power supply for irrigation by the end of 2012. One of the technological constraints in meeting this target is the common electricity feeders for supplying power for both domestic and agricultural users. The excessive drawing of power for irrigation, mainly due to perverse incentives of subsidy and fixed charges, results in households not getting adequate power for domestic consumption. Illegal power connections exacerbate this problem. Therefore, one pragmatic technical solution is to have separate power feeders for agricultural consumers, enabling power distribution companies to ration the subsidized power supply farmers. Together with 100% metering and accurate billing in the domestic sector and installation of high voltage distribution systems (HVDS) to reduce power theft, feeder separation is expected to resolve financial sustainability issues of power distribution companies.

3. The government of MP has launched a feeder separation project with the assistance of Asian Development Bank (ADB) incorporating the following features: 24 hours of electricity supply for domestic/commercial use and eight hours of supply for agriculture use; the installation of HVDS systems; 100% metering for accurate billing of domestic consumption; remote metering for energy auditing and tracking the use of subsidized power by the agriculture sector; and reducing power interruptions and avoiding abnormal loading to feeders.

4. About $1.2 billion is expected to be invested on a feeder separation project in MP. The economic justification of a major investment like this requires quantification of benefits of the project to rural households. For rural households, this improved service is a new commodity and there is no market price to value such commodities. Therefore, non-market valuation techniques such as a Contingent Valuation Method (CVM) should be used to estimate the benefits of improved service. The main objectives of the study are to: estimate WTP for the 24 hour supply of good quality (voltage) electricity with improved customer service and billing in rural MP; assess the determinants of the demand or WTP for 24 hour electricity supply; assess feasible options for inclusive tariff designs; and establish a baseline socio-economic data set to measure the development impacts of feeder separation project at a later date.

II. LITERATURE SURVEY

5. This study uses Contingent Valuation (CV) methods to estimate the benefits or WTP of rural households in MP to receive 24 hour, good quality supply, with accurate billing and good customer service. The idea of using CV survey methods for valuing public goods and environmental services started as early as the 1960s and rapidly gained importance and recognition in empirical applications. Mitchell and Carson (1989) played key roles in providing a good understanding of CVM over the last two decades. The empirical application of CVM has grown rapidly after NOAA[1] panel report (Arrow et al. 1993), endorsed the selective and careful use of CVM to estimate non-market benefits. A comprehensive discussion of theoretical foundations and empirical application of CVM is given by Carson and Hanemann (2005), Shogren (2005), Champ *et al*. (2003), and Hensher *et al*. (2005). Whittington (1998a, 1998b, and 2002) undertook a number of studies to popularize CVM in developing countries. Gunatilake et.al (2007) provides a detailed discussion on good practices for application of the method in developing countries.

6. CVM, while widely used for eliciting household preferences for non-market environmental goods is also used for eliciting preferences or benefits of private goods, particularly goods provided by public utilities with administratively decided prices. The markets for private goods such as water supply and sanitation, health services, transport, and electricity are normally regulated due to various reasons. These regulated prices may not represent true benefits to the individuals. CVM is frequently used for assessing benefits in the water supply and sanitation sectors. Gunatilake and Tachiiri (2011) provide a review of recent water sector CV studies conducted in South Asian countries. Like water supply, electricity is a private good supplied in a regulated market. However, application of CVM to value electricity supply improvements is limited to few studies. A brief review of some of these studies is given below.

7. Sabah and Wilner (2011) used CVM to estimate WTP for electricity service by rural households in Kenya. The results indicate that respondents are willing to pay more for grid electricity services than solar power and households favored monthly connection payments over a lump sum amount. Some of the policies suggested in this paper include: subsidizing the connection costs for both sources of electricity, adjusting the payment periods and restructuring the market ownership of providing rural electricity services. Koundouri et.al (2009) estimated WTP for construction of a wind farm in the area of Messanagros on the island of Rhodes in Greece. The study uses double bounded dichotomous choice elicitation format and found that the respondents are willing to pay a premium of Euro 8.86 in their bi-monthly electricity bills for the construction of a wind farm.

8. Nomura and Akai (2004) undertook a CV survey of Japanese households to estimate the WTP for renewable energy. They report that the willingness of Japanese households to pay more, in the form of a flat monthly surcharge, for renewable energy is about ¥2000 yen (around $17 at the exchange rate of ¥115 per $) per month per household. Roe et. al (2001) analyzes US consumers' willingness to pay for energy related air pollution reduction using a CV survey. Results suggest that many population segments are willing to pay for decreased air emissions even if there is no alteration in fuel source. Furthermore, several groups are willing to pay significantly more when emissions reductions stem from increased reliance upon renewable fuels. The results of the survey were compared with hedonic pricing model results. While survey and hedonic results are not easily compared due to survey limitations, both point to

[1] National Oceanic and Atmospheric Administration

similar values for key environmental attributes, though the survey results are likely to overstate actual willingness to pay.

9. Wiser (2007) used a split-sample, dichotomous choice[2] contingent valuation survey of 1574 U.S. residents to explore willingness to pay (WTP) for renewable energy under collective and voluntary payment vehicles, under government and private provision of the good. He found some evidence that, when confronted with a collective payment mechanism, respondents state a somewhat higher WTP than when voluntary payment mechanisms are used. He also found that the private provision of the good elicits a somewhat higher WTP than does government provision. Farhar (1999) reports, using the utility market survey, that willingness to pay for renewable energy follows a predictable pattern with an average majority of 70% willing to pay at least $5 per month more for electricity from renewable sources, 38% willing to pay at least $10 per month more, and 21% willing to pay at least $15 per month more.

10. Rehn (2003),using a CV survey examined the WTP for three extra services – internet energy saving advice, personal energy saving advice and an insurance service – all supplied by electricity companies in the Swedish electricity market. The average WTP for all three services is low, in fact, well below 10 SEK per quarter of the year. The same empirical material, complemented with data form one outside source, is used for the testing of six hypotheses concerning consumer behavior and WTP for extra service in the electricity market. The results show support for one of the tested hypothesis, namely, when a consumer changes electricity supplier, he changes from a higher price company to a lower price company.

11. As evident from the above, most published studies conducted in developed countries have focused on incremental WTP for renewable energy. This approach is understandable given the universal access to electricity and growing concerns on climate change in these countries. Many developing countries are still struggling to reach universal access to electricity. Therefore, estimating the benefits of service improvements together with analysis on tariff and affordability, as undertaken in this study, are policy relevant.

III. METHODOLOGY

12. In order to achieve the above-stated research objectives, primary data from a random sample of 2083 households from 40 Gram Panchayats (GPs) from two districts of MP namely; Rajgarh and Guna, were collected. This study is the first of its kind in India. CVM, as applied in this paper, uses two elicitation formats; a bidding game[3] and single bounded closed ended elicitation format[4] (see Gunatilake 2007 for description of the elicitation formats). First the final bid value from the bidding game as a reported WTP is used and an estimate of ordinary least Square (OLS) regression model to identify the determinants of demand for improved services. Second, a Probit model is estimated, where only the first bid amount offered to the respondent to estimate the WTP as well as the demand factors for the WTP, is used. Both models were used to undertake validity checks on the estimated WTP.

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[2] Dichotomous choice CV questions describe the scenario, present a bid and ask whether the respondent accept it. Because there are only two answers to it (yes/no) it is known as dichotomous choice question. Whenever the sample is divided to subgroup for analysis it is a split sample CV study. A very common split is connected and non-connected households to the system.

[3] In *bidding game* the bid is increased until the respondent answers no. In the case of a yes answer, the reverse is done until the respondent answers yes.

[4] This format asks only one CV question with a yes or no answer. Other versions, for example, a double bounded format, repeat the referendum type question one more time with a higher or lower bid.

A. Development of the Questionnaire

13. As the first step in designing the survey, a scoping trip to Bhopal was undertaken by the study team to meet with electricity distribution company (DISCOM) officials. Information on existing billing and technology options of feeder separation were collected from the relevant authorities during this visit. In addition, the study team conducted key informant interviews with district Distribution Company (DISCOM) officials and a sub-center DISCOM official to understand the power distribution system, power demand, concerns from the supply side. Key informant surveys were also used to pilot some of the questions to generate detailed code list of possible answers.

14. Following Gunatilake et.al (2007), Focus Group Discussions (FGDs) were undertaken to understand the electricity situation in rural MP. Access to 24 hour electricity is a novelty for most households in rural India. Before offering a product that does not yet exist in the market, it is crucial to understand how people would react to such new offering in terms of comprehension, relevance, and credibility. In addition, information on existing levels of electricity supply, problems faced due to inadequate power, current billing, illegal electrical connections, political and cultural factors, and approximate amounts people may be willing to pay for improved electricity services was needed. FGDs were conducted in Bhojpur and Intkhedi GPs near Bhopal. In each GP, the study team conducted separate discussions with one Above Poverty Line (APL) and Below Poverty Line (BPL) household groups. About eight to ten people took part in each FGD. A professional moderator was hired for the discussions, and a note taker recorded all conversations for later analysis. Two professional researchers also participated in FGDs.

15. The FGD provided specific guidance as to how to structure the valuation scenario, the payment mechanism, and plausible range of bids. The findings from the FGD were used to design the detailed household and community surveys and planning of the study implementation. The draft questionnaire was prepared based on FDG findings, community surveys, and previous survey instruments of similar studies, and other surveys in the public domain[5]. Some of the questions were piloted during the scoping trip to mainly develop/refine questions and the answer code list. A draft questionnaire was reviewed by ADB staff assigned to the project and comments were also incorporated in revising the questionnaire.

16. The first section in the household questionnaire collects administrative information such as the identification of the household, informed consent, survey dates, etc. The second section is a household member roster of the member(s) age, sex, education, and occupation. The third section is on access to electricity. For household business and domestic use, the survey ascertains the level of service received, satisfaction with the service, equipment used, expenses incurred, customer service quality, billing accuracy, quality of supply, and the household's perceived benefits of a 24 hour supply. The fourth section is the WTP section as described in the next section of the paper. The fifth section is similar to Section three, but collects information on any shop or manufacturing unit the household may possess physically located away from the home in the same GP. Section 7 of the survey collects socioeconomic characteristics of households (income, expenditure, and assets). Section 8 is for households that also own or lease farmland and the possible use of water pumps for irrigation.[6]

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[5] These were not electricity sector CV questionnaires. Some sections from general surveys and some from CV studies in water sector were used to prepare the initial draft.

[6] The questionnaire is too long to be included as an appendix. Interested readers may contact the authors to obtain a copy.

B. Sampling

17. A stratified random sampling method is used to choose a representative sample from the study area. In the first stage of geographical selection, two districts – Rajgarh and Guna were selected, these are districts where ADB- funded feeder separation projects will be implemented. Three blocks were randomly chosen from each district using random number tables. Consideration was given to using a 2003 habitation survey which provided information about the number of households in the villages and GPs. Only GPs having 200-500 households were considered for drawing a sample of households for the study in order that smaller sized and larger sized GPs were avoided. Only 455 GPs met this right-size criterion out of 1013 GPs. From these, 40 GPs were randomly selected, using random number tables. These 40 GPs consisted of 110 villages; however, populations within some villages were too large to be included in the sample due to difficulties in providing logistics for conducting the survey. Therefore, samples were restricted to 76 villages that had at least 20% of the population of their respective GPs. In each GP, 50 households were selected. Households were selected by dividing the village into three or four segments and then households were selected randomly from each segment to meet the target sample size. The interviews were conducted with the household head as main respondents, but responses from other members of the household (to relevant questions) were accepted.

C. Elicitation of WTP

18. Following the guidelines of Gunatilake et.al (2007) special care was taken in designing the WTP elicitation questions. Enumerators reminded the respondent that their bills are for the current level of inadequate service and described the attributes of the improved service accurately (Appendix 1). Questions on current electricity services were asked to sensitize the respondents before the elicitation question. To further sensitize the responding households about the importance of other developmental initiatives apart from electricity supply, they were asked to rank the importance of other development priorities such as water supply, road, education and others.

19. Most CV surveys conducted for policy purposes use closed- ended referendum formats and the bids in such surveys are allocated randomly amongst the participating households. If a household gets a bid below its current bill[7], the credibility of the survey for that household will be reduced substantially. Therefore, the household was firstly asked its WTP for the current poor service. After understanding the scenario, the households are offered a starting bid higher than their WTP for their existing (inadequate) level of service. The respondents were reminded of the budget constraints their household faces and that they cannot pay more for electricity without reducing their expenses elsewhere. They were alerted against stating a lower WTP than what respondents can afford and willing to pay by cautioning that the government may not provide electricity service if they find respondents really do not want to pay enough for better services. The danger of higher bills if the respondent increases their WTP beyond their *ability* to pay was also indicated.

[7] Given that the current electricity bill of users is already high and the FGD indications of the range of WTP, there was a possibility of a substantial percentage of households bidding below their current bill.

20. To minimize hypothetical bias[8] of the bidding game, respondents were offered a price that was higher than their WTP for their current level of inadequate service. The bid is increased or lowered in predetermined steps based on the responses. The bidding game was ended by asking the exact amount the respondent is willing to pay and the source from which they would obtain this payment. Debriefing questions were asked from the respondents who did not want to pay, or pay equal or less than what they are already paying for inadequate electricity service.

D. Enumerator Training and Survey Implementation

21. The study team recruited experienced enumerators and supervisors mainly from Lucknow and Nagpur areas. All enumerators had at least a bachelor's degree, two years of work experience and had conducted at least one large social survey. This study employed four teams of seven people each – five enumerators, one field editor and one team supervisor. Two teams worked in Guna and the other two worked in Rajgarh. Both sites were supported by two field executives from NEERMAN[9] –the consultancy company hired to do the survey. All interviews followed survey research protocol for seeking verbal informed consent, ensuring confidentiality, and minimizing risk to respondents.

22. The enumerator training was conducted in Bhopal over ten days. The training included a mix of lectures, role plays, and field trials. The in-class training included: discussions on the purpose of the study, reviews the structure of the survey, reviews on the structure and purpose of the stated preference methodology and mock sessions in which enumerators administered the entire survey to each other. Lectures introduced the basic elements of the study and its relevance, concepts underlying the study, the importance of key questions, and how the data will be interpreted to the enumerator. Role playing and mock sessions generated the most intensive learning. Pretests were conducted for the entire draft questionnaire for two days, followed by a day for the debriefing and revising questionnaire. Then, in class sessions were conducted again for two days to undertake revisions and to conduct further practice. The study team also had a day of full dress rehearsal before moving the teams to Guna and Rajgarh districts.

23. Several quality control and quality assurance activities, summarized most recently by Scott et al. (2005), formed the key elements of the field supervision of the study. Supervisors selected households for the survey, spot- and back- checked questionnaires, accompanied interviews in the initial days of the project, and conducted community interviews. Editors checked completed questionnaires for a skipping pattern, legible numbering and basic consistency checks on the field. Professional researchers in the team randomly accompanied and visited teams, checked filled questionnaires, prepared status reports and field logs, oversaw field based data entry and scrutinized questionnaires before dispatching them for data entry.

24. The data was entered using the CSPro template employing three quality assurance and quality control procedures in CSPro template which consisted of a range check, intra record check and a final consistency check (Munoz, 2003). Range and intra record checks were done during the data entry. That is to say, the operator was allowed by the data entry system to proceed to the next question only if the data for the current question fell within the allowable range of responses for each question. An intra-record consistency check was administered

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[8] CV studies ask a hypothetical question of respondents with the aim of obtaining a hypothetical answer to value commodities offered in the future. This leads to a bias known as hypothetical bias. If the offered bid is lower than the current bill, it will result in a hypothetical bias.

[9] Network for Engineering and Economics Research and Management is a not for profit policy research organization based in Mumbai, India.

immediately after the entry of each questionnaire. For example, the family size reported by the household head must tally with the number of family members listed in the family roster. A final scan for overall consistency was conducted when all questionnaires had been entered. This final consistency check ensured that values from one question were consistent with values from another question. Errors identified post-data entries were corrected using the original completed questionnaires. Data from CSPro and Excel was exported to STATA format with appropriate labels for further analysis.

IV. SURVEY RESULTS

25. Table 1 presents education, occupation and castes of heads of households separately, for households with and without electricity. Some findings were: more than 60% of heads of households that use electricity attended school compared to 56% from households who do not have access to electricity. The years of education of the household head of the electricity using household is higher when compared to the household head that does not access electricity. Differences in the occupation of the household heads were also found; households which use electricity have a higher percentage of heads that work on their own or on another's farm, or work in a service type industry or own some type of business. The heads of the households which don't use electricity are more likely to be casual laborers. The difference is also obvious for scheduled castes (SCST) and below poverty line (BPL) households who are even further less likely to use electricity[10]. These differences are however, not very significant.

Table 1: Characteristics of Head of Household

Characteristics	**Percentage of households reporting**		
	No Grid Electricity	**Use Grid Electricity**	**Total**
HH head attended school (%)	56.17	61.73	59.53
Years of education (in those who attend school) [mean (sd)]	3.76 (4.00)	4.52 (4.45)	4.22 (4.29)
HH head's main occupation (%)			
Work on own farm	38.30	39.01	38.73
Work on own and other's farm	28.48	34.79	32.29
Labor	15.40	8.36	11.15
Service, professional, business	3.51	9.08	6.87
Not working	1.45	0.88	1.24
Other	12.84	7.66	9.72
Govt. assigned category of HH caste (%)			
SC (Scheduled caste)/ scheduled tribe (ST)	36.32	26.75	30.55
OBC (Other backward castes)	44.43	51.43	48.66
Open / general	19.01	21.58	20.56
Below poverty line (BPL) HHs	65.45	59.68	61.97

26. Table 2 shows the level of monthly expenditure, savings, net income (expenditure plus saving), reported income, number of assets owned by households and the percentage of households that own or lease farm land by electricity use/category of households. Reported income is higher than the estimated one from expenditure. This may be due to omission of some expenditure items. As expected, households that use electricity have higher expenditure, income and assets.

[10] Government assigned caste is an important indicator of poverty status as well as a key policy instrument used to target government program. Below Poverty Line (BPL) status is given to households not having enough income to purchase food that can give 2500 kcal per person per day. BPL status is also a key policy variable. However, not being BPL (or being APL) does not guarantee that you are not poor in conventional wisdom. On the other hand, being BPL does not guarantee that you are poorer than one in the APL group.

Table 2: Income and Wealth Indicators of Households

Wealth Indicator	Type of Households		
	No Grid Electricity	Use Grid Electricity	Total
Monthly household expenditure, Rs.	5248	6153	5794
Monthly household saving, Rs.	219	435	349
Imputed monthly household income (expenditure + savings), Rs.	5468	6588	6144
Imputed per capita monthly household income, Rs.	1003	1187	1114
Reported total household income	9321	10568	10073
Number of assets owned by household	3.4	4.1	3.9
% of Household own or lease a farm land	74	86	81

27. Although the survey collects information mainly about electricity, the study tries to assess other development needs of the households, as reported in Table 3. About 61% of the households who don't use electricity identify electricity as their most important need. In addition to this, 52% of households that use electricity, also identified electricity as a main development priority which indicates that in general, their perception is that, availability of electricity services are poor.

Table 3: Development Priorities in Next Three Years

Development Priority	Percentage Households Reporting (%)		
	No Grid Electricity	Use Grid Electricity	Total
Don't know / not sure	0.00	0.16	0.10
No problem	0.36	0.00	0.14
Roads	4.00	7.18	5.91
Household water supply	21.79	29.35	26.35
Sanitation and hygiene	2.66	1.83	2.16
Schools and education	0.36	2.23	1.49
Irrigation	0.97	0.88	0.92
Electricity	60.90	52.15	55.63
Employment	5.81	3.27	4.28
Health (more & better health facilities)	0.73	1.59	1.25
Others	2.42	1.36	1.79

28. Table 4 identifies the sources of energy used regularly to light the dwellings. While almost all villages included in the survey are electrified, a considerable proportion of households do not, in fact, have access to electricity. On- grid and off-grid households invariably use kerosene lamps for lighting as well, which is a clear indicator of inadequate supply of electricity. The survey also finds that the households who don't use electricity incur higher expenses on alternative sources of light than the households who use electricity. However, households with access to electricity also incur significant expense to cope with inadequate electricity supply.

Table 4: Regularly Used Sources of Fuel Types for Household Lighting

Source	Percentage of Households Reporting (%)		
	No Grid Electricity	Use Grid Electricity	Total
Electricity Line	5.69*	97.61	61.16
Generator	0.48	1.03	0.82
Kerosene	98.55	98.25	98.37
LPG / Gas light	1.57	1.99	1.82
Candle	7.87	7.72	7.78
Solar light, Solar power	0.12	0.16	0.14
Other	1.09	0.64	0.82
Monthly expenditure on alternative – except electricity – sources of light, Rs. per month	148.32	102.74	120.81

* These may be illegal uses of electricity

29. Table 5 presents the number of several common types of electrical equipment found within the households and the percentage of households that report the possibility of increased usage of electricity if a 24 hour supply were made available. More than 80% households who do not have grid electricity reported that they would increase their use of most of the items named if a 24 hour supply were made possible. Similar increases are reported by the households with current access to electricity.

Table 5: Ownership of Electrical Equipments and Their Use

Item	Type of Households					
	No Grid Electricity		Use Grid Electricity		Total	
	Average Number of items	% of HH reporting increased use with 24 hour supply	Number of items	% of HH reporting increased use with 24 hour supply	Number of items	% of HH reporting increased use with 24 hour supply
Light bulbs – GSL	0.5 (1.2)*	88	1.8 (1.2)	84	1.3 (1.3)	84
Light bulbs – CFL	0.0 (0.3)	88	0.3 (0.8)	76	0.2 (0.7)	82
Light bulbs - Tube lights	0.0 (0.1)	100	0.0 (0.1)	81	0.0 (0.1)	82
Ceiling Fan	0.1 (0.3)	92	0.4 (0.7)	89	0.3 (0.6)	89
Standing / Wall/ Table Fan	0.0 (0.2)	83	0.1 (0.3)	83	0.1 (0.3)	83
TV	0.1 (0.3)	88	0.2 (0.4)	82	0.2 (0.4)	83
Refrigerator	Na	Na	0.0 (0.1)	57	0.0 (0.1)	57

*Figures within brackets are standard deviations

30. The survey also assessed current service quality parameters. Results are summarized in Table 6 according to the summer and ‘other’ seasons. On average, electricity is available almost throughout any given month, irrespective of season. Supply is available for close to six hours every day with little variation by season. Supply is available for periods of one to three hours (approximately) at a time with an average of three interruptions per day. Table 6 also shows the attitudes of the surveyed households about current electricity services. As expected, the majority of the households were very unhappy with current service levels. More than 80% of households are very unsatisfied with the hours of supply, regularity of supply and quality of electricity in both the summer season and non-summer seasons.

Table 6: Access and Satisfaction with Service Attributes (Households Using Electricity)

Service Attributes/Attitudes	Season	
	Summer	Other
Number of days household get power per month	25.3	25.8
Number of hours household get power in a day	5.7	5.9
Number of times in a day supply is interrupted	3.0	3.1
Longest duration for continuous power	3.0	3.0
Shortest duration for continuous power	1.2	1.2
Satisfaction with hours of service electricity (% of households reporting)		
Very unsatisfied	84.32	81.59
Somewhat unsatisfied	10.91	11.31
Neutral	1.59	2.95
Somewhat satisfied	2.95	3.90
Very satisfied	0.16	0.08
Prior information on power outage (% of households reporting)		
Always know times of power outage	24.42	22.50
Sometimes know about timings	20.10	15.05
Power goes off at uncertain times	55.48	62.45
Satisfaction with regularity of Electricity supply (% of households reporting)		
Very unsatisfied	82.00	79.84
Somewhat unsatisfied	13.68	15.04
Neutral	1.76	1.76
Somewhat satisfied	2.00	2.80
Very satisfied	0.56	0.56
Symptoms of poor voltage quality seen in power supply	98.08	98.31
Satisfaction with quality of electricity (% of households reporting)		
Very unsatisfied	80.21	80.65
Somewhat unsatisfied	14.80	14.11
Neutral	2.17	1.94
Somewhat satisfied	2.25	2.58
Very satisfied	0.56	0.73

V. WILLINGNESS TO PAY FOR IMPROVED SERVICE

31. In this section, different models used to estimate household WTP for improved electricity supply and the results are given. Two different elicitation formats and corresponding regression models to assess validity of the construction of the elicitation question and estimate the WTP for the improved electricity service are shown. The bidding game and associated OLS regression model which uses the reported WTP at the end of the bidding game as a dependent variable are used, followed by a discussion of the single bounded dichotomous choice model that uses household responses to first bids (referendum question) in the bidding game and the associated Probit regressions model.

A. Bidding Game Results

32. The household demand or WTP for electricity is expected to be a function of quantity and quality of service offered, and socio economic characteristics of households. The household survey data provides information on several variables representing both quantity and quality aspects of rural electricity supply as described in the tables above. Different econometric models have to be considered for estimating the WTP function depending upon how the dependent variable is measured. In the bidding game, WTP is obtained through repeated bids where a respondent is offered bids until he refuses or accepts a bid. In modeling the WTP function, the maximum WTP at the end of the bidding game is used as the dependent variable, and classical ordinary least square (OLS) model is used to find out the determinants of WTP. In this case, the model is specified as:

$$\ln\_WTP_i = \beta_0 + \beta_1 \cdot elecuse_i + \beta_2 \cdot legal_i + \beta_3 \cdot impelec_i + \beta_4 \cdot numben_i + \beta_5 \cdot scst_i + \beta_6 \cdot apl_i + \beta_7 \cdot hhstd_i + \beta_8 \cdot homebuss_i + \beta_9 \cdot farmpump_i + \beta_{10} \cdot pucca_i + \beta_{11} \cdot numcld_i + \beta_{12} \cdot \ln\_pcnetinc_i + \varepsilon_i$$

where;

i = household level observation;

$\acute{\varepsilon}_i$ = error of regression;

β_j = coefficient of regression for j^{th} variable;

ln_WTP = natural log of monthly electricity bill household is willing to pay;

The variable not defined above and their hypothesized direction of effect are listed in Table 7. Table 8 presents descriptive statistics of all variables used in the OLS and Probit model specifications.

Table 7: Variables Used in Regression Models and Expected Effect of WTP

Variable	Description	Hypothesized Relationship
Elecuse	1 if household reported use of electricity; 0 otherwise	+ / – Uncertain. Household using electricity may agree to pay more OR household not using electricity have higher need and thus they may pay more
legal	1 if enumerators observe bill, meter, fuse box, or cable connection; 0 otherwise	+ Positive. Households with legal connection are most likely paying for electricity
Impelec	1 if households reports that electricity is most important development need	+ Positive. Households who rank electricity as most important can have higher WTP
numben	number of benefits of 24 hour electricity perceived by the household (range 0 to 7)	+ Positive. Households who perceive more benefits may pay more
scst	1 if household belongs to SCST category; 0 otherwise	+ / – Uncertain. SCST households may lack access due to social norms and thus may pay more OR they may pay less because they are typically poor or expect subsidy.
apl	1 if household belongs to APL category; 0 otherwise	+ / – Uncertain. BPL households may pay less because they are poor and expect subsidy OR they may pay more because electricity can help improve their income.
hhstd	years of education of household head (0 if no education)	+ Positive. Higher education is typically associated with higher WTP
Homebuss	1 if household has a home based business; 0 otherwise	+ Positive. Households with home business can value electricity more because better service can help improve the business
farmpump	1 if household owns a pump for irrigation purposes; 0 otherwise	+/- Uncertain, farmers may not like 8 hour supply restriction. However, it could still be an improvements from the current service
pucca	1 if household construction type is pucca[11]; 0 otherwise	+ Positive. Households in better constructed houses may value amenities more
Numcld	number of children of school going age (6-15 years)	+ Positive. Households with children may pay more for electricity benefits in education and comfort
ln_pcnetinc	natural log of per capita household income.	+ Positive. Income and WTP should always be positively correlated

Table 8: Descriptive Statistics for Variables Used in OLS and Probit Regression Models

Variables	Description	Mean	Std Dev	Min	Max
choice	Yes =1 No =0 response for the first bid	0.73	0.45	0	1
firstbid	First bid offered to HHs in bidding game (only probit model)	167	106	50	900
currwtp	HH WTP for current level of electricity service (less than 8 hours with inadequate customer service, billing, and quality of supply)	100	86	10	800
Elecuse	1 if household reported use of electricity; 0 otherwise	0.60	0.49	0	1

[11] Pucca indicates a better quality house, since it has a roof and walls made of robust materials.

legal	1 if enumerators observe bill, meter, fuse box, or cable connection; 0 otherwise	0.24	0.43	0	1
impelec	1 if households reports that electricity is most important development need	0.55	0.50	0	1
numben	number of benefits of 24 hour electricity perceived by the household (range 0 to 7)	2.49	1.10	0	7
scst	1 if household belongs to SCST category; 0 otherwise	0.31	0.46	0	1
apl	1 if household belongs to APL category; 0 otherwise	0.38	0.49	0	1
hhstd	years of education of household head (0 if no education)	4.21	4.30	0	18
homebuss	1 if household has a home based business; 0 otherwise	0.07	0.26	0	1
farmpump	1 if household owns a pump for irrigation purposes; 0 otherwise	0.49	0.50	0	1
pucca	1 if household construction type is pucca; 0 otherwise	0.12	0.33	0	1
numcld	number of children of school going age (6-15 years)	1.41	1.36	0	7
ln_pcnetinc	natural log of per capita household income.	6.84	0.57	4.61	8.97

33. The results of the OLS regression model are given in Table 9. The OLS regression model results serve two purposes; validity tests and prediction of WTP under different policy scenarios. Confirmation of expected sign of coefficients with statistical significance indicates that the CV scenarios were well understood by the respondents. As shown in Table 9, most of the variables in the OLS model have expected signs. Per capita household monthly income is positively associated with household WTP for improved electricity supply and it is significant at an 0.05 significance level. In the OLS model, the elasticity WTP with respect to per capita household monthly income is 0.344 implying a 1 % increase in income will result in 0.344 % increase in WTP. Given that the economy of MP is growing at approximately 8%, the WTP for electricity will significantly increase in the future. The policy relevance of this result is that the electricity board can have a scheme of progressive tariffs for raising revenue to meet the cost of improved electricity services described in this study.

Table 9: Estimated WTP Function Using OLS Specification

Variable	**Coefficient**	**Standard Error**	**t-value**	**P>|t|**
Elecuse	0.136**	0.048	2.81	0.008
Legal	0.185**	0.054	3.46	0.001
Impelec	0.108**	0.032	3.41	0.002
Numben	0.141**	0.020	7.12	0.000
Scst	-0.051	0.044	-1.16	0.254
Apl	0.143**	0.044	3.27	0.002
Hhstd	0.017**	0.004	3.7	0.001
Homebuss	0.123**	0.052	2.34	0.025
Farmpump	0.060	0.036	1.69	0.100
Pucca	0.067	0.052	1.3	0.201
Numcld	0.043**	0.010	4.15	0.000
Ln_Pcnetinc	0.344**	0.045	7.66	0.000
Constant	1.987	0.289	6.88	0.000
Observations	2083			
R-squared	0.2915			

** Coefficients are statistically significant at at 0.05 significant level.

34. APL households, households with home businesses, the level of the head of household's education, and households with more school going children have shown a positive

and statistically significant relationship to the WTP for improved electricity service. Only pump ownership, quality of house and cast variable do not show the expected results. Thus, the overall results confirm the construct validity of the CV scenario.

35. Households that use electricity are willing to pay 13.6% more. Households who seem to have legal connections have an 18.5% higher WTP. Each additional child of school going age in a household increases the WTP by 4.3% whereas households who own a home business are willing to pay 12.3% more than other households. For each additional benefit a household can identify, the WTP increases by almost Rs. 6. The households perceive the benefits of improved electricity service in terms of education of children, and the productivity of home businesses, which validate the hypothesis that electricity is indeed a critical input for improving standard of living in rural MP.

B. Dichotomous Choice Model Results

36. In this model, only the response to first referendum style question in the bidding game as a dependent variable to estimate the WTP function is used. Economic theory and practical field applications have strongly supported referendum-style dichotomous choice questions in estimating WTP function as it is similar to real life market transactions (Huang and Smith, 1998). WTP function was estimated using a Probit model because the dependent variable is a choice (0 or 1) to the first bid. The Probit model is,

$$\Pr(choice=1)_i = \beta_0 + \beta_1 \cdot \text{firstbid}_i + \beta_2 \cdot \text{currwtp}_i + \beta_3 \cdot \text{elecuse}_i + \beta_4 \cdot \text{legal}_i + \beta_5 \cdot \text{impelec}_i + \beta_6 \cdot \text{numben}_i + \beta_7 \cdot \text{scst}_i + \beta_8 \cdot \text{apl}_i + \beta_9 \cdot \text{hhstd}_i + \beta_{10} \cdot \text{homebuss}_i + \beta_{11} \cdot \text{farmpump}_i + \beta_{12} \cdot \text{pucca}_i + \beta_{13} \cdot \text{numcld}_i + \beta_{14} \cdot \text{ln\_pcnetinc}_i + \varepsilon_i$$

where, in addition to notations explained above,

choice = 1 if household respondent (head) accepts the offered bid, 0 otherwise;
firstbid = the amount of monthly bill offered to the household for 24hour, good quality supply with better customer service and accurate billing; and
currwtp = the WTP of respondent for current level of (inadequate) service.

Table 10: Estimated WTP Function Using Probit Model

Variable	Coefficient	Standard Error	t-value	P>|t|
Firstbid	-0.005**	0.000	-9.27	0.000
Currwtp	0.005**	0.001	8.34	0.000
Elecuse	0.138**	0.035	4.2	0.000
Legal	0.097**	0.025	3.4	0.001
Impelec	-0.034	0.030	-1.14	0.255
Numben	0.028**	0.014	1.99	0.046
Scst	0.010	0.035	0.27	0.787
Apl	0.042	0.028	1.45	0.146
Hhstd	0.001	0.003	0.37	0.710
Homebuss	0.022	0.048	0.45	0.651
Farmpump	0.058**	0.026	2.3	0.021
Pucca	0.051*	0.028	1.73	0.083
Numcld	0.019*	0.010	1.87	0.061
Ln_Pcnetinc	0.128**	0.031	3.94	0.000
Constant				
Log Likelihood	-1053.922			

Variable	Coefficient	Standard Error	t-value	P>|t|
Wald Chi2	157.56			
Predicted (Pr = 1) Correctly	68.53%			

** Statistically significant at 0.05 level, * statistically significant at 0.1 level

37. Two independent variables to the Probit model were added, WTP for current service (Currwtp) and the first bid (Firstbid). The first bid or the offered price is an important determinant of the yes or no choice. This variable is expected to have a negative relation to WTP and in almost all CV studies; a strong negative relationship has been reported. Given the potential complication of the first bid being less than the current bill, confirmation in the survey was made to provide a bid greater than the bill. In order to capture the impact of this, the WTP for the current poor service as a dependent variable was included.

38. The Probit model results are given in Table 10. As expected, the first bid shows a negative relationship while income shows a positive relationship to WTP confirming negative and positive price and income effects of demand. These variables are statistically significant at the 0.05 level. WTP for current services (Currwtp), electricity using households, households with legal connections, households with water pumps and households that report more uses for electricity have a statistically significant positive relationship to the WTP. Households residing in good quality houses and households with more school going children also show positive relationships to WTP at a 0.1 significant level. Thus, the Probit model also confirms the construct validity of the CV scenario.

C. Willingness to Pay Estimates

39. As described above, both OLS and Probit models are in conformity with the construct validity of the survey instrument. Moreover, theoretical expectations of the price and income relationships with the demand for improved electricity service are confirmed with statistical significance. Therefore, the estimated WTP can be used for policy purposes. In the bidding game simple average of the maximum WTP obtained at the end is considered as the mean WTP. In the Probit model with the first bid response as the dependent variable, mean WTP has to be calculated using the estimated marginal effect coefficients and the mean values of the variables (See Gunatilake 2007 for details). Estimated WTP values using the two models are given in Table 10. WTP values from Bidding game (Rs. 219 per month) and Probit model results (Rs. 233 per month) are very close and that provide further confidence on the estimated WTP. More detail WTP for different subgroups based on the bidding game results are given in Appendix 2.

Table 11: Estimated WTP from Different Econometric Models

Elicitation Method	Method of Estimation	WTP, Rs. per month
Bidding Game	Simple average	219
Dichotomous Choice 1	Calculated from Probit Model results	233

40. The above estimated WTP can be used as the benefits in the cost benefit analysis of the feeder separation project. Capital costs considered in the economic evaluation of the project include; project material and construction costs, physical contingencies, excluding taxes, price contingencies, and financial charges during construction. The key benefits of the project considered in the original economic evaluation were savings in technical losses, economic benefits owing to additional consumption of electricity with a 24 hour supply and savings owing

to reduced failures of distribution transformers. Once these benefits and costs were incorporated into the analysis, the project provided an economic Internal Rate of Return (EIRR) of 20.6%. Additional consumption was in this calculation was valued using the elasticity of an econometrically estimated demand function. The relevant area under the demand curve was used as the gross benefit of additional consumption. If the mean WTP was used together with the technical loss reduction and prevented transformer failures, the project provided an EIRR of 34%. Appendix 3 provides the details of EIRR estimation. This increase is reasonable because conventional demand estimates use the actual prices paid by the consumer and reflects the benefits of available poor services rather than the benefits of improved service. Therefore the area under the demand curve may underestimate the benefits of the improved service.

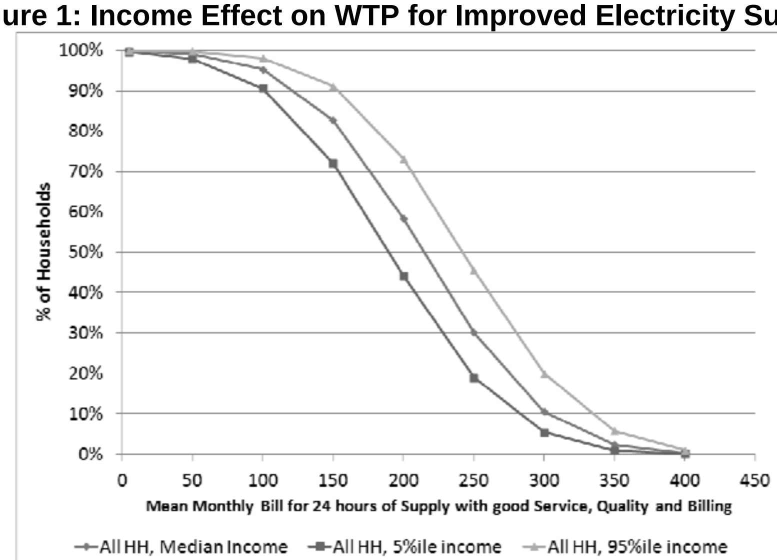
VI. POLICY SIMULATIONS

41. In this section, estimated WTP function from the Probit model is used to predict the demand or uptake rate (probability of accepting the improved service) of electricity services in response to household income, billing structure, and various other policy changes.

A. Income Effect

42. The WTP changes in response to household income. Probit coefficients[12] and mean values of the variables are used to demonstrate this effect. The methodology of prediction is fully explained in Gunatilake et.al 2007. The predicted uptake of the service for different income groups at different levels of monthly bills are demonstrated in Figure 1. Across all income groups, at least 90% of households will continue to use electricity at their desired level as long as their monthly bill remains lower than Rs 100. On the other hand, more than 80% of households may not be able to afford the improved service at monthly bills of Rs 300 or more. While the responses converge at extremely low or high bills, income effect is more visible at middle level bills. For example, Figure 1 shows there is a marked difference in uptake rates when a monthly bill amount is 200. Approximately 75% of high income groups are willing to pay Rs. 200 per month while only about 45% of poor households will accept the improved service with this bill amount.

Figure 1: Income Effect on WTP for Improved Electricity Supply



[12] For the simulation we used the coefficients. Marginal effects were used for estimating the WTP.

B. Effect of Tariff Structure

43. To simulate the effect of a real life tariff structure, one needs estimates of monthly bills with different tariff structures and usages for different income groups. First an estimation of the consumption of electricity at household level was made by collecting information on the types of electrical equipment households have and the approximate use of this equipment on a daily basis. For each type of equipment, a standard wattage was assumed.[13]. Based on the above assessments, an estimation of the number of units (kwh) that a household consumes in a month was made. However, estimations for this can only be done for the households that are currently using electricity (60%). For the remainder, units consumed on the basis of a regression model that predicted the usage based on household characteristics was used[14]. Thus, for each income decile, an estimated "mean units consumed per month" was calculated. An increase of 20% above the estimated mean units consumed per month was made to account for purchase and use of additional electrical equipment with the availability of the improved service.

44. Table 12 shows the estimated number of units and associated tariff[15] by income deciles. The units presented below may indeed be a higher bound for high income deciles of rural households so that the associated monthly bill is also on the higher side. Even for single light point (SLP) households which may belong to the lowest few deciles of income, the assumed units and monthly bill is on a higher side.

Table 12: Estimated Monthly Bills Amounts for Different Tariff Schemes

Deciles	All households			SCST+BPL Households						
	Units (Kwh)	Monthly bill		Units (Kwh)	Monthly bill					
					No Fixed Cost		No Fixed Cost + Subsidy of 25 Units		No special discounts or scheme	
		Block Tariff	Flat Tariff		Block Tariff	Flat Tariff	Block Tariff	Flat Tariff	Block Tariff	Flat Tariff
1	24	69	105	23	67	64	0	0	67	104
2	30	86	122	30	86	82	14	9	86	122
3	32	124	127	29	83	79	11	6	83	119
4	36	137	138	29	85	81	13	8	85	121
5	36	139	139	33	110	92	38	20	130	132
6	41	155	152	36	118	99	46	26	138	139
7	43	162	158	34	112	93	39	21	132	133
8	50	196	178	48	159	132	86	60	179	172
9	57	221	196	53	176	145	103	73	206	185
10	91	348	290	81	280	222	207	149	310	262
All HHs	44	165	161	34	111	92	38	20	131	132

45. As monthly bills increase, the likelihood that the household will use the service at the usual level of consumption reduces. Figure 2 depicts how the monthly bills vary by income deciles for different tariff structures and population subgroups. Because of the structure of an increasing block tariff, larger consumption units (families) will get a higher bill. As shown in Figure 2, this increase is sharp for the highest income deciles. The same usage under a flat

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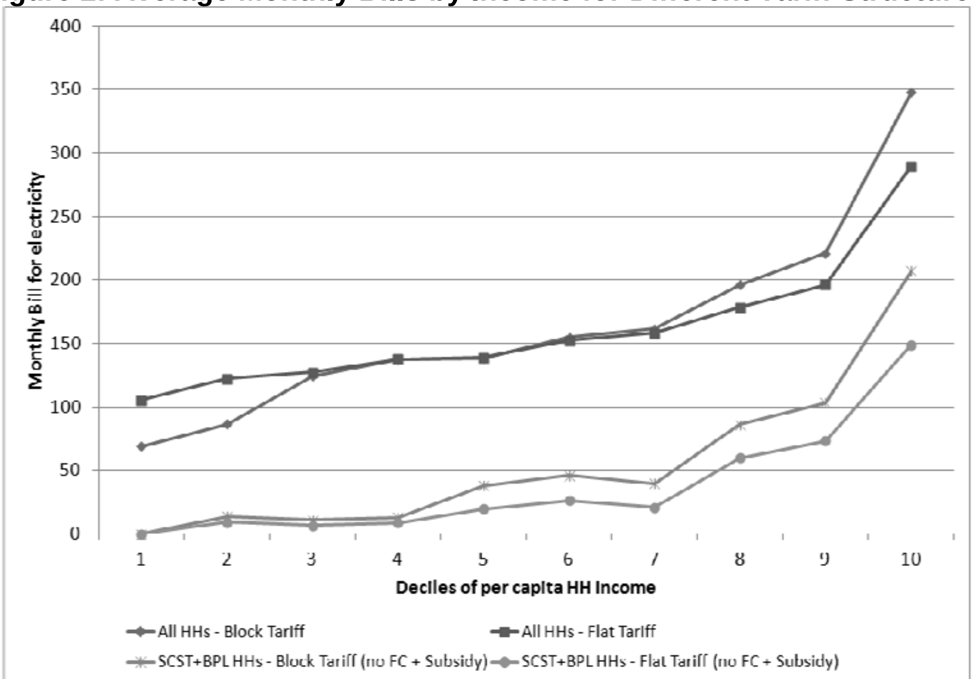
[13] Personal communication with Mr. R.B. Patil (Technofocus Consultants, Mumbai) on various technical matters and specifications related to electrical equipments, electricity supply and billing.
[14] This regression model was estimated using the data collected in this survey.
[15] Block tariff charges different prices based on the usage. The unit price paid by consumers with lower quantity of consumption is smaller than those who use more units. In contrast flat rate has a uniform unit rate. In effect larger consumption families pay a higher rate per unit of electricity under block tariff.

tariff will give a lower bill. On the other hand, at the lower end of usage (for low income groups) a flat tariff gives a higher bill compared to block tariffs. Below poverty line (BPL) and Scheduled Cast (SCST) households have similar bills under block and flat tariffs. This is due to subsidies given to these households. The bills at the higher side of usage also show sharp increases under a block tariff.

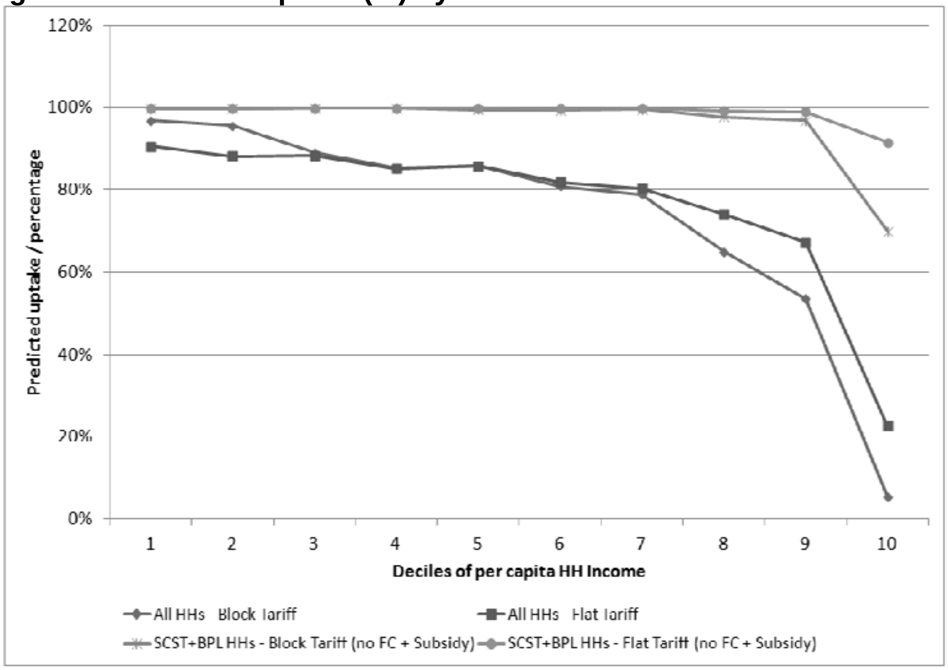
Figure 2: Average Monthly Bills by Income for Different Tariff Structures



46. The predicted bills were used as the bid value in the WTP function presented in Table 10 together with the average value of the other variables to predict the probability of acceptance of the service by different income groups. Figure 3 shows the uptake rates, or acceptance rates, for the bill amounts predicted in Table 12. It clearly shows that the uptake rates are drastically reduced for high income groups under block tariffs. This drop is not severe in the case of a flat tariff. This result should be viewed cautiously. The households which do not accept the service at the given monthly bill level may not necessarily drop out of the market. They can reduce their consumption or adopt household- level energy conservation measures and maintain an affordable monthly bill. Therefore, the presented uptake rate should not be equated to the percentage of households who will connect to the system.

47. Figure 3 also reveals that households with incomes higher than the 7th decile, clearly prefer a flat tariff to a block tariff. This result is expected, because higher income households consume more electricity, and thus, face higher unit charges as per the block tariff compared to the flat tariff. Results also show that the uptake is very high (>90%) in SCST+BPL households under both tariff structures, mainly because of concessions in the bill in forms of no fixed fees and subsidies of 25 free units per month. High income groups amongst SCST+BPL households also show a lower acceptance rate under block tariffs. Comparing the monthly bill associated with the 7th decile of income, it can be seen that price resistance starts at Rs 240 for all households and Rs. 180 for SCST+BPL households. These findings clearly show that block tariffs result in very high bills for high end consumers and may induce household level energy conservation.

Figure 3: Predicted Uptake (%) by Income for Different Tariff Schemes



48. Table 13 shows the potential revenue calculated for 1000 households under flat and block tariffs. A near universal rate of uptake takes place for the SCST and BPL households under both tariff structures with subsidies. However, the with-subsidy revenue from 1000 households is very low, indicating the conflicting situation of subsidized universal access against the financial sustainability of the power distribution companies. Revenue substantially increases if the subsidies are removed while maintaining an 86% uptake rate. Identifying the 14% households who reject the improved service without subsidy and designing a targeted subsidy scheme for these households may ensure both inclusiveness and financial sustainability of power distribution companies.

Table 13: Estimated Revenue Generation from Different Tariff Structures

Type of Households and Tariff	Uptake Rate (%)	Revenue, Rs
All households - Block Tariff	76.63%	126,233
All households - Flat Tariff	78.44%	125,973
SCST+BPL Households - Block Tariff (No FC)	91.76%	101,567
SCST+BPL Households - Flat Tariff (No FC)	95.14%	87,760
SCST+BPL Households - Block Tariff (No FC + Subsidy)	99.28%	37,916
SCST+BPL Households - Flat Tariff (No FC + Subsidy)	99.67%	19,676
SCST+BPL Households - Block Tariff (No discounts)	86.36%	112,863
SCST+BPL Households - Flat Tariff (No discounts)	85.86%	113,539

C. Assessment of Subsidies for Higher Uptake

49. Revenue maximization need not be the only objective of a tariff policy. Policy objectives should ensure that the uptake remains close to universal coverage together with a reasonable level of consumption of electricity. To simulate this policy objective, an estimation of the mean monthly bill in each decile of income for all households and for SCST+BPL households while

maintaining 95% uptake rate in 1st to 6th deciles was made. For comparison sake, the mean monthly bill for block tariff scheme for all households and SCST+BPL households are listed. The difference between the estimated monthly bill and the monthly bill required for a 95% uptake rate is defined as the average monthly subsidy needed. Results are reported in Table 14.

50. When all households are considered together, it can be seen that the monthly bill should be typically lower in order to ensure high uptake rates. The discount or subsidy needed on average ranges from Rs 29 in the 3rd decile group to Rs 52 in the 6th decile group. Interestingly, the lowest two income deciles do not require any discount to meet the objective of a 95% uptake. In the case of SCST+BPL households, up to the fourth decile, there is hardly any need for a subsidy to ensure 95% coverage. Overall, the results indicate that the lowest income groups do not require any subsidies because their consumption is low and their WTP is large enough to pay the bill. Although not conclusive, the results cast doubts about the need for subsidies.

Table 14: Estimated Discount in Monthly Bills to Ensure Higher Uptake

	All Households Rs/month			SCST BPL and SCST Households+ BPL, Rs/month		
Decile	**Mean bill for 95% coverage**	**Mean bill**	**Subsidy**	**Mean bill for 95% coverage**	**Mean bill**	**Subsidy**
1	68.85	82.00	-13.15	67.22	72.00	-4.78
2	86.39	90.00	-3.61	86.13	84.00	2.13
3	124.35	95.00	29.35	83.18	89.00	-5.82
4	137.34	96.00	41.34	85.36	93.00	-7.64
5	138.55	99.00	39.55	130.43	96.00	34.43
6	154.78	102.00	52.78	138.41	100.00	38.41
All HHs	164.72	128.20	36.52	130.69	125.90	4.79

VII. CONCLUSION

51. This paper presented the results of a contingent valuation study undertaken for the preparation of the Madhya Pradesh Energy Efficiency Improvement Investment Program. Survey results clearly show that existing electricity services are very poor and rural households consider good quality uninterrupted power supply as a top development priority. WTP for good quality uninterrupted power supply together with improved customer services and accurate and transparent billing is high enough to justify the investment project. An improved electricity supply would be a new commodity for rural households. The estimated demand functions that use actual prices (revealed preference methods[16]) paid by consumers may underestimate the benefits of improved services, because these prices may reflect the value of poor service to the consumers. Accurately estimated WTP through CV surveys may serve better in representing the benefits of an improved electricity supply. Power distribution problems in MP are very similar to those in many other states of India. Higher benefits of feeder separation and distribution

[16] Revealed preference methods use actual prices paid in the market to value commodities. In contrast, stated preference methods directly question the consumers to estimate the values.

improvements shown in this study, suggest that similar investments may be justifiable in other states.

52. Policy simulations using the estimated WTP functions show that price responsiveness is very similar amongst different income groups under very high or very low prices. In the middle, if the monthly bill is around Rs. 200, more than half of the poor opt- out from the system, whereas more than 75% of high income households would continue to enjoy the service. Block tariffs result in a drastic reduction in uptake rates for higher income groups. Given that these households may opt to reduce consumption rather than disconnect their service, block tariffs have potential to induce energy conservation. Hence block tariffs may serve as an effective demand management tool. Subsidized service can ensure near universal coverage but generate substantially low revenues for the utility companies. Removal of subsidies reduces coverage to about 86% whilst generating sufficient revenues. The role of subsidies are not clear however, as 90% coverage of low income, BPL, and SCST households can be achieved with very low, or no subsidies.

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Appendix 1: Elicitation Questions for Improved Electricity Service

You can indeed get 24 hour supply with accurate billing and good customer service. However, you also have to pay the bills regularly to get such a service. Such schemes are already implemented in 5 villages near Bhopal and households are enjoying the benefits already. This scheme will specifically do the following:

a) Give regular 24 hour supplies to rural households, but for agriculture you will get what you are getting now (not more).
b) Ensure that supply quality is good – no flickering or dimming of light, machines will not burn due to high current.
c) The power bills will be in easy to understand and accurate. For example the meters will be near your door so you can yourself verify the reading with the lineman. Even the meters will be improved so that the reading is accurate and no person – whether lineman or household – can tamper with the meter.
d) There will be a nominal installation fee for the new meter and wiring required under this scheme. However, this fee will be returned back to you as long as you make regular payment of the bills.
e) The supply lines in the village will now be covered in thick and strong plastic covering so that stealing power or illegal connections is impossible. Existing illegal connections (without meter / using jump cable) will be automatically stopped.
f) All households who get a new connection or continue using existing connection have to pay a monthly bill based on their meter readings. There is no discount for BPL households.

Now we will ask whether you are willing to pay a different amount of monthly bill for electricity under above scheme? When giving answer please consider the following:

1. You have fixed income every month, the more you spend on electricity the less you have to spend on other things.
2. Earlier, you told me that to obtain the existing levels of electricity in the village; you will be able to pay _______. Now we are going to give better service, we hope that you will be ready to pay more. There is no force to pay more, but please carefully understand the following.
3. You must think about how much monthly bill you are willing to pay very accurately. If you overestimate amount you are willing to pay, then Government will fix a higher fee or bill. Some people say that they want to pay less than what they are currently paying.

   They often give reasons such as the bill is over charged or I am a poor person. Some people can pay a lot more but they lie about being able to pay less thinking that government will then charge less fee or no fee at all. If all households in your village agree to a fee or bill which is lower than what they can afford and willing to pay, then government will assume that the electricity improvement project is not important to people and may not do improvements in electricity.

   Therefore, whether you over- or under-estimate, only you and your village will lose. You will ultimately be at the losing end.

Appendix 2: Willingness to Pay by Subgroups

Table A3.1. WTP for improved electricity supply by various subgroups

	HH does not use electricity		HH uses electricity		Total	
By Govt Caste Assigned Caste Category	***Others***	***Scst***	***Others***	***scst***	***others***	***Scst***
WTP for existing level of electrical service	104.56 (104.39)	86.47 (83.49)	109.84 (95.77)	86.01 (70.47)	107.92 (98.98)	86.22 (76.82)
WTP for 24 hour supply of good quality, accurate billing, and good customer service	202.44 (253.67)	165.25 (156.88)	256.59 (255.97)	188.82 (174.07)	236.9 (256.37)	177.7 (166.47)
Additional WTP = (B) – (A)	97.87 (202.4)	78.78 (105.02)	146.74 (218.71)	102.82 (143.2)	128.98 (214.15)	91.48 (127.11)
By Poverty Line Classification	***APL***	***BPL***	***APL***	***BPL***	***APL***	***BPL***
WTP for existing level of electrical service	124.21 (126.02)	84.1 (75.1)	126.94 (108.06)	87.56 (71.76)	125.96 (114.78)	86.11 (73.17)
WTP for 24 hour supply of good quality, accurate billing, and good customer service	240.99 (264.32)	161.36 (194.11)	296.29 (272.72)	199.26 (203.58)	276.37 (270.86)	183.38 (200.46)
Additional WTP = (B) – (A)	116.78 (181.73)	77.26 (167.77)	169.35 (229.3)	111.71 (177.97)	150.41 (214.76)	97.27 (174.53)
By SCST + BPL category	***Non - SCST+BPL***	***SCST+BPL***	***Non - SCST+BPL***	***SCST+BPL***	***Non - SCST+BPL***	***SCST+BPL***
WTP for existing level of electrical service	114.61 (105.26)	81.27 (83.53)	112.59 (102.27)	79.49 (66.57)	107.41 (97.15)	80.34 (75.06)
WTP for 24 hour supply of good quality, accurate billing, and good customer service	246.53 (263.34)	146.96 (133.63)	251.47 (254.4)	172.89 (160.56)	235.81 (251.23)	160.53 (148.75)
Additional WTP = (B) – (A)	131.92 (215.09)	65.69 (77.56)	138.88 (208.51)	93.4 (128.9)	128.41 (209.64)	80.19 (108.31)
By Household Construction Type	***Not Pucca***	***Pucca***	***Not Pucca***	***Pucca***	***Not Pucca***	***Pucca***
WTP for existing level of electrical service	95.89 (97.55)	129.9 (94.55)	99.65 (83.19)	122.95 (118.55)	98.06 (89.56)	124.33 (114.05)
WTP for 24 hour supply of good quality, accurate billing, and good customer service	184.92 (224.69)	249.8 (206.26)	224.18 (219.35)	311.41 (310.21)	207.52 (222.42)	299.18 (293.22)
Additional WTP = (B) – (A)	89.03 (175.19)	119.9 (146.53)	124.53 (185.33)	188.46 (266.74)	109.46 (181.9)	174.85 (248.84)
By Ownership / Lease of Farm Land	***No Farm***	***with Farm***	***No Farm***	***with Farm***	***No Farm***	***with Farm***
WTP for existing level of electrical service	71.11 (49.36)	107.51 (108.22)	89.25 (77.3)	105.76 (92.04)	79.2 (63.91)	106.39 (98.15)
WTP for 24 hour supply of good quality, accurate billing, and good customer service	138.65 (213.63)	206.73 (225.08)	193.85 (244.88)	245.64 (237.01)	163.28 (229.45)	231.62 (233.47)
Additional WTP = (B) – (A)	67.54 (209.3)	99.23 (158.48)	104.6 (229.38)	139.89 (197.17)	84.07 (218.98)	125.24 (185.16)
All Households combined	**188.93 (224.02)**		**238.47 (238.69)**		**218.83 (234.19)**	

Appendix 3: Use of WTP for Cost Benefit Analysis

A4.1: Cost Benefit Stream with conventional consumer benefits

Year	Project Costs, Rs. Million			Project Benefits, Rs. Million					Net Benefits
	Capital and Maintenance	Power Purchase	Total Cost	Energy Savings	Consumer Benefits		Avoided Transformer Failure	Total Benefits	
					Consumer Surplus	Sales Revenue			
1	5211.2		5211.2	634.6	225.9	378.2	146.5	-	- 5,211.2
2	7968.6	297.3	8265.9	1,623.5	838.3	1,034.0	146.5	-	- 8,265.9
3	379.5	404.4	783.8	1,642.0	1,117.7	1,378.7	146.5	1,238.7	454.9
4	379.5	606.6	986.0	1,660.6	1,397.1	1,723.4	146.5	3,495.8	2,509.8
5	379.5	808.8	1188.2	1,665.2	1,467.0	1,809.6	146.5	4,138.4	2,950.2
6	379.5	1,011.0	1390.4	1,670.1	1,540.3	1,900.0	146.5	4,781.1	3,390.7
7	379.5	1,061.5	1441.0	1,675.2	1,617.3	1,995.0	146.5	4,941.7	3,500.8
8	379.5	1,114.6	1494.0	1,680.6	1,698.2	2,094.8	146.5	5,110.4	3,616.4
9	379.5	1,170.3	1549.8	1,686.2	1,783.1	2,199.5	146.5	5,287.6	3,737.8
10	379.5	1,228.8	1608.3	1,692.1	1,872.3	2,309.5	146.5	5,473.6	3,865.3
11	379.5	1,290.3	1669.7	1,698.3	1,965.9	2,425.0	146.5	5,668.8	3,999.1
12	379.5	1,354.8	1734.2	1,704.9	2,064.2	2,546.2	146.5	5,873.9	4,139.7
13	379.5	1,422.5	1802.0	1,711.7	2,167.4	2,673.5	146.5	6,089.2	4,287.2
14	379.5	1,493.6	1873.1	1,718.9	2,275.7	2,807.2	146.5	6,315.3	4,442.2
15	379.5	1,568.3	1947.8	1,726.5	2,389.5	2,947.6	146.5	6,552.6	4,604.8
16	379.5	1,646.7	2026.2	1,734.4	2,509.0	3,095.0	146.5	6,801.9	4,775.7
17	379.5	1,729.1	2108.5	1,742.7	2,634.4	3,249.7	146.5	7,063.6	4,955.0
18	379.5	1,815.5	2195.0	1,751.5	2,766.2	3,412.2	146.5	7,338.4	5,143.4
19	379.5	1,906.3	2285.8	1,760.7	2,904.5	3,582.8	146.5	7,626.9	5,341.1
20	379.5	2,001.6	2381.1	1,770.3	3,049.7	3,762.0	146.5	7,929.8	5,548.8
21	379.5	2,101.7	2481.2	1,780.4	3,202.2	3,950.1	146.5	8,247.9	5,766.8
22	379.5	2,206.8	2586.3	1,791.0	3,362.3	4,147.6	146.5	8,581.9	5,995.7
23	379.5	2,317.1	2696.6	1,802.2	3,530.4	4,354.9	146.5	8,932.7	6,236.1
24	379.5	2,433.0	2812.5	634.6	225.9	378.2	146.5	9,300.9	6,488.4
25	379.5	2,554.6	2934.1	1,623.5	838.3	1,034.0	146.5	9,687.5	6,753.4

EIRR = 20.6

Table A4.2: Cost benefit stream of the project with WTP as consumer benefits

Year	Project Costs, Rs. Million			Project Benefits, Rs. Million				Net Benefits, Rs. Million
	Capital and Maintenance	Power Purchase	Total Cost	Energy Savings	Consumer Benefits (WTP)	Avoided Transformer Failure	Total Benefits	
1	5211.2		5211.2	634.6		146.5	-	-5211.20
2	7968.6	297.3	8265.9	1,623.5		146.5	634.6	-7334.02
3	379.5	404.4	783.8	1,642.0		146.5	1,604.9	1225.49
4	379.5	606.6	986.0	1,660.6		146.5	1,586.4	1206.94
5	379.5	808.8	1188.2	1,665.2	7493.28	146.5	8,233.8	7854.34
6	379.5	1,011.0	1390.4	1,670.1	7493.28	146.5	8,252.3	7872.89
7	379.5	1,061.5	1441.0	1,675.2	7493.28	146.5	8,270.9	7891.44
8	379.5	1,114.6	1494.0	1,680.6	7493.28	146.5	8,289.4	7909.99
9	379.5	1,170.3	1549.8	1,686.2	7493.28	146.5	8,294.1	7914.63
10	379.5	1,228.8	1608.3	1,692.1	7493.28	146.5	8,299.0	7919.50
11	379.5	1,290.3	1669.7	1,698.3	7493.28	146.5	8,304.1	7924.61
12	379.5	1,354.8	1734.2	1,704.9	7493.28	146.5	8,309.4	7929.98
13	379.5	1,422.5	1802.0	1,711.7	7493.28	146.5	8,315.1	7935.61
14	379.5	1,493.6	1873.1	1,718.9	7493.28	146.5	8,321.0	7941.53
15	379.5	1,568.3	1947.8	1,726.5	7493.28	146.5	8,327.2	7947.75
16	379.5	1,646.7	2026.2	1,734.4	7493.28	146.5	8,333.7	7954.27
17	379.5	1,729.1	2108.5	1,742.7	7493.28	146.5	8,340.6	7961.12
18	379.5	1,815.5	2195.0	1,751.5	7493.28	146.5	8,347.8	7968.32
19	379.5	1,906.3	2285.8	1,760.7	7493.28	146.5	8,355.3	7975.87
20	379.5	2,001.6	2381.1	1,770.3	7493.28	146.5	8,363.3	7983.80
21	379.5	2,101.7	2481.2	1,780.4	7493.28	146.5	8,371.6	7992.13
22	379.5	2,206.8	2586.3	1,791.0	7493.28	146.5	8,380.3	8000.87
23	379.5	2,317.1	2696.6	1,802.2	7493.28	146.5	8,389.5	8010.05
24	379.5	2,433.0	2812.5	634.6	7493.28	146.5	8,399.1	8019.69
25	379.5	2,554.6	2934.1	1,623.5	7493.28	146.5	8,409.3	8029.82

EIRR = 34%

Willingness to Pay for Good Quality, Uninterrupted Power Supply in Madhya Pradesh, India

Herath Gunatilake and co-authors show that benefits justify the investments on feeder separation and 24-hour power supply to rural areas in India. Block and flat tariffs exhibit similar impacts on revenue generation, but block tariffs are better for energy conservation. The study questions the rationale for electricity subsidies.

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