De-central power generation as suitable supplement to urban power distribution systems? Results from a choice experiment in India

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The power sector in the south IndianState of Andhra Pradesh faces a significant supply deficit as well as restrictions in the national availability of fossil resources and grid capacity. Moreover, electricity supply is of low quality in terms of scheduled and unscheduled power cuts and peak deficit is continuously growing. Planned installments of new generation power plants – mainly coal fired – will be carbon intensive but insufficient to cover power demand with growth rates of eight to ten percent per year. These developments highlight the importance of energy efficiency improvements to moderate growth in power demand. In the case of Hyderabad, characterized by rapid growth of power demand in the sectors of domestic and industrial customers, renewable energies for power generation have become more important during the last years. Consideration of demand for service quality improvements and stable security of supply requires precise knowledge of individual preferences in terms of marginal values of willingness to pay (WTP) and the determinants of these values. Until now research on energy efficiency measures rarely considers consumers' preferences. In order to increase understanding of the WTP for improved electricity quality we use a choice experiment to estimate how consumer surplus changes with the introduction of energy efficiency measures and in how far consumers are willing to bear additional costs due to these initiatives. With a survey of 800 private households we estimated the marginal WTP for improvements of power supply quality in terms of reduced scheduled and unscheduled power cuts, for renewable energy and preferences of organizational form of the distribution company. With the results of this study we discuss how preferences for local applications of efficiency technologies can be realized and what are the pre-conditions on the policy level.
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1. INTRODUCTION

The power sector of the Indian state of Andhra Pradesh (AP) faces the problem of rapid growing demand for energy and electricity on one hand and carbon intensive power generation on the other. These are characteristic features of emerging megacities. Moreover, the current state of the energy sector in AP indicates failures in the governance structure in terms of insufficient implementation of energy efficient technologies and support of renewable energies.

The current state of the power sector of AP indicates several problems in terms of power supply deficit, high Transmission and Distribution (T&D) losses, high carbon intensity of power generation, and rapid growing peak load. The growing deficit of power supply causes direct costs for imports and additional costs due to economic losses of outages and high carbon intensity. Additional capacity for power generation is insufficient to meet growing demand. Therefore, demand side measures are an important strategy to reduce the demand surplus of more than six percent per year.

The goals of our household survey on energy are, first, to achieve representative results on energy consumption patterns and individual attitudes towards energy efficiency, second, to estimate the marginal willingness to pay (MWTP) of private households for improvements of quality of power supply, and third, to decompose the attributes of this product. The sample of the survey includes 800 households which were selected randomly in Greater Hyderabad. We defined five attributes of this good for the choice experiment (CE), duration of scheduled and unscheduled power cuts, share of renewable energy in the electricity mix, organizational form of distribution company and costs. With an orthogonal array of 27 choice sets with each two alternatives we estimate the MWTP for varieties in the levels for each of the five attributes. With these results we formulate policy recommendations regarding policies for the support of renewable energies for power generation and for investments in grid maintenance and local power generation.

The paper is structured as follows: Section 2 gives a brief overview about the energy market of AP and in particular of Hyderabad. In Section 3 we briefly explain the concept of CEs and Chapter 4 details the conduction of the survey.Chapter 5 contains the results of the analysis. In Chapter 6 we interpret the findings in the view of sustainable energy policy.

2. MAIN FEATURES OF THE ENERGY MARKET IN ANDHRA PRADESH

In response to recent demand for successful reforms, the Indian parliament passed the Electricity Regulatory Commissions Act in 1998 to bring the whole power sector in India under independent regulation. Thus the Central Electricity Regulatory Commission (CERC) was founded in 1998. The Act also mandated that each state establishes its own State Electricity Regulatory Commissions (SERCs) which many of them did. The Electricity Act 2003 {Ministry of Law and Justice 2003 #153} defines the functions of the CERC and the SERCs which can be broadly categorized into tariff regulation, monitoring quality of service, adjudicating disputes, enforcing licensing conditions, monitoring compliance, and redressing grievances. Additionally, they have a recommendatory role which includes recommendations for approval of licenses and an advisory role under which it advises the government on related matters. In 1999, the AP State Electricity Board (APSEB) was unbundled into APGENCO and APTRANSCO. While APGENCO was mandated to acquire, establish, construct, and operate power-generating stations in the state, APTRANSCO was made responsible for both transmission & bulk supply and for distribution & retail supply. Four state-owned distribution companies (APDISCOM) are responsible for power distribution to end customers divided into northern, eastern, western and central districts. Around 60 percent of the installed capacity is generated by APGENCO and around 29 percent by the National Thermal Power Corporation (NTPC). Private companies provide approximately 11 percent of the installed capacity.

Despite recently installed thermal capacity, excess demand is still growing in AP and particularly in Hyderabad. While AP continues to face deficits in both energy and peak supply, there has been an improvement over the years. The deficit in energy availability, which was 8.7 percent in financial year (FY) 1998-99, had been reduced to 4.1 percent in 2007-08. This development was accomplished by initiating demand side management (DSM) measures, restricting rural supply to 7 hours per day, and limiting the power purchase by APDISCOMs to the approved level. Peak deficit fluctuated from 9.3 percent in FY 1998-99 to 19.9 percent in FY 2001-02 and 8.8 percent in 2007-08 {Directorate of Economics and Statistics, Government of AP 2005 #551}.

The Electricity Act 2003 recognizes the role of renewable energy technologies for supplying power to the utility grid as well as in stand-alone systems. The Act provides for the Independent Power Producers (IPP) to set up renewable power plants for captive use, third party sale, power trading and distribution. APERC issued the order on “Renewable Power Purchase Obligation” (RPPO) in September 2005, and specified that every distribution licensee shall purchase not less than five percent of his consumption of energy from non-conventional sources. Non-conventional sources include cogeneration from renewable sources of energy like bagasse, mini-hydel, wind, municipal waste, industrial waste, and biomass.

In a recent development, with effect from April 2010, the CERC notified a mechanism called Renewable Energy Certificates (REC). It is a market-based instrument which enables renewable energy trade amongst various stakeholders. A REC is a paper or an electronic document which represents the property rights of power generated from renewable sources. Basically it allows a buyer to fulfill its renewable purchase obligations by buying certificates from other geographical areas as well. Under the CERC regulation 2010, a renewable energy producer will be eligible to get credit of a REC under certain conditions and will be subsequently allowed to trade the credits. This procedure is expected to increase the mix of renewable energy in total energy mix up to 15 percent within the next ten years as per the mandate of the National Action Plan for Climate Change. This should also help AP to fulfill its regulatory targets concerning the renewable energy mix in total power generation. The state of renewable energies and the main features of the energy sector in AP with emphasis on the electricity sector are shown in table 1.

Energy Sector	
De-investment: Growth rate of installed capacity in 2008	< 1 %
Population growth rate per year in average	3.5 – 4 %
Growth rate of connected load since 2004	ca. 9 %
Growth rate of total electricity consumption since 2004	9.4 – 10.3 %
Electricity Generation	
Overall Capacity in AP (as on 31.05.2010)	13,920.58 MW installed capacity
Share of thermal power generation (as on 31.05.2010)	9,377.08 MW (67.4 %)
Share of hydro power generation (as on 31.05.2010)	3,617.53 MW (26 %)
Capacity of new thermal installations	- 2010/11: 710 MW (APGENCO) - until 2016: 12,392 MW Thermal + 2,140 MW Hydel (APGENCO)
Additional CO_2 emissions of thermal power plants (4 Mt CO_2 per GW)	up to 50 Mt CO_2 per year until 2016
Electricity Transmission	
T&D losses over all sectors	19,41 % up to May 2009
Annual gap between power supply and demand (04/2009 - 03/2010)	5,230 GWh = 6,6 % (compared to 4.1 % in 2007/08)
Electricity Distribution	
Peak load (04/2009 - 03/2010)	12,168 MW
Peak demand deficit (04/2009 - 03/2010)	1,288 MW (10,6%)
Renewable Energy	
AP Renewable Power Purchase Obligation (2005)	> 5 %
Achieved in AP (as on 31.05.2010)	approx. 5.1 %
Achieved for Central Hyderabad for 2009	ca. 1.9 %
Installed capacity in AP for 2009 (as on 31.05.2010)	711.69 MW
Overall potential for AP	2,397.00 MW

Table 1: Profile of the Energy Sector in AP *Sources: {APTRANSCO 2008 #536}, www.apcentralpower.com/content/APCPDCL/View3.2.1.jsp*

Although the share of coal fired power plants amounting to approximately 46 percent (5,720 MW) is still high, this number is going to increase as there are many ongoing and proposed projects in the pipeline to meet the growing demand and supply deficit. According to government sources another 4,000 MW of installed capacity will be added in the next four years {Commissionerate of Industries 2006 #978}. This implies a direct surge in carbon emissions as an inevitable by-product. However, even new 500 MW coal fired power stations will each contribute a minimum of 2 Mt CO2 per year to climate change, i.e. each installation will have significant climate change impacts as shown in table 1. Additionally, the power demand surplus is an increasing problem for APTRANSCO and the distribution companies. Demand has continuously increased and has reached its peak in March 2008 with 195 GWh per day. In 2008, APTRANSCO simultaneously purchased power amounting to 17 GWh from six states to reduce the five per cent supply gap and paid a sum of 2.23 million Euros per day towards this bulk purchase. Temporarily, the shortage peaked at 29 GWh per day. To counter this development, APGENCO would have to invest in additional capacity to the tune of 1,000 MW to generate 17 GWh per day. Despite several measures launched by the Central DISCOM (APCPDCL) such as continuous monthly energy audit of feeders, capacity of energy generation and transmission fail to keep up with the growing demand for energy and electricity in particular. On the supply side, hydro capacity is limited and accommodating a steady growth of power demand requires new fossil power plants.

3. CHOICE EXPERIMENT METHOD

The CE method (thorough explanations are e.g. found in {Hensher 2007 #990} or {Louviere 2006 #859}) allows eliciting choice probabilities and Willingness to Pay (WTP) values for characteristics or attributes of a good. The respondent is asked to choose between alternatives which include these attributes. The levels of the attributes vary over the alternatives and are designed in a way that there is always a trade-off between alternatives. In order to calculate WTP values a cost attribute is included. A respondent usually answers six to 16 choice sets and the number of attributes does not exceed eight. Figure 1 depicts a choice set card as used in this survey.

Choice Set 1			
No		**Alternative 1**	**Alternative 2**
1	**Duration of scheduled power cuts**	Summer: 15 minutes/day Winter: 5 minutes/day	Summer: 0 minutes/day Winter: 5 minutes/day
2	**Duration of unscheduled power cuts**	Summer: 30 minutes/day Winter: 5 minutes/day	Summer: 30 minutes/day Winter: 5 minutes/day
3	**Renewable energy in energy mix**	5 % renewable	10 % renewable
4	**Institutional set up**	Government (APCPDCL)	Private
5	**Additional costs per month**	0 % increase	10 % increase
Please tick one option			

Figure 1: Choice set card *Source: own composition*

The choice of the attributes and its levels is a major challenge for the researcher. If attributes are irrelevant to the respondent or dominated by other attributes or if levels are too close or too far away from each other, the external validity and hence the whole experiment could be on stake. Usually, extensive pretesting and focus group discussions are conducted. If some attributes are not relevant for the respondents or if the levels are very close or very far away from each other, wrong or meaningless results are likely to occur. CEs can be conducted online, per post or with in-house interviews. While the former ones are less costly, the latter is more thorough and gives control over the decision process. After collecting the data, several econometric models are applicable for estimation of choice probabilities and WTP values. The simplest model is the conditional logit model {McFadden 1974 #933} but its use is restricted by several strong assumptions. A more flexible formulation is the random parameters logit (RPL) model (e.g. {Louviere 2006 #859}, {Train 2008 #858}), which assumes the parameters to vary randomly across individuals. This means heterogeneity of preferences and allows calculating individual WTP values. A special case of the RPL is the latent class (LC) model (e.g. {Greene 2003 #1009}. In this model, the heterogeneity is assumed to be discrete and limited to a number of classes. While the researcher determines the number of classes, the statistical maximization procedure estimates parameters for each class and individual probabilities for being a member of a class.

4. SURVEY DETAILS

4.1. Development of attributes

In terms of electricity quality, one might think of several possible attributes like power cuts, voltage fluctuations, service hotlines, online billing service or environmental damage. Using all possible attributes would overburden the respondents' cognitive ability {Alpizar 2003 #927}[3]. It is hence the task of the researcher to identify the attributes that are most relevant for the consumer and the study purposes. For example, Carlsson and Martinson {Carlsson 2008 #527} specialized on power cuts only, Morrison and Nalder {Morrison 2009 #525} used power cuts, voltage fluctuations and waiting minutes in phone line.

To identify the attributes that are most striking for our study area, namely Hyderabad's private households, we relied on four prerequisites. First, we used an explorative study conducted within the Megacity Project "Sustainable Hyderabad" in March 2009 in Hyderabad {Hanisch 2010 #980}. The study asked private households for the major problems related to their electricity supply and their WTP for reduced power cuts and investigated the status quo supply situation. Second, we conducted a small survey with 30 representatives of different areas in Hyderabad asking for a ranking of problems and the status quo of their power supply. Third, we performed pretests with different combinations of attributes and asked the respondents in focus group discussions about their opinion on our choice of attributes. Fourth, experts in the electricity sector were interviewed and asked for their opinion on different attributes and levels, after presenting the questionnaire to them.

A thorough analysis of the results and further pretests led to the following attributes and corresponding levels in table 2.

[3] To overcome this problem, {Goett 2000 #929} separated the respondents into groups. Each group was confronted with different attributes which allowed for a high number of attributes without testing the respondents' cognitive abilities. However, a study like this requires a large number of respondents.

Attribute	Attribute Level
Scheduled Power cuts	0,15,30 minutes per day in summer
Unscheduled Power cuts	0,15,30 minutes per day in summer
Renewable energy in electricity mix	2%,5%,10%
Institutional Set up	Government, Private company, cooperative society
Additional costs per month	0%,10%,20%

Table 2: Attribute and attribute levels *Source: Own composition*

We varied the levels of power cuts only in summer as it turned out that the biggest problem with power cuts is the non-availability of cooling systems. In winter, most people disclaim space cooling while in summer a 24h use is not uncommon. Deciding on the levels of power cuts was a major challenge. The official data from Central Electricity Authority {Central Electricity Authority, Ministry of Power, Government of India 2009 #926} contradicts the results from the explorative study and the focus group discussions. The former states an average duration of ten minutes per day while the latter perceive power cuts between 60 and 120 minutes per day. Hence, we decided to take 60 minutes as the maximum (30 minutes scheduled+30 minutes unscheduled) and the optimal solution with zero minutes as minimum. The pretests confirmed that unscheduled power cuts are perceived differently and put a much higher burden on the consumer, which made it necessary to divide between scheduled and unscheduled power cuts.

The status quo share of renewable energy in the electricity mix in AP is two percent, however the AP Electricity Regulatory Commission (APERC) set the standard to five percent. Our expert interviews revealed that in the near future, a maximum of ten percent is possible. We considered these three options as most realistic.

Incorporating organizational form of the distribution company gives us insights on the preferences for reform and market liberalization. The status quo, Government (APCPDCL) can be substituted with either private, profit maximizing companies or with a cooperative structure, where the consumers are part of the distribution company.

The additional costs per month are given in percentages and derived from expert interviews and the explorative study, where consumers were asked about their willingness to pay for improvements in electricity quality. The amount never exceeded 20 percent of the electricity bill.

Having created the attributes and its levels we have totally 35=243 alternatives. We then created an orthogonal array[4] with 54 alternatives and randomly created 27 choice sets with each two alternatives. One choice set was created in a manner that one alternative dominated the other one i.e. within all attributes the first alternative was better except for organizational form which is nominal. We can use this choice set to control for inconsistent or irrational behavior. The remaining choice sets do not

[4] An orthogonal array is defined as orthogonal and balanced i.e. there is no correlation among the attribute levels and all attribute levels appear with same frequency {Kuhfeld 2009 #928}.

contain any dominating alternatives. As 27 choice sets overload the respondent {Alpizar 2003 #927}, we blocked the treatment into three surveys with each nine choice sets.

4.2. *Development of the questionnaire*

Apart from the choice experiment, the questionnaire comprised questions regarding the consumption pattern, socio economic data, attitudes, knowledge and perceptions towards renewable energy and regulation of the electricity sector.

We asked about usage and the duration of use of appliances as well as overall energy consumption to get an overview on this and investigate in the potential for energy saving. It also facilitates cost calculations for replacement of inefficient appliances with more efficient ones.

The part on perceptions, knowledge and attitudes can on the one hand be incorporated in choice modeling and on the other hand give general information on the consumers' opinion on the energy sector. The socio economic questions serve as control variables and give us the possibility to segment the analysis in groups with different background concerning income, occupation etc.

The integration of the Choice Experiment was the major challenge when developing the questionnaire. As we covered the whole Hyderabad area (GHMC), the respondents included slum inhabitants which are often illiterate. A thorough and easy to understand description of the intention of the choice sets and of the attributes were read out and separate choice setcards (Figure 1) with an English version on the front side and a Telugu (the local language in Hyderabad) version on the backside were handed out to the respondents. We instructed the field investigators to explain each choice set card separately and test for the understanding of respondents. We also included questions on perception of the attributes and the choice sets after the choice experiment.

4.3. *Conduction of the survey*

The sampling was based on individual consumption data from AP Central Power Distribution Company Limited (APCPDCL), the local distribution company. A simple random sample was not possible, as the addresses of the private households were incomplete. Therefore we conducted a stratified and clustered random sample. The APCPDCL data was then used to stratify the sample. We derived the distribution of electricity consumption and categorized it by slum, middle class and high class with other data mainly from the explorative study and our pretests. Hence we had a distribution pattern with ten percent high class, 50 percent middle class and 40 percent slum.

Before conducting the first pretest (40 respondents), field investigators (FI) were recruited from local universities and trained for two days. The training was carried out together with a social scientist from Hyderabad, who brought in his local knowledge and expertise in field work. The pretest data was then analyzed and the questionnaire modified. Next, a second training and pretest (60 respondents) was carried out. As we found problems in slum areas concerning the understanding of choice sets, we added one more day of training with special focus on the choice questions. The survey was then carried out in all 150 wards in Greater Hyderabad area inquiring 73 high class, 342 middle class and 383 slum households. The FIs were allocated to different wards and social category. Muslim FIs primary went into Muslim areas.

5. RESULTS

A discussion on the choice of different models would overburden the purpose of this paper. Therefore we will only report the results of a LC model which, after testing different models, performed better than other models and also allows differentiation of households into classes/subgroups. In order to keep the model simple, we used a linear utility function with alternative-specific variables only and no interactions. We assume a linear relationship for scheduled power cuts (SCH), unscheduled power cuts (UNS), renewable energy in energy mix (REN) and cost (COST) on utility. Although this assumption might not be true for more extreme values, it may still fit for our range. The categorical variable organizational form is dummy coded (PRIV, COOP). Table 3 gives the variables, the codes and our expectation on signs:

Attribute	**Attribute Level**	**Code**	**Expected sign**
Scheduled Power cuts (SCH)	0 minutes per day, 15 minutes per day, 30 minutes per day	0, 15, 30	-
Unscheduled Power cuts (UNS)	0 minutes per day, 15 minutes per day, 30 minutes per day	0, 15, 30	-
Renewable energy in energy mix (REN)	2%, 5% , 10%	2, 5, 10	+
Private Company (PRIV)	Dummy 0= no private company 1= private company	0,1	?
Cooperative (COOP)	Dummy 0= no Cooperative 1= Cooperative	0,1	?
Additional Costs per months (COST)	20%, 10%, 0%	0,0.1,0.2	-

Table 3: Coding structure and expected signs *Source: own calculations*

We expect scheduled power cuts, unscheduled power cuts and cost to have a negative sign, i.e. when the attribute level increases ceteris paribus (e.g. the duration of power cuts increase), the probability of choosing decreases. The opposite is assumed for renewable energy. Additionally, we expect unscheduled power cuts to be more severe than scheduled power cuts, i.e. the value of the coefficient for the former is bigger than for the latter. This is because an unscheduled power cut cannot be incorporated in daily planning and households cannot prepare for it. Therefore the reduction of unscheduled power cuts should have higher priority. For organizational form, there are no a priori expectations.

Table 4 gives the parameters for the conditional logit specification. We use this specification to generate starting values for the LC model. We further excluded all socio economic variables in the estimation as these turned out not to have sufficient explanation power for heterogeneity. Hence, the modeled heterogeneity is unobserved.

Variable	Coefficient	MWTP Betai/betacost*100	Standard Error	P[|Z|>z]|
SCH	-0.020	0.271	0.002	0.000
UNS	-0.005	0.069	0.002	0.001
REN	0.010	-0.134	0.005	0.054
PRIV	-0.123	1.636	0.050	0.015
COOP	-0.160	2.129	0.046	0.001
COST	-7.503	100	0.228	0.000

Table 4: Results of conditional logit *Source: own calculations*

The results from the conditional logit provide first insights in the structure of consumer preferences. We find all sings as expected while the coefficient for scheduled power cuts is far bigger than the coefficient for unscheduled power cuts, which contradicts our assumption. The coefficient for renewable energy is significant only on a 10 percent level and the two dummy variables are jointly significant on a 1 percent level (Wald Test H0: Private=Coop=0). The coefficients do not have any informative value per se as they describe the effect of a one unit change of an attribute on utility. As there is no a priori scale of utility, the utility value is determined by the scale or variance of the error term. Using a high scale leads to very different coefficient results. However, the scale will cross out when calculating WTP measures. These can then be compared to other models. Table 5 gives goodness of fit measures for the conditional logit and LC models with two to five classes.

	Conditional Logit	LC 2 classes	LC 3 classes	LC 4 classes	LC 5 classes
No. param.	6	14	21	28	35
Pseudo R^2	0.138	0.164	0.234	0.237	0.247
predictions	0.597	0.648	0.794	0.804	0.879
AIC	1.184	1.162	1.068	1.064	1.052
BIC	1.190	1.174	1.087	1.090	1.085
HQIC	1.186	1.166	1.074	1.073	1.063

Table 5: Measures of fit for conditional logit and LC *Source: own calculations*

The conditional logit is clearly outperformed by the LC model, which is an indication for heterogeneity. To find the optimal number of classes, the literature often proposes goodness of fit measures like AIC and BIC {Colombo 2009 #1012}. In our estimation, we find the best fit in LC5. Table 6 reports the parameters and WTP measures of the LC5 model.

	Class 1		**Class 2**		**Class 3**		**Class 4**		**Class 5**	
Variable	beta	WTP	Beta	WTP	beta	WTP	Beta	WTP	beta	WTP
SCH	-1.379***	-1.600	-0.612***	-0.6855	-0.002		-0.449***	0.551	-0.082***	0.224
UNS	-0.650***	-0.754	-0.736***	-0.8252	-0.003**	0.190	-0.240**	0.294	-0.024***	0.065
REN	-0.730***	0.847	1.875***	-2.101	-0.012**	0.724	2.137***	-2.621	0.223***	-0.606
PRIV	12.586***	14.607	-8.506***	9.5323	0.011		15.796***	-19.380	-1.088***	2.956
COOP	12.276***	14.247	-20.946***	23.475	0.088**		3.767***	-4.621	-0.973***	2.645

COST	-86.164***		-89.228***		-1.675***		-81.509***		-36.786***	
Class Prob.	0.049**		0.045**		0.462***		0.039*		0.406***	
***=1% significance level; ** 5% significance level; * 10% significance level										

Table 6: Results of the LC 5 classes model *Source: own calculations*

The class probability indicates the probability of a random individual to be member of a class. Class 1, Class 2 and Class 4 have class probabilities smaller than five percent and can be interpreted as small outlier groups. Class 3 and Class 5 have probabilities of 46.2 percent and 40.6 percent and hence dominate the preference structure of Hyderabad households.

A closer look at Class 3 reveals that its members are rather irresponsive to changes in electricity quality. Scheduled power cuts are not significant and hence a WTP is not calculated. Also, the organizational form does not play a role in the respondents' choice (Wald Test does not reject H0: COOP=PRIV=0). The parameter for renewable energy is negative which indicates that these consumers prefer a less climate friendly solution. In Class 5 however, all parameters are significant on a one percent level and have the expected signs. A governmental solution is preferred to cooperatives and private companies and more renewable energy is regarded as positive. Increases in scheduled and unscheduled power cuts both reduce the choice probability and, as in the conditional logit and against our assumption, a scheduled power cut is regarded as more severe than an unscheduled power cut. The results from Class 1 and Class 4 reveal that there is a small group of about nine per cent that favors a nongovernmental power supply.

6. POLICY IMPLICATIONS

The results from a choice experiment provide details on consumer preferences and allow for demand orientated policy recommendations. In this case, it makes sense to investigate the MWTP more detailed. The MWTP basically states how much income people can disclaim by a one unit change of an attribute to remain the level of utility. Hence it is simply the Marginal Rate of Substitution between an attribute and the cost attribute. With a linear utility function, the MWTP is the coefficient of the attribute divided by the cost coefficient. For example, the MWTP of Class 5 for a one unit (which is one minute) decrease in scheduled power cuts is 0.224 percent additional to the electricity bill. I.e. a consumer that belongs to Class 5 and has an electricity bill of INR 100 would be willing to pay 0.00224*100*60 = INR 13.44 additional per month for a one hour reduction of scheduled power cuts. Certainly, we have to be very careful with this value as the linear relationship may be only valid for our range. The same logic applies for all other attributes. A member of Class 1 would pay 14.25 percent additional to his electricity bill if he is being supplied by a cooperative. When a cooperative is installed for a Class 5 member, he would have to be compensated by a 2.65 percent decrease of his electricity bill to remain on the same utility level.

To get a better understanding of the heterogeneity we categorize the classes based on their WTP values. Class 1 members are not interested in renewable energy and favor a non-governmental electricity supply. We will therefore name them "Conservative Liberals". Class 2 members are in line with our expectations. Most importantly they have a higher WTP for the reduction of unscheduled power cuts than scheduled power cuts. Hence we name them the "Rationalists". Class 3 members are characterized by high p values which indicate their indifference towards quality of electricity supply. They are named the “Non-Carers”. Class 4 members strongly support a private supply solution and support renewable energy. We call them “Conscious Liberals”. Class 5 members favor a governmental supply solution and support renewable energy. Their WTP for the reduction of power cuts is rather low, compared to the other classes. We name them the “Cost Sensitive Traditionalists”. Table 7 summarizes the classes and their striking characteristics.

Class Name	**Class size (%)**	**Characterization**
Class 1: Conservative Liberals	4.9	Regard renewable energy as not attractive Favor private supplier
Class 2: Rationalists	4.5	Strong preference to reduce unscheduled power cuts Behavior as expected
Class 3: Non Carers	46.2	Rather irresponsive to changes in quality
Class 4: Conscious Liberals	3.9	Regard renewable energy as important Favor private supplier
Class 5: Cost Sensitive Traditionalists	40.6	Low WTP values Favor governmental supply

Table 7: Class characterization *Source: own composition*

It is obvious that nearly half of the sample is not aware or not interested of electricity issues. Another 40 percent show strong preferences but are very cost sensitive. This means that the majority of Hyderabad households are not willing to pay additional money for improvements of electricity supply. To get more insights we calculate the average willingness to pay in INR based on the monthly electricity expenditure. Table 8 gives the average electricity expenditure[5] by class and the average absolute WTP values for the classes.

[5]There are no significant differences on electricity expenditure between classes. (Wilcoxon Ranksum Test)

	Class 1			Class 2			Class 3			Class 4			Class 5	
	WTP	AWTP	factor	WTP	AWTP	factor	WTP	AWTP	factor	WTP	AWTP	factor	WTP	AWTP
SCH	-1.60	-7.96	9.46	-0.69	-3.30	3.93				-0.55	-2.16	2.57	-0.22	-0.84
UNS	-0.75	-3.75	15.34	-0.83	-3.98	16.25	-0.19	-0.69	2.82	-0.29	-1.15	4.71	-0.07	-0.24
REN	-0.85	-4.21	-1.85	2.10	10.13	4.46	-0.72	-2.62	-1.15	2.62	10.27	4.52	0.61	2.27
PRIV	14.61	72.66	-6.55	-9.53	-45.94	4.14				19.38	75.95	-6.85	-2.96	-11.10
COOP	14.25	70.87	-7.14	-23.48	-113	11.40				4.62	18.11	-1.82	-2.65	-9.93
Av. Ele. Expen.	497.4344			481.931			362.155			391.92			375.301	

WTP: Willingness to Pay in per cent additional to the monthly electricity bill
AWTP: Willingness to Pay in INR additional to the monthly electricity bill
SCH and UNS: Reduction of scheduled and unscheduled power cuts by one minute
REN: Increase of renewable energy by 1 per cent
PRIV and COOP: Change of power supplier from state owned to private or cooperative
Av. Ele. Expen: Average expenditure on electricity per month in INR for the corresponding class

Table 8: WTP values from the 5-class latent class model *Source: own calculations*

The results show that sustainable investment in improved and also greener energy will not be supported or financed by the majority of Hyderabad households.

It turns out that the Conservative Liberals have an absolute WTP for scheduled power cuts and unscheduled power cuts which is 9.46 times and 15.34 times higher than the WTP of the Cost Sensitive Traditionalists, respectively. In Class 2, the Rationalists, the factor for unscheduled power cuts is even 16.25. Tab. 8 shows this factor for all classes with reference to Class 5.

Thisfactor alsoshows the high heterogeneity between the classes and has strong implications. While the majority has a very low WTP to reduce scheduled and unscheduled power cuts, there are small groups of Hyderabad households that do suffer from power cuts and are willing to pay a significant amount additionally. The highest WTP is observed with the rationalists, who would pay 3.98*60 =238 INR per month additionally to reduce the unscheduled power cuts by one hour.

Taking a closer look at renewable energy indicates the heterogeneity in preferences as well. While the traditional liberals favor less renewable energy and would pay on average 4.21 INR for a decrease of one percent, the Rationalists and the Conscious Liberals would pay about 10 INR per month to increase the share of renewable energy by one percent. The two major groups, the Non Careers and the Cost Sensitive Traditionalists do prefer a higher share of renewable energy but would only pay on average 1.15 INR and 2.27 INR per month, respectively. Concerning the organizational form, the majority favors a governmental solution.

Subsequently, demand orientated changes in electricity quality have to be considered with care. The problem of power cuts for private households might be overstated and only a small group would significantly invest in better quality. Also renewable energy is regarded as rather unimportant by most households.

The choice experiment presented in this paper is part of the megacity project "Sustainable Hyderabad" and will be supplemented with the calculation of aggregate WTP values and the overall consumer welfare. Moreover, the market analysis of the entire project comprises a supply side analysis in order to reveal the entire costs of reducing power cuts. Finally, the implementation of small scale back-up solutions has to be examined. All these data are required to examine the insights our estimates of the WTP for renewable energy provide for the design of a green tariff.