

# A Preliminary Study on Electricity Affordability and Willingness to Pay (WTP) On Maximum Demand (MD) Charge Among Residential Electricity Customers in Malaysia

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**Abstract:** Implementation of maximum demand charge is a possible solution to better reflect the cost of generating and delivering electricity. However, this implementation leads to additional charge in the electricity bill and would effect on the electricity affordability among the residential customers. As a preliminary study on the issue related to electricity affordability and willingness to pay for maximum demand charge, this paper uses survey data collected from 411 residential electricity customers in Malaysia and descriptive analysis. Findings from this study indicates most of the respondents do not face electricity unaffordability problem and seem to be willing to pay for the maximum demand charge.

**Index Terms:** Maximum Demand Charge, Willingness to Pay, Electricity Affordability,

## I. INTRODUCTION

Malaysia Electricity Supply Industry (MESI) currently is aiming to achieve economic viability-reflective of market price [1]. One of the possible ways to achieve this is by having the cost of servicing electricity being shared by all electricity users. In Malaysia, Tenaga Nasional Berhad (TNB) charges peak demand using Maximum Demand (MD) charge. The MD charge is essential to finance as high as 30 percent of the total electricity costs [2]. However, only commercial and industrial customers are paying the MD charge. The small customers at low voltage level are only paying energy charge as their peak load requirement is still low [3]. To the best of the authors' knowledge, there is no academic study done in Malaysia on issue related to electricity affordability and willingness to pay (WTP) for MD charge. Using questionnaires from survey on 411 respondents, both issues are investigated using descriptive analysis.

## II. LITERATURE REVIEW

### A. Overview of Malaysian Electricity Supply Industry (MESI) and Maximum Demand (MD) charge

As part of the initiatives by the Ministry of Energy, Green Technology and Water, MESI Reform was introduced to ensure the nation's electricity supply industry could power the country rapid economic growth. The reformation is useful to ensure long-term electricity system security, supply quality as well as manageable and sustainable tariffs for the benefits of the country. One of the potential solution to achieve these goals which is in the interest of this paper is adding MD charge in the residential electricity bills.

MD can be defined as the highest level of electricity demand being recorded by TNB system during a 30-minute interval in a month. The charge is based on the recorded MD in kW multiplied by the respective MD rate. MD charge helps utilities recover the cost of providing the capacity to meet the peak demand, which is more expensive than meeting the average demand [4]. Therefore, it is important for TNB to have enough generation, transmission and distribution capacity to meet the peak demand whenever required by customers [5]. Failure to provide sufficient capacity leads to energy brownouts or worse yet, blackout.

### B. Willing to Pay (WTP) on MD charge

WTP is a highest price a consumer is willing to buy for one unit of [8]. These studies claimed socio-economic characteristics, such as age, education, household size, number of dependents, gender and income are important factors influencing WTP measure. In a study by Carlsson & Martinsson (2007), they suggested income is a major determinant of WTP for electricity services other than age and education [9]. While, Goett et al (2000) find households are WTP about half the price of a kilowatt-hour to reduce the number of power outages from four to two and its duration from 30 minutes to 30 seconds [10]. For products or services. Baidoo et al (2013) applied WTP measure for a wide range of goods including water, Padi et al (2015) used WTP measure on waste management and Vondolio (2009) used it on biodiversity conservation [6][7].

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Quartey (2011) has claimed that WTP for electricity generated from alternative sources correlated negatively with the number of households' dependants but positively correlated with monthly electricity bills and power usage [11]. In a study done by Abdullah and Mariel (2010) on WTP for improved electricity services, factors such as household size, age, employment status, bank account holding and years of residence in the study area are considered as important factors to influence WTP for reductions in power outages [12]. While in another study by Abdullah and Jeanty (2011), people with higher income and interest in home-based business seem to be more WTP for reliable electricity services [13].

## C. Electricity Affordability

The households' electricity affordability is an important issue that need to be considered if the MD charge is being imposed on them. This is because MD charge will be an additional charge in their electricity bill that leads to higher electricity bill. But, it can also be an incentive for residential customers to be more energy efficient by consuming less electricity or be more supportive towards renewable energy practice such as installation of solar panel. In a study by Panayides (2013), affordability is being measured as a percentage of income spends on electricity [14]. Hence, unaffordability is when a household spends more than 10 percent of their income on the electricity bill. Individuals with difficulty in paying electricity bill will be less likely to pay for the MD charge. Alternatively, there are other three measurement of electricity affordability such as the percentage of income goes into electricity bill, the percentage of income goes into essentials and basic need electricity [14]. In another study by Ranasinghe (2011), he measured electricity affordability using more direct questions such as the respondents' difficulty to pay the electricity bill, are they are to the monthly electricity bill on time and whether they had taken steps to reduce electricity bill such as using alternative energy for cooking, using energy saving bulbs and self-control electricity consumption [15]. DeCicco et al. (2013) find residents who are in the bottom property value tercile will face electricity affordability problem if their home energy bills are doubled from its current value and residents in the top and middle property value terciles will only face electricity affordability problem if their home energy bills are tripled from its current value [16].

## III. METHODOLOGY

### A. Survey Design

In collecting the information for the purpose of this research, a survey approach is used since it is able to deal more directly with the respondent's attitude in terms of their feeling, thoughts, and perception [17]. The survey approach also gives more accurate response to evaluate information on respondent's attitude since it is able to draw generalized conclusions from the target population [18]. In the first stage, the survey is conducted based on pilot test whereby the questionnaire is distributed to 154 respondents randomly selected in Peninsular Malaysia. The purpose of the pilot test is to examine respondents' views on the questionnaires and to ensure the questionnaire is clearly defined with no ambiguity prior to the actual survey. As the result from the pilot test, six questions were removed. Then, the survey proceeds with

actual survey whereby the final questionnaires are distributed to 465 respondents randomly selected in Peninsular Malaysia. The survey questionnaires used to collect information on respondents' electricity affordability related to their WTP for MD charge is presented in Table 1. The WTP questionnaires are answered based on five point likert scale varying from 'Definitely not willing to pay' to 'definitely willing to pay' and electricity affordability questionnaires are answered based on nominal and interval scales.

**TABLE 1. Survey Questionnaires for Willingness to Pay (WTP) and Electricity Affordability**

Constructs		Measures
Willingness to Pay (WTP)	W TP1	To produce a better alignment between the price that consumers pay with the cost of MD in the system.
	W TP2	To reduce/eliminate intra-class cross-subsidies that are currently being used to pay for the MD charge.
	W TP3	To encourage consumers to reduce peak-coincident demand that causes high MD charge.
	W TP4	To promote fairer cost allocation by paying the MD charge among ratepayers.
	W TP5	To ensure that utilities recover their cost of service from the MD charge paid by all consumers.
Electricity Affordability	E A1	Can you afford to pay electricity bill under the current economic condition?
	E A2	Have you taken any steps to reduce your electricity bill?
	E A3	What kind of energy for cooking that you used?
	E A4	Do you use energy saving bulbs in your house?
	E A5	Do you spend money for other sources of energy? (Such as solar energy)
	E A6	What is your current home status?
	E A7	How many percentages of your monthly income represent your electricity bills?
	E A8	What is your average monthly expenditure (eg. house rental, food, transportation, utilities, insurance, etc.)?
	E A9	If MD charge eventually needs to be paid, what is average MD charge as % of total monthly expenditure can you afford to pay?

### B. Descriptive Analysis

This study uses descriptive analysis to investigate the household's socio-economic characteristics and their electricity affordability related to their WTP for MD charge. The descriptive analysis is useful to make some general observations about the data collected in socio-economic characteristics such as number of male and females, marital status, the age range, the level of education, occupation, the range of household income, household size and residential location of the respondents. The same approach also is useful to explore and summaries the respondents' electricity affordability such as affordability to pay electricity bill, steps taken to reduce electricity bill, kind of energy cooking used, energy saving bulb usage, money spent for other sources of energy, home status, percentage of monthly income represent electricity bills, average monthly expenditure and percentage of MD charge from total monthly expenditure that respondent afford to pay.



**IV. RESULT AND DISCUSSIONS**

**A. Socio-Economic Characteristics and Descriptive Statistics**

There are 465 respondents collected from the final survey with majority of them aged 20 years and above. Although the respondents are randomly selected, they are limited to those who has knowledge on electricity bill and indirectly involved in paying the electricity bills. Once the data set are being filtered and all records with missing data are removed, the final dataset is equal to 411 respondents. The result of the descriptive statistics on the respondents' socio-economic

characteristics are presented in Table 2. A majority of the respondents are female (60%) and married (74%). The sample shows quite an evenly age distribution with 30 percent of the respondent are between 20 and 30 years old, 35 percent falls between 31 and 40 years old and 35 percent falls above 40 years old. Nearly 71 percent of the respondents holds a degree and 54 percent of them working in the education sector. However, majority of the respondents (46%) earning less than RM5,000 per month. Mostly, the respondents lives in a house occupied by 4 to 6 peoples (61%) and situated in rural area (68%)

**TABLE 2. Socio-Economic Characteristics and Descriptive Statistics of Survey items (N=411 respondents)**

Characteristic	Categories	Distribution (%)	Mean	Mode	Standard Deviation	Sample Variance
Gender	Male	40	0.596107	1	0.491275	0.241351
	Female	60				
Marital Status	Single	25	0.754258	1	0.442223	0.195561
	Married	74				
	Others	1				
Age	Age between 20 and 24	10	2.43309	4	1.404618	1.972951
	Age between 25 and 30	20				
	Age between 31 and 35	21				
	Age between 36 and 40	14				
	Age above 40	35				
Education Level	SPM	6	2.76399	3	0.957776	0.917334
	STPM	3				
	Diploma	11				
	Degree	71				
	Master	9				
	Ph.D.	0				
	Others	0				
Occupation	Students	9	2.29927	2	1.286127	1.654121
	Businessman	8				
	Education	54				
	Private Officer	8				
	Government Officer	18				
	Others	3				
Household Income	Income less than RM2,000	14	1.518248	2	0.870398	0.757593
	Income between RM 2,001 and RM 5,000	32				
	Income between RM 5,001 and RM 10,000	42				
	Income more than RM 10,000	12				
Household Size	1 to 3 peoples	26	0.868613	1	0.606681	0.368061
	4 to 6 peoples	61				
	7 peoples and above	13				
Region	Rural	68	0.316302	0	0.465599	0.216782
	Urban	32				

**A. Affordability and Descriptive Statistics**

Based on the 411 respondents' dataset, 87% of them seem to be able to pay electricity bill under the current economic condition, while 13% of them cannot afford to pay for their electricity bill (EA1). Nearly 91% of them have taken steps to reduce their electricity bill by using gas for cooking (78%) and energy saving bulbs in their house (74%) (EA2, EA3, EA4). However, most of them still have not spend money for other sources of energy (EA5) such as solar energy (75%). This shows they is still yet to be participate towards renewable energy technology. As for their electricity affordability measurement, 44% of the respondents used 4 to 6 percent of their monthly income to pay the electricity bill, 41% of them are using below 3 percent of their monthly income to pay for the electricity bill (EA7) and 46% of them has an average monthly expenditure above RM1500 which included house rental, food, transportation, utilities, insurance and other payments (EA8). Based on these results, most of the respondents has quite high monthly expenditures. Finally, up to 63 percent of the respondents can afford to pay 3 percent and below of the total monthly expenditure for the MD charge (EA9).

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**TABLE 3. Affordability and Descriptive Statistics of Survey Items (N=411 Respondents)**

Characteristic	Categories	Distribution (%)	Mean	Mode	Standard Deviation	Sample Variance
EA1	Yes	87	0.126521	0	0.33284	0.110783
	No	13				
EA2	Yes	91	0.087591	0	0.283044	0.080114
	No	9				
EA3	Electric	21	2.352798	3	1.231541	1.516693
	Kerosene	0				
	Fire Wood	1				
	Gas	78				
EA4	Yes	74	0.257908	0	0.438016	0.191858
	No	26				
EA5	Yes	25	0.751825	1	0.43248	0.187039
	No	75				
EA6	Owned	74	0.255474	0	0.436659	0.190671
	Rented	26				
EA7	Below 3%	41	0.793187	1	0.807618	0.652246
	4%-6%	44				
	7%-9%	11				
	Above 10%	4				
EA8	Below RM500	17	1.93674	3	1.150138	1.322818
	RM500-RM1000	19				
	RM1001-RM1500	18				
	Above RM1500	46				
EA9	Below 3%	63	0.491484	0	0.733718	0.538342
	4%-6%	28				
	7%-9%	7				
	Above 10%	2				

### B. Descriptive Statistics of WTP and Distribution of Responses

The purpose of this study is to investigate an issue related to electricity affordability and WTP for MD charge. In Table 4, it shows 48.42% of respondents are more **WTP** on MD charge if the charge contributes to the benefit of producing a better alignment between the price that consumers pay with the cost of MD in the system (WTP1). However, 9.98% of respondents are not WTP and another 35.04% of respondents are not sure whether they are WTP on MD charge based on benefit WTP1. Next, there are 35.28% of respondents are more WTP on MD charge if the charge could reduce or eliminating intra-class cross-subsidies (WTP2). But there are only 19.95% of the respondents not WTP and 29.44% are not sure whether they are WTP on MD charge based on benefit WTP2. Then, there are 41.61% of respondents are more WTP on MD charge if the charge encourages consumers to reduce peak-coincident demand that causing high MD charge (WTP3). However, 15.82% of the respondents are not WTP and 26.03% are not sure whether they are WTP on MD charge based on benefit WTP3. There are 53.77% of respondents are more WTP on MD charge if the charge promotes fairer cost allocation in paying the MD charge among ratepayers (WTP4). But, 9.25% of the respondents are not WTP and 20.68% percent are not sure whether they are WTP on MD charge based on benefit WTP4. Finally, 44.28% of respondents are more WTP on MD charge if the charge ensures the utilities to recover their cost of service (WTP5). However, 10.22% of respondents are not WTP and another 26.76% of respondents are not sure whether they are WTP on MD charge based on benefit WTP5.

**TABLE 4. Descriptive Statistics and Distribution of Responses of WTP**

	Definitely not willing to pay (WTP=0)%	Not willing to pay (WTP=1) %	Not sure (WTP=2) %	Willing to pay (WTP=3) %	Definitely willing to pay (WTP=4)%
WTP 1	1.70	9.98	35.04	48.42	4.87
WTP 2	3.65	19.95	29.44	35.28	11.68
WTP 3	1.22	15.82	26.03	41.61	15.33
WTP 4	0.97	9.25	20.68	53.77	15.33
WTP 5	1.46	10.22	26.76	44.28	17.27

### V. CONCLUSION AND RECOMMENDATIONS

From the survey data collected for this study, electricity unaffordability seem not to be a serious issues to most of the respondents. These could potentially contribute to the positive feedback on WTP on MD charge with high percentage on 'willing to pay' response. This could give an indication that the public are willing share the cost of servicing electricity. Hence, MESI objective to achieve economic viability-reflective of market price will soon be achieved.

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