Analyzing the "Energy-Efficiency Gap": An Empirical Analysis of Air conditioners in the Household Sector of Delhi

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ABSTRACT

Most of the studies in the energy efficiency gap (EEG) tradition broadly define EEG as the difference between the actual and optimal level of energy efficiency. The optimal level of energy efficiency is defined at the societal level (that weigh social costs against social benefits) and the private level (that weigh private costs against private benefits). In this paper, an attempt is made to quantify the size of energy efficiency gap for air-conditioners for high income urban households in Delhi. Using primary data of 101 high income urban households, the paper finds that average energy efficiency gap is about 10% of total electricity demand of air conditioners at the household level. The maximum current saving potential measured as a difference between hypothetical energy consumption if everyone adopts five star air-conditioners and actual energy consumption is estimated about 14% total electricity demand of air conditioners. Results from the OLS regressions demonstrate that individual's habits, attitude, awareness of energy efficiency measures and perceptions significantly determine the size of the energy efficiency gap. Among other things, our empirical analysis shows central role information can play in guiding investment in energy efficient technologies. From the analysis of improving access to understandable information about cost savings, payback period and emission reduction it is found that full information leads to the significant reduction in the size of the expected private energy efficiency gap from 10% to 2.98% at the household level.

Keywords: Energy Efficiency gap, Role of Information, Air conditioner, Delhi

1 INTRODUCTION

During the past two decades, policy makers have been increasingly supporting investments in energy efficiency and renewable energy technologies. The key motivation for adopting these technologies include both social and private gains, reduction of greenhouse gas emissions, mitigation of climate change risk and strong private financial gains with expected lower energy usage (Gerarden et al. (2015)). However, there are a number of studies discussing how consumers, firms and government officials under invest in energy efficient technologies and there exists an energy efficiency gap between actual and the optimal level of energy efficiency (Gerarden et al. (2015), Gillingham and Karen (2014), Hunt and Greenstone 2012, BEE 2010, McKinsey & Company 2009,).

Jaffe and Stavins (1994) and Gerarden et al. (2015) discuss different notions of optimality of energy efficiency leading to different definitions and measures of energy efficiency gap. Broadly, optimality can be defined at two levels-social and private. The difference between actual and socially optimal level of energy efficiency is energy efficiency gap at the societal level and the difference between the actual and privately optimal (or cost minimizing) level of energy efficiency as energy efficiency gap at the individual level.

Why government under invests in technologies for which social benefits exceed social costs? Why households or firms under invest in technologies for which private benefits exceed private costs? Many studies in past have identified number of market and non-market failures that preclude households, firms and government officials from realizing investments in energy efficient technologies (that reduces this gap) and associated gains. Market failure explanation includes factors such as information asymmetries, externalities, principal-agent problems and credit constraints. Often there is a lack of information with respect to net benefits consumers may obtain from investing in higher energy efficient technology. In addition, more efficient appliances have a higher upfront cost leading consumers to adopt less efficient cheap substitutes. Energy prices do not reflect the cost attached to the environmental degradation; hence consumers undervalue their savings and are discouraged to invest in them. Behavioral anomalies exist due to factors such as uncertainty about energy prices and energy savings, biased beliefs about the future and bounded rationality. (Jaffe and Stavins (1994); Gerarden et al. (2015), Gillingham and Karen (2014), Hunt and Greenstone (2012); Newell (2013)). The "status quo bias" explained by Kahneman and Tversky (1979) suggests that people give much more importance to an uncertain loss as compared to a probable gain. As the future savings remain uncertain, the losses in the form of initial investment are certain, hence consumer weight these losses more than the gains cherished over the lifetime of the equipment.

The key question to ask is then –What is the current size of energy efficiency gap for pertinent actors? A state-level study commissioned by the BEE (2010) estimated about 20% savings potential in the residential sector both at the All- India level and for the state of Delhi. The energy saving potential was assessed based on the previous studies.

Two relevant studies for India at the macroeconomic level are Neil et al. (2008) and Prayas (2011). Both these studies found the highest potential for energy efficiency improvement in case of air-conditioners because of its very high unit energy consumption. Neil et al. (2008) estimated the maximum cost-effective potential of efficiency improvement for household refrigerators, room air conditioners, industrial and agricultural motors, and distribution transformers in India. They used Life cycle cost (LCC) analysis for each of these products to calculate the cost-minimizing option for an average market consumer assuming average hours of operation, average market prices of these products and the average replacement years. Between 2010 and 2020, for the air-conditioners the study estimated potential savings in electricity consumption at 124 TWh (which is equivalent to 11% reduction in electricity consumption by air-conditioners during this period relative to base case scenario) and potential reduction in CO_2 emission at 119 Mt if consumers shift from existing equipment to the maximum cost-effective option.

Prayas (2011) constructed different high efficiency hypothetical scenarios (based on international standards) for India and compared the current level of electricity consumption with these scenarios for estimating the existing energy efficiency gap. For instance, India lags behind Korea, China and Australia with respect to energy efficiency standards. In 2010, India complied on standards implemented in China and Korea in 2000. In 2010, highest rated air conditioner in Australia had an EER of 5.25 while India still has 3.10. For 2020, the study estimated potential reduction in energy consumption of 60TWH (that is equivalent to 50% of total forecasted residential demand of 120 TWH in 2020 by Central Electricity Authority) and 39 TWH with a shift to super-efficient models of four appliances (air-conditioner, refrigerator, television set and ceiling fan) from a moderate Standard & Labelling program and aggressive[1] Standard & Labelling program proposed by Bureau of Energy Efficiency respectively. Further, the study found that air-conditioner alone contributes about 44% in the total potential savings.

As most of the earlier studies based their assessment of energy efficiency gap or energy saving potential at the macro level, we felt it will be useful to estimate the gap at the micro level using household data. The key objective of this paper is to quantify the size of the energy efficiency gap for air-conditioners[2] at the household level in Delhi. In Delhi, which is one of the most populous and developed cities of India, residential sector accounts for 44% of the total electricity demand. Of the total residential electricity demand of Delhi, air conditioners alone account for about 56% (BEE 2010). The number of households owning an air cooler or an air conditioner doubled from 32.9% in 1993 to 60% in 2009 in urban Delhi (which is 97.5% of the total Delhi population, Census 2011) while it increased from 20.6% to 26% in rural Delhi (NSSO (2000, 2005, 2009). As per 2004-2005 National Sample Survey Organization survey[3] only 9% have access to air conditioners in Urban Delhi. Nevertheless, with increasing incomes, there is a very high possibility that the total air conditioning electricity demand could increase considerably (Gupta, 2012). In this study we have focused on urban high income household with monthly income greater than one lakh.

This is the first study to quantify energy efficiency gap for the air-conditioner at the household level for India. Using primary data of 101 high income urban households, the paper finds that average household's energy efficiency gap is about 10% of total electricity demand of air conditioners at the private household level. The maximum current saving potential measured as a difference between hypothetical energy consumption if everyone adopts five star air-conditioners and actual energy consumption is estimated about 14% total electricity demand of air conditioners. Results from the OLS regressions demonstrate that individual's habits, attitude, awareness of energy efficiency measures and perceptions significantly determine the size of the energy efficiency gap. It is found that provision of comprehensive information about cost savings, payback period and emission reduction reduces the size of the energy efficiency gap significantly to 2.72% from 10% at the private level. The key contribution of this paper is that it provides significant empirical evidence of the central role of information and behavioral changes in guiding investments in energy efficient technologies.

The following section discusses data and methodology. This is followed by discussion of results in the third section. The policy implications are discussed in the fourth section and the last section concludes.

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[1] Aggressive S&L assumes a 60% reduction for refrigerators and 25% for other appliances in unit energy consumption in 2020 and Moderate S&L is Business as usual.
[2] Air Conditioners are appliances which alter the air temperature and humidity to more comfortable levels as desired.
[3] This is the only round of NSSO that provides data on the ownership of air coolers and air conditioners separately.

2 Data and Methodology

We base the empirical results in this study on the basis of the primary data collected through in-person interviews of the high income urban households in Delhi in 2014-2015. The sample of 101 households was collected through purposive random sampling. The survey data include information on type and number of air-conditioners possessed, hours of operations, socio-economic characteristics, awareness and habits of households.

2.1 How is EEG Measured?

Firstly, we quantify the energy efficiency gap at the household level. We take star rating on energy labels launched by the Bureau of Energy Efficiency (BEE) as an indicator of the level of energy efficiency of a given air-conditioner. The BEE provides star rating on the basis of energy efficiency rate (EER), which is measured as cooling capacity (watt) over power consumption (watt) of the air-conditioner (See Table 1). The star rating varies from one to five. The greater the number of stars on the energy label the higher is the energy efficiency of the appliance. A sample label for air conditioner has been provided in Annexure A.

We quantify the energy efficiency gap for air conditioners at the household level in two different ways. First, we measure it as the difference between the actual level of energy efficiency and the cost-minimizing level of energy efficiency. We calculate cost-minimizing level of efficiency through Life Cycle Cost (LCC) method.

Life Cycle Cost of a given starred air conditioner model is the present value of the total life time costs and is given by this formula:

$$LCC = C + \sum_{n=1}^{L} \frac{O}{(1+r)^n}$$

O = Annual operating cost = Annual hours of energy used × Price of energy

C= Equipment retail price, r= Consumer discount rate.

For each household in the data we calculate the LCC for all the six models (with star rating ratings ranging between 0-5). Suppose a household is currently using a two star air-conditioner and the LCC analysis shows that for a given hours of operation a four star air-conditioner is the optimal choice i.e. the four star air-conditioner minimizes cost. We first obtain the difference between the energy units consumed per hour between the two star and the four star air-conditioner. We then multiply the difference between the energy units consumed per hour in these two models with the annual hours of use to get energy efficiency gap for this consumer. We call this measure of energy efficiency gap as private energy efficiency gap (PEEG) as this is based on the criteria of minimizing private costs.

Second, for comparison purposes we develop another measure of energy efficiency gap as a difference between actual and the maximum possible level of efficiency. In the current study, the maximum possible level of efficiency is given by a five-star air-conditioner. In the above example, we will get the second measure of energy efficiency gap by multiplying the difference between the energy units consumed per hour between the two star and the five star air-conditioner with the annual hours of use. We call this measure of energy efficiency gap as social energy efficiency gap (SEEG) as this is based on the criteria of highest possible level of energy efficiency. As there are significant negative externalities associated with the energy use we can expect the socially optimal level of energy efficiency to be close to the maximum possible level of energy efficiency.

If this household uses more than one air-conditioner, we calculate the energy efficiency gap for each air-conditioner separately taking in to account its hours of operation. We sum the energy efficiency gap across all the air-conditioners to get the energy efficiency gap at the household level.

2.2 What factors determine the EEG at the household level?

Secondly, we study the key factors influencing the size of energy efficiency gap through regression analysis.

There have been many empirical studies to study the impact of socio-economic factors, informational and behavioral barriers on profitable energy-saving investments. An incomplete list includes: Newell and Siikamäki (2013), Mills and Schleich (2012), Ameli and Brandt (2015), Larrick and Soll (2008), DeCanio (1998), (Sallee, 2013), Zhao et.al (2012), Palmer et.al (2011). Table 2 summarizes few important studies.

Mills and Schleich (2012) found that household units with higher share of younger members are more likely to adopt energy efficient appliances and place higher importance on energy savings for environmental concerns than households with relatively higher share of elder members that place higher priority on financial savings. Similarly, Ameli and Brandt (2015) found that households with meters and knowledge about their energy bills are more likely to invest in energy efficiency. In order to measure the energy efficiency behavior of consumers, they created an index highlighting the knowledge of KWH energy used by their appliances and if they are engaged in an NGO working for environmental causes. This index was found to be positively related to investment probability of energy efficient appliances. Further, they found that individuals that regularly perform low cost measures to conserve energy show greater probabilities to invest in energy efficiency. Busse, Knittel and Zettelmeyer (2013) showed that consumers are not myopic. They estimated that, in USA, the market share of cars with highest fuel efficiency increases by 21.1% with a 1$ increase in price of gasoline. There have been tremendous amount of studies examining the factors which affect the slow diffusion of energy efficient technologies internationally but surprisingly, there is a lack of research studying such issues for developing countries such as India.

Larrick and Soll (2008) estimated the impact of imperfect information in decision making. They found that due to lack of information consumers underestimated or overestimated the energy savings acquired from investing in higher fuel efficient vehicles. Newell, Jaffe, and Stavins (1999) found that consumers in USA became more responsive to energy prices after energy labels were introduced for energy efficient air conditioners and water heaters. As labels lower search costs, they greatly reduce the efforts of a consumer to get information related to its costs and efficiency (Sallee, 2013). Newell and Siikamäki (2013) found that labels which fail to highlight information about savings in operating cost lead to undervaluation of energy efficiency by one third and labels which do not highlight information relating to the physical energy used by the equipment, lead to an even further undervaluation.

A large number of variables of all types are considered in the analysis. We have included socio-economic variables such as household income, education, occupation and age of the decision maker and household size. In addition, we study the impact of non-socioeconomic factors such as habits, attitudes, behavior and awareness of households on the size of the energy efficiency gap.

To study the impact of energy conserving habits, we have constructed an energy conserving habit index (EEHI) based on the responses of three habit related questions in the questionnaire- If they turn off lights when leaving a room? If they set AC at 25 to limit electricity consumption? If they turn off appliances when not in use? For each question asked the score is assigned ranging from 1 to 4, 1 when never is selected, 2 when occasionally is selected, 3 when often is selected and 4 when always is selected. The sum of these scores for these three questions gives the index which ranges from 3 to 12. The higher value of the index indicates that a household practices greater energy conservation practices.

To study the impact of awareness, we construct energy efficiency awareness index (EEAI) for the households. This index takes a value of 0 when, respondents are unaware of BEE labels and gave an incorrect response to the question "Which type of light bulbs are most energy efficient?" It takes a value of 2 when they have knowledge of BEE labels and give correct response to the above question. It takes a value of 1 when they give a correct answer to either of the questions.

Further, we study how household preferences affect the energy efficiency gap. If a household gives higher priority to energy efficiency and environment related factors at the time of purchasing we expect a lower size of energy efficiency gap. We include a dummy variable named as Priority_Labels which takes value one if a household ranks energy efficiency labels given by BEE in top 3 factors influencing his choice of air conditioner. Another dummy variable named Priority_Environment takes value one if a household ranks concern for environment in top 3 factors influencing his choice of air conditioner.

2.3 How access to comprehensible information affects EEG?

Thirdly, we estimate the impact of removing information barriers on the energy efficiency gap. After learning about the current choice of the air-conditioner model and the usage pattern of the households, we study if households are willing to alter their current choices if they are provided with full information on the cost savings, payback periods and annual carbon emissions associated with all six types of air conditioners (with energy efficiency star rating ranging from zero to five). The difference between the energy consumption of consumer's current and preferred model is taken as an estimate of the impact of information on energy efficiency gap.

The comprehensive information on cost savings, payback period for all the different star-rated air-conditioners was obtained from the information guide of BEE. For these calculations BEE has assumed that a consumer uses an air conditioner for 8 hours a day and 5 months a year. Expected savings with the shift from any less than 5 star rated air-conditioner to existing relatively more efficient models are given in the questionnaire. For example, for zero star rated air conditioner, we have given possible cost savings for this consumer if he switches to one, two, three, four or a five star rated air conditioner as a difference between annual electricity cost of higher efficiency air-conditioner and zero star rated air conditioner. Payback period is calculated as a ratio of difference in the equipment cost and yearly savings where the base case for yearly savings and equipment cost is the zero star rated equipment. Annual carbon emissions were calculated by multiplying units consumed per day with the emission factor 0.81 (CLASP, 2011). Similar tables are calculated for all other star rated air-conditioners.

For the estimation of the energy efficiency gap it has been assumed that the preference made by the consumer is for the primary air conditioner only, i.e. the air conditioner(s) with the maximum usage. For rest of the air conditioners, the consumer will continue at the present efficiency level. Hence, a weighted difference between the units consumed at current and the preferred energy efficiency level is calculated for the primary air conditioners. The gap of all the primary air conditioners of a household is then summed up.

3. Results

3.1. Summary statistics

The socio-economic characteristics of the entire sample are listed in Table 3. The sample represents urban high income households with per month income greater than 1 lakh rupees. The mean income of the sample is 1.68 lakhs rupees. Figure 1 plots frequency distribution of the household income using histogram. About 45% of the sample observations have income greater than 2 lakhs. Equally important, the highest level of education in a household varies in the sample from a low of 15 years (equivalent to graduation) to a high of 22 years (equivalent to Ph.D.). About 83% of the sample households are nuclear families with average household size of 3.

The average age of the decision maker in the sample is 45 years and the average years of education of a decision maker are 17.79 years (equivalent to post-graduation) (Table 3). About 40% of the decision makers are salaried and 23% are self-employed. The average number of decision makers in a household is 1.5. Interestingly, 66% of the decision makes are females.

Table 4 summarizes the features of air conditioners possessed by the sample households. On average, sample households possess 2.6 units of air-conditioners. The average monthly electricity bill of 6 summer months (April, May, June, July, August and September) is Rs 21,000. The 3-star rated air-conditioner has the highest penetration of 38% followed by 21% penetration of 4-star rated air-conditioner and 19% of 5-star rated air-conditioner. More than 50% of air conditioners are used for 8 hours daily for an average of 6 months. Also, more than 70% of the sample air conditioners were bought after 2009.

Figure 2a and Figure 2b plot histograms of energy efficiency awareness indicators and EEAI respectively. Figure 2a shows about 59% of the households know what star ratings on a BEE label mean and about 61% of the people know that LED bulbs are the most energy efficient bulb in the market. About 45% of the households gave correct responses for both questions and about 24% of the respondents gave incorrect response for both questions.

Figure 3a and Figure 3b plot histograms of energy conserving habits indicators and EEHI respectively. Figure 3a shows a moderate level of energy conserving behavior overall. About 40% of the respondents always turn off the lights when leaving a room. Only 10% of the respondents always set air conditioner at 25 or higher[4]. About 57% households always or often turn off appliances when they are not being used. Though people more or less turn off lights and appliances when they are not in use, only a very small size of the sample set the thermostat of air conditioners at or above 25 degree Celsius for electricity savings.

3.2. Size of the energy efficiency gap

Table 5 shows the estimated PEEG and SEEG in energy units and rupees. Figure 4 and Figure 5 plots a histogram of frequency distribution of PEEG and SEEG at the air conditioner and household level respectively. On average, the PEEG is estimated at 285 units per air conditioner per year and 349 units per household per year. About 80% of the air conditioners and 91% of households in the sample have positive private energy efficiency gap indicating an opportunity for energy savings and private gains. On average, the gap is about 10% of total annual electricity demand of air conditioners by a household. This potential energy savings is equivalent to a reduction of more than 61 thousand kg of carbon emission annually.

On average, the SEEG is estimated at 394 units per air conditioner per year and 430 units per household per year. About 91% of the air conditioners and 97.02 % of households in the sample have positive social energy efficiency gap indicating an opportunity for social gains. On average, this is equivalent to about 14% of the total annual electricity demand of air conditioners by a household. This potential energy savings is equivalent to a reduction of more than 84 thousand kg of carbon emission annually.

3.3. Regression results

After identifying as many factors as possible that might influence the size of the energy efficiency gap, we carry out regression analysis to study how the variation in the size of energy efficiency gap in the sample can be explained with the different kinds of factors. Two regressions are reported in Table 6. The first column reports results of the regression with private energy efficiency gap as the dependent variable and the second column reports results of the regression with social energy efficiency gap as the dependent variable. The explanatory power as measured by adjusted R^2 for both the energy efficiency gap equations is about 40 percent. Most of the variables in the regression turn out to be significant and have expected sign.

The household per capita income is found to have a significant and negative effect on private energy efficiency gap. This implies that more income tends to be associated with less energy inefficiency. As regards number of years of highest education in the household, it is observed

[4] Setting temperature at 25 leads to lower power consumption by air conditioner and hence, reduces electricity bill substantially

that coefficient is negative in both regressions but not significant. The coefficient on Dummy_PHD_Decisionmaker is highly negative and significant, reiterating the positive impact of education on energy efficiency choices. The coefficient on HH_Selfemployed is negative and significant in both regressions at conventional levels of significance. Thus, self-employed rich households tend to make relatively more energy efficient choices compared to salaried households. The coefficient on HH_size and HH_No_Decisonmakers is negative and but significant only for HH_size. This indicates that the energy efficiency tends to be negatively related to the number of family members and number of decision makers. It might possibly be the fact that when a decision regarding purchasing an air-conditioner is taken by larger number of household members they tend to discuss its costs and benefits well.

The important aspect of the finding is with regard to the index of energy efficiency awareness and index of energy conserving habits. The results seem to suggest that higher the index of energy efficiency awareness and energy conserving habits lower is the size of the energy efficiency gap. Both the coefficients are found to be significant and highly negative. Juxtaposed with the fact that the coefficient on Dummy_BEE_Labels_Priority being negative and significant, these findings suggest that informational programs can play an important role in bringing behavioral changes related to energy efficiency choices.

HH_SingleFamily, HH_females_proportion, and Age_Decisionmaker tend to be negatively related to energy efficiency gap. Households with older decision makers and especially middle aged ones, have higher probability of energy efficiency awareness and hence lower energy efficiency gap. HH_females_proportion is significant for PEEG regression and Age_Decisionmaker is significant for SEEG regression. All other variables are insignificant at conventional levels. The results with respect to HH_rented and HH_AC_Annualuse are not robust.

3.4. Role of information

We find that the impact of provision of full information about cost savings, payback period and emission reduction reduces the size of the energy efficiency gap significantly. After obtaining the information 77% of the sample households expressed their willingness to change their current efficiency level choice and the remaining household wanted to continue with the current choice (Figure 6). About 54% of the sample households decided to increase their energy efficiency level whereas 23% respondents decided to reduce their current energy efficiency levels due to low usage.

On average, the new PEEG is estimated at 65 units per air conditioner per year and 84 units per household per year. The PEEG has reduced from 10% to 2.98% of the total electricity demand of air-conditioners by households. This shows central role information can play in guiding energy consumption decisions.

4. What policy makers can do to reduce this gap?

We can draw important energy policy implications from the above analysis. Over the years, the Bureau of Energy Efficiency has adopted policies such as energy efficiency labeling to guide energy efficiency choices and to reduce the existing energy efficiency gap in India. However, we find that when households are given the complete information regarding expected costs and benefits of energy efficiency of different models of air-conditioners, more than 77% of the households expressed their willingness to change the current energy efficiency choice.

Figure 7 give histogram of frequency distribution of reasons for shifting the energy efficiency level. About 61% are willing to shift their efficiency level for the savings for cost benefits and about 11% considered increasing their energy efficiency level for the environment. About 27% acknowledged both the reasons (cost savings and environmental concerns) for changing their current choices. This shows there exists a vast information gap in the electric appliances market. One direct policy implication would be to make the current energy efficiency labels clearer and understandable to a common buyer for minimizing such information barriers. This is particularly important as the information has the maximum impact at the point of sale. In addition, policy makers should promote creative and thought-provoking campaigns and advertisements to increase the awareness of the public regarding energy efficiency measures.

Figure 8 give histogram of frequency distribution of reasons for the respondents who were not willing to shift their energy efficiency level. Results show that 24% of total non-shifters were not interested and 18% did not intend to improve their energy efficiency level mainly because they were satisfied with their current choice. High investment cost was barrier for about 17% who said that higher energy efficiency level was expensive. About 13% of the respondents did not shift because they attach high degree of uncertainty with cost savings and benefits associated with greater energy efficiency. About 11% of the respondents did not shift as they felt that the payback period for such an investment is too high. This shows that successful implementation of energy efficiency policies depend a lot on non-market barriers such as behavioral anomalies, beliefs, attitudes and perceptions of the relevant households.

In addition, respondents in the survey were asked to rank various factors that they consider when purchasing air conditioner. Figure 9 shows that brand command the highest priority among the households followed by price. This is not surprising as people are quite brand conscious nowadays, price seems to be relatively less important for the urban high income households. Most of the people ranked operating cost at number three, design[5] at number four, energy efficiency labels at number five, concern for environment at number six and comfort[6] at number seven. Results from regression analysis reveals that households that ranked energy efficiency labels in top three have significantly lower energy efficiency gap.

The significant negative impact of individual’s energy conserving habits, attitudes and perceptions on the energy efficiency gap throws light on how lessons from behavioral economics can be adopted by the policy makers to solve energy efficiency problem. In this context, the research in behavioral economics suggests that individual may change their behavior when they are informed that their energy consumption is very different from the peers. This is because they incur psychological costs which they want to reduce (Houde et.al (2013); Cialdini (2007). Houde et.al (2013) found that access to real-time information feedback can achieve up to 20% reduction

[5] It refers to features and looks.
6 Comfort includes the noise or air quality of an air conditioner.

in residential energy consumption. Even small economic incentives to sellers and buyers can have large impacts on behaviors and can thus play a very important role in adoption of energy efficient air conditioner.

Figure 10 plots the histogram of responses of the households about their degree of support for various policies encouraging electricity conservation. More than 70% of the households strongly support the provision of subsidies and incentives in the form of voucher, rebates or rewards. Even though 60% of the respondents were against raising electricity prices, many respondents suggested to increase prices of higher slabs of electricity consumption. Most of the respondents agreed that awareness of energy efficiency is quite low and around 80% of the respondents feel more information should be provided on energy efficiency. Most respondents supported advertisements and campaigns as tools to raise awareness for energy efficiency. More than half of the respondents were not satisfied with the current labels on appliances and suggested that the labels must be increased in size and more relevant information should be provided in addition to the simplified stars.

5. Conclusion

In this study we try to estimate the size of the energy efficiency gap of air conditioners for the high income urban households in Delhi. The private energy efficiency gap estimated at 10% of the household demand for air conditioners indicates existing saving opportunity for the private households. It is found that provision of comprehensive information about cost savings, payback period and emission reduction reduces the size of the energy efficiency gap significantly to 2.72% from 10% at the private level. This highlights the existence of limited and incomplete information in the market about the possible costs and benefits of energy efficiency investments.

This paper tests the significance of non-economic and non-social factors in determining the size of the energy efficiency gap. Apart from socio-economic factors such as income, occupation and education, individual's energy conserving habits and attitudes, awareness of energy efficiency measures and perceptions are other important factors found to have a significant negative impact on the size of the energy efficiency gap. This is particularly important for the designing of information programs by policy makers for promoting energy efficiency choices in view of the change that is required in the behavior and attitudes of the households.

As the sample size was only 101, the study is exposed to the risk of small sample size, making the results susceptible to data fluctuations. However it must be noted that most of the results are consistent with existing literature and seem quite plausible. As the study was focused on the high income consumer it does not depict the behavior trends for an average consumer and hence the results can't be replicated for the entire population of Delhi. The study can also be extended for other energy efficient appliances at national level.

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