Discount Rates and Energy Efficiency

Discussion Paper

August 2012

Prayas Energy Group

Discount Rates and Energy Efficiency

A Discussion Paper

Authors: Aditya Chunekar and Sambhu Singh Rathi

Prayas (Energy Group)
Athawale Corner ,
Karve Road, Deccan Gymkhana,
Pune 411 004
Phone: 020 - 6520 5726; Fax : 020 - 2542 0337
E-mail: energy@prayaspune.org; Website: http://www.prayaspune.org/peg

For Private Circulation

August 2012

About Prayas

Prayas (Initiatives in Health, Energy, Learning and Parenthood) is a nongovernmental, non-profit organization based in Pune, India. Members of Prayas are professionals working to protect and promote the public interest in general, and interests of the disadvantaged sections of the society, in particular. The Prayas Energy Group works on theoretical, conceptual regulatory and policy issues in the energy and electricity sectors. Our activities cover research and intervention in policy and regulatory areas, as well as training, awareness, and support to civil society groups. Prayas Energy Group has contributed in the energy sector policy development as part of several official committees constituted by Ministries and Planning Commission. Prayas is registered as SIRO (Scientific and Industrial Research Organization) with Department of Scientific and Industrial Research, Ministry of Science and Technology, Government of India.

Discount Rates and Energy Efficiency

Aditya Chunekar and Sambhu Singh Rathi
Prayas Energy Group

1. Background

Energy efficient appliances are more expensive than normal appliances with same features but save money through savings in electricity over their life-time. Analysis of the present cost and future benefits over the life-time of the appliance shows that, in most cases, energy efficient appliances are actually much cheaper than their in-efficient counterparts. However, one has to pay the cost upfront and reap the benefits in future. This involves an inter-temporal choice which an individual has to make in many other aspects of life such as health and education. Discount rate is a useful economic concept that can be used to analyze such decisions involving inter-temporal choices. It is the magnitude of consumer's preference for present over future value(Stern, 1986). Discount rates have important policy implications as they can be used to predict consumers' decisions under a policy and thereby help to evaluate its impact. In energy efficiency policy domain, discount rates have been used to forecast market penetration of energy efficient appliances and evaluate the potential of energy efficiency programs (Train, 1985). In this paper, we have reviewed the fundamental concepts of discount rates and their implications for energy efficiency policies. We have also described a specific approach based on discount rates to effectively design financial incentives for energy efficient appliances in India. Further, we have also discussed the limitations of using discount rates based approach and the data challenges that it faces in India before making our conclusions on the same.

2. Energy Efficiency Policies

Market penetration of energy efficient appliances has traditionally been very low as compared to the cheaper in-efficient ones with same features even though they have low life-cycle costs. The gap in the market penetration of an in-efficient appliance commonly sold in the market and that of the cost-effective energy efficient appliance is termed as 'energy efficiency gap'. It has also come to be known as 'energy paradox'(Jaffe & Stavins, 1994)since consumers do not seem to be acting rationally by choosing an option with less return on investment. This gap may be due to a number of reasons: consumers may be reluctant to pay the high upfront costs; energy efficiency may not be a priority while buying; they may lack information on the availability of energy efficient appliances; they may not have the expertise of calculating life-cycle costs; they may not be sure of the reliability of the new appliance; or they may be just acting irrational driven by some behavioral traits. There is extensive literature on the market barriers that result in the energy efficiency gap (Howarth & Sanstad, 1995; Jaffe, Newell, & Stavins, 2004; Stern, 1986).

Energy efficiency policies are designed to eliminate or reduce these market barriers to energy efficiency. The most common policies are labeling appliances based on energy efficiency to create awareness, setting minimum performance standards to eliminate energy in-efficient appliances from the market

and price mechanisms such as tax credits and financial incentives to bring down the price of energy efficient appliances. Some recent policy interventions have been based on behavioral principles that affect consumer decisions. There is increasing literature on how certain behavioral traits of a consumer may result in his purchase of energy-inefficient appliance even if it is not cost-effective. Policies aimed at correcting behavioral biases that go against purchase of energy-efficient appliances are gaining popularity (Rathi and Chunekar, 2012).

Price mechanisms are focused on bringing down the price of an energy efficient appliance to that of an energy in-efficient appliance with same features most commonly sold in the market. Energy efficiency policies are mostly cost-effective since it is cheaper for the government to invest in energy efficiency and reducing the demand for electricity rather than building power plants to meet the additional demand. For instance, in India, the cost of saving electricity through a price based program to increase the market penetration of an energy efficient ceiling fan[1] is approximately Rs 0.63 per kWh[2],which is less than a third of the total cost of generation which is about Rs 2.3 per kWh. This program is cost effective even without monetizing the primary benefits: enhancement of energy security and alleviation of environmental problems associated with energy-use. However, even with the benefits, there is potential for making these price based policies more cost effective. Price mechanisms may have considerable free riders; consumers who may have bought the energy efficient appliances with less incentive or no incentive at all. There may be still other consumers who may respond to some behavioral interventions in combination with price mechanisms. If we can identify such consumers and design programs and incentives accordingly, government can achieve same impacts by paying less in form of incentives. One of the approaches to achieve this involves the study of discount rates.

3. Discount Rates

Discount rate is an indicator of a consumer's valuation of his future benefits from current investment. In terms of the investments in energy efficiency, the discount rate indicates how much he is willing to pay for an energy efficient appliance today so that he derives benefits in terms of energy savings in the future. A larger discount rate means the consumer values the benefits in the near term more than the benefits in the future. The present value of any investment can be calculated by discounting the expected benefits at the discount rate. It can then be assumed that a consumer buys an energy efficient appliance if his present value of the benefits exceeds the incremental cost over an average appliance. For instance, consider a consumer who is thinking of buying the energy efficient ceiling fan mentioned above. How much extra will he be willing to pay for it over an in-efficient fan? The present value of the incremental cost after discounting the benefits for a consumer with discount rate of 10% will be about Rs. 1100 while that to the consumer with discount rate of 70% will be about Rs 200. Thus a consumer with 10% discount rate may pay as much as Rs. 1100 today over the price of a normal fan whereas a

[1]The energy efficient fan consumes 35W as compared to 75 W of an average fan and can be produced at an incremental cost of Rs 300. The usage is assumed to be 1800 hours per year with a factor of 0.8 to account for speed variation. Life of the fan is 15 years.

[2]Ratio of annualized incremental cost over the life of fan calculated using an interest rate of 10% and annual saving of the fan in kWh. T&D losses = 20%

consumer with 70% discount rate may be ready to pay only about Rs. 200[3]. Thus, discount rates can be helpful in estimating the price at which a typical consumer will buy an energy efficient appliance. In the followings sub-sections, we will look at the factors that affect discount rates and the typical discount rates that consumers use while making energy efficiency investments.

3.1. Factors Affecting Discount Rates

An individual's discount rate depends upon the returns from an alternative investment and the risk of investment in question (Sutherland, 2003). For instance, a consumer has an option of investing his money in stocks or just deposit in bank rather than buying an energy efficient appliance. If his rates of return from these alternative investments range in 9-13% then he will expect his investment in the energy efficient appliance to pay at a same rate or more. Hence his discount rate will be in the similar range. But this applies to someone who has surplus cash ready for investment i.e. a high income consumer. Middle and lower income individuals will have to forego their present consumption or borrow money to pay for that extra amount required for energy efficient appliance. The interest rates at which the lower income households borrow money are generally higher resulting in a higher discount rate. It has been consistently observed that an individual's discount rate increases as his income decreases.

The discount rate also depends upon risk and irreversibility associated with the investment. The investment in a bank can be risk free. However, a consumer may perceive an investment in energy efficiency as risky. This may be either due to lack of information or because the appliance is new to the market. Additionally, the purchase of appliance is irreversible. The consumer cannot sell his appliance as he can sell shares of a company in case he realizes he has made a wrong choice. This makes the consumers' discount rate higher. It has been observed that irreversibility of energy efficiency investments increases the discount rate to four times than the norm(Sutherland, 2003).

3.2. Typical Discount Rates for Energy Efficiency Investments

There is a large body of research to estimate consumer discount rates related to energy efficiency investments. Review of this literature can be found in Train(1985) and Frederick, Loewenstein, & O'Donoghue(2002).

Most of the studies use qualitative choice theory to analyze a set of observed individual decisions. This involves analyzing purchase decisions of individual consumers that have to choose among alternatives that vary in investment cost and energy efficiency. Researchers then compute a discount rate that would make actual purchase behavior economically rational in terms of net present value. Few studies directly ask individuals their willingness to pay for an energy efficient appliance and compute discount rates accordingly. The discount rates that are calculated in such manner are actually the implicit discount rates. The implicit discount rate can depend on a number of other factors than consumer's income or risk perception such as age, education or ownership status of the consumers. It is

[3]The example is only to explain the significance of discount rates in buying decision of consumers. The calculations consider a tariff of Rs 4 per kWh and do not consider the price variations of electricity over the life of the fan.

fundamentally impossible to estimate true discount rates (Jaffe & Stavins, 1994)and hence implicit discount rates are used to analyze consumer's decisions on energy efficiency investments.

There is a significant variation of discount rates for different energy efficiency investments. The range from Train(1985) literature review is about 0-300% while that of (Frederick et al., 2002)is from negative to infinity.Table.1 shows typical average discount rates that consumer used for different energy efficient appliances as reviewed by Train(1985). Most of the studies have found that the consumers use high discount rates while making energy efficiency investment, in some cases, several times higher than the standard market rates on saving and borrowing.

Appliance	Average Discount rate range
Refrigerators	40-100%
Space Heating	5-35%
Air-conditioners	0-30%
Other appliances	15-70%

Table 1: Estimates of average discount rates Source: (Train, 1985)

Another common observation is the dependence of discount rate on income. Most of the studies observe that discount rates decrease as income increases. This is mostly due to liquidity constraints that middle and low income households face as we have already discussed in the previous sub-section. For instance, Figure 1, shows the variation of discount rate with income for the purchase of air-conditioners as estimated by (Hausman, 1979). It can be seen that discount rate decreases exponentially as income increases.

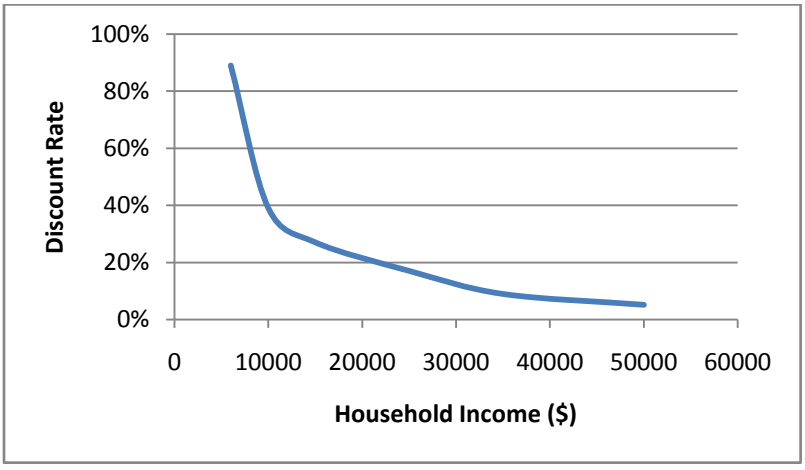

Figure 1: Consumer discount rate and income for Air-conditioners (Source: (Hausman, 1979))

All the above studies have been done outside India and there is very scarce literature available in India on estimating discount rate for energy efficiency investments. Reddy(1996)analyzed energy consumption data of 1000 households in Bangalore to estimate discount rates that households use when changing the fuel used for cooking purposes i.e. shifting from firewood to kerosene to LPG. He found the discount rate of urban households ranged from 10.5% to 208.2% and the rates decreased

exponentially with household income. This finding was consistent with the typical observations related to energy investments.

Ekholm, Krey, Pachauri, & Riahi(2010)compared six studies from the literature review of Train(1985) and converted Indian expenditure levels to comparable dollars to estimate the corresponding discount rate. They estimated that the discount rates in India vary from 62% to 74% in rural areas and 53% to 70% in urban areas. It has to be noted that the range of discount rates is quite different from the one predicted by Reddy(1996).They attribute this difference to the parameters employed while estimating discount rates.

However, there is no study estimating discount rates related to purchase of energy efficient appliances in India. As we have seen discount rates depend on number of factors and can vary significantly from one investment to the other as well as from one country to the other. We need to conduct separate studies for India to estimate the discount rates that Indian consumers use while buying energy efficiency appliances. Approximation of discount rates based on studies done in USA may not give an accurate estimate of the discount rates in India.

4. A Possible Use of Discount Rates in Energy Efficiency Policies

In this section, we illustrate a possible use of discount rates in energy efficiency policies. Let us re-visit the ceiling fan from section 2: an energy efficient fan that consumes 35W as compared to a normal fan's 70 W and costs Rs. 300 more. This results in an annual saving of around 50 units of electricity at the consumer end[4]. Accounting for transmission and distribution losses (T&D) of 20% the savings at the bus-bar will be about 63 units. Both the fans have an average life of 15 years. We saw that if government decides to incentivize the full incremental cost of Rs 300, the cost of conserved energy (CCE) is Rs 0.63/kWh[5], less than a third of the cost of generation of electricity in India (Rs 2.3/kWh). The benefits from enhanced energy security and reduced emissions are not even monetized here. The program is definitely cost-effective. But can we use discount rates to make it more effective?

We have already seen that discount rates change the way consumers perceive an investment. Figure 2 shows how perceived cost of conserved energy (CCE) changes with discount rates for the energy efficient fan above. CCE is the ratio of annualized incremental cost over the life of fan calculated using the discount rate and annual saving of the fan in kWh. It indicates consumer's cost of saving per unit of electricity by investing in an energy efficient appliance. For instance, CCE for a consumer with 70% discount rate is Rs 6/kWh. He will buy the fan only if he is paying a tariff of Rs 6/kWh or above. Otherwise, he may think it is beneficial to buy an energy-inefficient fan and spend on electricity rather than spending more on an energy-efficient fan.

[4] Assuming annual usage of 1800 hours and using an accounting factor of 0.8 for the speed variation.

[5] Assuming constant electricity prices over the life of the fan. This is a conservative estimate since the prices of electricity are bound to increase.

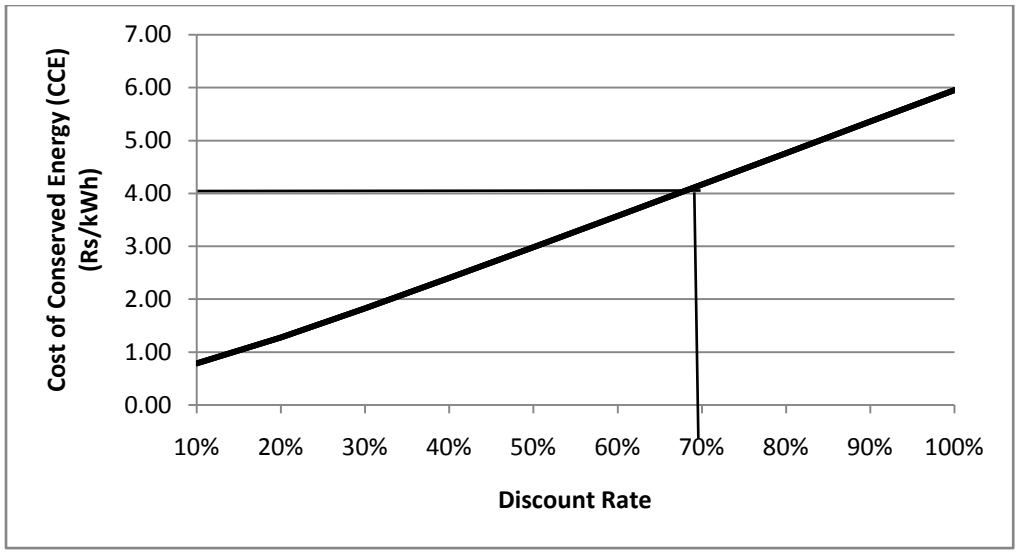

Figure 2: Variation of CCE with Discount Rate for Energy Efficient Fan

There is no data available on discount rates' estimates for purchase of energy efficient appliances in India. But, to illustrate the approach, let us consider that India's population has three income groups: rich, middle and poor. The characteristics of the population are assumed as shown in Table 1. The discount rates' assumptions are loosely based on studies done by Reddy(1996) and Ekholm et al., (2010). The objective here is not be precise regarding the data on discount rates but use rough estimates to illustrate the approach. The three sections also pay different electricity tariff similar to the differential electricity tariff system in India.

Income class	Discount Rate	Electricity Tariff (Rs/kWh)
Rich	20%	4
Middle	80%	3
Poor	150%	2

Table 1: Characteristics of a hypothetical population

Based on the above characteristics, investment in energy efficient ceiling fan will be perceived differently by different income groups. Normally, a consumer will buy an energy efficient appliance only when the present value of the benefits exceeds the present cost. The present value of the annual benefits from the savings in electricity for each income class can be calculated using the tariff that they pay and discounting the benefits using the corresponding discount rates. The present values for different income classes are shown in Table 2.

Income class	Present Value (Rs.)
Rich	943
Middle	189
Poor	67

Table 2: Present Value of the investment in energy efficient ceiling fan for hypothetical population

Table 2 shows that only middle and poor class consumers need incentives to buy the energy efficient ceiling fan. For a rich individual, present value of the benefits from the energy efficient fan exceeds the present incremental cost by almost three times. On the other hand, a poor individual may be ready to pay only about Rs. 70 extra for the energy efficient fan while a middle class individual may be willing to pay about Rs. 200. Although both income classes may need financial incentives to make the investment in energy efficient fan cost-effective, it may not be necessary to incentivize the entire incremental amount of Rs 300. Government can just pay a part of it. It can further decide on what should be that incentive level: Rs. 230 or Rs. 100? We may have to look at the sales trends across income groups for that purpose. If we know that most of the future purchases are going to be in middle class, then we may direct the incentives at them. The poor may not buy the super-efficient fans in this case. However, they can still buy the energy-inefficient fan which turns out to be beneficial to them at the tariff that they are paying. On the other hand, if the majority of future buyers are poor then we can set the incentive based on poor individual's present value calculations. In this case, there may be free riders in form of middle class and rich class. But the objective of such a program has to be to achieve maximum market penetration of energy efficient ceiling fans in as much cost-effective manner as possible. So an option which is more cost-effective but has less total impact is not aligned with this objective. Thus implicit discount rates can be used to effectively design incentives and also identify the target population of the program.

4.1 Limitations and Challenges of the Discount Rate Approach

Discount rates can be useful to understand purchase decisions of consumers and thus, help to predict market penetrations of appliances. However, its estimation has always been fraught with uncertainty. As seen in various studies, there is very little consensus on the discount rates of consumers for making decisions regarding energy efficient investments, even for similar investments. Arriving at a robust estimate of discount rates is a big challenge as it depends on a variety of characteristics of the consumer/s whose discount rate is being estimated. Hence, discount rates should not be the only criterion to estimate the amount of financial incentives for energy efficient appliances. Rather, it should be looked upon as a guiding principle. Moreover, not all factors leading to high discount rates can be addressed by providing incentives. For instance, if lack of information is resulting in high discount rates, government can't overcome that by paying financial incentives. In this case, government can reduce the discount rates by increasing awareness through mass outreach programs.

Apart from the limitations, there are serious data challenges to using discount rate approach in India. There is hardly any study on implicit discount rates for making purchase decisions regarding appliances in India. Further, there is no primary data on sales of appliances across various income groups. A recent study by Prayas (Rathi and Chunekar, *forthcoming*) provides a rough estimate of sales across various income groups using two rounds of National Sample Survey Organisation (NSSO) household expenditure surveys. A private organisation, CMIE, has been gathering panel data on household expenditure which can be used to estimate sales across income groups

Conclusion

Discount rates are useful to find preferences of customers to buy energy efficient appliances. Consumers normally use high discount rates while making energy efficiency investments. This is evident from the lower market penetration of energy efficient appliances. Among the number of factors affecting consumer discount rates the most significant ones are income and risk perception. In this paper, we have described an approach where discount rates can be used to estimate cost effective incentive level. This approach may have some limitations due to uncertainty involved in estimating discount rates. Hence, we suggest that discount rate based approach should not be the only approach to design a financial incentive program but should be used in conjunction with other approaches such as an approached based on behavioral principles. We also suggest that research needs to be undertaken to estimate appliance specific discount rates of Indian consumers. There is also a need for data on sales appliances across different income groups to identify buying patterns to design targeted energy efficiency policies.

Acknowledgements

We would like to thank Dr. Shonali Pachauri at International Institute for Applied Systems Analysis (IIASA) and Dr. Nitin Pandit at International Institute for Energy Conservation (IIEC) for providing external review comments. While they bear no responsibility to the final paper, their comments have helped the paper significantly. We would also like to thank our colleagues Shantanu Dixit, N Sreekumar, Daljit Singh, Ann Josey, Ashok Sreenivas and Kiran Kadav for useful discussions and suggestions. Above all, this paper would not have been possible without the guidance of late Girish Sant. However, any errors that remain are ours.

Further Reading

Ekholm, T., Krey, V., Pachauri, S., & Riahi, K. (2010). Determinants of household energy consumption in India. Energy Policy, 38(10), 5696–5707. doi:10.1016/j.enpol.2010.05.017

Frederick, S., Loewenstein, G., & O'Donoghue, T. (2002). Time Discounting and Time Preference : A Critical Review. Journal of Economic Literature, 40(2), 351–401.

Hausman, J. A. (1979). Individual discount rates and the purchase and utilization of energy-using durables. The Bell Journal of Economics, 10(1), 33–54.

Howarth, R. B., & Sanstad, A. H. (1995). Discount Rates and Energy Efficiency. Contemporary Economic Policy, 13(3), 101–109. doi:10.1111/j.1465-7287.1995.tb00726.x

Jaffe, A. B., Newell, R. G., & Stavins, R. N. (2004). Economics of Energy Efficiency. Encyclopedia of Energy, 2, 79–90.

Jaffe, A. B., & Stavins, R. N. (1994). The Energy Efficiency Gap: What does it mean ? Energy Policy, 22(10), 804810.

Rathi, S. S., & Chunekar, A. R., (forthcoming). Appliance Ownership in India: Evidence from NSSO Expenditure Surveys 2005-06 and 2009-10. Prayas Energy Group, Pune, India.

Rathi, S. S., & Chunekar, A. R., (2012). To Buy or Not to Buy or can be 'Nudged' to Buy. Prayas Energy Group, Pune, India.

Reddy, B. S. (1996). Consumer Discount Rates and Energy Carrier Choices in Urban Households. International Journal of Energy Research, 20, 187–195.

Stern, P. C. (1986). Blind Spots in Policy Analysis: What Economics Doesn't Say about Energy Use. Journal of Policy Analysis and Management, 5(2), 200–227.

Sutherland, R. J. (2003). The High Costs of Federal Energy Efficiency Standards for Residential Appliances. Retrieved from http://www.cato.org/publications/policy-analysis/high-costs-federal-energy-efficiency-standards-residential-appliances

Train, K. (1985). Discount Rates in Consumers' Energy Related Decisions: A Reivew of Literature. Energy, I(12), 1243–1253.