

# A Primer on Consumer Surplus and Demand: Common Questions and Answers

by Henry M. Peskin

**Measuring consumer's surplus is an increasingly popular approach to quantifying the monetary benefits of energy projects at the World Bank. This note provides a brief primer on the concept and addresses some concerns and criticisms for this method.**

## Introduction

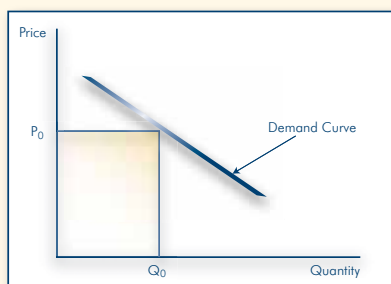
Consumer's surplus—a measure of well-being that relies on the difference between what a person, household, or group is willing to pay for energy and what actually has to be paid—has a long history in economics as a method for estimating the benefits of public projects (Marshall, 1930; Varian, 1978). The first use of applying consumer's surplus for valuing the benefits of electricity in the World Bank was seen as early as 1975 (Anderson, 1975). This was followed by a more elaborate exploration of the concept in the mid-eighties (Pearce and Web, 1985). Recently, the increasingly popular approach is applied in almost all rural electrification projects, including in countries such as Bolivia, Lao PDR, Peru, and Philippines (O'Sullivan and Barnes, 2006). The procedure, although fairly easy to apply, is not always well understood and is not without its critics, even by those educated in its underlying principles.

This paper provides a brief primer on the concept and addresses some of the more frequent criticisms that emerge when applying this method. One criticism not addressed is that money and well-being are not necessarily the same thing and therefore questions whether *any* monetary measure of benefit is valid. This criticism is the subject of a companion paper currently in preparation on benefit estimation (see Box 1).

## Consumer Demand

The starting point for an understanding of consumer's surplus is the consumer demand curve shown in Figure 1:

Figure 1: Demand Curve



The demand curve shows the relationship between the price facing the consumer and the quantity consumed at that price. Of course, the quantity of energy consumed at any point in time depends on far more than its price—the weather, the taste for energy-consuming items such as radio and TV, the need to support energy needs of business, and most importantly, the consumer's income. Clearly, if one chooses to focus just on the relationship between energy prices and energy consumed, these other factors must somehow be held "constant." In general, if all the non-price factors remain fixed, the higher the price of a good (in this case energy), the less likely the consumer will demand it.

The demand curve shows price-quantity relationship for an individual, a household, a group of individuals, or a group of households. The interpretation of the curve differs if it shows an individual or a group, especially if the group contains a mix of incomes and tastes.

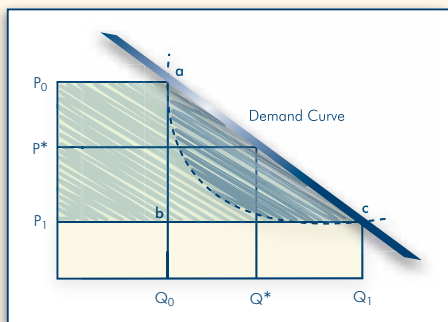
For a heterogeneous group, the tendency for higher prices leading to lower energy consumption usually implies that most of the consumption at high prices is by those individuals with

ESMAP is a multi-donor trust fund managed by the World Bank Energy and Water Department (EWD) that promotes the role of energy in poverty reduction and economic growth in an environmentally responsible manner. Its work applies to low-income, emerging and transition economies and contributes to the achievement of internationally agreed development goals.

higher incomes or with a stronger desire for energy. For an individual, the lower consumption at higher prices usually means that the individual will tend to substitute for other goods that provide a less costly means to maximize his or her satisfaction or well-being. In either case, if the market price of energy is below what some people would be willing to pay for it, these people would experience a gain in their well-being. This gain is the principal argument for using consumer's surplus as a benefit measure.

Consumer's surplus can be illustrated in the following diagram:

Figure 2: Demand Curve showing Consumer's Surplus



If the price of energy fell from  $P_0$  to  $P_1$ , those individuals (or a particular individual) who would be willing to pay  $P_0$  in order to consume  $Q_0$  of energy, can now consume the  $Q_1$  of energy at the lower price. The original “ $Q_0$ -consumers” (or in the case of an individual, the “ $Q_0$  consumption”) realize a “benefit” of  $P_0 - P_1$  for each of the units of  $Q_0$  consumed. This benefit would be realized for *any* consumption less than  $Q_1$  corresponding to *any* price higher than  $P_1$ , such as for those willing to pay  $P^*$  for  $Q^*$  units of energy. Thus, when one considers *all* consumption-price combinations between the original  $Q_0, P_0$  combination and the new  $Q_1, P_1$  combinations, the *total* of all gains is represented by the shaded triangle  $a, b, c$  plus the rectangular area  $P_1, P_0, a, b$ .

In brief, energy is demanded for the service that it provides. Therefore, to calculate consumer's surplus requires an estimate of demand for lighting, entertainment, communications, or other services closely linked to energy. For lighting, the demand is quantified as kilo-lumen hours and for entertainment, it is radio or television listening or viewing hours. Thus, it is possible to obtain a measure of consumer's surplus by using the price and quantity of kilo-lumen or radio listening hours for households using kerosene, batteries or electricity from a grid system (World Bank, 2002). This note assumes that the benefit measured by consumer's surplus is a satisfactory measure of the benefit of policy that brings about lower energy prices and considers key challenges in this approach.

## Estimating the Demand Curve

Consumer's surplus greatly depends on the shape of the demand curve, particularly between the original  $Q_0, P_0$  combination and the new  $Q_1, P_1$  combination. If the curve were not a simple straight line but instead bowed or bent towards the origin of the graph such as indicated by the dotted line, the consumer's surplus would be smaller, as shown by the more lightly shaded area. Although the consumer's surplus *could* be far smaller than that measured in the World Bank's ESMAP energy studies, the investigators chose not to assume that it is smaller (World Bank, 2002).

Instead, the studies based the demand curve (and the resulting measure of consumer's surplus) on actual price-quantity observations drawn from household surveys. For combinations not observed, there was a simple linear extrapolation between points that were observed. Of course, the extrapolated points may not fall on the “true” (but unobservable) demand curve.

However, since the extrapolations rely solely on what can be observed, the investigators feel that this is a more honest approach than simply *assuming* some sort of curvature between the observable points. Such assumptions are necessarily arbitrary and could produce a wide range of results. Besides the problem of estimating the “correct” demand curve, the application of the consumer's surplus method has raised a number of questions and criticisms addressed below.

## Are two points adequate for estimating the demand curve?

Of course, if only two points are observed, the estimated demand curve will necessarily be a straight line, as in the above diagrams. If it is somehow known that the “real” demand curve has more curvature, then a two-point estimate is certainly not adequate. However, *estimating* more curvature requires more observation.

Fortunately, for those studies where data permitted estimation of some curvature, the difference between the straight line consumer's surplus and the more correct (and lower) value obtained with a more curved demand curve was fairly small (Barnes, Fitzgerald and Peskin, 2002). The qualitative conclusions of the studies were not changed. While this fortunate outcome cannot be guaranteed in all future energy studies, a large gain in consumer's surplus—regardless of the shape of the demand curve—is an expected outcome of the large fall in energy costs due to electrification.

## Whose demand curve is it anyway?

These studies have chosen to estimate the demand curve for groups of similar households—similar with respect to their tastes for energy and their abilities to pay for energy. Because it would be impossible to group households by all the factors that could affect energy demand, the households were grouped by income class (and in some studies, also by location). Certainly, not every household within an income class is just like every other household in that class. For some prices, certain households may consume somewhat more or somewhat less. The expectation is that within the income class for any observed price, the consumption is on average “correct.”

## Does willingness-to-pay overestimate ability-to-pay?

Some critics of the consumer’s surplus—with its reliance on the difference between the “willingness-to-pay” price and the market price—argue that the willingness to pay may be higher than the household’s *ability* to pay. An underlying assumption behind this criticism is that a household’s low income may make it impossible to pay as much as it may desire. It should be kept in mind, however, that the demand curves in the ESMAP studies cited above are based on observations of what is *actually* paid for a given amount of energy consumption. In principle, therefore, there is no difference in these studies between the “willingness-to-pay” price and the “ability-to-pay” price. It is true that because households within the groupings may not be exactly the same, certain households in the group may not be able to afford certain consumption levels depicted by the demand curve. Or on the other hand, other households in the group may be able to afford somewhat *more* energy than depicted by the demand curve. With a large enough household survey, the observed actual payment-quantity consumption levels should be, on average, correct for all households in the group.

## Why is consumer’s surplus so large?

The consumer’s surplus estimates in all of the energy studies completed so far at the World Bank have been quite large—even where the data allowed for demand curve estimates with “curved” shapes. Moreover, the estimates have been large even for the least wealthy income classes. This result is not surprising when one realizes how much even the poorest



### Box 1: What Does it Mean to Measure Project Benefits?

Benefit or well-being is essentially a psychological concept that depends on physical factors facing the household such as the level of wealth, amount of consumption, or the state of the environment. While the costs or prices of such factors may affect their physical levels, these costs or prices should not directly affect the well-being of a rational household. If one household paid \$30 thousand for an automobile, while another household paid \$50 thousand for the *same* automobile, under assumptions of rationality, the second household would not be considered better or worse off (everything else being equal). Thus, the heavy dependence of consumer’s surplus on prices is considered a deficiency of consumer’s surplus as a measure of benefits. (This deficiency is a form of what economists refer to as *money illusion*.)

Fortunately, consumer’s surplus is a good approximation to two accepted benefit measures that do not share this defect (but which are harder to estimate): the *equivalent variation* measure and the *compensating variation* measure. These measures monetize the physical factors by assigning prices: original or “base” prices for the former and post-policy prices for the latter. In fact, consumer’s surplus lies between the two.

households are willing to pay for those energy services that apparently are highly valued—in particular, lighting. For example, according to a study in the Philippines of rural electrification, the non-electrified household is likely to spend per kilo-lumen hour 48 times more than the electrified household. If the average rural household can get their lighting at the lower price through electrification, their monthly demand for lighting increases by a factor of 50. Of course, these estimates could be much different for those countries far poorer than the Philippines. Nevertheless, the combination of a high willingness-to-pay for a small quantity of energy with a huge increase in demand with lower energy prices easily explains the high consumer’s surplus estimates.

## Aren’t the estimates affected by subsidies and taxation?

Since the demand curves are based on actual behavior, they reflect any subsidies or taxes that affect the energy prices facing the household. For example, the very high “price” of lighting with kerosene is even higher where kerosene is heavily taxed and the very low price of electricity facing the household is even lower where electricity subsidies are large. Both effects tend to increase consumer’s surplus. Indeed, as the companion paper on benefit estimation argues, this high sensitivity to price changes is one defect in using consumer’s surplus as a measure of electrification benefit. (See Box 1.) A more important problem is that a consumer’s surplus measurement of electrification benefit is often very partial: it looks at electricity demand and not elsewhere in the economy. Subsidies, for example, could have a short-run effect of

increasing household consumer's surplus but a longer-run effect of decreasing household benefit if the costs of the subsidy eventually fall on the household in the form of higher household taxes or a decrease in governmental services. Consumer's surplus estimates (or any other benefit estimate for that matter) may not tell the whole story. They may reflect the short-run benefits of energy policy on lower energy costs facing the household but ignore longer-run effects on well-being from, for example, decreased medical care due to shifts from health programs to energy programs. Such adverse longer-run outcomes are hardly inevitable but suggest the need for a holistic approach to all policy making.

### Why not simply ask consumers about their benefits from electrification?

There are several methods of measuring electrification benefit other than by estimating consumer's surplus. Indeed, some of these methods have to be used in the absence of data permitting estimation of a demand curve. If there is only interest in determining the *qualitative* benefits of electrification, direct questioning of electricity users and potential users may be more than adequate. These direct surveys have indicated a very strong, qualitative desire for electrification. However, surveys of other possible public services, such as health or education, also indicate strong desire for these programs as well.

Some economists have used survey methods of determining quantitative estimates of benefit and a few of these have been used to assess World Bank programs as well. These methods are known as *contingent valuation* surveys. Unfortunately, they are difficult to apply because they require very carefully worded questions in order to ensure that the respondent will answer truthfully. Therefore, even where successful, contingent valuation surveys are usually very expensive. For these reasons, this approach is controversial among economists.

### Conclusion

Policy choice requires more than expressions of *qualitative* preferences of what is or is not desirable or beneficial.

*Quantitative* preferences (monetary measures that can be compared across programs and to quantitative costs) are necessary to make choices between many desirable projects. Quantitative benefit estimates thus assist in the selection of these programs. Quantitative benefit estimates can also assist in the management of programs as well. For example, the apparent very high consumer's surplus estimates associated with electrification suggest that the need for subsidization may be far less than is currently believed necessary.

Consumer's surplus estimation is an important and practical method of developing such quantitative estimates of benefits. The increasing popularity of this approach at the World Bank is well justified.

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