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Willingness to Pay for Water and Energy:

An Introductory Guide to Contingent Valuation and Coping Cost Techniques

Francesco Devicienti,
Irina Klytchnikova,
and Stefano Paternostro

Poverty Reduction Group, PREM
The World Bank
Washington, D. C.

Comments and suggestions welcome

ABSTRACT

*In order to determine the impact of many water and energy reforms, analysts need to elicit the preferences of users and their demand for the goods in question. When these goods are not routinely bought and sold in the market, the standard approach of demand estimation based on observed prices and quantities is not viable. Instead, analysts must resort to the types of non-market methods described in this paper. The two methods most widely used in the context of water and energy are **contingent valuation** and **coping cost**. These methods are described in the paper with particular emphasis on their application in developing countries. The paper suggests that both the contingent valuation and coping cost methods are useful tools for the evaluation of water and energy projects, particularly if they are used together to validate results. Moreover, it is critically important that the analyst carefully confront a number of technical and practical issues before the results of these non-market approaches to preference elicitation may be validated. These issues are also described in the paper.*

KEYWORDS

Willingness to pay, contingent valuation, coping cost methods, cost-benefit analysis, water, energy.

TABLE OF CONTENTS

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1 INTRODUCTION

Policymakers committed to economic development and poverty reduction often have to prioritize the types and number of public actions that should be undertaken in a specific area, context, and country. As with most policy actions, a sound valuation is usually necessary to decide which among the set of feasible alternatives should be recommended and adopted. In principle, this requires that *all* benefits for each proposed action be compared to *all* the costs of the action in order to determine the action with the highest net benefit score.

While the choice is generally based on a comparison between the average level of the costs and benefits in the population, the distribution of the gains and losses among the said population is also crucially important. Careful evaluation not only allows the analyst to judge whether the project is worth implementing, but also assists in determining ways in which final users and beneficiaries should be required to contribute (user fees, accession costs, and so on). It also enables an assessment of the risks faced and the potential social and political opposition on account of the perceived "unfairness."[1]

There are, however, certain types of public actions for which it is not simple to compute the associated benefits and costs in monetary terms, nor to provide an evaluation of the welfare impact on the targeted population. The welfare assessment of changes that occur in the markets for private goods and services (for example, due to the implementation of price-subsidy reforms) is easy to carry out in principle, as it can be based on the observed changes in quantities and prices. However, the estimation of the costs and the benefits of environmental resources whether provided directly by the state, or indirectly through regulation (for example, water supply, sanitation, energy, and so on), is often made more difficult when an explicit market is absent.

Economists have nonetheless developed a variety of techniques to value *non-market goods*. This paper intends to convey a general introduction to these techniques—both *revealed* and *stated preference*—and practical guidance to analysts interested in the applications. Reflecting its intent to offer practical help, the paper restricts its focus to the theoretical and empirical issues arising in a particular range of applications: reforms aimed at improving the supply of water and energy in developing countries. While the broad methodological aspects discussed are likely to be relevant in other contexts, the specifics of these types of reforms and of the technical and practical issues arising in the relevant evaluation justify this focus.

Although the paper concentrates on techniques for valuing non-market goods, this is not to say that the more traditional, relatively well-known techniques for estimating a demand curve for goods and services based on market price-quantity data (and sometimes supply functions, too) are less useful. On the contrary, when the analyst is in a position to use these techniques, for example, when a rich, detailed dataset is available, traditional techniques are likely to offer a more consistent and reliable and less controversial framework of analysis. However, the requisite conditions for the use of these methods (mainly, but not only a required information base) are unlikely to be met in practice in most developing countries. For example, electricity demand models are seldom employed for measuring willingness to pay in most developing countries because of insufficient data, particularly data relating to the prices and quantities of all the energy sources relied on by households.

The rest of the paper is organized as follows. Section 2 provides a brief classification of the main non-market methods that have been used to elicit the consumer preferences relating to water and energy provision, anticipating some of the main lessons learned in the paper. The distinction between market and non-market goods and the related implications for the evaluation strategy are also discussed.

Table 1 contains a summary description of existing demand assessment techniques. These include the quantitative approaches discussed in the paper (*stated preferences* and *revealed preferences*), as well as some qualitative approaches. The latter have been discussed elsewhere (for example, Bamberger 2000) and are beyond the aims of this paper, though it should be noted that they complement the techniques detailed in this note and work as stand-alone tools.

Section 3.1 reviews *coping cost methods* (a type of revealed preference approach also known as *averting expenditure*) that have been used for evaluating water sector improvements; other revealed preference approaches for water are contained in Sections 3.2 and 3.3. Stated preferences methods, or *contingent valuation*, for water are reviewed in Section 3.4, which focuses on practical and theoretical considerations. A prototypical questionnaire to determine household willingness to pay for improved water supply has been included in Box 1.

Section 4 deals with willingness to pay for improved energy services and briefly discusses the production loss method, the captive generation method, and contingent valuation. Box 2 contains an example of a prototypical questionnaire to examine the willingness of firms to pay for improved energy supply.

Section 5 concludes.

2 OVERVIEW OF THE PAPER

Public actions aimed at improving the supply of water and energy are recognized as a growing priority in developing countries. Policy interventions may take the form of infrastructure building (for example, pipelines or electricity networks), the privatization of loss-making public utilities, the modification of existing government regulations for private provision of the services (for example, changes in the tariff structure), or improvements in service quality (reliability, safety, and so on) and access (for example, coverage of remote areas). The evaluation of private projects may also be undertaken through the techniques discussed in the following sections.

In each of these cases, a sound cost and benefit analysis can inform a desirable course of action and potential tradeoffs. In general, one may argue that the main difficulty lies in estimating the (monetary) value of the benefits accruing to consumers and beneficiaries or their *willingness to pay* (WTP) for the good or service provided. The assessment of the costs,[2] on the other hand, poses fewer conceptual and practical problems, at least as far as infrastructure and operation costs are concerned.[3]

If the analyst can estimate a demand curve for a particular service because accurate price-quantity data are available through specialized surveys or, to a lesser extent, through a Living Standard Measurement Study (LSMS; see Whittington, O'Sullivan, and Barnes 2004), then this demand curve can be used not only to predict changes in behavior in response to changes in pricing policy, but also to calculate estimates of welfare change that rely on standard cost-benefit methods.[4] If the analyst is unable to estimate the demand from market data, there are two broad categories of approaches that can be used to compute the value to consumers (and other beneficiaries) of reforms in the provision of water and energy services:

a. The "*revealed preference in surrogate market*" *approach* is based on what people "do" to cope with the absence of a market for the good they need; hence, it is also named the *coping cost method* or the *averting expenditure method*, and
b. The "*stated preference approach*," which is based on what people say when they are asked directly about the good in question; this is often referred to as *contingent valuation* (CV), especially when used in the context of environmental amenities.

Revealed preference approaches rely on the observed behavior toward some market good that possesses a connection to the non-marketed good of interest, for example, when the demand for improved public water is inferred by the purchase of bottled water or the purchase of water from private vendors. Stated preference approaches, meanwhile, rely on answers to specifically designed surveys relating to the non-market good in order to understand the basis of the demand.

Examples of revealed preference techniques that have been used in the evaluation of water and energy projects in developing countries include *travel cost methods, hedonic pricing methods, averting expenditure methods, production loss methods,* and *captive generation methods*. The names of the various methods sometimes relate more to the specific area in which the methods have been applied rather than to fundamental differences in approaches. They are all based on the same broad principles: the deficient quality of service provided by, say, utilities that impose major coping costs on consumers. These usually take the form of investments in alternative supplies (water storage tanks, water treatment equipment, electricity generators, candles, and batteries) to deal with supply interruptions and inadequacies. If consumers are not able to mitigate the consequences of inadequate supplies, they may suffer from lost production or reduced household welfare. In general, the coping costs avoided will be a lower bound on the magnitude of the economic benefits of service improvements. If a lower bound estimate of the benefits is greater than the cost of the intervention, this benefit estimate can prove particularly useful.

The CV (stated preference) approach has recently been employed to evaluate water and energy projects in developing countries. A CV survey constructs scenarios of possible future government action. Survey respondents are asked to *state* their preferences concerning these actions. The choices made by respondents are analyzed in a manner similar to the choices made by consumers in actual markets. In both cases, the economic value is derived from the choices observed either in an actual market, or in a hypothetical market created in the survey (Carson 2000). For example, respondents may be asked if they would agree to pay a specified monthly increase in their electricity bill in exchange for improved service reliability.

The use of contingent valuation has engendered much debate among proponents (for example, Hanemann 1994) and critics (for example, Diamond and Hausman 1994). Each of the revealed preference methods is also subject to support and criticism on account of the respective strengths and weaknesses, that is, each method has its advantages and disadvantages that relate to the nature of the good involved, the type of project to be assessed,[5] and the type of available information.[6] While the following pages are not meant to provide a full account of the merits and difficulties of the various approaches, they briefly describe these in the context of water and energy supply improvements, and they reflect a deliberate attention to the subset of approaches that have found more extended application in developing countries.

Two qualifications apply to the remainder of the paper.

a. A larger number of WTP applications in developing countries refer to water rather than energy. To some extent, this relates to the specific characteristics of water and energy. Water is a household necessity that, for the most part, cannot be substituted. Energy, on the other hand, can be seen as a production input for firms and households, and one type can be replaced by a number of alternative sources (electricity and various types of fuels). As a result, models explaining energy choices and use are likely to be more demanding for the analyst, not least in terms of data requirements. Despite differences, most of the general methodological issues are shared between the two sectors. These general issues will be discussed first in relation to water given the higher number of studies on this sector.
b. A distinction is made between the WTP of households and the WTP of firms based on the different ways in which these goods are used by these two types of economic agents. Households mainly use water for drinking, cleaning, cooking, and heating purposes, while farms (and small producing households) employ water mainly for irrigation. The literature on the pricing of irrigation water has been surveyed elsewhere and will therefore not be covered at length here (see Johansson 2000; Asian Development Bank 1999). The WTP methods described in the water section therefore refer mainly to the household use of water. The section on energy, on the other hand, focuses mainly on the willingness of firms to pay both in manufacturing and in agriculture (where the main energy use is for irrigation). The same underlying principles discussed for the willingness of households to pay for improved water services can, when suitably modified, be applied to the analysis of the willingness of households to pay for improved energy services and, to a lesser extent, the willingness of firms to pay.

Before the various approaches for measuring the WTP are described in detail, it is helpful to highlight important features of the goods in question, as these are central to the methods that analysts employ in their cost and benefit analyses.

First, water and energy services are not pure public goods, and the basis of the cost-benefit analysis therefore relates to market transactions that are observed in principle. The goods are provided either by the state, which is motivated predominantly by natural monopoly considerations, or by the private sector within a detailed regulatory framework established by the state. In each case, the final consumer is usually asked to pay a price for service access and use. In some cases, the quantities consumed and the price paid by final users can be retrieved. The welfare evaluation of price changes (a modification of the tariff structure) can therefore be undertaken as in the case of pure private goods, that is, estimating consumer demand and deriving the welfare impact of the proposed changes.[7]

Second, even when price and quantity information may not be readily available (because existing utility data are unreliable or unavailable to researchers) or when there is no market for the goods in question, it may still be possible to look at data relating to substituted goods (for example, bottled water when public pipe drinking-water does not exist) for an assessment of demand. This is a simple example of the techniques described in this paper to value non-market goods, that is, coping cost approaches.

Certain circumstances require different techniques for valuing non-market goods, and this is likely to occur when (a) the service is absent altogether in a particular area, and, consequently, no transactions are observed from which consumer preferences may be understood (for example, remote mountainous areas); (b) there are no close substitutes that can be used to understand consumer preferences indirectly; and (c) new dimensions are added to existing goods (for example, fundamental quality changes). In the last case, the new good may be viewed as non-marketed to the extent that current consumers have not yet engaged in complete transactions for this good (or the new variety) and can only be asked their preferences for the new good in the context of a mental experiment. These techniques will be described at some length in this paper under the heading of the stated preference or contingent valuation approaches.

3 WILLINGNESS TO PAY FOR (IMPROVED) WATER SERVICES

3.1 Averting expenditure method

The averting expenditure method (AE) is based on the proposition that, when other goods are used to compensate for the adverse effects of deterioration in water systems, the value of the improved water supply can be measured by the total expenditure of households for these goods. Since these goods are, effectively, substitutes for a better service, their purchase reveals the willingness of buyers to pay for improved service, which may in turn be used as a measurement of the WTP.

The theoretical underpinnings of the AE method derive from a sort of household production model (Courant and Porter 1981; Bartik 1988; Lee and Moffitt 1993). Households are assumed to have preferences for the quality *Y* of a given public good (for example, municipal water) and a composite good *Z*, including "all other goods." The household's budget constraints state that total expenditure on the composite good, plus the "minimum averting expenditure," should not exceed available income. The minimum averting expenditure is the minimum amount of money spent on averting inputs that allow the household to obtain any given quality level *Y* from the existing quality level *X* and averting inputs *A*. The household optimal choice of the AE is shown to depend on the price of the composite good (p_Z), the existing quality *X*, household income, the price of the averting inputs (p_A), and a vector of household characteristics reflecting tastes and preferences.

A number of important assumptions have to be satisfied in order for the AE to produce good measures of the WTP for service improvements.

a. Averting expenditures must not generate direct benefits to the household (that is, they should not enter the household's utility function); in other words, they are only incurred as a means of improving the existing quality of the public service. For example, time spent collecting alternative sources of water may have a social dimension that is valued for itself by the household, rendering the AE that

Table 1. Demand Assessment Techniques for Water Supply: A Summary

	ELICIT RELATIVE DEMAND AMONG DIFFERENT SERVICES	PARTICIPATORY RAPID APPRAISAL OPTION SELECTION: INTERNALLY FACILITATED	PARTICIPATORY RAPID APPRAISAL OPTION SELECTION: EXTERNALLY FACILITATED	REVEALED PREFERENCE SURVEYS	CONTINGENT VALUATION METHOD	"REAL" DETAILED OPTIONS CONSIDERED BY COMMUNITY GROUPS OR BALLOT
DESCRIPTION OF TECHNIQUES	Improvements to a wide variety of different services, such as water, drainage, roads, and so on, are considered by the communities, which express their relative demand for these services. The total funds available for each community area should be reasonably fixed.	Community volunteers are encouraged and trained to undertake a participators survey in their own community. Preferences and commitments are then agreed on in meetings.	A variety of participatory rapid appraisal techniques are used by trained researchers or facilitators to triangulate and confirm the preferences of different community groups, which are also involved in the analyses.	Revealed preference surveys estimate the time and financial costs of current household behavior (for example, payments to water vendors and the time saved in collecting water, expenditures on substitute energy sources, time saved in collecting fuelwood, and so on).	A questionnaire survey to determine the maximum willingness of individuals to pay for various options for level of service (including improved reliability) and payment arrangements within the context of the current or specified institutional regime.	Detailed options and their implications (costs, operations and maintenance, institutional, and so on) are considered by communities using participatory rapid appraisal or the ballot.
POTENTIAL BENEFITS	• Simple and easily understood • Expresses "real" demand if only in relative terms • Preferences can be refined during micro-planning	• Good community sense of ownership • Enhances empowerment • Useful if demand assessment involves ongoing negotiation	• Good community sense of ownership • Extension staff can assess appropriate time to elicit demand • Can enhance empowerment • Can be used in changing the institutional environment	• Can provide reasonably accurate estimates of current time and cost expenditure and hence possible willingness to pay for service improvements • Data and analysis requirements are modest • Good baseline data for impact assessment • Compatible with participatory rapid appraisal	• Provides good data for project appraisal • Good data on the WTP and potential revenues for different service levels, assuming a thorough survey is undertaken • Can guide tariff subsidy and cost recovery policy • Similarity to public opinion polls means results conceptually easy for non-specialists and the understanding of politicians	• More precise cost estimates lead to less confusion • Institutional charging of operations and maintenance implications can be thoroughly assessed • Can be used in a changing institutional environment
POTENTIAL RISKS AND CONSTRAINTS	• Possible group or strategic bias • The WTP for different service levels not readily known • Process can be manipulated by extension workers who do not use sufficient technical or financial rigor	• Possible group bias • Liable to lack technical and financial rigor • Reliant on skills being present in the community • Requires substantial flexibility by external funding agencies and local support institutions	• Possible group bias • Process can be manipulated by extension workers who do not use sufficient technical or financial rigor if they are not adequately supervised • Extension workers with good facilitation skills are required	• Cannot estimate the household response to price increases (including for new levels of service options) • Poverty may constrain the ability of poor people to convert the time savings resulting from service improvements into cash payments for services	• Risk inhibiting community decisionmaking and ownership by, for instance, raising expectations about particular options • Relatively high cost and requires specialized consultation for reliable results • Inaccuracies may occur in a changing institutional environment	• Risk that key decisions will be based on misleading results from an unrepresentative group unless care is taken to avoid group bias • Requires detailed cost information, so the earlier demand assessment may need to use other methods • Detailed work on some options can be redundant • Requires flexibility by funding agency
TYPICAL USAGE	Suitable for village or slum general improvement projects. Nongovernmental organizations often use these techniques	More suitable where low-technology, low-costs solutions are definitely viable, for example, hand pumps	Suitable in most situations, possibly complemented by other methods	Suitable where substantial water supply problems exist; to be used in conjunction with participatory rapid appraisal methods	Suitable for informing strategic decisions on levels of service, cost recovery policy, and so on in large investment programs, for example, urban systems or policy frameworks for small rural supply schemes	Suitable where difficult choices are to be made between different options

Source: DfID 1998. See also Klugman 2002, "Water and Sanitation," Chapter 23.

includes such time costs a potentially biased estimate of household WTP.

b. Averting expenditures must be a perfect substitute for a change in the quality of the public good. Some averting actions do not meet this condition; for example, a point-of-use water treatment system installed in the kitchen sink will not reduce adverse health effects resulting from inhaling chemicals evaporating from water in the shower (Abrahams, Hubbell, and Jordan 2000).
c. If large fixed costs have already been incurred, the AE should include an annualized stream of such costs. Averting behaviors such as installing home water treatment systems have significant fixed or sunk costs. In such cases, the sunk cost may alter household behavior regarding the provision of improved service. If households solve their water problem through these investments, they may not need improvements. Therefore, using these averting costs may be misleading.

The theoretical models outlined above also provide the basis for the econometric approaches that have been used to model the AE and obtain WTP estimates. A linear regression model is generally assumed to be of the following form:

$$AE_i = W_i'\beta + \varepsilon_i$$

where AE_i denotes the total averting expenditure of household i, W_i includes the determinant of the AE as suggested by the theoretical model (for example, p_z, p_A, X, and so on), and ε_i is the usual error term.

In the studies that have used averting expenditure methods to estimate the WTP for water improvements, AE_i has included measures of household labor and monetary resources to avoid exposure to the bad quality of municipal water (for example, time for boiling water), the cost of filters, the annualized costs of required equipment, purchases of bottled water, and the like. The opportunity cost of time is often computed on the basis of a minimum wage or an hourly wage estimated from family income.

Since AE_i is a continuous variable, ordinary least square regressions are used (often supplemented by median regressions to check for the robustness of the results in the presence of outlier observations). Once estimates of β have been obtained, the model can be used to predict the AE (which, in this approach, is a measure of the WTP) for any profile of households and local or service-related characteristics. The project is said to pass the cost-benefit test if the estimated total WTP exceeds the project's cost. Note that, in principle, the distribution of the benefits and, therefore, the distributional and poverty impact of the project itself could be provided by estimating the WTP for different profiles of consumers, for example, the poor versus the non-poor (as defined in terms of total household expenditure or any other chosen indicator). Gender and social dimensions could also be explored by comparing the WTP for men and women, young and old, and so on.

3.2 *Travel cost methods*

Analysts rely extensively on the travel cost method to place a value on outdoor recreational locations such as national parks and fishing and hunting sites. This method relies on observations of people's behavior, particularly expenditure for transportation and other trip-related expenses incurred when traveling to and from the site of interest. Moreover, it calculates the benefits derived from the specific site and uses this information to find optimal levels of service provision (Bishop and Heberlein 1990).

The method is, however, more appropriate for valuing recreational sites than for estimating the WTP for improved water services. In fact, households often use various alternative sources to maintain a certain level of water quality, for example, municipal and private tankers for non-drinking water and private vendors and bottled water for drinking purposes. Measuring the value of the time spent carrying water from the specific site may not provide a complete picture, and other non-transportation costs (for example, investments in storage and pumps to cope with intermittent and poor quality public water) should be considered. In this respect, the travel cost method can be seen as a special case of averting expenditure in that it focuses on a particular type of expense only, namely, travel. Though likely to provide a lower bound (or conservative) estimate of the WTP only, the method may still be a practical and easier alternative to the more demanding methods discussed in the following sections (see Whittington, Mu, and Roche 1990 for an application to water provision in Kenya).

3.3 Hedonic pricing methods

The hedonic pricing approach has been used extensively to estimate the value of property and housing prices (Blomquist and Worley 1981; Rosen 1974). It assumes that a good (or service) can be fully characterized by its attributes, that consumers have very good information on the attributes of goods, and that price differentials reflect the values of different attributes of goods. For example, in housing markets, the price of a house can be broken down into the value of its main attributes, that is, physical structure, age, number of rooms, neighborhood characteristics, quality of neighborhood schools, accessibility to work, crime rates, and perhaps some measure of the quality of local drinking water, air quality, noise pollution, and aesthetic views. Assuming each of these attributes has an associated implicit price, the market price of the property is equal to the sum of the implicit prices, multiplied by measures of the attribute. The application of the hedonic pricing method to capture the effect on prices of improvements in environmental quality requires observations of sufficiently varying quality levels within the confines of a single housing market (Leggett and Bockstael 2000).

Korman (2002) notes the limitations of the hedonic pricing method for valuing water quality improvements in Famagusta, Cyprus, mainly on account of the fact that water quality did not vary sufficiently across the single markets or locations. The method could still be applied if the geographical domain of the analysis were extended to capture more variation in water quality. Water is, however, not location specific (Whitehead and Van Houtven 1997), and everyone generally has access to the same level of water quality at the village or even regional level.

3.4 Contingent valuation methods

3.4.1 Introduction

While previous methods for estimating the WTP are based on the actual behavior of the subject involved, the CV method relies on the subject's responses to a survey questionnaire (O'Doherty 1998). Moreover, unlike travel cost, hedonic pricing, and averting expenditures, the CV method does not require public goods or services to be linked to actual market transactions. If a market for the public good in question does not exist, a hypothetical market can be created by a mental experiment using a properly devised questionnaire. It is well reported that, with stated preference techniques, researchers can design surveys to elicit references for goods with attributes that are not currently available in the market (Rubey and Lupi 1997).

However, the hypothetical nature of the market, the description of the public good in question, the elicitation format, and the payment routines of the CV method may cause biases in the estimation of the WTP. Diamond and Hausman (1994) state that lack of experience in the markets for environmental commodities and in the consequences of such decisions can make CV questions difficult to answer and raise uncertainties about the responses to the questions. Research in this field has focused on the hypothetical nature of the CV method and calls into doubt the accuracy and reliability of the method's value measure. Decades of experimentation and research have, however, gone a long way toward mitigating or eliminating weaknesses and enhancing the strengths of the CV method. Researchers in this field (for example, Smith 2000; Hanemann 1994; Arrow and others 1993; Freeman 1993; Portney 1993; Mitchell and Carson 1989; Cummings, Brookshire, and Schulze 1986) suggest various measures for improving the reliability of the estimates and minimizing the potential biases arising from the implementation of a CV study.

In response to the debate about the shortcomings of the CV method due to its hypothetical nature, the U. S. National Oceanic and Atmospheric Administration assessment panel issued a set of guidelines for conducting CV surveys to assure the reliability and usefulness of the information that is obtained using the method (see Arrow and others 1993). Among others, the panel recommended the following approaches: (a) a conservative survey design so that the WTP is underestimated rather than overestimated; (b) the use of the WTP questions rather than the willingness to accept questions; (c) the use of the referendum form rather than open-ended questions; (d) an accurate description of programs and policies; (e) a reminder of substitute commodities; (f) the use of yes-or-no follow-up questions; and (g) checks on the respondent's understanding of the scenario (Haab and McConnell 2002).

The CV method has been employed by several authors to measure the value of water quality improvements (Carson, Flores, and Meade 2001; Alberini and Cooper 2000; Ready, Malzubris, and Senkane 1997; Hanemann 1994; Carson and Mitchell 1993; Green and Tunstall 1991; Whittington and others 1990; Schultz and Lindsay 1990; Mitchell and Carson 1989; Edwards 1988; Korman 2002).

In these studies, the CV method has been helpful in predicting household behavior as hypothesized by economic theory. For example, CV analysis has enabled researchers to predict the number of connections to water supply systems after conditions have improved, as well as the amount of additional revenues for water authorities (Alberini and Cooper 2000). Similarly, Griffin and others (1995) report that, based on results in Kerala State in India, the actual behavior of households can be predicted with remarkable precision using the CV method. They conclude that a carefully designed and conducted CV study can supply reliable information on how people value goods and services.

3.4.2 CV biases and the various elicitation formats for non-marketed goods

Three potential types of bias may arise during the implementation of a CV study (Mitchell and Carson 1989; Cummings, Brookshire, and Schulze 1986).

a. *Strategic bias* arises when a respondent thinks that s/he may be able to influence an investment or policy decision by not answering the interviewer's questions truthfully (Whittington and others 1990; Whittington, Mu, and Roche 1990). Such strategic behavior may influence results in one of two ways. Suppose an individual is asked how much she would be willing to pay for potable water from a public water supply. If she thinks that the water utility will provide the service only if responses are positive, but that someone else will ultimately pay for the service, then she will have an incentive to overstate her willingness to pay. On the other hand, if she believes that the water utility has already made the decision to provide the public with water and the purpose of the survey is to determine the amount people will have to pay for the improved services, she will have an incentive to understate the extent of her true willingness to pay.
b. *Starting-point bias* may result from the bidding game or dichotomous choice elicitation formats. A specific price is asked, and, when a respondent is unsure of an appropriate answer and wants to please the interviewer, s/he may interpret this initial price as a clue to the "correct" bid. Starting-point bias exists if the initial price affects an individual's reported final willingness to pay (Boyle, Bishop, and Welsh 1985).
c. *Hypothetical bias* may result from a lack of clear understanding or correct perception of the characteristics of the proposed changes described by the interviewer. This source of bias is not likely to be significant for most public services, such as water, based on the strong general familiarity with such services. Respondents usually know the nature of the problem and comprehend the characteristics of the improvements (Griffin and others 1995; Whittington and others 1990).

The CV methods elicit consumer preferences and, therefore, the WTP. The elicitation questions take numerous formats: payment card, dichotomous choice, open-ended format, and stated-choice experiments. The different formats, each with its own advantages and drawbacks, have been shown to yield statistically different responses (Welsh and Poe 1998; Brown and others 1996). Bohara and others (1998) and Carson (2000) suggest that it is unreasonable to expect different elicitation formats to yield the same answers since they are not strategically and informationally equivalent.

Payment card method: The interviewer presents respondents with a range of WTP amounts ranging from $0 to a large sum and asks which amount presented on the card is the most they would be willing to pay for the level of the proposed change (see the example in Box 1). Although the payment card method reduces a starting point bias, it may have the following drawbacks. (a) Positioning amounts at the top or bottom of columns tends to draw "benchmark biases," and (b) the range of amounts offered may compel respondents to stay within certain bounds.

Dichotomous choice method: respondents face a single question of the form: "Are you willing to pay $x?" The bid level may be constant for the whole sample or may be varied across groups within a sample. Respondents accept or reject the WTP amount. This elicitation method has the advantage of being simple and familiar because respondents make a yes or no decision based on a given price in a manner that is similar to everyday market decisions (Freeman 1993). Schultz and Lindsay (1990) state that the dichotomous format minimizes both hypothetical and strategic biases, which are greater in an open-ended format. This method is also considered incentive compatible, because it is in a respondent's strategic interest to say "yes" if his/her WTP is greater than or equal to the price asked (Mitchell and Carson 1989). Diamond and Hausman (1994), however, disagree with this view, arguing that, since the results of the CV method research are not a real obligation, strategic behavior may occur with the use of a referendum approach as well.

The dichotomous choice approach faces a "starting point bias." This bias refers to the clustering effect of WTP bids around an opening bid by an interviewer. To minimize this starting point bias, the CV literature recommends a procedure that involves randomly assigning survey respondents to groups or subsamples and then asking each subsample to respond to different starting bid amounts. Alternatively, one should include follow-up questions to improve the efficiency of the dichotomous choice format questions. However, studies that have specifically tested for the starting point bias have found no evidence that a clearly defined referendum question is subject to such a bias (Herriges and Shogren 1996; McPhail 1993; Whittington and others 1990). This format also requires many more responses in order to estimate the maximum WTP and involves relatively more complicated econometric analysis (Bishop and Heberlein 1990). An additional drawback is the possibility of a relatively higher percentage of yea-saying responses to please or agree with the interviewer, regardless of the true valuation (Bishop and Heberlein 1990; Mitchell and Carson 1989).

Double bounded-dichotomous choice format. To minimize the disadvantages of the dichotomous choice method, respondents are asked, after the first question, to answer a follow-up supplementary dichotomous question based on their prior responses (Carson and others 1998). Those who have agreed to pay the amount used in the first discrete WTP question are asked if they are willing to pay a higher amount, 1.5 times the initial bid, and those who refuse to pay the amount in the first bid are asked if they would agree to a lower amount in the second discrete WTP question. Hanemann (1984) indicates that using the double bounded format could improve the statistical efficiency of the estimated mean and median WTP. Hanemann, Loomis, and Kanninen (1991) have found that the double bounded format provides a substantial gain in the variance-covariance matrix of the coefficient estimates. This gain leads to better confidence intervals for the estimated mean and median WTP. Calia and Strazzera (2000), however, show that the relative differences in estimates between the simpler dichotomous choice format and the double bounded-dichotomous choice format tend to decrease as the sample size increases.

Open-ended questions: This format requires respondents to state a WTP amount without the aid of an explicit context or process. The open-ended question alleviates the starting-point bias, and the WTP can easily be estimated. Respondents may, however, find it difficult to set a value for the proposed change and therefore register a "protest zero" offering a $0 WTP amount, despite the good having some value to them, as a means of refusing to answer (Mitchell and Carson 1989). The unacceptability of a large number of protest zeros that are indistinguishable from true zeros (that is, zero bids that are honest responses of low-income respondents or of people who do not positively value the proposed change) has led many CV researchers away from open-ended questions.

In summary, the open-ended format theoretically provides relatively unbiased responses as there is

Box 1. A Prototypical Questionnaire for Household WTP for Improved Water Supply

Below is an example of a CV scenario devised by Whittington (2000) for the case of tap water in urban areas. The questionnaire is usually inserted within the larger set of survey questions.

Interviewers first describe the set-up, ensuring that the interviewee fully understands the scenario, with which s/he might be unfamiliar. Interviewers might start by describing the characteristics of water supply systems in many developed countries, that is, that households have metered private connections and only pay for the water they actually use, that the water is safe to drink from the tap without further treatment, that the service is continuously available, and so on. The interviewee is then briefly reminded of the local situation.

> Such a system does not exist in [NAME OF TOWN]. Many households only have water for a few hours each day. Sometimes the water supply breaks down, and some people do not have service for several days. Many people in [NAME OF TOWN] treat their water before they drink it. Today, the typical household in [NAME OF TOWN] has to pay between $x and $y per cubic meter for the water they use if they have a metered connection. The average household water bill is about $z per month.

Interviewers then begin to describe the alternative scenario in detail.

> Water would be available 24 hours a day, 365 days a year, with sufficient pressure, safe to drink from the tap, and so on. Suppose that the price of water for this improved system were [p_1, p_2, p_3, p_4, p_5] per cubic meter. Because you would pay for the water you actually used, your water bill could vary from month to month. But suppose that, in a typical month, an average household would use about 15 cubic meters of water and receive a bill for [$15p_1$, $15p_2$, $15p_3$, $15p_4$, $15p_5$].[1,2] The price of a water connection would remain the same as it is today, or about $x.
> Suppose that a vote were held in [NAME OF TOWN] regarding a project to build a modern water system here. If the price of the new system were [p_1, p_2, p_3, p_4, p_5][3] per cubic meter, would you vote for the new water supply project or against it?

So, the first question will require a simple "yes/no/do not know" answer.

> Now suppose that the improved water supply system were installed in [NAME OF TOWN]. Would your household want to be connected to this system if the price of water from the new system were one of [p_1, p_2, p_3, p_4, p_5] per cubic meter? Or would you make other arrangements for obtaining your water supply?

This requires another "yes/no/do not know" answer. "Yes" means connect or stay connected to the new system, and "no" means do not want to be connected, will make other arrangements.

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[1] The household would only be asked about one price in this question, the price determined by the part of the split sample to which the household was assigned. The assignments are random, so that each split of the sample is a random subset of the whole.

[2] These questions depend on the head of household or spouse knowing the number of cubic meters the household uses. In fact, in many developing countries, households with private metered connections know more about their water usage than do households in industrialized countries. Nonetheless, the survey designer must ensure that this assumption is generally valid in the country of the survey.

[3] A respondent would receive one of these prices, which would be randomly assigned.

nothing inherent in the question that may influence responses (and it has no starting point bias). However, respondents may find it difficult to set a value, and they therefore report a zero amount. This difficulty could result in a high no-response rate, as well as protest bids (Mitchell and Carson 1989). Moreover, the open-ended format provides greater opportunity for respondents to act strategically. The literature on the CV method strongly recommends using a dichotomous format in order to minimize, even if not completely eliminate, the biases (Arrow and others 1993). The use of person-to-person interviews to decrease sample selection bias and minimize the non-response rate is also generally recommended (Arrow and others 1993). As a result, the dichotomous format has been the preferred method in empirical work.

There is also evidence that estimates of the WTP based on open-ended questions tend to be systematically lower than those based on dichotomous choice formats. This conclusion, however, mainly holds true for environmental and public goods rather than for private goods. When people are familiar with a particular service, as in the case of water supply, Korman (2002) suggests that the two methods are likely to produce similar WTP estimates.

3.4.3 Validation of the CV results

The CV method remains subject to criticism, and good CV practice therefore includes a number of tests to validate results.

a. Tests of the *theoretical validity* of the model. "Theoretical validity" is measured by examining the relationship between the WTP and the explanatory variables that are theoretically the determinants of the WTP for the improved public services. Theoretical predictions should be confirmed by the estimated coefficients. For example, economic theory suggests that the percentage of the respondents willing to pay a particular price should decrease as the price they are asked to pay increases. This is one of the fundamental postulates of economic theory, that is, the law of demand.
b. *Correlation test (convergent validity)*. This refers to the correlation between the WTP measures resulting from the CV method and the AE method. Using the revealed preference method to verify the results of the stated preference method and compare the magnitude and correlation between the two methods is highly recommended and is employed in empirical studies. Carson and others (1996) review 83 studies and conclude that CV estimates are, on average, smaller than those based on revealed preference techniques. They find that correlations range from 0.78 to 0.92.

This correlation test was used by Korman (2002) in a study of the WTP for water improvements. The households analyzed in Famagusta (Cyprus) were adversely affected by municipal services, and, because alternative (private) water markets exist, averting expenditures were used to meet the water requirement. Korman could then compare the results of the averting expenditure method to those of the contingent valuation method and check the validity and feasibility of using contingent valuation for estimating the benefits of improved potable water services in Famagusta (see section 0).

Griffin and others (1995) conducted an unusual experiment in the Indian State of Kerala in which they compared the stated responses to a CV questionnaire with the actual connections to a piped water supply by the same households a few years later (also a test of convergent validity). They found that stated responses are accurate in predicting the actual connections both on average and for particular households in the survey. However, stated responses provide a much poorer prediction of connections by similar households in a similar location. They concluded that the benefit transfer approach, that is, when estimates from one location are applied to a different location, may be more successful when omitted factors that are different across the locations are taken into account more accurately. This calls for rigorous qualitative work during the stages of questionnaire design and follow-up.

3.4.4 Other recommendations

Whittington (1998) reviews the issues that relate to the implementation of the CV method in developing countries. He reports that CV surveys are now becoming relatively easy and more straightforward. The survey response rates are typically high in developing countries, and respondents are receptive and give consideration to the questions asked. Moreover, he indicates that it is much cheaper to carry out in-person surveys in developing countries and therefore to have larger sample sizes than are usual in industrial countries. He concludes that it seems feasible and desirable to use CV studies in developing countries to help evaluate a wide range of projects. Whittington also suggests that, with regard to cultural and ethical settings, CV researchers should be cautious in the design and implementation of the survey. This includes treating respondents with respect as citizens rather than as experimental subjects, giving them time to think about their responses, and making sure that referendum prices do not spread confusion and misinformation about the cost of addressing possible problems of public concern.

Another important issue regarding the elicitation of information is the choice of the initial bid format. The most commonly used format is a variable initial bid whereby respondents are divided into different subsamples and given different starting bid amounts. Variable initial bids are useful in testing for starting point bias, and they make the calculation easier of the mean and median WTP from binary choice data. Whittington and others (1990) point out that variable initial bids may cause problems in eliciting information from respondents who may readily notice that different households have been told different costs for the proposed plan. This may create uncertainty about the cost of the program and result in bias in the reported WTP. While studying the WTP for water services in southern Haiti, Whittington and others (1990) conducted tests to determine whether the starting point bias would be a major problem. Three versions of their questionnaire were randomly distributed, each starting with a different initial bid. They found that the mean WTP did not vary much with a different starting point bid.

3.4.5 Theoretical underpinnings of the WTP measurement for improved services

What is the welfare impact on a household if the quality of a public service increases? If the existing quality level of the service (say, municipal water) is given by Q_0, its price for the household is given by $p^W{}_0$, and the price of the other "composite" good is $p^Z{}_0$, then the improvement in water quality from Q_0 to Q_1, with no concomitant price changes, produces a welfare gain of:

$$CV = E(p^W{}_0, p^Z{}_0, Q_0, U_0) - E(p^W{}_0, p^Z{}_0, Q_1, U_0) > 0$$

where CV is the compensating variation that provides the true measure of the welfare effect of the water quality improvement that is being evaluated, $E(.)$ represents the consumer's expenditure function, and

U_0 is the household's initial level of welfare. Note that $E(p^W{}_0, p^Z{}_0, Q_0, U_0)$ is simply the household's initial income, I_0. The CV is the amount of money that the consumer is willing to pay to see the service's quality improve from Q_0 to Q_1 and is exactly the measure that the contingent valuation method aims to elicit from respondents to the household survey.

In equation (2), U_0 is the maximum utility (indirect utility) achieved by the consumer when facing prices $p^W{}_0$ and $p^Z{}_0$, quality Q_0, and income I_0, that is, $U_0 = V(p^W{}_0, p^Z{}_0, Q_0, I_0)$. After substituting, (3) can therefore be rewritten as a (generic) function $f(.)$ of the prices and qualities in the status-quo and in the hypothesized improved scenario:

$$CV = WTP = f(p^W{}_0, p^Z{}_0, Q_0, Q_1, I_0).$$

3.4.6 Econometric modeling of the WTP using CV methods

Once an error term is added to (3), one obtains the empirical counterpart, the foundation for the WTP estimation based on contingent valuation methods:

$$CV_i = WTP_i = f(p^W{}_0, p^Z{}_0, Q_0, Q_1, I_0 \,;\, H_i) + \varepsilon_i$$

where a vector H_i of household characteristics (household size, the education and occupation of the household head and the spouse, and so on), as well as other variables reflecting preferences, tastes, and local circumstances, has also been included.

The econometric methods to be used depend in part upon the elicitation format adopted by the survey investigator. A number of cases can be distinguished.

a. If open-ended questions were used when establishing the WTP for the proposed quality change, WTP_i, in (4) is a continuous variable, and standard ordinary least square methods (and quintile regressions) can be employed. However, in CV surveys with an open-ended elicitation question, researchers often face a large proportion of zero WTP responses, some of which reflect true negative WTP, which is then censored at 0; others are protest zeros, and still others are true, valid zeros. In such a situation, *censored regression models* (Tobit, for example) should be used.
b. In the case of a simple binary (dichotomous choice) elicitation question to a given cost of quality improvement, a random utility-based method provides the underpinnings of the estimation approach. The probability that the respondent agrees to pay $\$R$ for the quality improvement is written in terms of a utility comparison:

$$\Pr(\text{yes to } \$R) = \Pr(V(p^W{}_0, p^Z{}_0, Q_1, I_0 - R; H_i) + \varepsilon_i > V(p^W{}_0, p^Z{}_0, Q_0, I_0 \,;\, H_i) + \varepsilon_i)$$

Assuming that the error term ei has a distribution function $F(.)$, one can easily derive the familiar expression for dichotomous choice models: Pr(household i says "yes" to $\$R) = F(X_i'\beta)$. Logistic or normality assumptions for $F(.)$ give rise, respectively, to *logit* and *probit* models. Today, these are easily implemented in most statistical software.

c. If double bounded-dichotomous choice formats are used to elicit household WTP, the econometric models become slightly more complicated, but are still easy to implement. Suppose a two-bid format is used, where the first dichotomous choice question is an accept/not-accept $\$R$ offer, with a further offer of $\$(R+d)$ following acceptance, or a counteroffer of $\$(R-f)$ following initial decline. The four possible patterns of answers are summarized below.

		Initial question ($R)	
		Yes	No
Follow up	yes	$\$(R+d)$	$\$(R–f)$
$(+\$d$ or $-\$f)$	no	$R	0

The four possible choices can be analyzed through an *ordered probit* (or *logit*) model, where the true latent (unobserved) WTP is WTP*, and the observed choices are seen as the outcomes of a discrete random variable:

$\Pr(\text{no, no}) = \Pr(R–f > \text{WTP}^*)$,
$\Pr(\text{no, yes}) = \Pr(R > \text{WTP}^* \geq R–f)$,
$\Pr(\text{yes, no}) = \Pr(R \leq \text{WTP}^* < R+d)$, and
$\Pr(\text{yes, yes}) = \Pr(R+d \leq \text{WTP}^*)$.

The coefficient estimates from the double bounded model are assumed to be more efficient (smaller variance of the estimated coefficients) than those from the single bounded estimation model.

3.4.7 Example: Estimating an average willingness to pay for water service improvements in Famagusta (Cyprus)

Korman (2002) used the AE and the CV methods to estimate the willingness of consumers to pay for improved water supply in Famagusta. She stresses that, in the CV survey, consumer WTP for improved municipal water depends on the information widely available about the improvements consumers should expect. Although, in the CV method, estimates of the WTP may be subject to potential biases (hypothetical, strategic behavior, and starting point bias), the guideline recommendations for minimizing these biases are incorporated in the design of her survey. As recommended by the National Oceanic and Atmospheric Administration, Korman implemented the dichotomous choice format because people are familiar with this type of arrangement in their daily lives (Arrow and others 1993). Furthermore, the method minimizes strategic bias and non-response rates. Since respondents are familiar with the nature of the water supply service, it was assumed that hypothetical bias would be minimized.

In particular, Korman used a double bounded-dichotomous choice format to increase the statistical efficiency of her WTP results. The open-ended question followed by the double bounded-dichotomous choice format was used to check for "yea-saying behavior" among respondents to the dichotomous choice format and to observe whether households were consistent in their answers to the WTP questions. By doing this, Korman expected to minimize the starting point bias. Furthermore, person-to-person interviews were employed to decrease sample selection bias and minimize the non-response rate (Arrow and others 1993).

Because the CV method is still open to criticism, various tests were employed to confirm the validity of the method (Carson, Flores, and Meade 2001; Carson and others 1996; Mitchell and Carson 1989). Theoretical validity is measured by examining the relationship between the WTP and the explanatory variables, which are theoretically the determinants of the WTP for the improved water services. Econometric analysis is used to test the theoretical validity of the CV methodology and to estimate the responses of households about any water improvements that might be undertaken by the Cyprus government. Furthermore, a convergent validity test was applied to compare the CV results and the AE method. This test compares the estimated mean and the correlation of the WTP in two methodologies. The data collected during the field survey permitted this comparative analysis.

3.5 Stated choice experiments

Over the past decade, many economists have turned to the methods that are known as stated preference, conjoint analysis, attribute-based methods, or stated choice experiments. These evaluation approaches have their origin in marketing and transportation research studies. Stated preference methods are useful when the objective is to value different attributes of a program or service (Louviere, Hensher, and Swait 2000). In a stated choice experiment, a survey respondent is asked to choose from several options, each of which is associated with a number of characteristics and a price. A series of experiments is presented to each respondent, varying attributes across respondents to provide the necessary variation so as to enable econometric estimation (Hensher, Shore, and Train 2003).

The stated choice provides the basis for estimating the marginal WTP of respondents for each attribute and each service level of the proposed program or service. This approach is useful when the program in question is characterized by a multitude of traits and the policy objective is to choose the optimal combination of traits. In addition, choice experiments can be helpful in predicting behavior. An and others (2002) applied this framework to estimate not only the WTP of respondents for an electricity supply improvement, but also the impact that fuel switching would have on the use of fuelwood and the preservation of wildlife habitat. Carefully designed, the choice experiments can also help alleviate the hypothetical bias inherent in the CV approach.

The framework for analyzing responses to stated choice experiment questions follows the same logic as the analysis of the WTP relying on the three preceding methods, although the model specification is different. In each choice situation, respondents face several options that differ in terms of their service or program attributes, such as the frequency and timing of outages, the level of voltage fluctuations, the existence or non-existence of prior notification of outages, and the price of services. In each choice situation, respondents choose the option that provides the highest level of utility. This choice can be formulated as a standard or a mixed logit model. The latter model incorporates the variation in preferences for different aspects of service quality among customers (Revelt and Train 1998). Hensher, Shore, and Train (2003) offer an accessible discussion of the model's specification and an application to the valuation of drinking water and the service quality of water disposal.

4 WILLINGNESS TO PAY FOR ENERGY SERVICES

4.1 Introduction

Projects and policies that improve the access to reliable, modern energy services can make an important difference in the welfare of the poor. What is the starting point for improving access? What kinds of improvements will poor households and communities value? Answering these questions requires an understanding of how these households obtain and use energy services today both for consumption and productive activities. It is also essential to understand the demand of poor households for better energy services, as well as the willingness of these households to pay for the services.

Traditionally, data collection on these issues was weak because state monopoly providers had limited incentives and capacity to learn about current and potential customers. More recently, policy advisers and donor agencies have attempted to understand the demand of the poor for services and to tailor projects to the preferences of the poor. Nonetheless, there is still a wide gap in the available data.

It is commonly estimated that two billion people lack access to electricity. These people rely on varied energy sources and often incur real costs far higher than those for equivalent energy supplied by electricity networks. Improving the energy sector is, however, not simply a matter of reaching 100 percent electrification. It means providing better options so that the change can involve cleaner, safer, cheaper energy sources and energy markets that are more responsive to the needs and demands of households and communities. Evidence suggests that the poor are, indeed, often willing to pay for better services. The *ESMAP Energy and Development Report* (ESMAP 2000) thus remarks that a major challenge is to open markets so that this demand can be identified and met.

4.2 Consumer choices and the demand for energy

Sound policy analysis entails an understanding of the ways policy interventions (for example, projects, investments, regulations) will affect development outcomes. Causal models are needed to link the improvements in energy infrastructure services with desired outcomes, such as improved household income, health, or well-being. Analysts need to know how policy interventions will affect household decisions and, in turn, energy markets.

Data generated through specialized surveys, a general-purpose LSMS, or the records of utilities can be used to create these causal models. If the information available is sufficiently rich, models of household demand for specific fuel types can be developed. Households consume energy for lighting, heating, water heating, cooking, and so on, often employing different types of fuel (electricity, wood, central gas, liquid propane gas, kerosene, dung, and so forth) for each of these activities. Household demand models can potentially explain household fuel choices, as well as the quantities of each fuel type applied, as a function of fuel prices, household income, and other socioeconomic factors. Panel data from repeated surveys are particularly helpful for evaluating the effects of policy interventions over time.

The econometric work associated with using surveys on prices and quantities, as well as socioeconomic information, to estimate household demand functions can be challenging and will vary from country to country. Infrastructure policy analysts need to ensure that there is variation in the prices of fuels (electricity) that results from changing cost conditions in order to identify the demand function. Nationally uniform tariffs may limit (spatial) price variation. Also, expanding the block tariff structure poses difficulties because the marginal and average price a household pays depends on the household's own decision about how much to use. At a minimum, the estimation of demand functions will necessitate the gathering of data on the tariff structures applied to different households in the survey sample. The complete modeling of household fuel choices and quantities often requires information that is unavailable, such as information on the prices of all types of fuels (including those not currently adopted by the household), the quantity of the chosen fuel type actually consumed, the access to or constraints on each type of fuel, the socioeconomic characteristics at the household and local (village) levels.[8] Even time-series econometric analysis relying on aggregate variables needs at least 20 years of data on electricity sales, the marginal prices of the electricity sold, and the prices of alternate fuels, as well as weather and economic data (for example, income). Sufficient data are often not available; electricity supply may be constrained, and other statistical issues arise, such as the identification problem. It may also not be possible to relate the resultant parameters of the econometric analysis based on a relatively large group of existing consumers, say, on the country level, to the consumer group under investigation. Therefore, the econometric approach to demand estimation is usually employed sparingly. However, there are various alternative strategies that the analyst can pursue in order to estimate the costs and benefits of infrastructure and policy interventions. These clearly depend not only on the nature of the policy action to be assessed, but also on the type and richness of the data on hand.

The approach that is frequently taken in practice for policy or project evaluations is simple. It consists of calculating the consumer surplus (CS in the equation) on the basis of a linear electricity demand function.[9] Say that (p_0, q_0) represents the average price for electricity and the quantity consumed by a representative household at time 0 in a particular geographic area. The second average data point (p_1, q_1) can be obtained, for the same area, at a later date (time 1), say, after a change in the tariff structure. This information should be readily available from the utility supplying the electricity. Consumer surplus of this change is then estimated as:

$$CS = 1/2(p_1 - p_0)(q_1 - q_0),$$

and is simply the area beneath the linear demand function, between q_1 and q_0. The consumer surplus in this case provides an approximation of the change in the welfare of the representative household that results from the change in the electricity price from p_0 to p_1.

Note, though, that the same approach can, in principle, also be adopted to assess the value to the consumer of electrifying a zone with no electricity. In this case, think of the second data point, (p_1, q_1), measured at time 0, but for a village where electricity is not available. The price and quantity refer now to an alternative source of energy consumed (converted to electrical units), kerosene, for example. The consumer surplus in this case provides a rough measure of the WTP for electrification (ESMAP 2002). Once again, the observation of household (aggregate) behavior with respect to an alternative energy source supplies the missing (non-market) information for a simple estimate of the electricity demand.

Clearly, the measurement of WTP here rests critically on a reliable estimate of the electricity demand function. A major weakness of the approach in (5) lies in its reliance on a linear demand function; the use of the function has no theoretical basis and is mainly a matter of convenience.

Choynowski (2002) presents an alternative approach to deriving the demand for electricity[10] and proposes a plausible semilog functional form, which is easy to estimate, is consistent with the underlying microeconomic theory, and readily lends itself to a calculation of the economic benefit of electricity provision.[11] Note, however, that, even with this generalization, the present approach is quite different from the econometric estimation of an electricity demand function, which, when employed for predictive purposes (ex-ante analysis), is generally based on more than only two data points. Moreover, while the two-point approach is useful in ex-post assessment exercises at the aggregate level and when the more demanding approaches are not viable, it remains limited in its utility for a social and poverty impact analysis of the policy change in terms of various subgroups in the population.

A number of studies have attempted to evaluate the welfare effects of utility privatization and the resulting price and access changes. For example, a recent WIDER project sponsored a series of studies to evaluate the welfare effects of utility privatization in Latin America. For simplicity, some studies assumed linear or perfectly inelastic demand (Waddams Price and Hancock, 1998; Waddams Price and Young, 2001; Barja and Urquiola, 2001), while others estimated consumer surplus for a range of demand elasticities (Freund and Wallich, 1995; Delfino and Casarin, 2001; Torrero and Pasco-Font, 2001). McKenzie and Mookherjee (2003) obtained electricity demand elasticity estimates from a complete demand system and calculated the equivalent and compensating variation of the price changes and access provision. While the approach that relies on assumed or estimated elasticities is helpful for evaluating the welfare effect of a price change or the provision of access to a new service, it is of limited benefit in the evaluation of service quality changes.

Two other general approaches make use of survey data to estimate the costs and benefits of infrastructure investments and policy interventions, including the interventions that affect service quality. The first and simplest approach is to use data on the household costs of coping with unreliable services as a measure of the benefits of service quality improvement (see section 2, for an example involving water). The argument is that, if service quality is improved, households experience economic benefits in the form of cost savings because they no longer have to spend financial resources trying to cope with unreliable services. In general, such avoided coping costs will be a lower bound on the magnitude of the economic benefits of service improvements.

The second approach relies on stated preference data. In special circumstances, it may be possible for an energy or infrastructure analyst to consider a stated preference questionnaire for inclusion in the specialized or LSMS-type survey and to question respondents directly about their demand (willingness to pay) for improved services. For example, respondents could be asked if they would agree to pay a specified monthly increase in their electricity bill in exchange for improved service reliability. Alternatively, choice modeling techniques might be employed to explore the conditions under which a household would switch its fuels for different uses.

4.3 Willingness to pay for improved energy services

The estimation of the value of service quality improvement in the electricity sector goes back to the late 1970s and the 1980s. The early studies relied on several approaches to value a reduction in outages, voltage fluctuations, and improvements in system reliability (Caves, Herriges, and Windle 1990). The methodological approaches ranged from examining the cost of backup generators and the valuation of lost commercial or home production by firms or households to stated preference methods. Recent studies have adopted a stated choice experiment framework to provide a marginal valuation of a range of service attributes (Goett, Hudson, and Train 2000). Nearly all the early and recent studies have valued the costs of unreliable services and occasional outages in developed countries, where the nature of the outages tends to be different from those in the developing countries.[12]

Outages have short-run and long-run effects on household electricity consumption. In the short run, during an outage, households incur losses from not being able to turn on their electric appliances to produce lighting, heating, or cooking services. If they rely on backup equipment during outages, they will incur an associated cost. The same is true for firms. While they are likely to incur higher outage costs in the short run, they adjust production methods over the long run to minimize the losses borne during outages. The optimal electricity reliability literature and energy demand modeling studies have long recognized the existence of these costs and have applied them as proxies for the WTP to avoid outages (Pasha, Ghaus, and Malik 1989; Matsukawa and Fujii 1994; Beenstock, Goldin, and Haitovsky 1997). Sanghvi (1983) and Westley (1984) have shown that studies that apply this approach in a context in which adaptive response is possible substantially underestimate the WTP to avoid blackouts.

Outages are associated with short-run costs, which are reflected in the outage costs, as well as with the long-run costs of coping with unreliable electricity supply. The coping methods may include a search for electricity substitutes, the purchase of non-electric appliances, fuel switching, or other behavioral adjustments. The total shortage costs consist of the expected outage costs and the adaptive response costs, which is the way Sanghvi (1983) refers to the coping costs. Due to the presence of the shortage costs, the WTP for each unit of unreliable electricity supply is lower than it would be if the supply were more reliable, even if fuel switching does not take place. This implies an outward shift of the electricity demand curve associated with an improvement in supply.[13] Sanghvi (1983), Dias-Bandaranaike and Munasinghe (1983), and Westley (1984) contend that ignoring the demand curve shift can bias the results by grossly underestimating the benefits of a reliability improvement and of the optimal level of reliability.

4.3.1 WTP of firms for electricity service improvement

Two recent studies provide an illustration of the use of stated and revealed preference techniques in welfare evaluation in the energy sector. A recent World Bank (2001) study uses a revealed preference approach to evaluate the impact of policy reforms in the power sector on agriculture in India. The analysis is conducted at the farm microeconomic level, within a partial equilibrium framework, and focuses on the impact of policy reforms on production costs, yields, cropping patterns, the demand for electricity, and farm incomes for various categories of farmers (classified as marginal, small, medium, and large). To evaluate the impact of policy reform quantitatively at the microeconomic level, an econometric model based on data on the observed choices of farmers is employed. This predicts what farmers are likely to do when the policy changes occur. The study does not rely on CV methods to elicit responses and the WTP for the changes in policy. The report acknowledges the potential advantage of the CV approach in eliciting such information on a given hypothetical situation without the need to extrapolate from past behavior. However, it discards such an approach on the grounds that "earlier studies have pointed out that responses are very sensitive to the manner in which the questions are phrased and upon the timing of such a survey vis-à-vis the household's recent outage experience" (World Bank 2001, page 9).

Another recent study by the Energy and Resources Institute (TERI) in New Delhi relies on a variety of stated and revealed preference techniques, and estimates the WTP of firms for improved energy supply in Haryana and Karnatala (TERI 2001). TERI surveyed about 500 manufacturing industries and 900 farmers in each of the two Indian states using pre-tested schedules on a stratified sampling basis to collect primary data for the calculation of the cost of unserved energy (CUE).

The starting point of the study is the recognition that the power sector in many developing countries is characterized by administered prices, a high level of cross subsidization, low recovery of revenues, and strong political influence. In such a scenario, it is difficult to arrive at an acceptable restructuring of tariffs because the market gives only limited indications of the burdens that can be borne by different segments. In these circumstances, estimates of the value of electricity and the CUE are important for both investment planning and tariff-setting.

This study was undertaken in the two Indian states in order to provide guidance to decisionmakers regarding consumer perceptions of the quality and availability of power supply, as well as their willingness to pay different or higher tariffs for improved power supply. The study implemented three methods to estimate the CUE.

- The value of the production lost for each unit of power outage (*production loss method*);
- The cost of alternative or backup power generation (*captive generation method*); and
- The WTP for reliable and uninterrupted electricity supply (*WTP method*), that is, a CV analysis.

These methods each have advantages and limitations (see below). Obtaining relevant information by surveying a number of farms and industries is crucial for the implementation of the methods.

The production loss method

With the production loss method, one looks at the value of the production loss that can be attributed to the interruption (or other poor quality indicators) of power supply to estimate the CUE. In the agricultural sector, the production loss method derives the CUE based on the incremental crop output not realized (opportunity loss) due to the non-availability of power for irrigation. The production loss method gives the maximum amount that a consumer can pay, which may be interpreted as the upper bound on electricity tariffs. A problem with the method is that adjustment processes are not accounted for in the responses, with the result that the CUE is often overstated. For example, industrial enterprises that suffer from power cuts will seek to minimize the outage effects by rescheduling production to other periods. Similarly, agricultural users can often reschedule the use of pump sets. These rescheduling possibilities are not incorporated into the estimates respondents make of their lost production. A further disadvantage of the method is its reliance on the recall ability of respondents. The value of losses may also often be overstated because the entire loss of production is attributed to the power cut. Moreover, the industries surveyed may be able to offer estimates of the loss in revenue, but may not be able to estimate the loss in value added.

Despite these limitations, the production loss method provides an estimate of the upper limit on the electricity tariffs that the firms would be willing to pay.

The captive generation method

Deriving the CUE by the captive generation method is based on gauging the cost incurred by the consumer due to the use of standby energy generation. In other words, the average economic costs of backup power generation by captive units in industries provide an estimate of the CUE. In agriculture, the cost of supplying an equivalent amount of water using diesel pumps gives estimates of the CUE by way of the captive generation model.

The CUE obtained through this method supplies an indirect estimate of the tariff a consumer will be willing to pay for electricity. The assumption is that, if a consumer is willing to undertake self-generation, s/he would be willing to pay at least the cost of self-generation as the price for grid power. This is similar to the assumption underlying the revealed preference approaches discussed for water (see elsewhere above).

This approach too, has limitations. On the one hand, it may yield an overestimate in that consumers may be willing to pay the estimated price only for a fraction of the units (those generated during the power cut), but not for all the electricity units in the required production process. In other words, the captive generation method only estimates the CUE at the margin. On the other hand, the price may be underestimated, as some of the costs cannot be monetized, for example, the additional investment required, the inconvenience of the hot air and noise from the generator, and the additional responsibility of manipulating the generator. Moreover, the price is generally only applicable to consumers with an available backup supply. Despite these limitations, the captive generation method provides a lower bound on the tariff a consumer is willing to pay at the margin.

Contingent valuation methods

The consumer is willing to pay an amount that lies between the upper bound (production loss method) and the lower bound (the cost of alternative generation). The WTP approach measures the price the consumers are willing to pay. The WTP is established through CV methods (estimating consumer WTP in a hypothetically improved power supply scenario) based on a bidding game approach.

Relative to the other two methods, the main advantage of the CV method is that it generates a comprehensive measure of the total value of electricity supply to consumers. The success of the method in estimating the WTP depends on the extent to which respondents are well informed and are able to assess the total value of the electricity and the services provided.

This approach is also subject to limitations. It is highly dependent on questionnaire design and the understanding respondents possess of the hypothetical scenario (see Box 2 for an example).[14]

The value of the CUE estimated by the CV method is usually above the estimates derived through the captive generation method and below the estimates derived through the production loss method. However, in developing countries, due to the significant share of poor people, the value is also influenced by consumer *ability* to pay. Notwithstanding the limitations, this method helps to narrow the range between the upper and lower limits on electricity tariffs and provides insights for a more practical policy on electricity tariffs.

TERI survey results

In industry, the three analytical methods applied by TERI (2001) gave different estimates of the CUE. For example, in Haryana state, the estimates were rupees (Rs) 7.15 per kWh with the production loss method, Rs 3.38/kWh with the captive generation method, and Rs 5.16/kWh with the WTP method. As the actual tariff per kWh is only Rs 3.6, there is room for a tariff increase according to the methods as long as this is accompanied by improved service quality.

As expected, the CUE estimates generated through the WTP method are higher than those based on the cost of captive generation for industries, but less than those based on the production loss method. The CUE estimated by the production loss method was also quite different in the two states. This reflects:

a. Differences in the percentage share of industries that had installed captive generation capacity (and were thus less reliant on grid supply);
b. Differences in the value added per unit of output; and

c. The diversity in product manufactured and in production processes (which also had an effect on the confidence intervals of the mean CUE).

The estimates of the CUE by way of the captive generation method were similar in the two states; the cost in low tension industries was found to be greater than the cost in high tension industries.

Box 2. A Sample Questionnaire on WTP for Energy Supply Improvements for Farms (Teri 2001)

Scenario Description (Interviewer to Read Out)

"As you are aware, businesses in this state face problems of power supply. Some companies make do with their grid supply, while others rely partly or wholly on captive generation. As things stand, you pay a certain amount for grid supply, as well as paying for any damage due to voltage fluctuations and interruptions to supply. You may also pay for standby or captive generation, which can be far more expensive per kWh than grid supply.

"An improved electricity supply may increase your company's productivity. However, if output is to be increased, you will incur costs besides the cost of electricity. Looking to the future, it is possible to fix the problems of restricted and poor quality grid supply. To do this will require significant new investment in generation, transmission, and distribution. This new investment is expensive, and the cost would have to be recovered through the electricity tariff."

[The question numbering below is the same as in TERI 2001]

24. "We do not yet know exactly how much this investment would cost, but I would like to know if you agree in principle with paying for an improved grid supply?"

24.1 ❑ Yes 24.2 ❑ No If No, Go to Question 29

Bidding Game

25. "Now I am going to read you some costs per kWh that a stable and uninterrupted electricity supply might cost you. There would not be any other charge for supply. Please tell me if you would be willing to pay this amount for the improved service. Please do not agree to pay if your company cannot afford it or if you feel there are other things that are more important for you to spend money on."

Rs/kWh	[4 or x]
8.00	
2.50	
7.00	
3.00	
6.00	
3.50	
5.50	
4.00	
5.00	
4.50	

Box 2. A Sample Questionnaire on WTP for Energy Supply Improvements for Farms (Teri 2001)-continued

26. "Do you have any preference for the power supplier?"

26.1 ❑ SEB 26.2 ❑ Private agency 26.3 ❑ Any other (specify) 26.4 ❑ Indifferent

27. "Is the answer to 11.2 [that is, the current tariff] equal to or higher than the highest number ticked in question 25?"

27.1 ❑ Yes 27.2 ❑ No If Yes, continue. Otherwise, Go to Question 30.

Read Out: "From the figures you have given us, it appears that you are currently paying [from 11.2] per kWh for grid supply. You have also said that you are not willing to pay more than this for the improved electricity supply we have described. Is this really the case, or would you like to revise the amount you say you would be willing to pay for improved supply?"

28.1 ❑ No change 28.2 ❑ Revise bid. If No Change, Go to 29. If Revise Bid, Ask:

28.3 "So what is the maximum you are willing to pay per kWh for a stable and uninterrupted electricity supply?" Rs/kWh________

If 28.3 Completed, Go to 30

29. "Please, could you give the reasons why you are not willing to pay more for the improved electricity supply?"

(Interviewer to code various reasons.)

Code	Mark a tick	Reason
01		Cannot afford to pay (threat of bankruptcy)
02		Do not believe they would get improved supply
03		Demand is already met from self-generation
04		Can meet additional demand from self-generation at lower cost
05		Believe the current tariff is already above the cost of grid supply to industry
06		Believe the current tariff is above the industrial tariff in other states
07		Other (please specify)

30. "Which of the following statements *best* describes the way you felt when we described the option of an improved supply to you?" [Tick One Only]

30.1 The introduction of new investment in the electricity sector in this state has a good chance of improving the electricity supply.
30.2 This new investment may improve the electricity supply, but it will take so long to produce benefits that it is not worth much to me.
30.3 I just did not believe that the system for improved supply you described could be introduced or made to work in our state.

Some of the known difficulties were encountered in the WTP method. Thus, a percentage of the industries surveyed did not believe that a scenario of improved power supply (reliable and good quality; see the questionnaire in Box 2) from the grid was possible. Of those who accepted the scenario, only about half were willing to pay more than they currently paid. (The estimated WTP is about Rs 5.2/kWh in both states.) The industries unwilling to pay more expressed concerns that the current cost was unaffordable—the industrial tariff was already above the cost of supply—and stated that they would rather rely on generation. Probit regressions were used to analyze the factors correlated to the willingness of the industries to pay more (yes/no answer). The variables that tended to be associated with the decision to bid for improved electricity supply were:

a. The small share of electricity to total cost;
b. The low tariffs/prices compared to other states;
c. The type of industry and its sensitivity to continuous electricity supply;
d. The experience of high levels of unscheduled outages; and
e. The unofficial payments to state electricity boards for power restoration.

The results highlight the factors to be addressed so that consumers can be persuaded to pay higher tariffs. These factors include institutional issues (such as unofficial payments made to a utility's staff) and factors related to the quality of electricity supply. In particular, the study underlines the urgent need to address unscheduled outages, followed by scheduled outages and voltage fluctuations; consumers should be provided with better information about supply so they can plan their industrial activities accordingly and limit their production losses.

4.3.2 Willingness of households to pay for energy service improvements

The production loss method and the captive generation method cannot easily be applied to households. The first method requires an estimation of the value of production in the home and the contribution of energy as an input to this production process. Residential outage costs are the market value of services lost due to an interruption. However, obtaining the market value of these services is difficult. Since households are able to shift household production to a time when electricity supply is restored, the production loss calculation is complicated further (Caves, Herriges, and Windle 1990). The second method is based on the premise that a household will respond to poor service reliability by using backup generation equipment.[15] The purchase and operating costs of this equipment provide a measure of the losses due to poor service reliability. While this is a reasonable approach to estimate the losses of firms, many households do not own backup generation equipment. It may thus be more useful to obtain information on the amounts households spend on electricity substitutes so as to adjust to poor supply quality or lack of supply.

CV methods can be applied to households, as well as to commercial and industrial sectors in order to estimate the value of the improved reliability of energy services. However, the application of these methods in the case of energy is less straightforward than it is in the case of water. People are not used to thinking of electricity consumption in terms of kilowatt hours, whereas they are familiar with the measurement of the consumption of water in terms of, for example, buckets. As a result, the questions about consumption levels at different prices in the TERI (2001) survey had to be phrased in terms of capacity rather than kWh. An and others (2002) were faced with a similar problem when some of the survey respondents in China did not understand how a range of prices per kWh would translate on a monthly electricity bill. If respondents do not have a clear understanding of the unit of measurement, this can become a serious weakness of a CV study. In a CV survey of households in Azerbaijan, Lampietti and others (2004) posed questions about consumption levels at different prices in terms of the hours of use of each electric appliance rather than in terms of total monthly kilowatt hours.[16]

A range of service attributes may be important in electricity sector reforms, and a service quality improvement cannot always be captured by one characteristic. A survey of Azeri households (Lampietti and others 2004) revealed that low voltage is nearly as important an obstacle to the use of electric appliances as are outages. Stated choice experiments are particularly useful for eliciting the marginal WTP for different service attributes. An and others (2002) applied this framework to estimate electricity demand and to predict the likely impact of a reduction in voltage fluctuations and in outage frequency on fuelwood use. Box 3 briefly presents this study of *willingness to switch* between energy sources (from fuelwood to electricity), with implications for giant panda habitat conservation in China. The marginal WTP for a reduction in voltage fluctuations and outages can easily be calculated once the demand function and the parameters on service quality variables are known. Thus, stated choice experiments, if carefully designed, permit the analysis of a range of policy issues and the tradeoffs faced by households.

Since stated choice questions tend to be more complicated than the WTP questions, it is critically important to conduct focus group discussions and other qualitative work prior to finalizing the survey instrument. This preparatory work helps to specify properly the attributes of a service or program that is being evaluated, as well as the so-called levels of each attribute. (Levels are the ranges that characterize each attribute.) For example, the attributes might include the outage levels, voltage fluctuations, the provision or non-provision of prior notification of an outage, and the price levels that are used in the various versions of choice experiments.

5 CONCLUDING REMARKS

To estimate the value of improved water or energy supply, analysts need to elicit the preferences of beneficiaries (or the consumer demand for the good). This is more difficult in cases where the analysis cannot rely on price and quantity data on the goods and services involved. In these cases, analysts have to resort to alternative, non-market strategies to elicit the necessary information for a cost-benefit analysis.

This paper has reviewed two main approaches available when the standard estimation of the demand system is not viable: the *contingent valuation* (or *stated preference*) *approach* and the *coping cost method* (or *revealed preference* in a surrogate market). Examples of how to conduct each type of analysis have been provided with reference to policy interventions aimed at improving the supply of water and energy in developing countries.

The paper suggests that contingent valuation and coping costs methods are useful tools for the evaluation of water and energy projects. This is so particularly when analysts are aware of the technical and practical issues to be confronted before these non-market preference-elicitation techniques may be trusted.

Box 3. Modeling the Choice of Households to Switch between Energy Sources

Despite its status as a nature reserve, Wolong Nature Reserve (China) has experienced continued loss of giant panda habitat due to human activities such as fuelwood collection. Though available throughout Wolong, electricity has not replaced fuelwood as an energy source. A recent paper by An and others (2002) relied on stated preference data obtained from in-person interviews to estimate a random utility model of the choice of adopting electricity for cooking and heating. The goal of the study was to estimate the demand for electricity under different conditions of price and quality, as well as to relate the demand to demographic characteristics. Although critical for the approach undertaken, adequate market data spanning these conditions were unavailable. For example, the amount of electricity employed by each household was not accurately recorded or not available in some areas, and the variation in electricity prices was small. Stated preference techniques were applied to overcome this problem.

Willingness to switch to electricity was explained by demographic and electricity factors such as price, voltage, and outage frequency. In particular, the differences between the current value of these energy variables (that is, in the status-quo fuelwood-use scenario) and the hypothesized scenario (switching to electricity) were adopted as crucial explanatory determinants of the willingness to switch. The results suggested that lowering electricity prices and increasing electricity quality (mainly the voltage levels) would encourage local residents to switch from fuelwood to electricity and should be considered in the mix of policies aimed at promoting panda habitat conservation.

Contingent valuation surveys are now becoming relatively easy and more straightforward. The survey response rates are typically high in developing countries where respondents are receptive to listening to and considering the questions asked. Moreover, it is much cheaper to carry out in-person surveys and therefore to assemble larger sample sizes in developing countries than it is in industrial ones. Assuming a thorough survey is undertaken, CV methods can provide analysts with good data on the willingness to pay and on the potential revenues for various levels of service. They can thus guide tariff subsidy and cost recovery policy. Another advantage lies in the similarity of the CV to public opinion polls, which means that results are conceptually easy for non-specialists and politicians to understand. Overall, it seems increasingly feasible and desirable to use CV studies in developing countries to help evaluate a wide range of projects. However, CV researchers should apply caution in the design and implementation of the survey and take into account the specifics relating to a particular cultural and ethical setting.

Coping cost methods also supply reasonably accurate estimates of current time and cost expenditures. The coping costs avoided will generally represent a lower bound on the magnitude of the economic benefits of service improvements and, hence, of willingness to pay, reflecting the fact that often only a fraction of the actual coping costs are observed by the analyst. If a lower bound estimate of benefits is greater than the costs of the intervention, this benefit estimate can prove especially helpful. On the other hand, the data and analysis requirements tend to be relatively modest.

The importance of cross-validating the WTP results with the two approaches has also been highlighted in the paper as an example of best-practice strategy whenever this is a feasible option for the analyst.

While the usefulness of revealed and stated preference techniques for valuing non-market goods has been the main focus of the paper, this should not be taken as an attempt to dismiss more traditional and relatively well-known techniques for estimating a demand curve for water and energy services based on market price-quantity data. On the contrary, if it is practical for analysts to employ them, for example, when a rich and detailed dataset is available, then these techniques are likely to offer a more consistent, more reliable, and probably less controversial framework for analysis. However, the conditions necessary for the appropriate application of these methods (mainly, but not only, the required information base) are unlikely to be met in practice in most developing countries.

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NOTES

[1] *For instance, a study by Lampietti and others (2001) has analyzed the scope and consequences of recent utility pricing reforms in both the water and energy sector in Armenia. The motivation of the analysis, which was undertaken using some of the techniques discussed in this paper, was to understand how cost recovery efforts in water and electricity affect the poor, the challenge for the government of Armenia being to strengthen the financial stability of the utilities, while improving service quality and minimizing the potential welfare burden of these efforts on the poor.*

[2] *Here "costs" refer to the costs incurred by the state (or private agency) that will undertake the project or policy intervention, while "benefits" are the benefits accruing to the final service users (for example, consumers) and should actually be thought of as* ***net*** *benefits (that is, net of the costs incurred by the final users themselves).*

[3] *The assessment of a more comprehensive notion of costs that also includes, for example, externalities, or non-use value in the case of environmental goods, remains a more difficult issue. In the case of public goods (for instance, turning a natural area into a public park), some of the infrastructure costs (for example, building costs) might still be easily computed; others, however, such as those generally referred to as "negative externalities," are much more difficult to evaluate. The park might, for instance, subtract pasture opportunities from a nearby farm or have a negative impact on wildlife conservation. These costs, too, might be computed in principle, but arguably more controversially and with a smaller degree of confidence than in the case of standard types of costs. Similarly, some of the benefits might be easily estimated (in the park example, the travel costs saved by local households that now find a closer recreational area or tourist-related earnings for the local community), but other types of benefits, such as those*

reflecting the "intrinsic" value of the park for the community of beneficiaries involved, as well as the "positive externalities" of less air pollution and better air quality, are of more difficult assessment in money terms.

[4] *For a basic discussion of such issues, see Boardman and others 2001.*

[5] *For example, a quasi-public good such as public water provision as opposed to pure-public goods such as a remote wilderness area or the overall level of air quality. CV methods are usually the only feasible methods for including passive use considerations in the economic analysis of environmental goods or for assessing pure public goods.*

[6] *A specialized survey as opposed to an LSMS-type survey, non-survey information, data from the records of the utilities, and so on.*

[7] *However, often the price paid does not reflect consumer benefit or the willingness of consumers to pay on account of various market distortions (for example, taxes and subsidies) that further complicate, both conceptually and econometrically, the demand estimation based on observed price and quantities. See, for example, Hentschel and Lanjouw 1997.*

[8] *For an example of a detailed state-of-the-art questionnaire on household energy usage that assembles potentially all the information required for a complete household microeconometric model (including CV modules), see the Azerbaijan Household Energy Survey (Lampietti and others 2004).*

[9] *By definition, consumer surplus, plus revenue, equals gross economic benefits (or willingness to pay).*

[10] *As Choynowski (2002) stresses, the demand for energy is a derived demand and is essentially an input into the production of services from a stock of electricity-consuming equipment in the household. As such, it should not enter directly into the household's utility function, but indirectly, through the user cost associated with the services produced by the electricity-consuming equipment.*

[11] *In particular, it features a negative relationship between price and quantity and, unlike many single equation and demand system models, also allows for the possibility that the demand may be finite even at zero price. Moreover, it does not assume a constant price elasticity. The functional form is written* $ln(q) = a+bp$*, where a and b are parameters to be estimated. Economic benefit (EB in the equation) is simply the area beneath the (nonlinear) demand function. It can be reckoned as* $EB = q_1(p_1 - 1/b) - q_0(p_0 - 1/b)$.

[12] *Two exceptions are an early study by Dias-Bandaranaike and Munasinghe (1983) that valued an improvement in service reliability in Costa Rica and a recent study by An and others (2002) that conducted stated choice experiments to value a service reliability improvement and the implications of the resulting fuel switching for a giant panda habitat in China.*

[13] *The area between the two demand curves provides an approximation of the true welfare change when the weak complementarity assumption is satisfied. In this setting, this assumption means that the welfare level of those households that do not consume electricity is not affected by a change in the quality of supply. If this assumption is not satisfied, then the area between the demand curves for electricity at the original and improved quality levels does not capture all of the welfare gains from a quality improvement, and this area has no welfare significance. It is implicit in the analysis of Sanghvi (1983) and Westley (1984) that the weak complementarity assumption is satisfied.*

[14] TERI (2001) notes that, in the agriculture sector, this difficulty was faced because most of the farmers were not used to kWh billing. As a result, the questionnaire had to be designed for capacity (hp) based tariffs. The responses received from respondents showed that, while a significant number of farmers were willing to pay more on a per hp basis, the same did not hold true on a per kWh basis. As the additional hours of power demand were factored into the analysis with the bid levels, only an insignificant number of farmers were found willing to pay more on a kWh basis. As a result, no statistically significant conclusions could be drawn in the agriculture sector through this method.

[15]Matsukawa and Fujii (1994) found that few residential customers in Japan owned backup generation equipment. They had to narrow their study of outage costs to industrial and commercial customers.

[16] The 2003 Azerbaijan Household Energy Survey (Lampietti and others 2004) was conducted as part of a World Bank poverty and social impact analysis of proposed reforms in the electricity sector. The first objective of the survey was to provide a measure of the WTP for a reduction in outages. The second objective was to supply information about hypothetical quantity demand at a range of prices so as to enable the estimation of electricity demand. It was important to ask questions about the quantities respondents would consume at the new prices after the implementation of the future reform, assuming a perfect reliability level. Questions about the hours of use of appliances were clearer to respondents than were questions in terms of monthly electricity consumption in kilowatt hours. Since access to electricity is universal in Azerbaijan (though service quality has deteriorated in many rural areas in the last decade), Azeri households are familiar with electricity as a service and are accustomed to a range of electric appliances. However, even the questions in terms of hours of use of each appliance turned out to be too hypothetical for those households that have become accustomed to the poor quality of electricity supply in some rural areas in the last 10 years. Many households could not answer the questions because they did not believe the scenario of a service quality improvement, because they were angry at the possibility of a price increase, or simply because they were no longer used to operating their electric stoves and heaters.

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