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Pricing Water and Sanitation Services

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Background Paper on Pricing Water and Sanitation Services

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1. Introduction

A tariff is an important management tool that can be used to assist with efforts to improve the delivery of water and sanitation (W&S) services. The pricing of W&S services is, however, controversial, and it is important to understand why there is so little consensus on water and sanitation tariff issues. There are four main reasons. First, there is disagreement over the objectives of water pricing and tariff design. Water pricing decisions affect several different objectives or goals of policymakers, often in conflicting ways. This means that if one person is looking solely (or mostly) at the consequences of a particular water pricing policy in terms of one objective, and another person is looking at the same water pricing policy in terms of its impact on another objective, they may reach quite different conclusions about the attractiveness of the pricing policy.

Second, because people do not generally know what it costs to provide W&S services, it is difficult for them to judge what is a "fair" or appropriate price to pay. Third, there is disagreement over what would actually happen if different water tariffs were implemented. The empirical work is often lacking that would enable someone to know with reasonable confidence how changes in water prices would affect the quantity of water that different customers would use and whether or not price changes would affect customers' decisions to connect (or stay connected) to the water distribution system.

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Fourth, although there is some competition in the water market, there is no market test for different water tariff structures. Many tariff structures are feasible and can partially accomplish some of the competing objectives of water pricing. There are typically an insufficient number of providers of piped water services for customers to reject inappropriate tariff structures. Bad ideas thus do not get weeded out of either sector practice or policy discussions. Even in different private sector participation arrangements, water tariff structures are typically set by the regulatory agency, and the private sector operator has to treat them as a given and manage the system as best he can (given this constraint).

The purpose of this paper is to provide the reader with a better understanding of the main issues involved in the design of W&S tariffs. Section 2 summarizes the costs of providing piped W&S services. Obviously these costs vary widely depending on local circumstances, but the presentation of some estimates different components of the costs of providing such services illustrates that they are not cheap. Section 3 discusses alternative development paths for moving from low levels of W&S service (or no service at all) to modern piped services, and shows the costs associated with various incremental changes. Section 4 presents the four main objectives of tariff design. Section 5 summarizes the main tariff options. Section 6 describes the basic ideas of dynamic marginal cost pricing in the W&S sector and illustrates how a two-part tariff can be used to achieve both economic efficiency and cost recovery objectives. Section 7 discusses how subsidies can be best used in the W&S sector to reach poor households. Section 8 offers some concluding remarks.

2. The Costs of Providing Water and Sanitation Services

A key feature of water and sanitation investments is that they are very capital-intensive. The majority of costs are incurred early in the life of the project, and the subsequent stream of benefits (and revenues) occurs over many years. Baumann and Boland (1998) estimate that the ratio of *annual* investment in the U.S. water industry to gross revenues was 0.43 in 1993.[2] Someone (e.g., private investors, government) must take a long-term perspective and put large amounts of capital at risk. If future revenues are needed to pay for the high capital costs in the early years, investors need assurance as to their rights to this revenue stream.

In contrast, poor households in developing countries tend to have high rates of discount (Poulos and Whittington, 2000) and thus short planning horizons. Such households cannot easily make the long-term commitments required to pay for W&S services. They are also uncertain about the prospects for long-term economic growth and their ability to pay in the future. The challenge of W&S tariff design in developing countries must be understood within the context of this fundamental mismatch of perspectives between investors and consumers.

In urban areas there is widespread consensus that the long-term goal of W&S service providers in developing countries should be to offer 24-hour, potable water supply piped into people's homes, to remove wastewater with a piped sewerage system, and to treat this wastewater to a standard sufficient to minimize the environmental effects

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[2] They note, "no other major industry group in the United States even approaches this ratio of annual investment to revenue."

of its discharge to surface water bodies.[3] Even in many "rural" communities, households aspire to this level of service. The treatment and delivery of water to households, and the removal and treatment of the wastewater generated, cost serious money. These costs must be paid by someone—either households must pay, or households must receive subsidies (e.g., from richer households, industries, donors, higher levels of government).

Of course, costs vary depending on individual circumstances, and estimates of what it will cost to provide a certain level of service may vary widely. Also, most investments are incremental in nature. Only rarely would a community incur the costs of complete ("full-service") piped water and sanitation systems at a single point in time. Nevertheless, some rough calculations may prove useful for our discussion of water pricing and tariff design. The approach here is to present some illustrative average unit costs of providing an urban household with modern W&S services. First, I look at representative unit costs per cubic meter for different components of W&S services. Second, I provide some typical quantities of water that different representative households use in a month. Third, I multiply representative unit costs by typical monthly household water use to obtain estimates of the monthly economic costs of providing a household with improved, piped W&S services.

The economic costs of providing a household with modern water and sanitation services are the sum of seven principal components:

1. Opportunity costs of diverting raw water from alternative uses to the household (or resource rents)

[3] Some people in the sector do question the wisdom of pursuing the goal of piped sewerage. See, for example, Esrey and Andersson (2000).

2. Storage and transmission of untreated water to the urban area
3. Treatment of raw water to drinking water standards
4. Distribution of treated water within the urban area to the household
5. Collection of wastewater from the household (sewerage collection)
6. Treatment of wastewater (sewage treatment)
7. Any remaining costs or damages imposed on others by the discharge of treated wastewater (negative externalities).

Table 1 presents some illustrative average unit costs for each of these seven cost components, expressed in U.S. dollars per cubic meter. The unit costs of these different cost components could vary widely in different locations. For example, in a location with abundant fresh water supplies, item 1 (the opportunity cost of diverting water from existing or future users to our illustrative household) and item 7 (the damages imposed by the discharge of treated wastewater) may, in fact, be very low or even zero. However, in more and more places these opportunity costs associated with water diversion and the externalities from wastewater discharge are beginning to loom large.

Some cost components are subject to significant economies of scale, particularly storage and transmission (item 2), the treatment of raw water to drinking water standards (item 3), and the treatment of sewage (item 6). This means that the larger the quantity of water or wastewater treated, the lower the per-unit cost. On the other hand, some cost components are experiencing diseconomies of scale. As large cities go father and farther away in search of additional fresh water supplies, and good reservoir sites become harder to find, the unit cost of storing and transporting raw water to a community increases.

There are also tradeoffs between different cost components: one can be reduced, but only at the expense of another. For example, wastewater can receive only primary treatment, which is much cheaper than secondary treatment; but then the negative externalities associated with wastewater discharge will increase.

The cost estimates in Table 1 include both capital expenses and operation and maintenance expenses. The opportunity costs of raw water supplies (item 1) are still quite low in most places, on the order of a few cents per cubic meter. Even in places where urban water supplies are diverted from irrigated agriculture, the unit costs will rarely be above US$0.25 per cubic meter. Desalinization and wastewater reclamation costs will set an upper limit on opportunity costs of raw water of about US$1.00 per cubic meter for cities near the ocean, but the opportunity costs of raw water are nowhere near this level in most places.

Raw water storage and transmission and subsequent treatment (items 2 and 3) will typically cost US$0.30 per cubic meter. Within a city the water distribution network and household connections to it (item 4) comprise a major cost component, in many cases on the order of US$0.75 per cubic meter. The collection and conveyance of sewage to a wastewater treatment plant (item 5) is even more expensive than the water distribution; this will cost about US$1.00 per cubic meter, 40% of the total cost. Secondary wastewater treatment (item 6) will cost about US$0.35 per cubic meter. Damages resulting from the discharge of treated wastewater are very site-specific, but environmentalists correctly remind us that that they can be significant, even for discharges of wastewater receiving secondary treatment. Let us assume for purposes of illustration that these costs are of the same order of magnitude as the opportunity costs of raw water supplies (US$0.05).

As shown, total economic costs are about US$2.50 per cubic meter in many locations. I emphasize that costs shown here are not intended to represent an upper bound. For example, in small communities in the arid areas of the western United States costs of W&S services can easily be double or triple these amounts per cubic meter. Note too that these cost estimates assume that financing is available at competitive international market rates, and that countries do not pay a high default or risk premium.

Table 2 presents a reasonable lower-bound estimate of unit costs of piped W&S services. Here the opportunity cost of raw water supplies and the damages from wastewater discharges are assumed to be zero. Only minimal storage is included, and the only intake treatment is simple chlorination. Costs for the water distribution network assume the use of PVC pipes and shallow excavation. Wastewater is collected with condominial sewers, and the only wastewater treatment is provided by simple lagoons. Given all these assumptions, one can manage to reduce unit costs of piped W&S services to about US$1.00 per cubic meter.

How much water does a typical household in a developing country "need"? The quantity of water used by a household will be a function of the price charged, household income, and other factors. Currently most households in developing countries are facing quite low prices for piped W&S services. One can look at typical water use figures from households around the world to see how much water one might expect a household to use for a comfortable modern lifestyle. For households with an in-house piped water connection, in many locations residential indoor water use falls in the range of 110 to 220 liters per capita per day. For a household of six, this would amount to about 20 to 40 cubic meters per month (Table 3). At the current low prices prevailing in many cities in developing countries, such levels of household water use are not uncommon. Other things equal, households living in hot, tropical climates use more water for drinking, bathing, and washing than households in temperate or cold climates.

Assuming average unit costs of US$2.50 per cubic meter, the full economic costs of providing 20 to 40 cubic meters of water to a households (and then dealing with the wastewater) would be US$50.00 to US$100.00 per month (Table 4), more than most households in industrialized countries pay for the same services and far beyond the means of most households in developing countries.

One would expect poor households in developing countries with in-house water connections to respond negatively to higher W&S prices: they might curtail use to as little as 50 to 60 liters per capita per day. For a household with six members, at 55 liters per capita per day, total consumption would then amount to about 10 cubic meters per month. The full economic costs of this level of W&S service at this reduced quantity of water use (assuming our unit costs of US$2.50 per cubic meter remained unchanged) would then be US$25.00 per month per household. At entirely plausible levels of water use (110 liters per capita per day), the total economic cost would be about US$50.00 per month for the same household. With the unit costs of the low-cost system depicted in Table 2, the full economic cost of providing 10 cubic meters per month would be US$10.00 per household per month. This estimate should be regarded as a lower bound on the full economic costs of piped W&S services in most locations.

In industrialized and developing countries alike, most people are unaware of the magnitude of the true economic costs of municipal water and sanitation services. There are several reasons why these economic costs are so poorly understood.

First, the capital costs are heavily subsidized by higher levels of government, (and, in developing countries, by international donors), so that households with services do not see the true capital costs reflected in the volumetric prices they pay. Second, in many cities tariff structures are designed so that industrial water usage subsidizes residential usage; households thus do not even see the full operation and maintenance costs in the prices they pay. Third, because many water utilities run financial deficits (in effect running down the value of their capital stock), water users in aggregate do not even see the full costs of supply. Fourth, most cities do not pay for their raw water supplies: typically the water is simply expropriated from any existing water sources (and their users) in outlying rural areas. Fifth, wastewater externalities are typically imposed on others (downstream) without compensation.

Sixth, the subsidies provided to consumers of water and sanitation services are not only huge, but also regressive. It is often not politically "desirable" for the majority of people to understand that middle- and upper-income households, who generally use more water, are thus actually receiving the most benefit from subsidies. Tariff designs may in fact be made overly complicated in order to offset this reality and appear to be helping poorer households (Komives et al., 2005). Most fundamentally, poor households are often not connected to the W&S network at all and hence cannot receive the subsidized services. Even if they do have connections, the poor use less water than richer households, thus receiving lower absolute amounts of subsidy.

The estimates presented here are intended merely to suggest what W&S costs are like in many developing countries. A reasonable question to ask is whether costs differ much across countries in the developing world and between industrialized and developing countries. Labor costs are obviously lower in developing countries, but because W&S projects are capital-intensive, this cost component has less of an impact on total costs than for other goods and services. There are to my knowledge no publicly available international indices of W&S project construction costs. To illustrate the magnitude of international cost differentials for some related goods and construction costs, Table 5 compares costs of rebar, cement, and industrial construction in eleven large cities in both industrialized and developing countries. Costs are indeed lower in cities such as New Delhi and Hanoi than in London and Boston, and lower costs for inputs such as cement and steel will translate into lower costs for W&S projects.

It is, of course, less expensive to provide intermediate levels of W&S services (such as public taps and communal sanitation facilities) than the costs in Table 2 would indicate. Monthly household costs for such services are, however, often quite considerable, roughly US$5.00 to US$10.00 per month for much smaller quantities of water and much lower levels of sanitation services. These costs are often reported to be as low as US$1.00 to US$2.00 per household per month, but such accounts often systematically underestimate key cost components and rarely reflect the real costs of financially sustainable systems. It is also important to appreciate that intermediate services impose additional costs on households in terms of extra time spent accessing the services and increased “coping” costs for the inconveniences of using off-site services

(Bahl et al., 2004; Pattanayak et al., 2005). Indeed, there is reason to question whether intermediate W&S services provide significant health benefits at all (Esrey, 1996).

3. Water and Sanitation Development Paths

The high capital costs of water and sewer systems have important implications for water prices and tariff design. Decisions on how to price water and sanitation services in developing countries are typically made in a dynamic, changing environment. Pricing and tariff design decisions made today should not lock households into low-level equilibrium solutions that will constrain them from improving their W&S services as economic growth occurs.

In-house piped W&S services are unaffordable today in many cities in developing countries, but as economic growth occurs, there is general agreement that this goal is both desirable and achievable. It is thus important to consider carefully how pricing and tariff design decisions influence the evolution of W&S service provision and the ability of managers and planners to upgrade services when economic growth creates the resources to make this vision a reality. There are numerous strategies or “development paths” for moving from a situation where households have poor or no services to modern W&S services, and it is necessary to reflect explicitly on the pros and cons of each, and how pricing and tariff design decisions push service providers and households along a particular development path, or create hurdles that must be overcome to make progress.

For purposes of illustration, Table 6 compares three levels of water services and four levels of household sanitation. Let us consider a household without either improved water or sanitation services (Case 1). Within the parameters given in the table, such a household might progress from this status to full modern W&S services (Case 12) along any of four principal development paths.

First, some water planners would advocate a “water first” development path (Case 1 → Case 2 → Case 3 → Case 6 → Case 9 → Case 12): here W&S service providers concentrate on first getting piped water services into the household; only after this stage is achieved would investments go to the installation of neighborhood sewers and then to wastewater treatment. Note that the household itself has important investments to make. On the water side, in-house plumbing is required to take full advantage of the piped water connection. Similarly, the household would typically be responsible for the installation of a private water-sealed toilet, without which the installation of neighborhood sewers would be of less value. Proponents of a “water first” development path argue that people want water services first and do not recognize the need for removing wastewater from the household until water has been provided and wastewater removal has become a problem. Also, as described above, sewers and wastewater treatment are very expensive, so it makes sense to provide the less expensive services first.

From a pricing perspective, a “water first” strategy has important implications. Under this strategy, revenues for water sales should not be diverted to subsidize sewers or wastewater treatment, at least until the majority of the population has high-quality water services. Also, any available subsidies from higher levels of government should be used to “push” households toward in-house piped service. For example, subsidies might be used to reduce the up-front connection charge for a household water hookup.

Public health professionals sometimes argue in favor of a second development path: “not one without the other” (Case 1 → Case 5 → Case 9 → Case 12). Proponents of this approach believe that there are important public health complementaries from providing improved water and sanitation together, and that households should not be allowed to receive in-house piped water without hooking up to a sewer line. Engineers often point out that it is cheaper to install water and sewer lines at the same time, particularly in cities where this may entail tearing up streets, sidewalks, and other infrastructure.

Such “bundling” of W&S services has important implications for tariff design. If households are required to have sewer services when they receive piped water services, then from a household’s point of view, W&S services cannot really be charged separately.[4] If the service provider attempts to recover the full costs of both services, and the household is willing to pay the cost of the water services but unwilling to pay for the sanitation services, the household will reject the entire bundle. Thus when services are bundled and tariffs are designed to recover the costs of service, tariffs can easily become a barrier to the provision of full modern services (Case 12).

A third development path might be termed “sanitation first” (Case 1 → Case 4 → Case 5 → Case 8 → Case 9 → Case 12). The rationale here is that improved sanitation is a more important first step than improved water services in achieving the desired public health benefits. Thus if resources are limited, public authorities should tackle sanitation problems before building piped water distribution networks. From a pricing perspective, if demand for improved sanitation services turns out to be low, this development path

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[4] Note also that W&S service providers cannot practically meter the amount of water that a household receives separately from the amount of wastewater that it discharges. Thus even if a provider claims to calculate water and wastewater charges separately, and apply a separate volumetric charge to each flow, from the household’s perspective this is simply an accounting trick. The household effectively faces a single weighted volumetric rate for the combined service.

requires more initial subsidies, with revenues from water to follow when households eventually receive in-house water connections.

A fourth set of development paths might be termed "demand-driven" in that the paths are not selected by "experts" but rather by people themselves. There are numerous plausible development paths that households might choose (e.g., Case 1 → Case 3 → Case 6 → Case 9 → Case 12; or Case 1 → Case 6 → Case 9 → Case 12). If households' preferences are allowed to shape the evolution of W&S services, prices and tariff design have an especially important role to play. Prices provide the signals about the real resource costs of the various steps from the status quo to full modern services. If these signals are incorrect, households may take an unwanted or unnecessary "detour" on the road to Case 12.

4. Objectives of Tariff Design

Setting water (and sanitation) tariffs requires that one strike a balance between four main objectives. [5]

Cost Recovery. From the water supplier's point of view, cost recovery is the main purpose of the tariff.[6] Cost recovery requires that, on aggregate, tariffs faced by consumers should produce revenue equal to the financial costs of supply. Moreover, the revenue stream should be relatively stable and not cause cash flow or financing difficulties for the utility.

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[5] This section draws heavily on Boland (1993) and Whittington, Boland, and Foster (2002).

[6] For example, the World Bank's Operational Manual Statement No. 3.72 emphasizes the importance of this cost recovery objective and the financial autonomy of the borrower.

Economic efficiency. Economic efficiency requires that prices be set to ensure that customers face the avoidable costs of their decisions. In other words, prices should signal to consumers the financial, environmental, and other costs that their decisions to use water impose on the rest of the system and on the economy. In practice, this means that the volumetric charge should be set equal to the short-run marginal social cost of bringing one additional cubic meter of water into a city, delivering it to a particular customer, collecting and treating the wastewater, and discharging the treated wastewater into a receiving water body. In many cities, the cost of bringing in additional water is higher than the cost of supplying the water already on hand, as the cheapest sources tend to be developed first. The short-run marginal cost should include not only the financial cost of public works undertaken but also the social cost of diverting water resources into public supply rather than using it for other purposes. An efficient tariff will create incentives that insure, for a given water supply cost, that users obtain the largest possible aggregate economic benefits.

Equity. The term "equity" is often used to denote quite different things. Here I use it to mean that the water tariff treats similar customers equally, and that customers in different situations are not treated the same. This usually means that users pay monthly water bills that are proportionate to the costs they impose on the utility by their water use.

Affordability. One objective of tariff design is to ensure that poor households are able to obtain adequate supplies of clean water. The terms "equity," "fairness," "poverty alleviation," and "affordability" are often used interchangeably to express this desire. I prefer to treat "affordability" as an objective distinct from "equity," "fairness," and "poverty alleviation," because a W&S tariff that is affordable may not be equitable or perceived as fair. Moreover, an affordable tariff may not pull poor households out of poverty. Many people feel that water services are a "basic right" and should be provided to people regardless of whether they can pay for them. These considerations have led to recommendations that W&S tariffs be kept low and that water be provided free or at minimal cost, at least to the poor, through systems of subsidies.

There are a number of tradeoffs between these different objectives and the W&S tariffs used to calculate customers' bills. For example, providing water free through private connections in order to achieve the objective of affordability conflicts with the objectives of cost recovery and efficient water use. Also, poor customers can sometimes be relatively expensive to serve (e.g., due to outlying location), and hence it might not be regarded as equitable to charge them the same as, or less than, other customers.

Additional objectives and considerations may be involved. For example, a tariff design should be easy to explain, understand, and implement. A tariff design should be acceptable both to the public and to political leaders. This may require the tariff to conform to perceptions of fairness, often quite different from notions of equity. Water tariffs may be designed to discourage "excessive" uses of water, thus promoting water conservation, where "excessive" may be understood as a deviation from some notion of a "fair" amount.

A successful W&S tariff design should not be controversial, nor should it become a focus of public criticism of the water supply agency. Human beings are, however, acutely sensitive to situations perceived to be unfair, and fairness is often in the eye of the beholder. It can prove to be especially difficult to design a W&S tariff that is perceived to be fair when customers do not understand the true resource costs of providing modern water and sanitation services. Consider the four cases in Table 7. If household members understand the real resource costs of supplying modern W&S services and believe the household should pay a share of these costs proportionate to its use of such services (Case A), a W&S tariff that is perceived to be fair can be relatively easily designed. But if household members do not understand the real resource costs of supplying modern W&S services, it may prove difficult for them to believe that a tariff is fair even if they believe the household should pay a share of these costs proportionate to its use of such services (Case B). For example, such a household may perceive a proposed W&S tariff to be “price gouging” even if it is not.

On the other hand, household members may understand the real resource costs of supplying modern W&S services but not believe the household should pay a share of the costs proportionate to its use of such services (Case C). This may be because of past injustices, a feeling that this household is more deserving of help than others, or any number of reasons. Or household members may neither understand the real resource costs of supplying modern W&S services, nor believe the household should pay a proportionate share of the costs proportionate to its use of such services (Case D). This is the most difficult situation for all stakeholders, and unfortunately it is quite common. In Case C and especially in Case D, the negotiation of W&S tariffs often becomes a political problem largely unrelated to the costs of service delivery.

5. Tariff Structures–the Alternatives

A tariff structure is a set of procedural rules used to determine the conditions of service and the monthly bills for water users in various categories.[7] Table 8 presents a simple classification of the different types of water tariff structures. Two main types of tariff structures are used in the municipal water supply sector: a single-part tariff and a two-part tariff. With a single-part tariff, a consumer's monthly water bill is based on a single type of calculation. With a two-part tariff, a consumer's water bill is based on the sum of two calculations. The single type of calculation used in a single-part tariff can be one of two kinds: a fixed charge or a water use (volumetric) charge; volumetric charges can be handled in several different ways.

Figure 1 illustrates how the price of water to the consumer changes as the quantity of water used increases for some of these tariff structures. Figure 2 shows how the customer's monthly water bill varies as the quantity of water used increases for selected tariff structures.

Single-part tariffs

Fixed charges. In the absence of metering, fixed charges are the only possible tariff structure. With a fixed charge the consumer's monthly water bill is the same regardless of the volume used. In many countries renters in multi-story apartment buildings have unmetered connections to their units and thus effectively pay a fixed charge for water (perhaps incorporated into the rent). Fixed charges are still quite widely used in industrialized countries, such as Canada, Norway, and the United Kingdom (and

[7] This section draws heavily on Whittington, Boland, and Foster (2002).

until recently in New York City), where water has historically been abundant and hence metering is not widespread.

The fixed charge itself can vary across households or consumer classes depending on characteristics of the consumer. For example, historically a common way to charge differential fixed charges was to set higher fixed charges on more valuable residential properties, sometimes on the assumption that people living in higher-value dwellings tend to use more water and/or have a greater ability to pay for the water they use. It was also common to assign businesses a different fixed charge than households, on the assumption that firms use more water than households, and notions of fairness (e.g., that firms have a greater ability to pay for water than households). Another common approach is to charge different monthly fees depending on the diameter of the pipe used by the customer to connect to the distribution system (Lauria and Hopkins, 2004): single-family domestic connections generally require a smaller bore than connections for larger concerns (e.g., businesses, hospitals, apartments).

From the perspective of economic efficiency, the problem with a fixed-charge system is that consumers have no incentive to economize on water use, as using more water will not increase their water bill. If the short-run marginal cost of supply is very low due to excess capacity in the system, this may not be a big problem. However, from a cost recovery perspective, a fixed-charge system creates a potentially large problem for the utility (or operator) if some households still lack individual connections: customers that do have a connection can supply water to other users (e.g., unconnected households, vendors) without incurring an increase in the household water bill. Moreover, because the fixed charge offers no incentive to economize on the use of water, a fixed charge that provided sufficient revenues at one point in time will become increasingly inadequate as the economy and incomes grow and water use increases. W&S service providers will be reluctant to expand coverage because more customers may mean more financial losses. Fixed-charge tariffs are thus especially prone to locking communities into low-level equilibrium traps of few customers, low revenues, and poor service (Whittington et al., 1990).

Volumetric charges. The second way to structure a single-part tariff is to base consumers' water bills on the amount of water they use. In mathematical terms, the monthly water bill is thus a function of the quantity of water a consumer uses. The precise formula used for the calculation of the water bill can differ. There are three main options: (1) a uniform volumetric charge; (2) a block tariff where the unit charge is specified over a range of water use for a specific consumer, and then shifts as use increases; and (3) an increasing linear tariff whereby the unit charge increases linearly as water use increases. All volumetric charges require that the consumer has a metered connection and that this meter works reliably and is read on a periodic basis.

Uniform volumetric charge. With a uniform volumetric charge, the household's water bill is simply the quantity used (e.g., cubic meters) times the price per unit of water (e.g., US$ per cubic meter). This is the most common type of volumetric charge among water utilities in the United States, Australia, and a number of European countries and is also very common for industrial and commercial users throughout the world. A uniform volumetric charge has the advantage that it is easy for the consumer to understand, in part because this is how most other commodities are priced. From an economic efficiency point of view, it can be used to send a clear, unambiguous signal about the short-run marginal cost of using water.

Block tariffs. Block tariffs come in two main varieties: increasing and decreasing. They create a stepwise price structure as illustrated in Figure 1. With an increasing block tariff (IBT), consumers incur a low volumetric per-unit charge (price) up to a specified quantity (or "block"); for any additional water consumed, they pay a higher price up to the limit for a second block, even higher for the third, and so on. IBTs are widely used in arid areas such as Spain and parts of the Middle East, where water resources have historically been scarce. The use of IBTs is also widespread in many developing countries in Latin America and Asia. With a decreasing block tariff (DBT), on the other hand, consumers face a high volumetric charge up to the specified quantity in the first block, pay less per unit for additional water up to the limit for second block, then less still for the third, and so on.[8]

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[8] Thus for both an increasing and a decreasing block tariff structure, the water bill is calculated in the following manner:

Let Q^* = amount of water sold to a specific consumer,
Q_1 = maximum amount of water that can be sold in the first block at price P_1,
Q_2 = maximum amount of water than can be sold to a consumer in the second block at P_2,
Q_3 = maximum amount of water than can be sold to a consumer in the second block at P_3.

If $Q^* < Q_1$, then the consumer's water bill = $(Q^*) P_1$.
If $Q_1 < Q^* < Q_2$, then the consumer's water bill = $P_1Q_1 + (Q^* - Q_1)P_2$.
If $Q_1 + Q_2 < Q^* < Q_3$, then the consumer's water bill = $P_1Q_1 + P_2Q_2 + (Q^* - (Q_1+Q_2))P_3$.

And so on for however many blocks there are in the tariff structure.

The rationale commonly given for an IBT structure is that, in theory, it can achieve three objectives simultaneously. It promotes affordability by providing the poor with affordable access to a “subsistence block” of water (the “lifeline” rate). It can achieve efficiency by confronting consumers in the highest price block with the marginal cost of using water. And it can raise sufficient revenues to recover costs.[9]

The IBT structure has become so widely used in both OECD and developing countries that many professionals working in the water sector assume that it must always be the most appropriate tariff structure. This is not the case. In practice, IBTs often fail to meet any of the three objectives mentioned above, in part because they tend to be poorly designed. An IBT may provide more expensive water to poorer households than to richer households, because in many cities the poor share connections, and in such cases the resulting higher volumetric use in turn results in higher prices for most of the water that those households consume.[10] Many IBTs also fail to achieve cost recovery and economic efficiency objectives, usually because the upper consumption blocks are not priced at sufficiently high levels and/or because the first subsidized consumption block is so large that almost all residential consumers never consume beyond that level.

The DBT structure was designed to reflect the fact that when raw water supplies are abundant, large industrial customers often impose lower average costs because they enable the utility to capture economies of scale in water source development, transmission, and treatment. Also, large industrial users typically take their supplies from

[9] Note that this argument assumes that the marginal cost of water is in fact higher than the first block price. But if a large expansion project has been recently completed, the short-run marginal cost of water may be very low.

[10] See. e.g., Whittington (1992), Boland and Whittington (2000), and Komives et al. (2005).

the larger trunk mains and thus do not require the expansion of neighborhood distribution networks. Although it is still used in some communities in the United States and Canada, the DBT has gradually fallen out of favor, in part because short-run marginal costs, properly defined, are now relatively high in some parts of the world, and there is thus increased interest in promoting water conservation by the largest customers. The DBT structure is also often politically unattractive because it results in high-volume users paying lower than average water prices.

Increasing linear tariff. The increasing linear tariff structure is rarely used. It is of interest largely because it illustrates that there are many ways that the water bill can be related to the quantity of water used. In this tariff structure, the price that a consumer pays per unit increases continuously (rather than in block increments) as the quantity of water used increases.[11] This tariff structure sends the consumer a powerful signal that increased water use is costly. Not only is each additional unit of water used sold at a higher price, but all the preceding units are sold at the last (high) price. A related but different tariff structure would require that only the last unit used would be sold at the highest price; other units would be sold at the price associated with that lower quantity.

It is important to recognize, however, that an increasing linear tariff cannot send the proper economic signal to a consumer about the short-run marginal cost of additional water use. This is because the utility's short-run marginal cost of providing water does not change appreciably as the water use of an individual household changes. An increasing linear tariff would thus be especially inappropriate if applied to large-volume

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[11] In other words, water bill = (Q*)P*,where Q* = amount of water sold to a specific consumer; and $P^* = \alpha_1 + \alpha_2 Q^*$ and α_1 and α_2 are positive constants.

industrial or commercial water users because it could drive the price they confront for increased water use far beyond the short-run marginal cost of supplying them additional water.

Two-part tariffs

With a two-part tariff, the consumer's water bill is based on the sum of two calculations: (1) a fixed charge, and (2) a charge related to the amount of water used. There are many variations in the way these two components can be put together. The fixed charge can be either positive (a flat fee) or negative (a rebate). The water use charge can be based on any of the volumetric tariff structures described above (a uniform volumetric tariff, an increasing or decreasing block tariff, or an increasing linear tariff.) In many cases, the fixed charge is kept uniform across customers and relatively low in value, and is used simply as a device for recovering the fixed administrative costs associated with meter reading and billing that are unrelated to the level of water consumption.

Seasonal and Zonal Water Pricing

In some circumstances the short-run marginal costs of supplying water to customers may vary by season. For example, a community may have relatively plentiful water supplies in the rainy season, but much more limited supplies in the dry season; water storage (reservoir capacity) will also be a factor. In such cases, it makes economic sense for water tariffs to reflect the varying circumstances. By charging higher rates in the dry season and lower rates in the wet season, water tariffs can be used to signal to customers that the water supply is not constant across the seasons, and that the costs of maintaining and distributing the water supply may vary as well. The higher dry season rate also serves as a reminder that each user's consumption of water reduces the amount available for others. Chile is one of the few developing countries that currently uses seasonal water tariffs.

Similarly, it may cost the water utility more to deliver water to outlying communities due, for example, to increased pumping costs for higher elevations or more distant settlements. A zonal water pricing structure charges users who live in such areas more for their water because it costs the utility more to serve them. Zonal prices can be used as an economic signal to users that living in such areas involves substantially higher water supply costs and that such information should be factored into customers' locational and water use decisions. However, this practice is comparatively rare, in part because it requires the water supplier to collect detailed geographically referenced accounting information. And this type of special tariff is only appropriate if the costs of serving the specially zoned areas are significantly higher than for the rest of the community. In fact, costs vary among all users, and a practical tariff always reflects averaged costs to some degree.

6. Achieving Economic Efficiency and Recovering Capital Costs: Fundamentals of Dynamic Marginal Cost Pricing in the W&S Sector

The high costs of the capital investments necessary to build modern W&S systems make the two-part tariffs described in the previous section especially attractive. They offer service providers a means simultaneously to achieve economic efficiency and cost recovery objectives and also to simplify the design of subsidies to aid poor households. Economic appraisal of W&S investments requires that stakeholders first determine the optimal price to charge for services, if the services are provided, and then determine whether the benefits are greater than the costs if this optimal price is charged. For large capital projects with no constraints on raw water supply, this volumetric charge (one component of a two-part tariff) may in some circumstances be very low because short-run marginal costs can be very low.[12] Such a price will result in large financial

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[12] The economic logic for setting price equal to the short-run marginal cost is straightforward (see, for example, Layard and Walter, 1978, pp. 171-176). Consider a community with an inverse demand curve for W&S services $p = \beta_1 - \beta_2 x$, where p = price of the services, x is the quantity of W&S services that can be supplied per time period, and β_1 and β_2 positive coefficients.

Let C equal the fixed costs per period of the W&S system, which is by definition assumed not a function of x. The investment is able to provide an amount of water Q_c per perod, where β_1/β_2 is less than Q_c. Net benefits are maximized when the optimal quantity of W& services x* is provided…

$$\text{Total Benefits} - \text{Costs} = \int_0^{x^*} (\beta_1 - \beta_2 x)\,dx - C$$

$$= \beta_1 x - ½\, \beta_2 x^2$$

$$d(B - C)/dx = \beta_1 - \beta_2 x = 0$$

$$x^* = \beta_1/\beta_2$$

Solving for the price that will achieve this optimal quantity, we see that the price should be set equal to zero (the short-run marginal cost)

$$p = \beta_1 - \beta_2 x^*$$
$$p = \beta_1 - \beta_2 (\beta_1/\beta_2) = 0.$$

If the price is set equal to zero to ensure customers receive the optimal quantity x*, the benefits of the project exceed the costs if

Total Benefits > Costs

$$\int_0^{\beta 1/\beta 2} (\beta_1 - \beta_2 x)\,dx > C$$

$$½\, \beta_1^2 / \beta_2 > C.$$

deficits unless a fixed charge for capital recovery and other fixed costs is also imposed (the other component of a two-part tariff).

The principles that a W&S service provider should follow to determine the volumetric and fixed-charge components of a two-part tariff in different circumstances have not been well understood in the water resources community. The key point is that short-run marginal costs change depending on the regional water resources situation, and both the volumetric and the fixed-charge components of the two-part tariff must change in response to changes in short-run marginal costs. A simple example can illustrate this point.

Consider a community without a modern W&S system that is thinking about undertaking a new project to develop such an infrastructure along with arranging a new source of raw water supply. The various stakeholders consider the benefits and costs of such an infrastructure improvement and decide that the project is desirable (benefits exceed the costs). Assume that capital for this project is not available from a higher level of government or a donor agency; the city instead borrows the necessary funds from a bond market, promising to repay the loan from new revenues available from the sale of W&S services. The citizens of the community agree to allocate the responsibility for repaying this loan among all who use the W&S services. Upon the advice of the engineering firm responsible for designing the project, the community decides to build excess capacity into their W&S system in order to accommodate future population and economic growth. The engineers’ argument is that it is cheap to build this excess capacity now due to economies of scale in the various project components.

Figure 3 presents the situation after this first project is built. The community now has the capacity to supply Q_c. What volumetric price should the service provider charge? Because the short-run cost of supplying additional water to the existing population is now low (because the capital costs have already been incurred), the volumetric charge should be low. The economic logic is that customers should not be discouraged from using more water if such use does not impose increased or significant costs on the W&S supplier or neighbors. If a customer derives a benefit from using more water and this use does not hurt anyone else, why not permit the additional water use?

However, the loan must still be repaid, so this consumer must pay a "fair share" of the capital costs. How a community determines a customer's "fair share" is essentially a political matter. That decision will not affect the economically efficient outcome unless it significantly affects the number of customers who decide to connect to the W&S system. If large numbers of customers decide to disconnect from the system after a project is completed and the new tariff structure imposed, in most cases this indicates a failure of the planning process. The voices of these customers were not likely to have been heard when the decision was made to build the project.

A numerical example will help to clarify this argument. Assume that this W&S project has an average cost of US$0.75 per cubic meter and a short-run marginal cost of US$0.25 per cubic meter. Suppose that if the typical household were charged US$0.25 per cubic meter, it would use 20 cubic meters per month. In this case the volumetric charge would yield revenue of US$5.00 per month (20 cubic meters × US$0.25 per cubic meter). However, when the loan repayment is considered, the utility actually "needs" US$15.00 per month from this household (US$0.75 per cubic meter × 20 cubic meters).

This implies that the fixed charge should be set equal to US$10.00 per month so that the utility can recover its average costs.

In this situation the volumetric price sends a signal that there is more water available for households at this low short-run marginal cost if households want to use it. The demand curve in period 1 (D_1) intersects the short-run marginal cost curve at a point far below capacity Q_c (Figure 3). Water is relatively abundant, and households, encouraged by a low volumetric charge, use lots of water. They pay a significant fixed charge in order to repay the capital that they collectively agreed to borrow. In a well-governed community, households would have been made fully aware of the magnitude of the volumetric and fixed charges that would be necessary when they decided (voted) to undertake the new W&S project.

Assume that this two-part tariff structure stays in place and that over time the population and economy of the community grow. As shown in Figure 4, the demand for W&S services shifts out and to the right. W&S services actually become more valuable to customers, but there is no need for the service provider to increase either component of the two-part tariff until point A in Figure 4 is reached, because the loan is being repaid and revenues are sufficient to pay the average costs of service. Customers thus enjoy an increasing consumer surplus on their W&S purchases. The citizens of this community are in effect reaping the benefits of their wise decision to invest in the new W&S project, and to include excess capacity into the project design. However, the community can "see" that this excess capacity is being used up, and the day is coming when the community will reach the limits of its existing water situation (Q_c).

The community must then decide what to do before point A is reached, because it takes time to develop a new project. Essentially it can either “make do” with the amount of water that it has (Q_c) or build another water project. Suppose that there is another raw water source available to the community, but a project to develop this second source is more expensive than the one included in the first investment. Assume that this second project would result in a system-wide average cost of US$1.00 per cubic meter. Assume that the short-run marginal costs of the combined system (after this second project is built) would increase as well, to US$0.50 per cubic meter.

Suppose that the community decides that this new, second project is too expensive (the benefits are less than the costs). The citizens vote against a bond referendum to raise money to undertake the new investment. Instead, they will try to make do with the water supply they already have. In this case the magnitude of the components of the two-part tariff must change, because the short-run marginal cost of using water changes. Now the volumetric charge must be used to ration the available water supplies, as shown in Figure 5. As population and economic growth proceed, the demand curve for water continues to shift up and to the right—but in this case the total quantity of water Q_c available to the community is already being used by existing consumers. The short-run marginal costs must now reflect the opportunity cost associated with taking water away from some customers: if one customer increases water use, another must decrease water use. The volumetric price of water thus keeps increasing to reflect this rising opportunity cost forgone (scarcity rent) and to ensure that the available water supply is accessible to users who need it most.

Suppose that the community allows this process to go on, demand keeps growing, and the volumetric price needs to increase from US$0.25 to US$1.00 per cubic meter in order to ration the available supply. Assume that if the short-run marginal cost is US$1.00 per cubic meter and the service provider charges this price, average household consumption falls from 20 cubic meters per month to 12 cubic meters per month. Households economize on their use of water because the volumetric price has quadrupled. In effect, by cutting back on water use existing customers are leaving water available for new customers and new and expanded economic activities. This should not come as a surprise to existing consumers, because they themselves voted down the bond referendum that would have provided the financing for the second water project.

Assuming that average costs do not change, the W&S service provider needs US$9.00 per month in revenue from the typical household customer (US$0.75 × 12 cubic meters). However, the volumetric charge yields US$12.00 in revenues (US$1.00 × 12 cubic meters). Most people would consider it unfair for the provider to reap “windfall profits” from the increase in the volumetric part of the tariff. The provider does not need the increased revenue to repay the loan or to pay its financial costs of operation. The purpose of the higher volumetric price is not financial, but rather to ration water use economically.

The two-part tariff can be used to resolve this “fairness” problem associated with water rationing. The fixed charge should be reduced as the volumetric charge increases. Instead of a positive fixed charge of US$10.00, for this example a negative charge (rebate) of US$3.00 per month will result in a typical household water bill of US$9.00 per month, precisely the amount the provider needs to cover its costs. In this example the fixed charge is negative, but this need not be the case. If the scarcity rent is small, the volumetric charge may not be large enough to recover the service provider's costs, a positive fixed charge may still be needed.

Now suppose that the rationing of the water available from this first project becomes an increasing burden on the citizens of the community, and they finally decide that it is worthwhile to build the second water project. This new project was projected to be more expensive than the first project, but nevertheless they vote to approve a bond referendum to finance it, because now they are paying a high volumetric price for water, US$1.00 per cubic meter, due to the high scarcity rent, and an increased supply will bring greater benefits than costs. Again, the community decides to build in excess reservoir capacity, to support further population and economic growth. After this second project is finished, what should the tariff be?

The principles are the same as before: the volumetric component of the two-part tariff should be set equal to the short-run marginal cost, which has now risen from US$0.25 to US$0.50 per cubic meter. When the new water project opens, the citizens in this community are relieved that the constraint on their water use has been relaxed, and the volumetric price falls to from US$1.00 to US$0.50 per cubic meter. Assume that in response to this decline in volumetric price the typical household increases its water use to 16 cubic meters per month. Note that this volumetric price is less than in the previous period, when the price was being used to ration supplies, but more than in the first period, when the community was smaller and the first water project provided cheap and abundant supplies.

If the typical household now uses 16 cubic meters and the volumetric charge is US$0.50 per cubic meter, the volumetric component of the two-part tariff yields US$8.00 per month. But this is not enough for the W&S provider to recover its average costs, which now include loan payments on the second project. The total average cost of providing services is a weighted average of the first and second projects. Recall that this is assumed to be US$1.00 per cubic meter. In this case the provider needs US$16.00 per month from the typical household (16 cubic meters × US$1.00 per cubic meter). The fixed-charge component of the two-part tariff must then be set at a positive US$8.00 per month.

This example illustrates how a two-part tariff can be used to send the correct signal to customers about the economic value of water and at the same time address the financial needs of the W&S provider. The key point is that the volumetric charge should be continually adjusted to reflect the real short-run marginal cost of using water (including any opportunity costs associated with forgone uses), and the fixed-cost component should be adjusted to meet the financial needs of the utility. It is the community's collective decision to agree (or not) to share the capital costs of the project that ensures that the benefits of the project exceed the costs and that the allocation of costs is considered fair by most parties.

Note that regulatory authorities will have an important role to play in the establishment of an optimal two-part tariff. Particularly in times of water scarcity, when a high volumetric price and possibly a negative fixed charge is warranted, a regulatory body needs to ensure that the public understands the rationale for the pricing policy adopted. Unregulated private W&S service providers cannot be expected to reduce their fixed charge as the volumetric charge increases.

The major objection to using a two-part tariff in this way is the possible instability in the volumetric price for services (in the example above, the volumetric price starts low, then quadruples, and then falls again). Some water resource professionals and utility managers feel that changing volumetric prices will confuse customers and prevent them from engaging in careful long-range planning. From this perspective, price stability is a major objective of tariff design. Households and businesses are, however, able to deal with changing prices in the telecommunications and energy sectors, so there is reason to believe that these fears are unfounded. Two-part tariffs are widely used in telecommunications pricing, although the negative rebate is not, because short-run marginal costs have continued to fall.

Note also that in some locations the period during which the volumetric price must be used to ration water use may be quite long. As cities need to go farther and farther afield in search of new supplies, managing water use with high prices may be increasingly attractive compared to incurring the rising capital costs of new projects. If the volumetric price of water cannot change in response to changing water resources circumstances, it will be increasingly difficult to develop rational W&S pricing policies. But what about poorer members of the community? How can they be provided with improved W&S services when such a two-part tariff is used?

7. Subsidizing Capital Costs; Reaching the Poor

Any discussion of W&S subsidies should begin with the question “Why do many people (both those working in the water supply sector and others elsewhere) assume that it is a good idea to deliver subsidies to the poor by reducing the water bills of households with private connections?” What is it about a piped water distribution network that makes it a good candidate for the delivery of subsidies to the poor? It does not follow that because water itself is a basic need, a piped water distribution system provides an efficient, effective way to deliver subsidies to the poor. After all, people also have basic needs for food, health services, and housing. The relevant question is not “How can piped water services be subsidized most effectively?” but “Which subsidy mechanisms reach the poor most efficiently and effectively?”

It is also important to ask how households themselves view the importance of the good or service to be subsidized. There is strong evidence that households indeed want improved W&S services as their incomes increase; this correlation between W&S coverage and household income suggests that these services are “normal” goods. As economic growth occurs in developing countries, more and more people are obtaining improved infrastructure services. Progress is occurring particularly in China and India. Figure 7 shows the percentage of households at different income levels that have four infrastructure services (piped water, sewer, electricity, and telephone); the data come from interviews with more than 55,000 households in 15 developing countries (Komives et al., 2001). What is noteworthy about these households is that at all income levels, more people have electricity than have piped water or sewer. Very few of the poorest households have piped water or sewer, yet almost a third of those households have electric service. As monthly household income increases from very low levels to US$300 per month, coverage of all of these infrastructure services increases rapidly; above US$300, coverage increases at a slower rate.

The data in Figure 7 should be interpreted carefully. It could be that more households have electricity because W&S networks were not available in their neighborhoods and electricity was, or because electric service was less expensive than W&S service. But in fact, monthly household bills for electricity are almost always higher than for W&S service; thus a comparatively lower cost of service does not explain the pattern we see here, where many households have obtained electricity even when they do not have piped water.

Figure 8 shows the percentage of households with different infrastructure services at different income levels in Kathmandu, Nepal. All of these households had the option to connect to all three network infrastructure services: electricity, water, and sewer. The majority of the very poor chose electricity, but not water and sewer. At higher income levels the percentage of households with W&S services is also higher, but the percentage of households with electricity is always higher still.

The important point to recognize from these examples is that although water itself is a necessity, this does not necessarily mean that people prefer piped water service to electric service. Indeed, because water is a necessity, households must already have some water source. The question is thus how much an *improved source* is worth to them. This will depend on many factors, but probably the most important is how poor the household's existing water service actually is.

Water and sanitation planners often present the need for improved services as a moral imperative or a basic human right, but given the choice, many households in developing countries would appear to want electricity before an in-house piped water or sewer connection. In fact, it is unusual for a household in a developing country to have a piped water connection and *not* have electricity. Figure 9 shows how the prevalence of different infrastructure "bundles" changes as household income increases. Almost no one, at any income level, has only a piped water service. However, many people do have electricity and not water. Many households in fact have no infrastructure services at all, although that percentage declines rapidly as household income increases. These data suggest that although most households would certainly like improved W&S services, this is by no means their most important development priority. Given the choice, many households would probably prefer to have any available subsidies directed to other sectors.

But suppose that a city's public health professionals and other development experts decide that water and sanitation services are "merit goods" that must be subsidized. How best can this be done? In his memoirs (Yew, 2000), the former prime minister of Singapore Lee Kwan Yew insightfully summarizes his philosophy: subsidize investment and savings, not consumption. He succinctly states the advantage of the two-part tariff with respect to making W&S services affordable to poor households. Subsidizing consumption by selling water at low volumetric prices *without an accompanying fixed charge* is a never-ending distortion, a signal that continually sends customers the wrong message about how expensive the fixed costs of W&S services really are. But once the capital costs are sunk, low volumetric prices may be appropriate to let consumers know the short-run marginal cost consequences of their decisions. This logic means that any available subsidies for piped W&S services should be directed to (1) lowering connection charges and (2) reducing the recurrent fixed charge component of the monthly bill.

Capital subsidies are of course not without problems. In theory, if the political process can ensure that only economically sound public investments are undertaken, capital subsidies can both assist poor households and foster economic growth. But capital subsidies for infrastructure investments in general, and for W&S investments in particular, require disciplined public sector decision making. Such discipline is extremely hard when subsidies come from outside the community that is to benefit from the investment. In most circumstances a community would be foolish to decline a capital grant for an infrastructure project with an associated stream of positive benefits. It is the high initial costs that are typically the hurdle to W&S improvements, and if someone else volunteers to pay these costs, why not let them?

In practice it has proved almost impossible for national governments or donor agencies to conduct rigorous economic appraisals of W&S projects. Whenever it appears that a particular project might not pass a cost-benefit test, water professionals appeal to intangible benefits to argue that the investment will in fact pass the test. This is particularly the case in the evaluation of rural W&S investments in developing countries, where neither donors nor national agencies attempt serious project appraisal of W&S projects. As Hirschman pointed out,

> The trouble with investment in social overhead capital (*e.g., water and sanitation investments*) . . . is that it is impervious to investment criteria. . . . As a result social overhead capital is largely a matter of faith in

> the development potential of a country or region. . . . Such a situation implies at least the possibility of wasteful mistakes. (1958, p. 84, emphasis added)

This is precisely what we have witnessed in the water and sanitation sector, where "white elephants" and poorly performing projects have been a standard feature of the sector landscape (Therkildsen, 1988). When higher levels of government (or donor agencies) pay the capital costs of W&S projects, numerous opportunities for rent-seeking and corruption arise (Lovei and Whittington, 1993; Olson, 2000; Davis, 2004).

If subsidizing the water bills of households connected to piped networks is a bad idea, what policies can instead or additionally be put into place to protect poor households from the rise in piped water bills that will be required for effective improvements and reforms? There are in fact a number of regulations or policy initiatives that can be coupled with the tariff structure to protect poor customers. The most obvious is simply to identify poor households and give them cash assistance to pay their water bills. This is essentially the approach now used in Chile. But even without such means testing, two sets of appropriate pro-poor policies are available.

Create a well-run system of public taps as a safety net for the poor

In every locale, W&S providers and regulatory bodies planning to install or expand a piped W&S system need to look carefully at any existing system of public taps.[13] In many places public taps will become obsolete if and when piped services become available: where the majority of households have piped water connections,

[13] The term "public taps" refers here to a system of fountains in public areas outside of people's residences where anyone can go to collect water—perhaps for a per-bucket charge or a fixed monthly fee. These public taps do not necessarily need to be run by a public sector utility; they could be efficiently built and managed by a private operator.

households without private connections will work out efficient ways of obtaining water from their neighbors at relatively low cost (Whittington, Davis, and McClelland, 1998). This solution depends on improving the piped distribution system so that connected households do not have to worry about running out of water themselves if they give or sell water to their neighbors.[14]

Public taps may nevertheless still have an important role to play because they may serve as a water source of last resort for the very poor. In some cases it is even possible to provide water free from public taps without substantially reducing the revenues of the water utility. This can occur when the availability of free water from public taps does not reduce the number of households desiring private connections for their exclusive use, and when only a small number of households cannot afford private connections.[15] One source of potential revenue for financing a subsidized system of public taps is the excess revenues that are available if the volumetric price of water from private connections is higher than average costs.

Preserve options for the poor

Poor households are hurt most when they have few options for self-help and when others have restricted their choices. In such cases it is common to find poor households being exploited. This is as true in the W&S sector as elsewhere. One important way to

[14] Public taps will become relatively high-cost sources of supply compared to purchasing from neighbors, because most unconnected households will have to walk farther to collect water from public taps than to obtain it from neighbors, and because the fixed costs of an attendant at the public tap will be large relative to revenues if only low volumes of water are sold.

[15] This is in fact the situation in many industrialized countries today. Water is often available free from public fountains, but the vast majority of households still demand private connections in their residences. See World Bank Water Demand Research Team (1990).

protect poor households is to preserve their choices so that local mafia or other rent-seeking actors cannot exploit them. There are three main things that can and should be done.

(1) *Ensure that poor households (and others) can have a private water connection when they want it*. Pro-poor policies should not trap poor households into always accepting a low level of off-site water service. If a poor household always has the option of choosing a private connection, when they can afford it, there are limits to the degree they can be exploited by rent seekers.

(2) Legalize water vending and sale of household water to neighbors. Vendors and neighbors with private connections create options for poor households: they promote competition in local water markets, limit the reach of spatial monopolies, and drive down water prices. The poor will benefit most from these lower prices. The system of public taps described above also adds to the choices available to poor households, fosters competition, and thus protects the poor from exploitation.

(3) Do not give private operators exclusive rights to provide water within a service area. Contracts with private operators should not contain exclusivity clauses. These limit competition and typically end up restricting poor households' options. Small-scale providers can often lower the cost of

providing piped water to poor households; they should be permitted to operate within the contract areas of larger private operators.

8. Concluding Remarks

Two-part tariffs have an important role to play in enabling water utilities simultaneously to achieve economic efficiency and cost recovery objectives. If a large-capacity expansion project has recently been completed, the short-run marginal cost of raw water supply may be very low. Economic efficiency requires that water be priced at short-run marginal cost. If a two-part tariff is used, however, the necessary revenues can be raised via a fixed charge, without distorting the price signal contained in the volumetric charge.

However, in periods of water scarcity (e.g., just before the construction of a water supply augmentation project), the situation is reversed. In this case, pricing at short-run marginal cost implies that the volumetric charge must include the opportunity cost to the user who does not receive water due to scarcity. This "scarcity rent" causes the volumetric charge to be relatively high in order to ration the available water supply among competing users. Such high volumetric charges may produce revenues in excess of financial costs. This can be "corrected" by employing a negative fixed charge (rebate), while the volumetric charge remains high enough to send the correct signal to customers from an economic efficiency perspective.

Such dynamic tariff design will require that W&S service providers, regulatory bodies, and public officials provide much more information to customers on the rationale behind sound pricing policies. As Hanemann (2005) has observed, it is extremely difficult for publicly owned W&S utilities to receive permission from political regulatory authorities for even modest rate increases, even though such increases are routinely granted to other service providers such as cable television. As water resources management becomes increasingly complicated, the public must become better informed about the challenges for tariff design posed by the high capital costs of W&S services, the long lives of the projects, and the tradeoffs between competing objectives. This degree of public understanding is unlikely to happen without increasing involvement and participation of stakeholders in the water resources planning and investment process in general and tariff design and in rate setting in particular.

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Table 1. Cost estimates: improved water and sanitation services

No.	Cost component	US$ per m^3	% of total
1	Opportunity cost of raw water supply	0.05	2%
2	Storage and transmission to treatment plant	0.15	6%
3	Treatment to drinking water standards	0.15	6%
4	Distribution of water to households (including house connections)	0.75	30%
5	Collection of wastewater from home and conveyance to wastewater treatment plant	1.00	40%
6	Wastewater treatment	0.35	14%
7	Damages associated with discharge of treated wastewater	0.05	2%
	Total	2.50	100%

Table 2. Cost estimates: improved water and sanitation services for low-cost option for private water and sewer connections

No.	Cost Component	US$ per m^3
1	Opportunity cost of raw water supply (steal it)	0.00
2	Storage and transmission to treatment plant (minimal storage)	0.10
3	Treatment of to drinking water standards (simple chlorination)	0.05
4	Distribution of water to households (PVC pipe)	0.30
5	Collection of wastewater from home and conveyance to wastewater treatment plant (condominial sewers)	0.35
6	Wastewater treatment (simple lagoon)	0.20
7	Damages associated with discharge of treated wastewater (someone else's problem)	0.00
	Total	1.00

Table 3. Range of estimates of monthly water use (in-house, private connection)

Per capita daily water use	Persons per household	Days per month	Monthly household water use
55 liters	6 persons	30 days	10 m^3
110 liters	6 persons	30 days	20 m^3
220 liters	6 persons	30 days	40 m^3

Table 4. Range of estimates of the full economic cost of providing improved W&S services (in-house, private water connection; piped sewer)

Monthly household water use	Average cost = US$1 per m^3	Average cost = US$2.50 per m^3
10 m^3	US$10	US$25
20 m^3	US$20	US$50
40 m^3	US$40	US$100

Table 5. Comparison of costs of rebar, cement, and industrial facility construction in 11 cities

City	Rebar (US$/ton)	Cement (US$/ton)	Industrial Construction (US$ per m^2)
London	981	96	850
Boston	1100	85	915
Los Angeles	992	135	699
Shanghai	435	43	592
Jakarta	528	68	269
Bangkok	482	63	301
Hanoi	349	62	409
New Delhi	600	64	247
Durban	1028	137	516
Nairobi	n.a.	n.a.	291
Buenos Aires	765	82	n.a.

Source: *Engineering News Record* (2004).

Table 6. Water and sanitation development paths

	1. Unimproved water source (e.g. pond, river)	2. Improved water source outside the home (e.g., hand-pump, public tap)	3. Improved water inside the home (private water connection or yard tap)
1. No improved sanitation	Case 1	Case 2 (US$5/mo/hh)	Case 3 (US$10/mo/hh)[a]
2. On-site sanitation (e.g. VIP latrine, pour flush toilet)	Case 4 (US$5/mo/hh)	Case 5 (US$10/mo/hh)	Case 6 (US$15/mo/hh)
3. Water-sealed toilet + neighborhood wastewater collection (e.g. small-bore or conventional sewers)	Case 7 (US$15/mo/hh)[b]	Case 8 (US$20/mo/hh)	Case 9 (US$25/mo/hh)
4. Water-sealed toilet + neighborhood wastewater collection + wastewater treatment	Case 10 (US$25/mo/hh)	Case 11 (US$30/mo/hh)	Case 12 (US$35/mo/hh)

[a] Water costs are not cumulative because having a private connection does not require a public tap or handpump.

[b] Sanitation costs are cumulative, i.e., level 3 includes the costs of in-house plumbing + neighborhood wastewater collection.

Table 7. Households' understanding of supply costs versus agreement to pay a proportionate share of the costs of W&S services: four cases

	A household understands the real resource costs of supplying modern W&S services	A household does **not** understand the real resource costs of supplying modern W&S services
A household believes that it should pay a "proportionate" share of the costs of W&S services	Case A	Case B
A household believes that it should **not** pay a "proportionate" share of the costs of W&S services	Case C	Case D

Table 8. Basic types of water tariff structures

1. Single-part tariffs
   - A. Fixed charge: monthly water bill is independent of the volume consumed
   - B. Water use charge
     - a. Uniform volumetric tariff
     - b. Block tariff: unit charge is constant over a specified range of water use and then shifts as use increases
       - (i) Increasing block
       - (ii) Decreasing block
     - c. Increasing linear tariff: unit charge increases linearly as water use increases

2. Two-part tariffs: fixed charge + water use charge

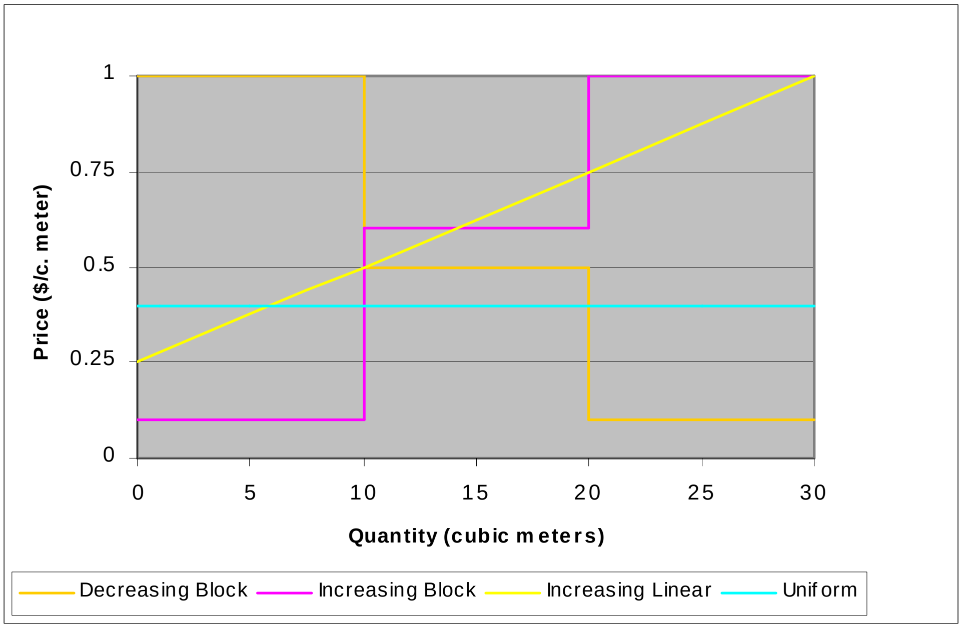


Figure 1. Price of water versus the quantity of water used for selected tariff structures

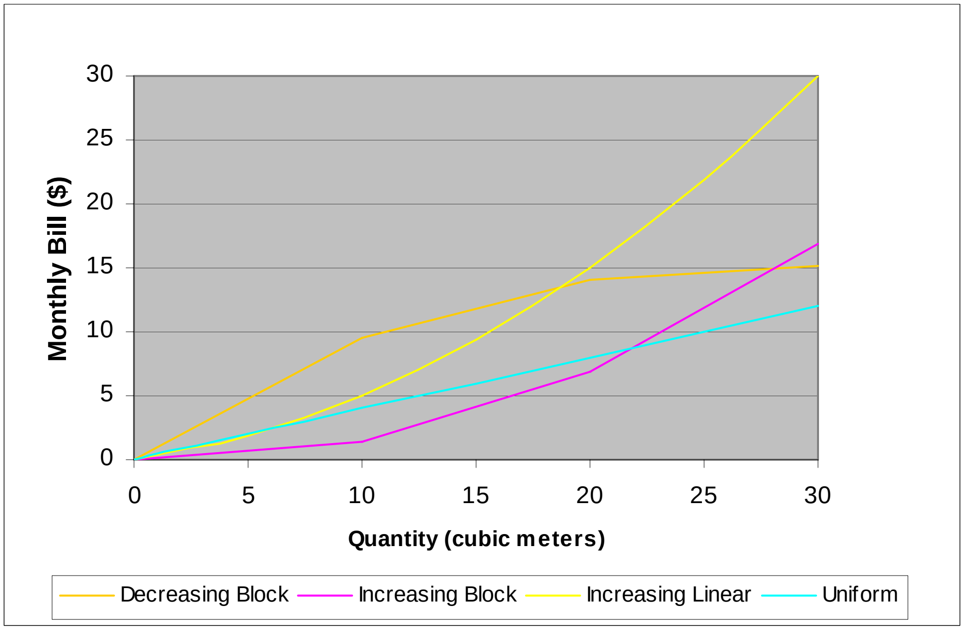


Figure 2. Monthly water bill versus the quantity of water used for selected tariff structures

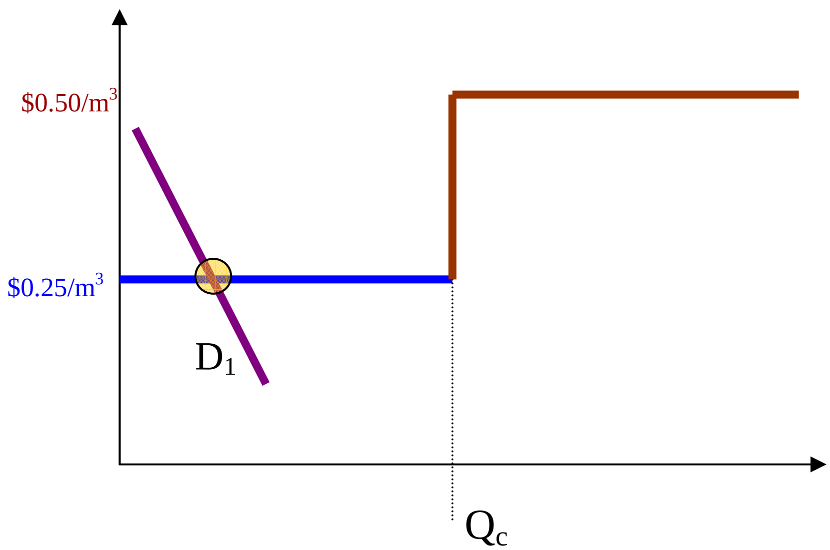


Figure 3. First period: first project is completed, excess capacity

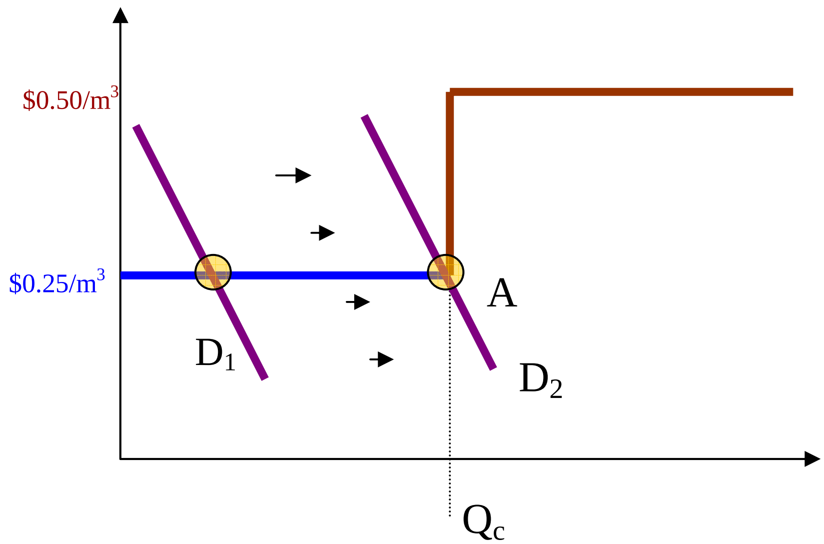


Figure 4. Second period: demand grows as population and economic growth proceed; system capacity is reached at point A

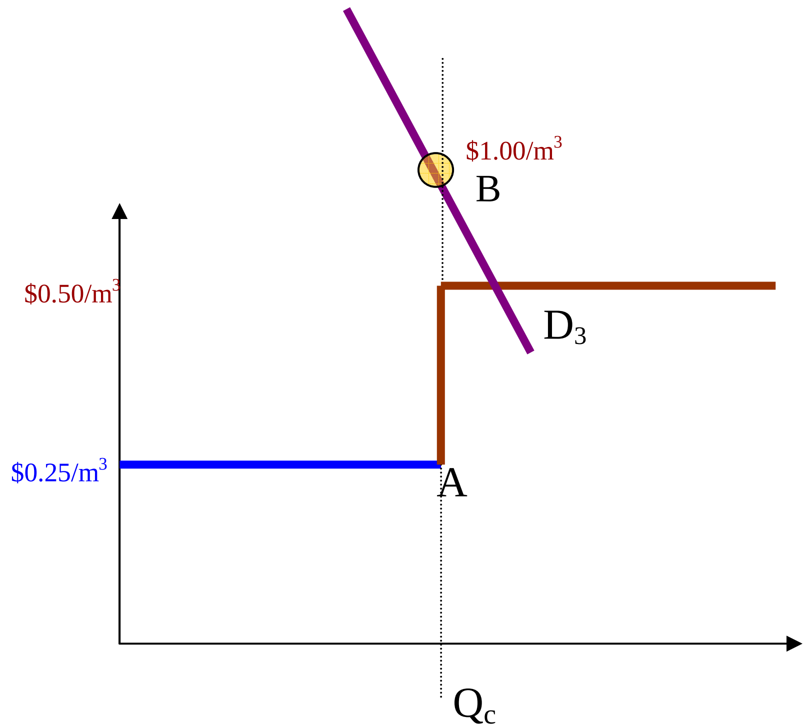


Figure 5. Third period: water from first source must be rationed

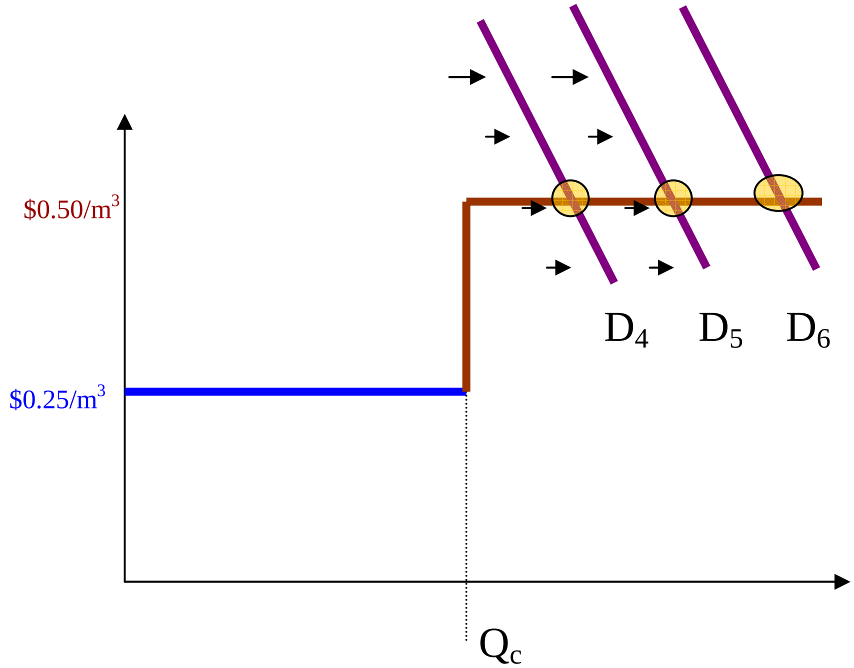
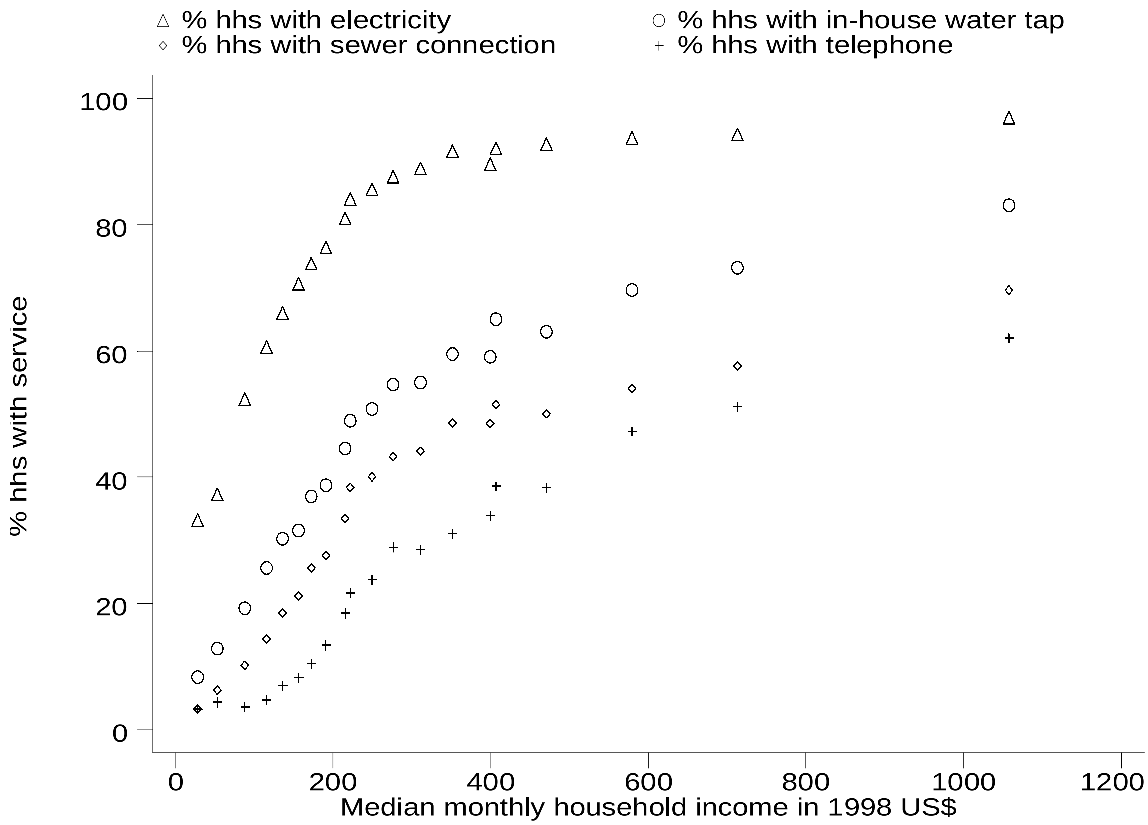
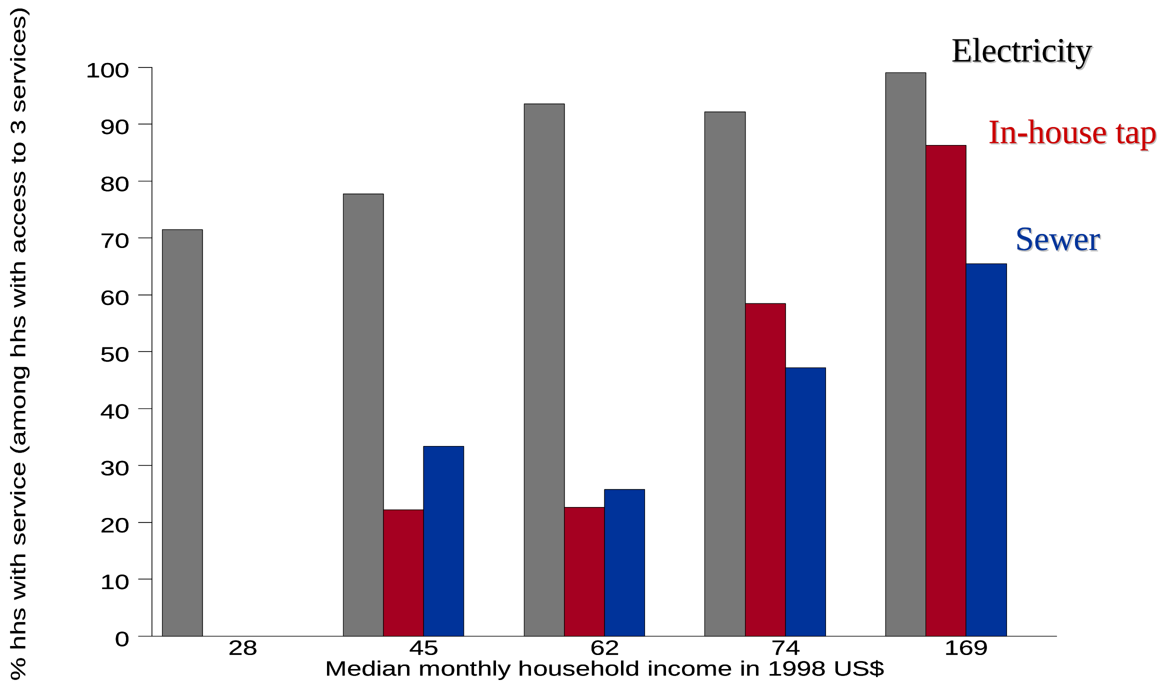


Figure 6. Fourth period: demand continues to grow after completion of the second water project



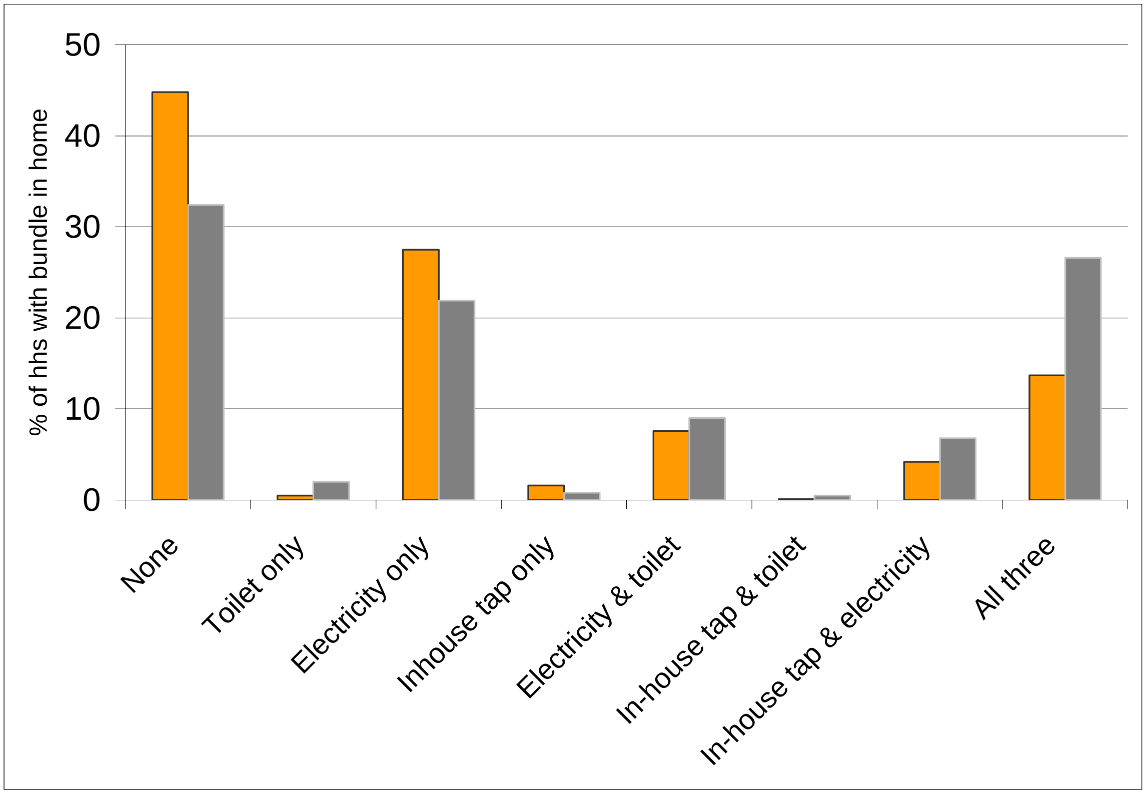
Source: Komives, Whittington, and Wu (2003)

Figure 7. Infrastructure coverage versus household income



Source: Komives, Whittington, and Wu (2003)

Figure 8. Infrastructure choices versus household income: Kathmandu, Nepal



Source: Whittington and Komives (2002)

Figure 9. Household infrastructure bundles versus household income:
Asia versus rest of the world