INDUSTRY AND ENERGY DEPARTMENT WORKING PAPER
ENERGY SERIES PAPER No. 53

Urban Interfuel Substitution, Energy Use, and Equity in Developing Countries: Some Preliminary Results

March 1992

The World Bank Industry and Energy Department, PRE

Urban Interfuel Substitution, Energy Use, and Equity in Developing Countries:

Some Preliminary Results

by

Douglas F. Barnes and Liu Qian
The World Bank

April 1992

Acknowledgments

This paper was presented at the 1991 International Conference of the International Association for Energy Economics, East West Center, Honolulu, Hawaii, on July 8-10, 1991. The research was prepared as part of a research project funded by the UNDP/World Bank/Bilateral Assistance Energy Sector Management Assistance Program (ESMAP) and the Research Administration Budget of the World Bank.

Abstract of

Urban Interfuel Substitution, Energy Use and Equity in Developing Countries: Some Preliminary Results

The limited understanding about the nature of the energy transition hinder efforts to formulate policy concerning the most effective and socioeconomic strategy for providing energy for households in urban areas. Understanding the energy transition will help provide a framework for understanding the policy choices for urban areas. At what stage do the externalities cause by significant harvesting of wood around urban areas justify intervention to encourage households to switch to other fuels? At what level of income is it realistic to expect that households will switch from traditional fuels to modern fuels? Do different energy pricing policies have a harmful or beneficial impact on the poor? Do wood prices rise gradually in urban areas or do they suddenly shoot up causing problems for markets? Is there a role for government policy to direct the pace of the transition between fuels?

The findings in this paper are a beginning attempt to start to answer some of these fundamental policy questions. From the preliminary evidence we can say the government policy plays a very important role in influencing households to chose one fuel over another. Secondly, policies to promote LPG for households with incomes that are less than about 25 dollars per capita per month are likely to lead to disappointment. Apparently electricity can be promoted at much lower levels income because of the high value urban households have for lighting, although this will require substantial capital costs by the electricity industry. In developing countries, wood fuels do not disappear completely as incomes rise since many high income households still use wood, reflecting the utility of these fuels for urban households. However, they do seem to disappear from urban households in large metropolitan areas over 1 million population, where wood apparently is very hard to obtain. The urban poor are probably affected most by urban fuel policies, since they are spending a significant proportion of their incomes on energy. Obviously, there is much more work to be completed before we fully understand the dynamic patterns affecting urban interfuel substitution in developing countries.

Table of Contents

Urban Interfuel Substitution, Energy Use and Equity in Developing Countries

Urban Interfuel Substitution, Energy Use and Equity in Developing Countries: Some Preliminary Results

I. Introduction

1.1 The dramatic growth of urban populations in developing countries has caused a rise in the demand for energy, food, water, and other resources. The growing number of people living in urban areas of developing nations is quite dramatic. Over 1.25 billion urban dwellers live in 360 cities over 500,000. Overall population growth rates for rural areas of between 1.5 and 4 percent per year are relatively high. By contrast, the urban growth rates are even higher at among 3 and 7 percent per year. The cause of the high growth rates is high birth rates and extensive migration from rural areas to cities. The migrants from rural areas bring with them their traditional patterns of energy use, which are mainly based on the use of wood fuels. In urban areas demand for wood products is highly concentrated, creating difficulties such as the environmental problems associated with harvesting trees around urban centers. However, the urban demand for fuels also creates opportunities for possible economies of scale in the distribution of modern fuels.

1.2 Rapid increases in demand for energy resources has been the basis for many energy-related problems in urban areas. In some countries, the poorer households that use wood fuels are affected by rapidly rising wood prices without other market choices being made available to them. In many cases' consumers do not even have a choice between wood-based and modern fuels because they are not available in the market place due to government policies or the relative remoteness of the urban location. The supply of modern fuels such as kerosene, LPG, and electricity to urban areas for cooking has been affected by sometimes inconsistent government policies. Even where substitute fuels are available, there can be a substantial difference between the economic cost of importing or producing the fuel and the cost that consumers actually pay. Also, the environmental externalities involved in harvesting trees for urban markets are not reflected in urban market prices of wood (Openshaw and Feinstein, 1988; Teplitz-Sembitzky and Schramm, 1989; Newcombe, 1984). The growth in demand for wood resources around cities has caused deforested rings around some urban centers extending 100 kilometers and more (Bowonder and co-authors, 1987b; Allen and Barnes, 1985; Anderson, 1986; Fishwick and Anderson, 1979).

1.3 The purpose of this study is to systematically analyze the dynamics of interfuel substitution in urban areas of developing countries, along with exploring the feasibility of substituting kerosene, LPG, or electricity for wood-based fuels. To accomplish this task the study examines the causes of interfuel substitution in urban areas. The research includes an analysis of consumer behavior and how it is affected by urban fuel policies, urban energy availability, and socioeconomic characteristics of households within urban areas. Finally, the analysis must examine the potential effect that encouraging interfuel substitution may have on income distribution and poverty.

1.4 Most past studies of interfuel substitution have been mainly for individual urban areas, so they have examined the transition for specific urban areas under study. The rewards of comparing energy use patterns between cities involve a major step forward in understanding the energy transition in developing countries. By comparing

energy use patterns between small and large cities, poor and rich income classes, between regions with extensive forests and regions with few trees, and between areas with government policies to subsidize modern fuels with those that tax them, a qualitative jump can be made in understanding the processes that drive interfuel substitution in developing countries. Making policy recommendations for individual countries is not the goal of this paper, as this is left to those more involved in individual country studies. Placing individual country in the context of a larger transition framework, the quality by individual country studies can be improved.

1.5 The results of this study shed some light on the effectiveness of existing energy policies in developing countries, the conditions under which transitions to modern fuels can be expected to occur, and the socioeconomic and environmental impacts and consequences of interfuel substitution. As expected, the preliminary findings indicate that government policy along with income has a significant impact on residential fuels use in developing countries. A somewhat surprising finding is that many of the poorest households in urban areas of developing countries use electricity, but rarely use LPG. In addition, wood fuel use is fairly extensive in all but the largest cities. It should be cautioned that the results presented in this paper are preliminary and more analysis is needed before firm conclusions can be drawn. Before turning towards a more detailed explanation of the energy transition, we turn to some of the main policy issues addressed in the study.

II. Main Policy Issues of the Energy Transition

2.1 The main objectives of the research are to systematically organize the individual country experiences and quantitatively analyze cross-urban patterns of interfuel substitution. Although well-known problems exist for making such cross national comparisons, they overcome some of the difficulties encountered in the analysis of individual countries or cities. This paper is a first step in analyzing the empirical patterns involved in the energy transition. The larger objectives of the current study are to examine the factors that are associated with the transition from traditional fuels to modern fuels. A different set of policies may be appropriate at different stages, whether it is to continue to use wood, to improve market access to modern fuels, or to promote a switch to modern fuels. The extent to which wood fuel demand can be reduced through interfuel substitution strategies are to be assessed. Some of the widely divergent patterns of interfuel substitution in urban areas that occur despite similarities in conditions need to be explained. Finally, the equity implications of existing fuel policies and for existing patterns of fuels use in urban areas are to be examined.

2.2 Most of the work done to date on urban interfuel substitution has been either at the level of one urban area or several urban areas within one country (UNDP/World Bank, 1989a, 1989a, 1989b, 1989c, 1989d, 1988, 1987; Alam and co-authors, 1986a, 1985b; Bowonder and co-authors, 1987a; Reddy and Reddy, 1983). Much useful knowledge has been gained from the many good individual country studies. Individual urban area or country studies have the advantage of examining in depth the local conditions that are associated with different kinds of fuel use, especially focusing on income as one of the key factors affecting substitution. General insights can be gained from all of them taken together. For example, the findings in Leach's (1986) classic studies of energy in South Asia are based on cross-country comparisons of average conditions and trends. His work provides useful insight regarding urban energy transitions in South Asia.

2.3 Based on the findings of urban energy studies, the factors known to influence energy transitions in various ways include the income, wood availability, access to modern fuels, fuel prices, and government policy. People with low incomes generally use fuelwood or charcoal as their main cooking fuel (Munslow and co-authors; Chauvin, 1981; Leach and Mearns, 1988; Sathaye and Meyers, 1985). By contrast, people with higher incomes tend to use modern fuels. Higher wood availability surrounding urban areas generally leads to more use of wood as a fuel, but does not affect the fuel used in the upper income groups. Generally people in large, more urbanized areas use more kerosene, LPG, and electricity. Evidence from urban energy studies suggest that government policies tend to encourage the use of certain fuels as people switch earlier than expected into the fuel and continue using the fuel longer than expected based on their income level (Fitzgerald and co-authors, 1990; Bhatia, 1988). These commonly held findings form the foundation for a complex series of forces that affect the conditions under which fuel choices are based.

2.4 The following stylized description of the energy transition has been developed utilizing the insights from the most recent literature on interfuel substitution (see Barnes and Dowd, 1990 for a review). This description provides a framework

concerning how people are currently meeting their needs for energy in urban areas, whether there are socioeconomic problems that typically occur at different stages in the transition, and whether it is feasible or desirable in particular contexts to speed up the transition to commercial fuels. The general description is based on both *static and dynamic* inferences. It is static in the sense that a given city is represented at a fixed point in time and at a fixed stage in the transition from wood to other fuels. As a consequence, differences in energy use between cities may be caused by unique characteristics of the city. But it is dynamic in the sense that cities and towns today is at different points in the energy transition.

2.5 *The lowest stage is characterized by small cities with relatively low income. In such cities there is extensive use of wood as a fuel, abundant wood resources around the city, low wood energy prices, and limited availability of modern fuels.* In this stage agricultural expansion and shorter farm fallows surrounding growing urban regions causes trees and bushes to be harvested from common land. At the same time migrants are streaming into urban areas, bringing with them their traditional and mainly wood-based rural cooking habits. Although demand for wood in the urban areas is increasing quite rapidly, this demand can be met fairly easily by the wood that is being cleared from land that will be used for agriculture and from other land surrounding the urban areas. As a consequence the price of wood compared to alternative fuels remains quite low, and there is little incentive for people to switch to alternative fuels. However, even at this stage higher income households will switch to fuels such as kerosene, charcoal or LPG, since these fuels generally are more convenient and produce less smoke than wood. But the general pattern is that a high percentage of the urban population will use wood as their primary cooking fuel.

2.6 *The second stage is characterized by medium sized cities with intermediate levels of wood use, moderate levels of wood resources around the city, wood energy prices that are at or somewhat below prices of modern alternative fuels, undeveloped fuel markets, and intermediate levels of household income.* In this phase, population growth causes deforestation and degradation of land around the cities. Consumer demand for wood products exceeds the rate at which trees are regrown on common land, so the wood is rapidly cleared from around the urban areas. During these stage trees continue to be harvested from common or fallow land, partly because the future costs of replanting and environmental consequences still have not factored into the relatively low market price of the fuel. The combination of decreasing supplies of wood fuels and increasing demand means that the price of wood fuels flares up or even goes past the price of competitive fuels. In this period there may be a significant substitution of charcoal and kerosene for wood. Charcoal and kerosene use will replace wood as the main cooking fuel because of both conveniences and the growing scarcity of wood. Since charcoal is lighter than wood, the transportation costs of hauling it to the city is lower than for wood. For kerosene, the fuel can be made readily available to middle class urban consumers without to much investment on their part in cooking equipment, and without too much investment by a government in a distribution system. At this stage the ability of consumers to pay for LPG and electricity for cooking would still be quite limited, although a growing number of higher income households will begin to use these fuels.

2.7 *The third stage is characterized by large cities with low levels of wood use, various levels of wood resources around the city, wood energy prices that are competitive with the price of alternative modern fuels, developed modern fuel markets, and high levels of household income.* This stage is characterized by the switch out of charcoal and kerosene to LPG or electricity. During this stage, incomes will have risen substantially in urban areas, markets for fuels will be better developed, and consumers will prefer do most of their cooking with LPG or electricity, while charcoal will remain a fuel used for specific traditional meals. Developed countries and some high income developing countries are at this stage today. It is the process of how, when and why people arrive at this final stage that is of interest in this paper.

2.8 The above description is very general and there are many exceptions. At present most of our understandings of the energy transition consist of case studies that simply describe the process of moving from wood to the higher value commercial fuels between income classes. From the extensive literature on individual cities or countries, it is obvious that the process is not so very straight forward. In the middle of the transition, there is a wide distribution of energy substitution and use. In addition there are distortions in the transition, including periods when wood might be cheap in urban areas because the prices are based on only cutting and transport costs. We provide this stylized account to place residential energy use in a wider context. In order to better explain the forces that cause the wide variation in energy use, we will examine the associations between government policy, citysize, and income class with respect to energy prices, energy choice, and fuel use by urban households.

III. Methods of Analysis

3.1 From a policy perspective it is just as important to understand how cities and towns today compare to one another as it is to understand how energy use has changed over time. It should be cautioned that when we talk of a transition, the analysis will be based on careful comparisons of cities today controlling for factors hypothesized to be important for the future fuel use in these cities. As cities evolve over time it is expected that the changes in their characteristics such as income, city size, and other factors will affect changes in fuel use. The ability to analyze such change is possible only with significant variation between energy use and socioeconomic characteristics of urban areas.

3.2 The effectiveness of government policies to encourage or discourage different types of fuel use can be evaluated through a comparative analysis of urban areas. As indicated, most existing studies have difficulty in dealing with the effects of country-specific policy issues, particularly the effects of subsidies or taxes on interfuel substitution. Although the work on individual countries in general is of high quality, some problems arise when trying to examine the reasons for interfuel substitution in urban areas. For instance, the comparative analysis of one urban area to another within one country can be idiosyncratic, because of the lack of variation in a country's policies towards fuels, a narrow range of price variation within urban areas, and relatively fixed resource endowments surrounding the city. In a single urban area, fuel policies generally do not vary for the period of the study. This can be problematic for the estimation of price elasticities because of the relatively small variation in prices for a given city at one point in time.

3.3 A comparative urban research design in combination with an analysis of urban household energy use in urban areas in individual countries will address most of the important issues involving interfuel substitution. The force that drives the transition from wood fuels to kerosene, LPG, or electricity will vary both between countries and between urban areas within countries. The analysis of the policy issues identified in the research requires significant variance across all the important factors in the study, including household energy use, income class, resource availability surrounding urban areas, government policy, and socioeconomic conditions dependent on type of urban area. The choice of comparative analysis of urban areas meets these requirements.

3.4 The analysis is based on actual surveys of urban household energy consumption in 11 countries. Because a typical urban survey includes both primary and secondary cities, there are data for about 4-5 cities per country (see Appendix A for cities in study) and the cities have been divided into about five income classes each. As a consequence, for the countries included in the project, a data base of about 250 representative urban income classes is analyzed. The sample contains large and small cities with significant variation across resources, along with cities which tax and cities that subsidize particular fuels. As a consequence the analysis will be able to determine the impact of these important variables on the process of interfuel substitution. For instance, in the analysis kerosene subsidizing countries can be compared to those who do not subsidize it (or those who tax it). In addition, we will analyze fuel choice and quantities used within countries to determine the influence of income, family size, and other characteristics on fuel choice and use in selected developing countries.

IV. An Overview of Urban Residential Energy Use

4.1 The overall results of the study indicate that government policy in many countries plays an important role in influencing the fuels that households will choose for satisfying their needs for energy in their homes. In the first section, the overall patterns of fuel use for 11 developing countries are presented. The 11 countries are from Asia, Latin America, and Africa, representing wide diversity of geographical features and economic development. In the second section, the effect of government policy will be presented by examining national aggregates of fuel profiles of consumption and prices. After this, we examine the effect of urban size on energy consumption. Finally, we will examine the differences in energy use between different income classes.

Overall Patterns of Urban Energy Demand

4.2 The most striking finding when examining the average energy consumption for the 11 countries is the relatively even distribution of energy use between the various fuels. Of course, the overall pattern of energy demand for 11 developing countries is a relatively abstract figure in that it does not capture the regional variation in fuel use, but nevertheless it gives a picture of the kinds of fuels being consumed in developing countries. To make the comparisons between cities more representative, the figures presented in this paper are weighted by city rather than the population in the cities. As expected, wood fuels comprise a significant percentage of urban household fuel consumption, with firewood and charcoal accounting for over 40 percent of total consumption (see figure 1). This is especially true for the cities in Africa, where both wood and charcoal are consumed in significant quantities, but it is also true for Haiti, a poor Caribbean country. Surprisingly, kerosene is not used for household purposes as much as might be expected, accounting for only one-tenth of total residential energy consumption. Coal that is specific to China comprises about one-tenth of total consumption. Finally, the highest value fuels LPG and electricity together accounts for about one-third of total consumption.

4.3 Expenditures on fuels present quite a different picture compared to consumption (see figure 2). Expenditures on wood fuels shrink to less than one-third of total expenditures of fuel, while expenditures on the high quality fuels of LPG and electricity increase to just less than two-thirds. This is an indication that urban households place higher value on electricity and LPG, and higher income families will purchase these fuels if they are available to them. Also, many of the households that use wood collect part of it, and this brings down their cash expenditure on this fuel. Based on energy content, electricity is the highest priced fuel followed by LPG. However, LPG is very price competitive with the other fuels typically used by middle income households, including kerosene and charcoal. As will be explained later in the paper, the poor spend a greater percentage of their income on energy, but purchase less and lower quality energy than more wealthy households.

Figure 1

Average Household Fuel Consumption

In Urban Areas of 11 Developing Countries

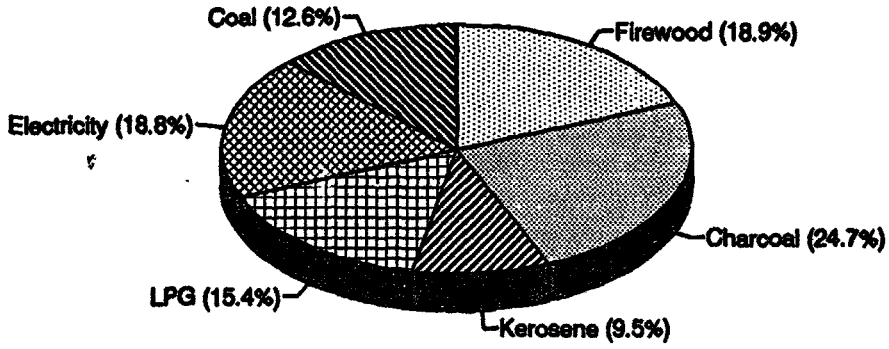
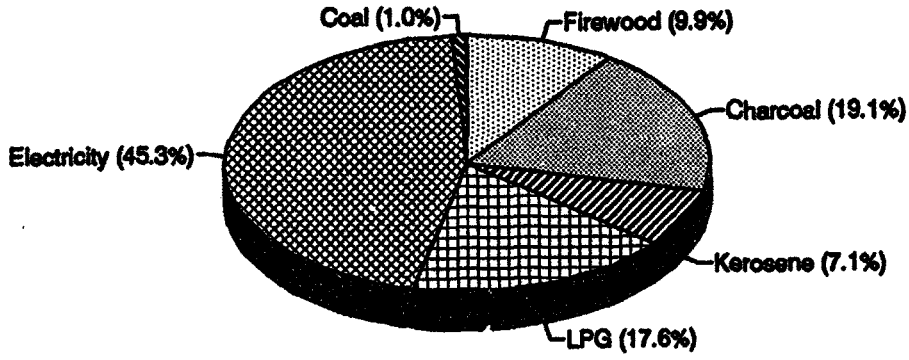


Figure 2

Average Household Fuel Expenditures

In Urban Areas of 11 Developing Countries



Energy Policies and Urban Fuel Use

4.4 The patterns of urban fuel use do little to explain some of the individual country variation in fuel consumption. It is evident from our preliminary analysis that government policy has a significant role to play in the fuels that people chose for use in urban households. Since most government policies that affect fuel--including whether modern fuels are taxed or subsidized--are decisions taken at the country level, in this section urban fuel use at the national aggregate is examined.

4.5 The subsidy or tax of modern fuels does appear to be a major factor in their adoption by households in developing countries. The three countries with significant subsidies in our sample include China, Zambia, and Indonesia. There are several interesting points to make about the countries that subsidize a major fuel. The first is that the subsidies do appear to encourage consumption of that fuel. For instance, coal in China is the lowest price fuel for all the developing countries in our study. As is evident from figure 3, coal accounts for a significant proportion of total energy use for the 5 towns and cities in our study. The reason that the energy use is so high for China is that heating is necessary in some of the towns in our sample, and coal is highly subsidized, so it is used very freely. Interestingly, wood is a major fuel in Xiushui, China, a region where fuelwood is available from the surrounding countryside and coal is not available in large quantities because the town is located between mountain ranges and is somewhat difficult to reach by road. Likewise, in Indonesia the effect of the government policy to make kerosene available both to assist poor households and to prevent deforestation seems to be effective, in those most people in Indonesia use kerosene for cooking. In fact, of the 11 countries in the study, Indonesia is the only country in which people use kerosene in a major way for cooking. However, the policy also has the effect of keeping higher middle class families from switching to the higher value fuels of LPG or electricity.

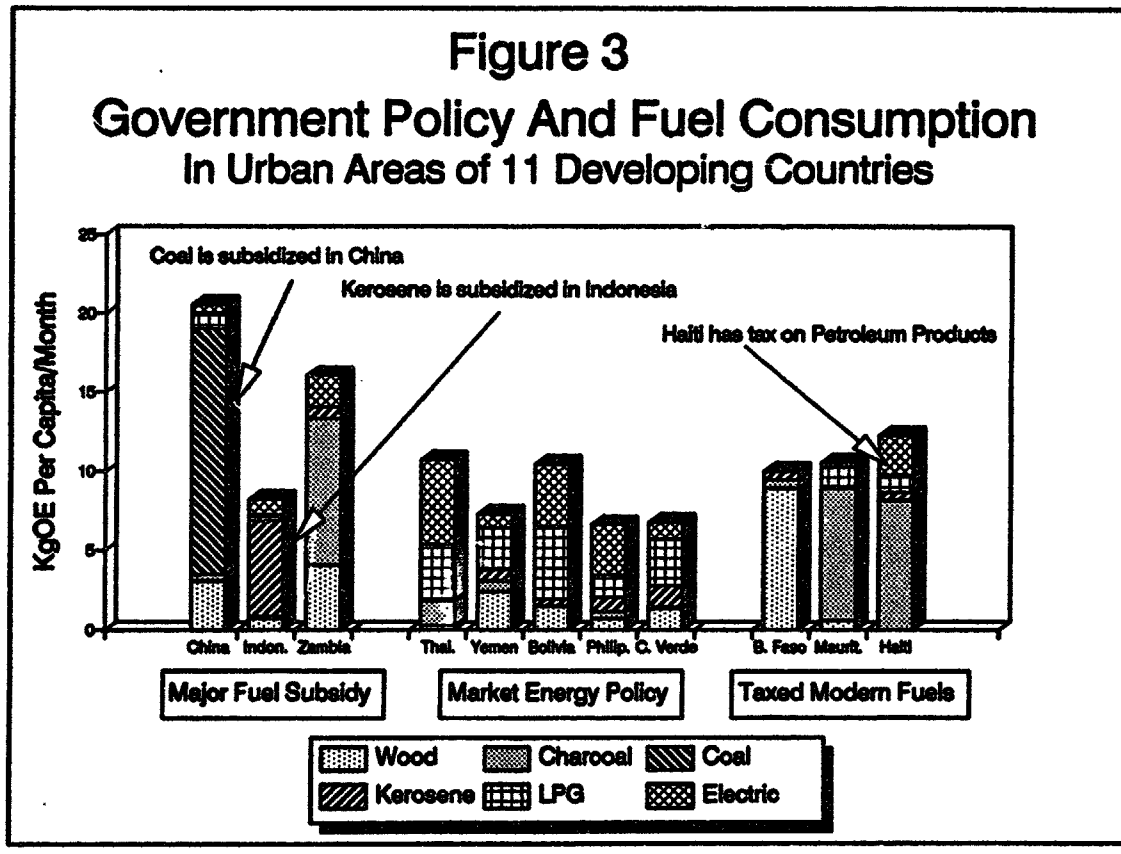
4.6 The countries that have a more market-oriented policy environment demonstrate a greater mix of fuels in use in urban households than those that either tax modern fuels or subsidize a major fuel. These findings even hold true after controlling for income across countries. Although these countries are somewhat weighted towards the more wealthy countries, most of these countries have policies to price fuels at their international value and to make the fuels available for use in the country. The most notable case is Cape Verde, a small African island nation. In Cape Verde the mix of fuel use is quite evident, with extensive electricity, LPG, and kerosene being used by urban households (see Figure 3). The prices of these fuels in Cape Verde are not subsidized and reflect their market value, and as a consequence people in the country spend a very high proportion of their income on modern fuels.

TABLE 1

The Relationship Between Government Policy and Urban Household Energy Consuption, Choice and Prices in Developind Countries, 1988

Energy Use and Price by Policy Type	Monthly Income US$	Firewood	Charcoal	Coal	Kerosene	LPG	Electricity
Energy Consumption (KgOE/Capita/Month)	21.80	2.61	3.38	5.19	2.30	0.46	1.24
Subsidy	77.98	1.25	0.63	0.00	0.73	3.06	2.94
Market	41.85	3.13	5.78	0.00	0.43	0.83	1.43
Taxed							
Energy Choice (%)	21.80	26.10	43.60	29.70	57.10	19.80	82.50
Subsidy	77.98	19.60	27.20	0.00	27.70	81.30	90.00
Market	41.85	39.40	66.20	0.00	64.40	27.20	50.40
Taxed							
Energy Price (US$/KgOE)	21.80	0.14	0.17	0.03	0.24	0.26	0.48
Subsidy	77.98	0.34	0.64	.	0.39	0.40	1.25
Market	41.85	0.30	0.40	.	0.55	0.85	2.24
Taxed							
Useful Energy Price (US$/KgOE)	21.80	0.97	0.77	0.11	0.69	0.40	0.56
Subsidy	77.98	2.42	2.92	.	1.11	0.61	1.47
Market	41.85	2.13	1.83	.	1.58	1.31	2.63
Taxed							
Middle Income Groups Only (US$ 20-40)							
Energy Consumption (KgOE/Capita/Month)	26.32	1.34	2.45	6.01	2.73	0.84	1.26
Subsidy	28.94	1.78	0.94	0.00	0.83	2.11	1.43
Market	29.03	4.97	4.77	0.00	0.42	0.70	0.42
Taxed							
Energy Choice (%)	26.32	12.90	29.10	35.80	53.90	30.80	86.50
Subsidy	28.94	35.30	36.50	0.00	42.60	66.70	90.20
Market	29.03	60.90	48.60	0.00	64.20	24.40	35.20
Taxed							
Energy Price (US$/KgOE)	26.32	0.13	0.21	0.03	0.23	0.26	0.51
Subsidy	28.94	0.33	0.56	.	0.35	0.35	1.05
Market	29.03	0.37	0.45	.	0.58	0.94	2.51
Taxed							
Useful Energy Price (US$/KgOE)	26.32	0.91	0.95	0.10	0.67	0.39	0.60
Subsidy	28.94	2.36	2.56	.	1.01	0.54	1.24
Market	29.03	2.62	2.05	.	1.66	1.45	2.95
Taxed							

Source: ESMAP Energy Studies.



4.7 The countries with taxes on petroleum products are among the poorest countries in the study. Burkina Faso, Mauritania, and Haiti all have taxes on kerosene or LPG, and as indicated in figure 3, people are discouraged from using these fuels. For all three of these poor countries, people are using mainly wood or charcoal for their residential energy needs. To be fair, this may be a reflection of the level of income of the cities in these countries, but certainly the tax and foreign exchange constraints associated with importing petroleum products contribute to the fuel mix in these countries. However, preliminary analyses controlling for income also tend to confirm these patterns.

4.8 The final point about the countries that subsidize a major fuel is that the price of other fuels in these countries is lower than in the other countries in the study. As indicated in table 1, the subsidy of a major fuel seems to pull down the price of

alternative fuels. As a consequence, a major subsidy does not just affect the fuel being subsidized, but rather can lead to distortions in the market prices of other fuels as well, including the price of wood fuels. This means that policy makers should be aware that fuel subsidies should not only be viewed as having a singular impact on particular fuels, but will have a more widespread effect in the fuel economy.

The Effect of Urban Size on Fuel Use

4.9 The size of the urban areas is expected to have an effect on both the price that people have to pay for a fuel and its availability for the local population. One reason that city size has such effects is that smaller cities often are in more remote areas that require transport of modern fuels. Consequently, higher transport costs may cause the price of modern fuels to be higher. In addition, smaller cities also obviously have smaller markets, so that the distributors of modern fuels may not be as interested in targeting them for sales. The lack of fuel alternatives in the market place may influence the other prices in the marketplace. Another factor is that biomass often is more readily available around the boundaries of smaller cities. The combination of sheer size and the volume of demand for wood fuels around larger cities makes the local collection problematic for poor urban residents. As a consequence they end up purchasing charcoal, kerosene, or coal for cooking and other end uses.

4.10 The expectation was that with an increase in city size, people would have less access to wood fuels around the cities. As a consequence, their use of wood fuels would decrease. Contrary to this expectation, for cities up to 1 million people, the use of wood fuels is fairly extensive and does not decrease (see figure 4). Although it appears that energy use is declining with city size, this is somewhat misleading because of the extensive use of coal in the small towns and cities from China in the study. Nevertheless, once cities reach a population of 1 million and above, their populations switch from using biomass fuels to modern fuels, including LPG, electricity, and limited amounts of charcoal. The large cities in the study include Manilla, La Paz, Bangkok, Port au Prince, and four cities in Indonesia, where very little charcoal and virtually no fuelwood is used for cooking. Partially because of the use of LPG and electricity in smaller cities in countries like Cape Verde and Zambia, the amount of these fuels used in the smaller cities is somewhat larger than expected. This is consistent with findings not reported here that useful energy for cooking does not appear to be dependent on city size.

4.11 The income that is spent on fuel is not significantly dependent on city size. The average share of income spent on fuel is about 12 percent, and it is slightly lower for cities above 1 million. The implication is that both city size and the mix of the fuels within different cities have very little to do with percentage of income spent on a fuel for urban households. Rather, as will be evident in the next section, the important factors affecting income expenditures on fuel include the level and distribution of income within cities. The important finding is that although the sheer size of the city does affect what fuels households will adopt, it seems to have very little to do with the amount of money people will spend on those fuels.

4.12 The size of the city is somewhat correlated with the price of different fuels (see table 2). As might be expected, the price of electricity, kerosene, and LPG declines

with city size, while the price of wood fuels remains almost constant. It is clearly part of the reason people in smaller towns and cities do not use as much modern fuels as that in the larger urban areas is because the prices they pay for the fuels are somewhat higher than in the largest cities, especially those above 1 million people, and incomes in such towns are generally lower. A surprising finding is that the price of wood fuels is higher in the smaller cities. This is probably because some of the smaller urban areas in the sample, including Mauritania and Yemen, have very little biomass around them. In a later analysis, we will be able to examine the impact of biomass supply around cities on residential fuel use patterns. As indicated above, the reasons that the price of the fuels is higher in smaller cities in part can be explained by the higher distribution costs for electricity and the higher transportation costs of LPG and kerosene.

TABLE 2

The Relationship Between City Size and Urban Household Energy Consumption Choice and Prices in Developing Countries, 1988

City Size	City Size ('000)	Monthly Income US$	Firewood	Charcoal	Coal	Kerosene	LPG	Electricity
Energy Consumption (KgOE/Capita/Month)								
Town	33.89	38.19	3.82	3.33	3.85	0.21	1.70	1.41
Small City	102.54	41.38	2.19	2.15	3.11	0.62	2.12	1.59
Middle City	526.98	35.74	3.41	3.08	0.00	1.40	0.60	1.27
Large City	3718.13	55.82	0.24	1.24	0.00	3.35	1.68	2.82
Energy Choice (%)								
Town	33.89	38.19	52.50	40.00	16.80	33.60	46.50	64.10
Small City	102.54	41.38	25.10	36.10	21.10	37.20	60.40	78.40
Middle City	526.98	35.74	47.90	53.30	0.00	64.50	23.00	69.50
Large City	3718.13	55.82	4.30	28.00	0.00	61.30	37.30	95.40
Energy Price (US$/KgOE)								
Town	33.89	38.19	0.27	0.29	0.03	0.45	0.53	1.64
Small City	102.54	41.38	0.26	0.57	0.03	0.40	0.48	1.23
Middle City	526.98	35.74	0.27	0.38	.	0.34	0.51	1.15
Large City	3718.13	55.82	0.22	0.29	.	0.24	0.36	0.78
Useful Energy Price (US$/KgOE)								
Town	33.89	38.19	1.92	1.33	0.09	1.28	0.81	1.93
Small City	102.54	41.38	1.82	2.60	0.12	1.14	0.74	1.45
Middle City	526.98	35.74	1.95	1.73	.	0.98	0.79	1.35
Large City	3718.13	55.82	1.58	1.32	.	0.69	0.55	0.92

Source: ESMAP Energy Studies.