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Author

Leitmann, Josef

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THE OTHER ENERGY CRISIS: Managing Urban Household Energy Use in Senegal

Josef Leitmann

Abstract

The persistent and growing demand for woodfuels in developing countries constitutes an important, often ignored resource and environmental problem. To gauge the impact of this other energy crisis, the case of Senegal in the 1990s is assessed, focusing on the important urban household sub-sector. A disaggregated database is used to highlight the problems of increasing urban energy demand met by unsustainable rural woodfuel supply, and the inadequacy of existing policies and programs. A flexible, consumer-oriented strategy is recommended, based on biomass supply system management, interfuel substitution, conservation, and a sound pricing policy.

Introduction

Rapid petroleum price rises and supply disruptions in the 1970s focused attention on a new threat to economic growth and stability-- the energy crisis. With increasingly dependent economies and a paucity of foreign exchange, developing countries were particularly hard-hit by the burden of high commercial energy costs. Today, that energy crisis has receded from view on the economic planners' horizon in both the industrialized and less-developed world as oil importers enjoy relatively low, stable prices in the short run. However, an important but partially hidden energy crisis has existed in the shadows of the familiar one: persistent and growing demand for woodfuels (firewood and charcoal), which is increasingly contributing to deforestation in the Third World.

To gauge the impact of this "other energy crisis" and outline a set of possible responses, the situation of Senegal in the 1990s will be assessed. The geographical focus of this analysis is *urban* because Senegalese city dwellers, representing about one-third of the population, consume half of the country's energy resources. Urban residents are intense users of fuels, particularly charcoal: consumption per capita in the five principal Senegalese cities alone is more than double that of rural per capita use of *all* fuels. Further, the urban population is growing at a rate nearly double that of rural areas. The sectoral focus is on *household* consumption because, of the 1.8 million tonnes of oil equivalent (TOE) of final energy consumption in Senegal in 1986, 1.1 million TOE, or 62 percent, was accounted for by household demand. Thus Senegal's cities, which produce no woodfuels, are casting an "urban shadow" over the countryside, with charcoalmakers cutting

precious forest resources to supply an ever-increasing urban residential demand.

The article is organized so as to: (a) stress the role of an accurate, disaggregated database in understanding the nature of household energy demand in cities; (b) identify the key problems -- in this case, increasing urban energy demand met by unsustainable rural fuelwood supply, and the inadequacy of existing policies and programs; and (c) suggest a flexible, consumer-oriented strategy based on supply system management, interfuel substitution, conservation, and a sound pricing policy. It is hoped that this approach will aid urban and energy planners to think about similar problems in other countries.

Economic and Demographic Background

Senegal is a small West African nation with a 1986 population of 6.8 million occupying 196,000 square kilometers (Figure 1). It achieved independence from France in 1960 and has since enjoyed a democratic social and political evolution. Dakar, the capital, is an important commercial and transport center for not only Senegal but also much of the landlocked Sahel. This, combined with the country's cultural and intellectual leadership, has given it special stature in francophone Africa.

Economically, the country inherited a well-developed physical and social infrastructure at independence. However, since then, Senegal has experienced the lowest GDP growth rate (2.3 percent per annum) of any African state not affected by war or civil unrest. In fact, with annual population growth of 2.9 percent, the real average annual growth rate between 1965 and 1985 has been negative (-0.6 percent); with a per capita income of \$420 per year (1986 dollars), Senegal is ranked at number 33 of the world's 40 low-income economies (World Bank 1988: 222, 224; World Bank 1987b: 1, 2).

Senegal has a resource-poor, open economy which is predominantly agricultural. Export earnings are derived from groundnut cultivation, supplemented by phosphate and fish production. The traditional economy revolves around millet growing and nomadic cattle herding for domestic consumption. Much of the modern sector employment, commercial activities, and social services are concentrated around Dakar. The economy is highly vulnerable to climatic vagaries and adverse movements in international commodity markets. These structural limitations have resulted in limited domestic savings, dependence on foreign aid, and limited industrialization.

Demographically, the population is very unevenly distributed, with regional densities ranging from 5 persons per square kilometer in the east to 1,711 in the Dakar metropolitan area, and a national average estimated at 33 per square kilometer in 1985 (World Bank 1987a: vi).

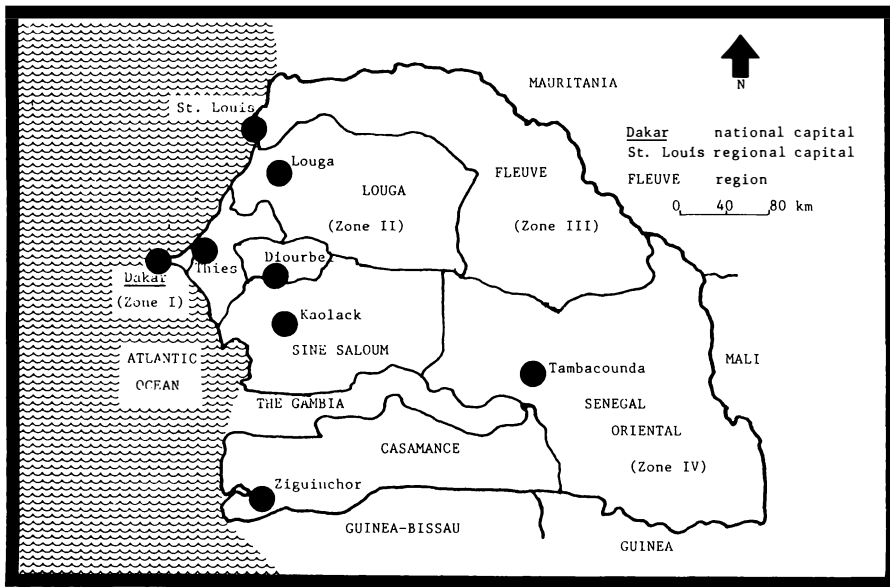


FIGURE 1. Author's Sketch Map of Senegal

Thirty-six percent of the population is classified as urban, and cities have experienced a 4.0 percent annual growth rate between 1980-85, as compared to 2.9 percent nationally. With a population of 1.3 million in 1986, Dakar encompasses one-fifth of the country's population and 55 percent of all urban dwellers. The other principal urban centers are Thies (151,000 inhabitants in 1986), Kaolack (149,000), Saint-Louis (118,000), and Ziguinchor (117,000) (Chatain et al. 1987: 2).

The Structure of Urban Energy Demand

As indicated in Senegal's 1986 energy balance (Table 1 below), households accounted for 62 percent of national energy consumption, or over 1.1 million TOE. By comparison, industry – the next-largest fuel-using sector – comprised 19 percent of the energy balance, or 350,500 TOE. Fuelwood, in the form of firewood and charcoal, is both the principal household and national fuel. On an energy basis, 93 percent of

Table 1

Sectoral Energy Balance, 1986
('000 TOE)

<u>Sector/Fuel</u>	<u>Fuelwood</u>	<u>Petroleum</u>	<u>Electricity^a</u>	<u>Total</u>
Industry	-	188.6	161.9	350.5
Transport ^b	-	152.1	-	152.1
Fisheries	-	74.7	-	74.7
Public/misc. ^c	40.5	45.4	18.9	104.8
Households	<u>1,043.8</u>	<u>24.7</u>	<u>48.2</u>	<u>1,116.7</u>
TOTAL	1,084.3	485.5	229.0	1,798.8

Notes:

- (a) Based on diesel/fuel oil consumed for generation; not included under petroleum.
- (b) Excludes international bunker sales of jet fuel and marine diesel fuel oil.
- (c) Includes fuelwood consumed by agro-industries and commercial consumption of electricity.

Source: UNDP/World Bank, *Senegal: Issues and Options in the Energy Sector*. (Washington, DC: IBRD, 1981): 3, with modifications based on survey data, population, and economic growth statistics for 1981-1986.

residential energy demand is met by fuelwood, which translates to 58 percent of overall energy demand.¹ Thus, households are the most important sectoral consumer of energy in Senegal and fuelwood is the most important residential, and national, fuel. Within the residential sector, it is important to disaggregate consumption figures between rural, semi-urban, and urban consumers to get a clear picture of fuel demand patterns, and to illustrate the important role that cities play in the use of certain types of energy. Table 2 below presents such a breakdown for the five principal Senegalese cities, other urban areas (defined as towns of at least 10,000 inhabitants), and rural dwellers. The 1986 population is 6,791,000, with 1,835,000 residents in the five cities, 610,000 in the semi-urban areas, and 4,956,000 in the countryside (Chatain et al. 1987: 2).

Table 2 underscores not only the difference in intensity and choice of fuel consumption between urban and rural inhabitants, but also the

Table 2

Urban vs. Rural Household Energy Consumption, 1986
(⁰⁰⁰ TOE)

<u>Sub-Sector</u>	<u>Wood</u>	<u>Charcoal</u>	<u>Electricity</u>	<u>LPG^a</u>	<u>Kerosene</u>	<u>Total</u>
5 cities	18.3	412.0	42.6	11.5	2.6	487.0
(per capita) ^b	10.0	224.5	23.2	6.3	1.4	265.4
Semi-urban	26.8	48.3	5.6	0.9	1.5	83.1
(per capita)	43.9	79.2	9.2	1.5	2.5	136.3
Sub-total	45.1	460.3	48.2	12.4	4.1	570.1
(per capita)	18.5	188.3	19.7	5.1	1.7	233.3
Rural	494.3	44.1	-	2.0	6.2	546.6
(per capita)	99.7	8.9	-	0.4	1.3	110.3
TOTAL	539.4	504.4	48.2	14.4	10.3	1,116.7
(per capita)	79.4	74.3	7.1	2.1	1.5	164.4

Notes:

(a) Liquefied petroleum gas.

(b) All per capita figures are expressed in kilograms of oil equivalent (kgoe).

Source: Based on 1987 household energy survey and 1986 SENELEC data.

greater per capita consumption in cities compared with towns. If one looks at only the national average, wood and charcoal seem to be on a par as the key residential fuels. However, by disaggregating consumption patterns, it is apparent that charcoal is primarily an urban and wood a rural fuel. Moreover, the average urban dweller consumes more than twice as much energy as a villager. Even urban averages, though, can be misleading. By separating the five cities from the towns, one learns that the five cities have a per capita consumption nearly double that of the towns. This is caused by much higher rates of charcoal, electricity, and LPG consumption per city dweller, with relatively little use of wood compared to town residents. Thus, Senegalese urban residents are intense users of fuel, particularly charcoal, of which the five-city per capita consumption *alone* is more than double that of rural per capita use of *all* household fuels.

To get a better picture of how household energy is consumed in the important city sub-sector, it is useful to further disaggregate the data by key end-use. Table 3 divides household consumption of energy for the five cities into their principal end-uses, i.e., cooking, lighting, appliances, and other uses (primarily water-heating). This type of breakdown

Table 3

City Household Energy Consumption by End-Use, 1986
(‘000 TOE)

<u>End-Use</u>	<u>Wood</u>	<u>Charcoal</u>	<u>Electricity</u>	<u>LPG^a</u>	<u>Kerosene</u>	<u>Total</u>
Cooking	16.5	370.8	-	10.4	0.5	398.2
Lighting	0.9	-	8.5	-	2.1	11.5
Appliances	-	-	30.7	-	-	30.7
Other ^a	<u>0.9</u>	<u>41.2</u>	<u>3.4</u>	<u>1.1</u>	<u>-</u>	<u>46.6</u>
TOTAL	18.3	412.0	42.6	11.5	2.6	487.0

Notes:

(a) Water heating, charcoal irons, etc.

Source: Table 2 and 1987 household energy survey data.

is useful in order to determine which fuels are being used for particular purposes, and at what intensities.

This presentation of consumption figures by end-use clearly indicates that cooking with charcoal is the primary energy-consuming activity in Senegalese cities, making up over three-quarters of total city residential energy use. When other fuels are included, cooking consumes 82 percent of household energy in Dakar and the four other cities. The next most important energy-consuming activity is charcoal for other uses (making tea, ironing); beyond charcoal, electricity is the most important city household fuel, with power being primarily used to run appliances (air conditioners, refrigerators, televisions, etc.) and to light residences.

Finally, it is important to consider the impact of this consumption pattern on the household budget. From 1987 survey data, monthly expenditure on household cooking fuels can range from 1,650 FCFA (US\$5.80) for a family primarily using LPG in Saint-Louis to 7,860 FCFA (\$27.60) for a household using charcoal as its principal cooking fuel in Thies. In terms of average daily expenditures, this represents 12 percent of the family budget in Dakar, ranging from 10 percent for wealthy neighborhoods to 15 percent in the poorer areas. In the secondary cities, an average of 15 percent of the household budget is used to purchase cooking fuels, ranging up to 20 percent in the low-income neighborhoods. To this, one should add about 5-6,000 FCFA (\$17.50-\$21.10) per month for families which use electricity and about 1,400 FCFA (\$4.90) for households which rely on kerosene for lighting. Thus, household energy expenses are a significant part of the family budget in Senegalese cities.

The Nature of the Problem

Urban Energy Demand and Rural Fuelwood Supply

Fuelwood is not only the most important national energy source in Senegal but, in the form of charcoal, it is also the key fuel for urban households. This is causing an increasingly negative impact on the rural environment, contributing to deforestation and subsequent loss of soil fertility, falling watertables, and declining agricultural productivity. With a high urban population growth rate, Senegalese cities are demanding more charcoal, which is produced in the countryside by carbonizing wood cut from the natural forest cover. Charcoal is traditionally produced by using earthen kilns with an efficiency (weight basis) of 18 percent (Christopherson and Karch 1987: 5); thus, to make one kilogram of charcoal requires an input of 5.5 kg. of wood. Because of urban growth and the intensity of urban fuelwood consumption in the form of charcoal, cities are casting an "urban shadow" over the countryside,

with charcoalmakers cutting trees to supply urban demand. This is in contrast to rural fuelwood consumption, where firewood is primarily gathered in the form of twigs and deadwood rather than being cut from live trees.

To portray the structure and growth of fuelwood demand, national consumption trends for firewood and charcoal are presented in Table 4.

Table 4

Firewood and Charcoal Demand Trends, 1987-1998
($'000 \text{ m}^3$ wood equivalent)

	All of Senegal	Demand		Type of fuel	
		Rural	Urban ^a	Fuelwood	Charcoal
1987	3,416	1,700	1,716	1,742	1,674
Percent	100.0	49.8	50.2	51.0	49.0
1998	5108	2183	2,925	2,304	2,804
Percent	100.0	42.7	57.3	45.1	54.9
Percent increase, 1987-1998	49.5	28.4	70.5	32.3	67.5

Notes:

(a) All municipalities (cities and towns).

These projections suggest that, *ceteris paribus*, wood consumption will increase rapidly over the decade. Specifically, much of the demand will be driven by a growing urban population requiring 70 percent more biomass fuel in 1998 than in 1987, primarily in the form of charcoal.

This demand must be compared with the existing forest resource to determine if, indeed, there is a problem. Unfortunately, there is no recent forest inventory available; the most current data are from late-seventies LANDSAT and aerial photographs. From this, it was estimated that Senegal had about 14 million hectares of natural forest cover

in 1980, or about 70 percent of the land mass. However, it should be noted that this resource is not evenly distributed throughout the country: (a) in areas of low population density, such as the Saint-Louis and Louga regions, natural forests cover 70 percent of the land and reach 90 percent coverage in the Tambacounda region (6 inhabitants per sq. km.); (b) in the more populated regions of the peanut basin (50-90 inhabitants per sq.km.), landclearing for agriculture and charcoalmaking has lowered the forest cover to 50-60 percent); and (c) in high-population-density regions such as Dakar and Thies (more than 170 people per sq.km.), forests cover less than 30 percent of the land (Gorse 1985: 3, 6-7; Madon and Matly 1987: 35).

The same database indicates the regional disparity concerning the volume of wood available. The Ziguinchor, Kolda, and Tambacounda regions together contain more than 90 percent of the nation's wood by volume but represent less than 20 percent of the population. This is also reflected in sustainable yields: they vary from 0.1 m³/ha./year in the north to between 0.4 and 1.5 m³/ha./year in the mid-south, with yields surpassing 3 m³/ha./year in parts of Casamance. The conclusion of this inventory was that only 5.4 million hectares (40 percent of the forest cover) could be used without risking degradation of the resource base.

Adjusting this information to reflect forest loss since 1980, available data indicate that the annual sustainable yield of wood is currently about 1.7 million m³. According to the 1987 household energy survey, urban residential demand for fuelwood alone amounts to 1.72 million m³ of wood equivalent per year. This is projected to increase to 2.92 million m³ of wood equivalent by 1998, or an increase of 70 percent. Thus, in a decade, virtually every region of the country would be in a deficit situation if present trends continue, with demand outstripping sustainable supply.² This would result in accelerated deforestation, with its ensuing environmental and economic costs.

The Inadequacy of Existing Policies and Programs

On the supply side, a number of actions have been taken to reforest rural areas, manage the natural forest cover, combat erosion, and rehabilitate depleted soils; however, none have made a significant dent in the problem. Between 15-20,000 hectares have been reforested, and village-level plantations are adding 2-5,000 hectares to this figure annually. Still, at these rates, the country will be far from the official goal of 500,000 reforested hectares by the end of the century. Attempts to increase the stock of wood in Senegal have not succeeded for the following reasons:

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- several projects were designed and implemented in a top-down fashion and were therefore viewed as administrative burdens by villagers who were not given usufruct rights to the reforested areas;
- the focus was on a government-sponsored co-operative approach, which is less appropriate than family or village-based implementation;
- the choice of species often favored non-native trees which may be fast-growing but do not correspond to the forage, building material, food, and other needs of villagers; and
- techniques for raising and distributing seedlings, fertilization, and silviculture were not adapted to local conditions.

In an attempt to regulate forest products, the government has instituted some controls on the commercial charcoal supply network: fixing a quota for production (102,000 tonnes in 1986/87); specifying production zones for charcoalmakers; and controlling transport through a permit system. However, quotas are not based on current estimates of sustainable yields. In addition, because of bureaucratic loopholes, fraud, and insufficient staffing, the controls have not been effective.

In the area of supply enhancement, the Government has developed a charcoal kiln that is 20 percent more efficient than traditional methods. However, charcoalmakers have been slow to adopt the new technology, primarily because fuelwood savings and greater output through more efficient carbonization are not translated into higher earnings for the charcoalmakers, as they work for a patron who captures the higher profits.

In the area of non-traditional sources of household fuel supply, three options have been considered: (a) agricultural residues, (b) imported biomass, and (c) carbonized peat. Analyses have concluded that crop wastes are mostly being used for other purposes, and the cost of imported charcoal or wood briquettes would be even higher than that of domestic fuelwood.³ Thus, the Government is pursuing the carbonized peat option and arranging financing for a pilot plant.

On the demand side, the Government has tried to improve the household energy situation by promoting improved cookstoves, undertaking an LPG substitution campaign, and readjusting energy prices. The improved charcoal stove, called the Sakkana, has not yet successfully penetrated the urban market because it retails for three times the price of its traditional competitor, publicity has been inadequate, and it takes 4-5 times longer to produce than the traditional model. Consumption of LPG has increased fivefold since the campaign began in

1974. Still, national consumption has not exceeded 15,000 tonnes and has had only a small impact on reducing charcoal consumption, primarily because it is being used as a supplement to, rather than a substitute for, charcoal. As for pricing, the Government attempts to set the price for charcoal but the 1987 household energy survey indicates that actual prices are 2 percent (for Ziguinchor in the charcoal-producing region) to 86 percent (for Kaolack) higher than the official prices, and both prices are well below the economic value of charcoal. For household petroleum products, small LPG bottles enjoy a 38-40 percent subsidy while the real price structure for kerosene includes taxes equivalent to 63 percent of its retail price.

Thus, the Government has expressed an interest in addressing the household energy problem. Institutions, policies, and programs exist to document, research, and combat the problem. However, they are often ill-advised (*viz.* the reforestation effort), understaffed (as is the case with the charcoal monitoring system), inadequately planned (e.g., stove production and promotion), or inconsistent (fuel pricing policy, for example). The net result of these efforts has been a slight reduction in the growth of charcoal consumption, primarily through the LPG campaign. Given the budgetary, foreign exchange, and environmental constraints, it is important to identify ways by which Senegal can do better in the future.

Towards an Urban Household Energy Strategy

Objectives and Principles

The long-term objective of an urban household energy strategy should be to concomitantly protect indigenous forest resources and to leave the urban consumer at least as well off with current or lower levels of energy consumption per capita. To do so, the following principles are important:

- *To each his/her own fuel:* households should be offered the broadest possible choice of fuels and stoves to account for city variants, income level, and cultural preferences;
- *Focus on the short-term:* energy problems are immediate, so solutions must be as well. Priority should be given to measures which can be quickly implemented, while realizing that consumer habits take time to change; and
- *Government involvement through a least-cost solution:* this requires a minimum increase in the number of public employees, stimulating competition, and enforcing prices which are as close as possible to economic costs.

The focus of the strategy should be (1) urban, because of the increasingly important impact that cities have on both fuelwood and commercial energy consumption, and (2) residential, because of the dominant role that households play in national demand for fuel.

The Approach

To reduce the increasing demand-driven pressure on Senegalese forests and to meet the fuel needs of urban consumers, four broad strategic options are available: (a) improved public and private management of the biomass supply system; (b) accelerated and diversified interfuel substitution; (c) demand management; and (d) gradual introduction of economic household fuel pricing. More effective control over wood-fuel harvesting and marketing would involve channeling wood cutting to the least fragile areas while protecting overexploited regions, modernizing the charcoal control system, and providing rural communities with the incentives, rights, and means to manage their renewable forest resources. Diversified substitution would entail the targeted introduction of kerosene as a cooking fuel, accelerated use of LPG as a primary fuel, and medium-term substitution of carbonized peat for charcoal. Demand management includes large-scale dissemination of Sakkanal stoves in Dakar and the secondary cities, and promotion of electricity conservation for both low-income users (lighting) and the wealthy (electric appliances). Pricing policy should be geared towards incremental introduction of economic fuel prices, which can reinforce the adoption of substitute fuels and improved stoves, as well as serve as a source of income to develop forest activities that protect the environment.

Control of the Biomass Supply System

The objectives for modernizing the management of Senegalese forest resources would be to:

- contribute to the success of interfuel substitution by limiting the quantities of wood and charcoal entering the cities illegally, in order to avoid making substitutes uncompetitive in the marketplace;
- channel harvesting towards areas with sufficient forest resources and limit exploitation in those regions and villages with low regenerative capacity; and
- promote the use of techniques which are not inefficient and harmful to the environment, especially in the area of carbonization.

To achieve these objectives, realistic guidelines for the use of forested areas must be developed, the fuelwood monitoring and control system needs to be modernized, and incentives as well as assistance

must be provided to rural communities to involve them in natural resource management.

Interfuel Substitution

The three key substitute fuels for charcoal and wood used by urban households are LPG, kerosene, and carbonized peat. Each energy source has different characteristics and requires a different promotional approach. LPG is an established cooking fuel which is not being used to its full potential. Kerosene is used by residences for lighting purposes but has not yet achieved its niche as a cooking fuel. Carbonized peat has not yet been fully researched and developed as a household energy substitute, but its potential is significant.

Demand Management

The key objective of demand management is to encourage energy conservation. With respect to urban households in Senegal households, there are three mechanisms for doing so: (a) production, promotion, and dissemination of more efficient cookstoves; (b) provision of information and incentives for reducing electricity consumption; and (c) economic pricing of household fuels. The first two approaches will be briefly covered in this section, and the last will be reviewed in the following one.

For cooking equipment, several actions are possible. To stimulate the production and marketing of Sakkanals, an artisanal training program and professional public promotion campaign can be undertaken. For LPG, kerosene, and peat stoves, the following would be required: (a) selection and improvement of the product; (b) technical assistance to producers and distributors; (c) financial measures; and (d) public information. Government incentives for companies to distribute new or improved cooking products could include:

- preferential loan terms to import more efficient and marketable LPG and kerosene stoves;
- tax relief on imports (stoves or components that cannot be produced locally in the short-term);
- pre-financing the first distribution of new products, and risk-sharing with private distributors during the introduction of new products on the market; and
- tax relief for fuels, i.e. kerosene, to make them more competitive with wood and charcoal.

These measures must be integrated into a general price policy for domestic fuels, spread out over a carefully planned schedule.

To encourage electricity conservation, the following efforts can be contemplated:

- introduction of more efficient lighting, i.e. fluorescent instead of incandescent, as well as mechanisms to spread the higher capital costs of the former over an affordable period;
- improved air conditioning, e.g. equipment labeling to give consumers information on power consumption rates, and import tariffs which favor more efficient units; and
- fees for grid connection and differential kWh rates which favor small domestic consumers.

Pricing Policy

Domestic fuel pricing policy is a crucial element of an urban household energy strategy for several reasons:

- revised pricing of woodfuels will allow for the retail price of forest products to reflect their true economic value to the Senegalese economy and ecology;
- if consumers face higher, but more realistic, woodfuel prices, they will have a stronger incentive to economize on consumption of wood and charcoal through *inter alia* use of more efficient cooking equipment;
- by adjusting petroleum along with woodfuel prices, the option of interfuel substitution away from biomass will be more attractive to households; and
- increased revenues from higher, better-enforced wood-related fees can be used by the Government and rural communities to better manage forest resources.

Environmental protection, conservation efforts, and the successful penetration of substitute fuels depend greatly on increases in the prices of charcoal and wood. This will be politically and socially acceptable only if consumers are offered affordable substitutes and means of avoiding significant increases in the family fuel budget. Therefore, it is crucial that price increases be synchronized with efforts to increase the supply and availability of substitute energy sources, as well as access to Sakkana stoves. In revising prices, the overriding policy should be one of bringing fuel prices as close as possible to their economic costs.

Implementation Considerations

Feedback should occur through several different channels: (a) a price-checking and weighing program in metropolitan markets to generate periodic data on the real prices of wood and charcoal; (b) analysis

of consumer or neighborhood control groups to evaluate the evolution of fuel consumption, the success of pricing policies, the impact on household budgets, the introduction of new fuels/stoves, etc.; and (c) a more extensive investigation midway through implementation to assess the effectiveness of activities and policies undertaken, and to propose new directions. This work could be done by the government ministries involved, NGOs, and/or independent evaluators.

Conclusion

During the 1990s, Senegal will confront the other energy crisis as its rural supply of sustainable biomass is outstripped by accelerating demand for fuelwood. This demand is (a) *urban*, coming predominantly from Senegal's five major cities, (b) *residential* in origin, (c) used mostly for cooking, and (d) represents an important share of the *family budget*. To protect domestic forest resources and satisfy consumer demand, policies and programs are warranted to: improve supply management, especially through village control of resources and government supervision of charcoal commerce; promote alternative fuels as substitutes for fuelwood; conserve energy through private sector initiatives to produce and market more efficient cooking equipment; and gradually introduce economic fuel prices so that their true costs are reflected in the marketplace. Implementation of these elements of a strategy will need to be synchronized and carefully monitored to ensure that the welfare of energy consumers and the environment are both being served.

NOTES

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¹Unless otherwise noted, household fuel data are drawn from a 1987 survey of 820 households in Senegal's five principal cities, conducted by the joint UNDP/World Bank Energy Sector Management Assistance Programme.

²The actual situation is, in fact, much more severe, as charcoalmakers do not harvest wood by removing a forest's sustainable yield for carbonization. Rather, they engage in near-clearcutting around villages and access roads, thus reducing the stock of wood at a much faster rate than by sustainable harvesting.

³The replacement cost of wood in Senegal, based on the average present value of production from plantation systems and management of the natural forest cover, is 15 FCFA/kg. in the forest. This yields an average economic cost for charcoal of 101 FCFA/kg. ex-Dakar, compared with a current retail price of 60 FCFA.

BIBLIOGRAPHY

- Ceccaldi, Leonardo. 1987. "Etude des combustibles de remplacement d'origine petroliere au Senegal." Greenwich, CT: Skaarup Oil Corporation (May).
- Chatain, Elisabeth, and Michel Matly. 1987. "Enquete consommateurs et substitution" (volumes for Dakar, Kaolack, Saint-Louis, Thies, and Ziguinchor). Senegal: Energy Directorate (April).
- Christoffersen, Kjell, and Edward Karch. 1987. "The Economics of Small-scale Charcoal Production: A Case Study of the Casamance Kiln." Washington, DC: Energy Initiatives for Africa/USAID.
- Gorse, Jean. 1985. "Fuelwood and Domestic Energy: The Fuelwood 'Crisis' in Tropical West Africa." Washington, DC: IBRD (September).
- Leach, Gerald, and Marcia Gowen. 1987. *Household Energy Handbook: An Interim Guide and Reference Manual*. Washington, DC: IBRD, Technical Paper No. 67 (July).
- Madon, Gerard and Michel Matly. 1987. "Senegal: Energie Domestique." Paris: SEED (May).
- Thiam, Alioune. 1984. "Etude de cas: filiere bois et charbon de bois au Senegal." Senegal: ENDA.
- UNDP/World Bank Energy Sector Assessment Programme. 1983. *Senegal: Issues and Options in the Energy Sector*. Washington, DC: IBRD Report No. 4182-SE (July).
- Visser, Piet. 1987. "Stoves for Fuelwood and Charcoal Substitution in Senegal." Eindhoven, Netherlands: Woodburning Stove Group.
- World Bank. 1987a. "Senegal: Population Sector Report." Washington, DC: IBRD (June).
- _____. 1987b. "Senegal--Structural Adjustment Program (SAL III)." Washington, DC: IBRD (May).
- _____. 1988. *World Development Report 1988*. New York: Oxford University Press.