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ENERGY CONSERVATION IN KENYA'S MODERN SECTOR: PROGRESS, POTENTIAL AND PROBLEMS

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Energy Conservation in Kenya's Modern Sector:*
Progress, Potential and Problems

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ABSTRACT

The importance that developing countries should attach to energy conservation has been a subject of some controversy. Results are presented here of a study that investigated efforts to improve efficiency of energy use in Kenya. It is shown that many firms have made substantial progress in reducing their energy use per unit of output. Although these are encouraging signs, we found a number of barriers to realization of the potential to improve the efficiency of energy use. We conclude that assistance to facilitate energy-efficient development in LDCs is as important in the long-term, and probably more important in the short-term, as aid to expand local energy supplies.

1 Introduction

From 1970 to 1980 the cost of oil imports by the net-oil-importing developing countries rose from 5.4 billion 1980 US dollars to nearly 50 billion US dollars.[1] This rapid increase, accompanied by generally flat prices for commodity exports, has placed a severe strain on the economies of many net-oil-importing developing countries. Faced with this situation, energy planners within the countries and in international agencies have looked largely to fuel substitution and development of indigenous petroleum resources as means of reducing the burden of oil imports. Energy conservation, or improvements in the efficiency of energy use, has more recently received mention as a matter of importance,[2] but there is both uncertainty and controversy regarding its relative role in the energy policy mix. MacKillop[3] has argued that "energy conservation, in general, is not an appropriate energy policy strategy for LDCs," since "only where large wasteful use of energy already occurs does there exist a serious conservation potential." This argument obscures two separate issues: the short-run prospects for energy conservation, taking the existing energy-using capital stock as given, and the importance of energy efficiency as the LDC economies grow.

Clear thinking on both of these issues has been hindered by a lack of information. Our study of energy use and conservation in Kenya's modern sector was designed to shed light on the response within the economy to higher energy prices and to assess the potential for and barriers to improved efficiency of energy use. Although the structure of the modern sector and the patterns of energy use within it differ among developing countries, findings from other studies[4] suggest that our results may be generally applicable for a wide range of low and middle-income developing countries.

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[1] World Bank, Energy in the Devloping Countries, World Bank, Washington, D.C., August 1980.

[2] World Bank, World Development Report 1981, World Bank, Washington, D.C., August 1981.

[3] A. MacKillop, 'Energy for the developing world: a critique of the new wisdom', Energy Policy, December 1980.

[4] J. Jankowski, 'Industrial Energy Demand and Conservation in Developing Countries', unpublished discussion paper, Resources for the Future, Washington, D.C., July 1981.

2 Energy in the Kenyan Economy

Like many other developing countries, Kenya faces problems with respect to both the commercial energy forms that have fueled economic development and the traditional energy sources upon which most of the population still depends for survival.[5] In the case of commercial energy, which accounts for around 30% of Kenya's total energy budget, rising costs have become an increasingly heavy burden on the national balance of payments. All oil and coal used in Kenya are imported, and the cost of these imports (net of petroleum product re-exports) in 1980 was 36% of total non-energy export earnings compared with 16% in 1978 and less than 2% in 1973. Within the local economy, high energy costs threaten the viability of many local enterprises that are counted on to provide jobs for Kenya's rapidly expanding population.

The largest user of commercial energy in Kenya is transportation (see Table 1). The large share claimed by transportation is due in part to Kenya's role as a regional hub for road, rail, sea and particularly, air transport. (Nearly one-sixth of the total energy use shown in Table 1 represents jet fuel purchased by international airlines.) About half of the transportation sector's energy use is for land transport. Gasoline accounts for about two-thirds of land transport fuel demand, and diesel fuel most of the remainder. Evidence we collected suggests that the operating fuel efficiency of Kenya's automobile fleet of some 100,000 vehicles is very low (25-35 litres per 100 km).[6]

Industry is close behind transportation as a consumer of commercial energy, and is actually the largest user if jet fuel purchased by international airlines is removed from the energy balance. Three industries -- cement, petroleum products, and food processing -- account for over two-thirds of the sector's commercial energy use (see Table 2), and overall some dozen firms account for over half of the total. Food and beverages, which is by far the most important industry in terms of their contribution to GDP, is the largest consumer of electricity. It is also an industry made up of many firms, both small and large, in contrast to the greater concentration in some other industries.

[5] Although fuels such as firewood and charcoal are routinely marketed in developing countries, the term "commercial energy" has become synonomous with the energy forms supplied by the modern sector of the economy: petroleum fuels, gas, coal, and electricity.

[6] This compares to about 15 litres per 100 km for the U.S. automobile fleet.

Between them, transportation and industry account for 80% of total commercial energy use. Agriculture, Kenya's most important economic sector, had an estimated 8% share in 1979, followed by the residential sector with 7% and the commercial sector with 4%.

3 Progress in Energy Conservation

Interest in energy conservation in Kenya as elsewhere has been the result of higher energy prices. Nominal prices of petroleum fuels were about four times higher in 1980 than in 1973, and nominal electricity prices had approximately doubled. When general price inflation is taken into account, however, one sees that there was only a two-fold increase in the 1973-80 period, and there was practically no change in real fuel prices between 1974 and 1979.[7] The price of electricity for residential customers in 1980 (about US$0.07/kWh) was, in real terms, below the level prevailing in 1973.

It is clear that the price shock of 1973/74 had an effect in Kenya. A look at aggregate data on petroleum fuel consumption confirms that growth in demand has slowed considerably since 1973, and, more importantly, has been less than growth in real GDP (see Table 3). From 1969 to 1973 the ratio of growth in petroleum fuel demand to real GDP growth was 1.6, but from 1973 to 1980 the similar ratio fell to below 0.9.

This drop is certainly significant, but it should not necessarily be taken as a sign of improved energy productivity within the major sectors of the Kenyan economy. Although demand for all fuels (with the significant exception of kerosene) showed slower growth from 1973 to 1980 than from 1969 to 1973, gasoline, jet fuel and fuel oil were primarily responsible for the sharp fall in the overall growth rate. The slower growth in fuel oil demand was due chiefly to increased hydro-electric production. As for gasoline and jet fuel, the reduced growth in demand was probably due to curtailment of transportation activity, which does not bring with it a proportional drop in economic production to the same degree as does a decline in agricultural or industrial activity.

These factors illustrate the limits of using energy-to-GDP ratios in assessing changing patterns of energy use. It is necessary to look inside the economy and link energy with the services which it performs. In this way, structural changes in the economy can be distinguished from

[7] Retail prices as of June 1980 were about US$0.63/litre for motor gasoline, US$0.44/litre for diesel fuel, and US$0.33 for kerosene.

changes in the efficiency or productivity of energy use.

This approach does require considerable data, particularly in a developing country context. In our study in Kenya we gathered data on energy use and goods produced or services provided from several dozen firms, and also assembled data on energy use and activity in the transportation and household sectors. Most of the data on energy conservation and our impressions of conservation efforts and barriers were gathered as a result of interviews with firms. Although our visits to Kenya took place after the oil price rises of 1979, the data refer to 1979 and earlier and thus largely reflect responses to the 1973 oil price shock only.

3.1 Energy conservation in Kenyan industries

Several factors complicate the assessment of conservation progress, which we measure in terms of reductions in the energy intensity of production or activity (i.e., energy use per unit of output or activity). Capacity utilization can have a significant effect on energy intensity. Some factories in Kenya are so pressed to produce that they run in excess of rated capacity and lose energy efficiency in the technical sense, although so doing may result in greater profits. Expansion of capacity can affect energy efficiency, as larger factories tend to use less energy per unit of output than smaller, and newer less than older.

Despite these difficulties, most of the reductions in energy intensity that we document here resulted from deliberate attempts to save energy. Conversely, most factories that had not attempted to improve energy use had constant or increasing energy intensities. Indeed, our interviews and examination of data on industrial energy use showed a clear distinction among firms. Some firms, notably the most energy-intensive ones (cement, oil refining, some steel companies) showed a keen awareness of the economic benefits of energy conservation and of systematic energy accounting. Managers could pinpoint increases or decreases in energy use relative to output, and, significantly, the reasons why they came about. Interviews with transnational firms, even those whose energy intensity is relatively low, revealed a similar awareness. The largest and best documented conservation gains came from a firm that is a subsidiary of a multinational firm.

The status of conservation among other firms, however, is mixed. In one firm the engineers complained that the firm would not likely invest a small amount to fix obvious leaks, improve boiler efficiency, or "optimize" a process, even if the returns for such investments were large. One of our guides pointed out that the boilers we had just viewed were run at unnecessarily high pressures. An engineer at a metal-processing firm told us he was satisfied simply to be able to start the equipment in the morning. The managing director of a very large and energy-intensive firm listed difficulties that held back his conservation effort: poor organization, varying oil quality, high demand for product that made high mill capacity factor more important than energy economies. The progress made towards more efficient energy use in his firm was slow, in spite of the increasing size of his fuel bill. In contrast, a manufacturer of food and household items had just hired an engineer who planned to make important process modifications to reduce energy use. Several firms had discovered sources of biomass scrap from other factories that would substitute for a considerable fraction of their oil use; while others have discontinued use of such scrap for boiler fuel because of pollution problems.

We found activities related to energy conservation scattered among the firms we visited, but no clear trend. Those firms that had made efforts to economize had generally succeeded; many firms simply had not tried. The data in Table 4 illustrate that a wide range of firms have been successful in reducing the energy intensity of their operations. In general, we observed that reductions in petroleum fuel intensity were much larger than reductions in electricity intensity. This is not surprising given the relative trends in price. In some firms, we found increases in energy intensity, particularly in electricity, despite efforts to conserve energy. The data on creamery operations (nationwide) present a striking example. Fuel intensity fell since 1972, but electricity use per unit output increased two-fold. We believe that this increase reflects mechanization of older facilities. Of course, increased electricity intensity does not rule out the presence of conservation practices; in the case of the creamery, electricity intensity would have been even higher in 1979 had not measures been taken to reduce consumption.

The effects of capacity utilization and economies of scale need to be kept in mind when interpreting energy intensities. We noted several firms that reduced energy intensities markedly without any apparent conservation efforts. In almost every case where this was observed the output of the firm had risen by as much as fivefold over the period examined. Similarly, firms whose output fell during slack years showed increased energy intensities in spite of reported conservation efforts, some of which we observed personally. The oil refinery, for example, used more fuel per unit output in 1979 than in 1973, apparently because reduced demand for its products forced it to run well below its capacity (though a concerted conservation effort reduced energy intensity somewhat in 1979 relative to 1977).

3.2 Energy conservation in transportation

Data limitations prevented us from forming precise indicators of energy intensity in the transportation sector. There are indications of reduced activity with respect to automobiles, as total automobile vehicle-kilometers travelled (as estimated by the Automobile Association) increased by an average of 3% per year between 1975 and 1979, while the estimated number of automobiles grew at a rate of nearly 6%. Growth in gasoline demand was down significantly in the 1973-80 period, averaging 3.7% per year as opposed to 11% per year from 1969 to 1973. Whether the fuel efficiency of the automobile fleet improved is an open question, but it is clear that its present fuel efficiency is very low, probably due to both poor vehicle maintenance and congested traffic conditions. Higher import duties on larger cars have apparently had some effect on the pattern of new car purchases.

There do appear to be improvements in the energy efficiency of bus and rail transportation. The bus company in Nairobi noted a 10% drop in energy consumption per vehicle-kilometer after a concentrated effort to improve operating efficiency was carried out, and its intercity counterpart also observed energy savings in 1980. Total energy use by the railroad was about 3.2 petajoules in 1980 compared with 6 petajoules in 1977. During this period there was no significant decline in rail travel. The main reason for the dramatic decrease appears to be a rapid shift from heavy diesel fuel and fuel oil to automotive diesel fuel, which burns much more efficiently in locomotives. There was also some upgrading of the locomotive stock.

3.3 Energy conservation in commercial buildings

The data we collected for commercial buildings show definite signs of energy conservation among hotels and mixed indications of conservation activity among office buildings (see Table 5). It should be kept in mind that the price of electricity, the major energy expenditure for most commercial buildings, did not increase nearly as much as did the price of petroleum fuels. We found that some of the larger hotels had considered energy conservation opportunities carefully, and solar water heating systems (with collectors assembled in Kenya) had been installed or were planned for many hotels. Office buildings (in Nairobi) showed no clear trend. Of the ten buildings for which we had several years of electricity consumption data, two showed a significant decrease in consumption, two showed significant increase, while the rest stayed at about the same level of consumption.

3.4 Energy conservation in residences

It is difficult to characterize conservation efforts in the residential sector due in part to changes in electricity tariff classification. We could detect no discernible drop in estimated residential electricity sales (not surprising given that the real price of electricity fell by 20% from 1973 to 1978). Similar uncertainty applies with respect to residential use of petroleum fuels, although it is noteworthy that total Kenyan kerosene consumption increased at a faster rate between 1973 and 1980 than between 1969 and 1973. This trend may reflect substitution of kerosene for wood in cooking.

4 Barriers to Energy Conservation

Although we observed as a general rule that concerted efforts to reduce energy costs were largely successful, there remain a number of barriers to improving the efficiency of energy use in Kenya. Lack of on-site expertise in improving the efficiency of existing equipment is a common problem, particularly among locally-owned firms. Competent engineers are often preoccupied, indeed overworked, just keeping the plant functioning. There is also a lack of domestic sources of hardware to improve the energy efficiency of existing equipment. The necessity to import some conservation equipment causes problems with import formalities and restrictions for those firms attempting to invest in conservation.

Inability to organize workers and management hinders conservation efforts. Several hotels experienced difficulty in training staff to manage lights, cooling and hot water equipment. The majority of firms we visited had difficulty providing energy consumption data that should be on hand in every manager's office. Lack of information on actual energy use patterns makes it difficult to devise effective energy management programs. We also encountered the belief that little could be done to reduce energy use in the firm's operations, as well as overwhelming management concern with other parts of factory operations.

A more subtle barrier to energy conservation is the protection of industrial outputs by tariffs and other means. We were told that in some cases profit margins may be so high as to make the gains afforded by more efficient energy use uninteresting to the individual entrepreneur, even though the sum of these gains would have a substantial positive impact on the overall balance-of-payments of the whole country. Thus, these government subsidies may inadvertently be causing the private sector to underinvest in conservation.

5 The Role of Energy Conservation

There is a prevailing popular notion that it is only the rich countries, with their high level of per capita energy use, who use energy "wastefully." Since, in this view, there is little fat in the developing countries' energy diet, placing a strong emphasis on energy conservation would be largely unproductive. We believe that this view is false. Although it is certainly true that energy use in the modern sector plays a much smaller role in the overall economy of the developing countries than in the wealthy countries of the North, it is also true that where the modern economy is present, energy is being used in a fashion wholly inappropriate to its cost.[8]

Our observations of Kenyan factories and buildings and discussions with their managers and engineers provided convincing evidence of the considerable potential to improve the productivity of energy use in existing operations. The size of the conservation "resource" is difficult to judge without a more comprehensive study than we were able to undertake. Our rough estimate is that savings of 20-25% of present consumption are attainable in the industrial sector through economically attractive measures. This is equivalent to roughly 1 million barrels of oil per year, which presently costs Kenya over US$30 million in foreign exchange to import. Probably a greater proportional savings is possible in ground transportation, although this potential, which involves better vehicle maintenance and improved traffic management, will admittedly be difficult to achieve. Commercial buildings, which account for only a tiny share of petroleum fuel use but over 25% of electricity consumption, also offer considerable room for cost-effective conservation.

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[8] This could also be said of the traditional economy in those areas where wood is becoming a scarce resource.

Perhaps even more importantly, it must be kept in mind that the economy of Kenya (and other developing countries) is, presumably, still in the early stages of its growth. Thus, Kenya has the opportunity to ensure that its new capital stock -- factory equipment, buildings, vehicles, appliances -- makes efficient and productive use of energy resources that will in all likelihood become more expensive to acquire. The potential savings in this area are probably much larger than those available from the existing capital stock, but they will not be fully realized without adequate planning.

6 Furthering Energy Conservation in Developing Countries

Although the potential for improved energy productivity in developing countries is considerable, the task of realizing it is probably more difficult in that context than in the wealthier countries of the North. This is due both to the barriers discussed earlier and to the general lack of capital to make investments in energy efficiency. Further, in the often volatile political climate in many LDCs, private decisions with respect to investments in energy efficiency may use a much higher discount rate than is appropriate from the longer-range perspective of national well-being. Probably even more so than in the industrialized countries, where the market is relatively well-equipped to respond to the demand for energy management products and services, there is a role for government involvement to facilitate efficient use of energy.

An oft-cited basic principle is the pricing of energy at or at least near its replacement cost. Without an accurate signal of the cost to the economy of using energy, firms and consumers are unlikely to make decisions that result in the wisest possible use of scarce resources.

For government action to be effective and targetted for the areas where it is most needed, a detailed understanding of the patterns of energy use in the economy is necessary. Once industrial energy use is better understood, the conservation problems and needs of individual factories or whole industries can be better addressed. From our work in Kenya we see the following pressing needs that should be addressed by energy authorities, trade and professional societies within countries, and international donor organizations:

- Training. Even in energy-intensive industries, where staff has always dealt with high energy costs, there appears to be a great need for training of both engineering/management personnel as well as assembly line workers. This is particularly important for local firms without access to the resources of transnational corporations. We were reminded constantly of staff reluctance to employ the most modern energy saving techniques because of a lack of personnel trained to monitor them.

- Implementation. The investment needs of conservation technologies are not necessarily appreciated or understood by government and private authorities who control investment. Support for conservation investments is called for in many instances.

- Evaluation. Better data on industrial energy use allows both managers and authorities to follow the progress towards more efficient energy use. With such information better judgements about investment needs, and indeed future industrial energy needs, can be made. Individual firms should also be assisted in developing systems to keep better track of their energy use.

- Import policies. Many important conservation technologies can only be imported into LDCs. We found evidence that import licenses may be refused, or that duties on imported equipment may be prohibitive. While it is certainly desirable for LDCs to develop their own "conservation industries", it seems advisable in the medium-term to allow the importation of energy saving equipment, whose benefits will be felt immediately.

6.1 Aid for energy-efficient development

Energy conservation is not a substitute for prudent development of local energy resources, but it can significantly reduce energy costs in the long-run as well as provide some near-term relief to energy-related foreign exchange problems. The World Bank and other organizations have called for massive energy-related aid to low-income developing nations. We feel that serious consideration should be given to aid that enhances the efficiency of energy use. At present it is institutionally easier to give or finance large energy-producing facilities with capital provided by donors or other lenders. Given the scarcity of such capital, however, it seems prudent to demand that contributions to LDC energy needs bring the greatest return possible. In contrast to most energy supply schemes, investments in energy efficiency have a diffused but relatively rapid impact, and thus can be instrumental in helping financially struggling developing countries through the present hard times. A long-range energy conservation program could considerably reduce the energy costs of development, and provide energy savings that will likely be less expensive than most of the energy supply alternatives.

Efforts to expand domestic energy supplies in LDCs, including the use of renewables, are certainly important, but the uses of energy, present and future, should be matched economically to the real cost of those domestic supplies. For this reason, any major energy aid to LDCs should include analysis of possibilities for more efficient energy use. Research oriented to the design of conservation programs that will be effective in the developing country context is needed. In Kenya and elsewhere, a relatively small amount of technical and financial assistance could yield substantial benefits.

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Table 1. Kenyan Commercial Energy Use by Sector, 1979

	Petroleum Fuels	Coal	Electricity[a]	Total
	(petajoules)			
Transportation[b]	39.8	nil	0.1	39.9
Industry[c]	21.2	1.6	4.5	27.3
Agriculture	6.6	nil	0.2	6.8
Residential	3.5	nil	2.0	5.5
Commercial	0.9	nil	2.5	3.4
TOTAL	72.0	1.6	9.3	82.9
(Electricity)	(4.2)	nil	-	

Source: Based on data collected from oil companies and East African Power & Lighting Co. (EAPL).

[a] Values reflect hydro-electric generation (counted at 1 kWh = 3.6 MJ) and oil used in electricity generation, with the total divided among the sectors according to electricity sales. Over 75% of Kenya's electricity is from hydroelectric stations.

[b] About 13 PJ are used in international air transport.

[c] Includes construction.

Table 2. Commercial Energy Use in Kenyan Industry, 1979					
	Petroleum Fuels	Coal	Electricity[a]	Total	Value Added[b]
			(terajoules)		
Cement	5570	1310	446	6016	9.3
Petroleum products	4730	nil	140	4870	1.9
Food and kindred	3215	nil	535	3750	93.3
Paper	1685	nil	86	1771	8.9
Textiles	1355	nil	290	1645	18.8
Chemicals	835	nil	70	905	6.8
Clay and glass	795	nil	37	832	1.1
Metal products	330	nil	202	532	20.4
Rubber products	280	nil	57	337	6.1
Transport equipment	95	nil	20	115	11.4
Other[c]	1550	330	412	2312	50.6
TOTAL	20440	1640	2295	24375	228.6

Source: Based on data collected from oil companies, individual firms, and EAPL.

[a] Values refer to EAPL sales only and do not include self-generation.

[b] Given in million Kenyan pounds; from 1977 census of industrial production.

[c] Includes small manufacturing shops.

Table 3. Trends in Kenyan Commercial Energy Use					
	1969	1973	1980	Average annual growth (%) 1969-73	1973-80
Petroleum fuels ('000 m^3)					
Gasoline	212	322	416	11.0	3.7
Kerosene	53	66	107	5.7	7.2
Gasoil	184	303	486	13.3	7.0
Heavy diesel	37	55	46	10.5	-3.6
Fuel oil	355	435	490	5.3	1.7
LPG	11	22	40	19.9	8.7
Jet fuel	203	342	464	13.9	4.5
Avgas	8	8	8	-	-
TOTAL	1063	1553	2057	10.0	4.1
Electricity generation (GWh)	664	990	1735	10.5	8.3
GDP (10^6 pounds)					
Constant prices[a]	524	667	920	6.2	4.7

Source: Central Bureau of Statistics and EAPL.

[a] 1972 base.

Table 4. Indicators of Energy Conservation in Kenyan Industry

Factory	Energy use per output (MJ) Fuel	Electricity	Output Unit
Vehicle assembly			
1977	5000	2020	vehicle
1979	3550	1730	
Truck assembly			
1978	1950	-	vehicle
1979	1780	2195	
Tires			
1975	35600	8930	ton
1979	19940	5760	
Tire recapping			
1977	21700	3095	ton
1979	13700	3455	
Cement (wet kiln)			
1977	6200	290	ton
1979	6020	265	
Cement (dry kiln)			
1976	3950	310	ton
1979	3980	255	
Paper/pulping			
1977	47500	-	ton
1979	38800	-	
Steel			
1977	4070	2125	ton
1979	3840	2410	
Creameries			
1972	1940	170	'000 ltr
1979	1480	350	
Food processing			
1975	6250	-	ton
1978	4370	-	
Soap			
1977	12760	495	ton
1980	10700	545	

Source: Based on data supplied by individual firms.

Table 5. Energy Conservation in Kenyan Hotels

(Energy per guest-day)

	Hotel #1		Hotel #2	
	1975	1979	1977	1979
Electricity (kWh)	16.1	14.3	35.5	23.7
Fuel (MJ)	138	102	306	253
	Hotel #3		Hotel #4	
	1977	1979	1977	1979
Electricity (kWh)	33.1	30.1	21.5	16.9
Fuel (MJ)	-	146	-	559

Source: Based on data supplied by hotels and EAPL.

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