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The Relation Between Traditional and Commercial Energy Sources.

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THE RELATIONS BETWEEN TRADITIONAL AND COMMERCIAL ENERGY SOURCES

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Introduction

The paper concerns a very specific aspect of energy policy in Less Developed Countries (henceforth, LDCs). That is, how to find efficient ways for developing integrated energy policies that take account of the interconnections between commercial energy (CE) and traditional energy (TE).

Since the late 1940s, economic thinking on LDCs has been strongly influenced by the idea that these countries have a dualistic structure. One sector is viewed as the 'modern' sector sometimes characterized as the 'advanced' sector; over time it became synonymous with the urban or industrial sector. The other sector was the 'traditional' sector sometimes characterized as the 'backward' sector; it became synonymous with the rural or agricultural sector. While many aspects of such an approach have been rightly castigated (Griffin,1969), dualism does help to identify a policy problem. In general, government policies in LDCs either at micro or macro levels, explicitly and implicitly, have been orientated towards influencing only the modern sector of the economy. In so far as policy has influenced the traditional sector it has usually done so by accident via secondary and tertiary effects. This has had serious implications for the achievement of policy targets. Energy policy, where it exists, is no exception to this generalisation. Thus government policy is orientated to influence the supply and demand of commercial fuels while ignoring non-commercial fuels. The paper seeks to examine how TE can be brought explicitly into the area of primary impact from policy making and discusses the consequences of this inclusion on policy targets, instruments and effectiveness.

Two clarifications are required. The first is to define what is meant by CE and TE. There are many possible approaches to these definitions but to illustrate analytical possibilities, definition by economic characteristics seems most appropriate. Commercial energy has two significant characteristics. It moves in corporately controlled markets - in most developing countries the corporation is state owned- and it involves a gross foreign exchange input. Essentially this covers coal,petroleum and electricity. TE on the other hand either moves in small local markets or moves in no markets at all in the sense that it is not traded and has no money price although it does have an opportunity cost. TE which is not traded could also be called 'non commercial energy'. TE's other characteristic is that it involves no foreign exchange input. TE therefore covers wood, vegetable and animal residues (sometimes called 'wastes', an inappropriate term because it implies no alternative use and hence no opportunity cost). There is also another dimension to TE: animate energy. In LDCs much physical work is performed by humans and animals that in more developed areas or countries would be done by machines powered by CE. Statistics on TE often do not include animate energy, although for a number of purposes (for example, comparisons of energy-intensities and assessments of levels of living) it is important that they should (Desai, 1978, 1980, Sankar, 1977).

The second clarification concerns the content of this article. The authors view the paper as a first step; at this stage, the paper's aim is to outline on a priori grounds an approach which might help policy-makers to formulate integrated energy policies. Thus there is limited empirical background to support some of the arguments. However, it is intended to add a structured empirical basis in later work.

There are two main reasons why the subject is worthy of study. First it is clearly important for the allocation of resources in the LDCs, with all that this implies for the development prospects of these countries. Second the LDCs are becoming increasingly important as an element in the world oil market in terms of their demand for crude oil. In 1971, LDC oil consumption accounted for some 16.4 percent of world oil consumption while by 1981 this percentage had increased to 24.5 . Furthermore, after 1979 when the industrial consumers' demand for crude oil fell, the demand from the LDCs for crude grew at some 4.37 percent per year compared to a decline in world oil consumption of 2.87 percent (BP Statistical Review). Anything which influences oil demand from the LDCs (as energy policy does) is therefore likely to play an important role in the future world oil market. And, as we hope to demonstrate, the relationships between CE and TE mean that the role of TE could itself be a significant indirect influence on oil demand.

The paper has been divided into two sections. In the first section some explanation is given as to why TE was neglected in the area of energy studies and then why this indifference turned into increasing concern and interest. The section then considers some of the conclusions which began to emerge following the development of empirical work on TE. The second section deals with the implications for energy policy formulation of incorporating TE. In the second section there are four sub-sections. The first examines the basis and origins of energy policy targets in LDCs. The second briefly examines arguments for and against exploring the linkages between TE and CE. The third sub-section then outlines a strategy for developing integrated energy policies with the aid of an augmented energy balance matrix and analysis of the various energy policy instruments available to LDC governments. Finally there is a sub-section which runs through one example based upon a priori reasonimg of how energy policy may differ when TE is taken into consideration.

SECTION ONE

1.1 Explanations for the neglect of TE

The first question to consider is why was TE neglected in energy studies in the LDCs before the 1970s. Two reasons can be suggested, the orientation of development policies and the lack of data.

A great deal has been written on the nature of economic development policies. At the risk of gross oversimplification the following points can be made. In the early years after the Second World War, development thinking was dominated by the ideas of dualism in which the poor countries were characterised as having large traditional/rural/backward sectors and very small or even non-existent modern/urban/advanced sectors. The object of the development process was to increase the size of the modern sector since it was assumed that the larger the modern sector the higher up the league tables of economic development was the country. Thus all efforts and attention were focussed upon the modern sector and its expansion while the traditional sector was condemned to either benign or malign neglect. Since the modern sector used CE (almost by virtue of a tautology) all energy interests were directed accordingly. Thus, the interest in CE first stimulated and was then in turn reinforced by the undeniably high growth rates in its consumption (for example, in the developing member countries of the Asian Development Bank, the growth rate was 10 per cent per year in 1965-1973, declining to 8.5 per cent in 1972-1978 (Asian Development Bank, 1982, p.30)). Even during the early sixties, when attention towards agricultural development grew (Johnston and Mellor,1961,Kuznets,1965,Nicholls,1964) the sector was still viewed as instrumentally important via what Kuznets called its market and factor contribution (Kuznets,1965) rather than intrinsically important. Thus TE which dominated in the agricultural/traditional sector remained in a backwater of neglect. This trend of neglect was further reinforced by the strong urban bias in the policies of most LDCs (Lipton,1977) since TE is largely used in the rural areas.

The second reason for the neglect of TE was the lack of data. This can be explained by four interconnected factors. The general lack of interest in the subject already outlined, was the first. The second was the fact that the measurement problems were considerable because the use of TE did not enter any accounts by virtue of the absence of money prices. Thus the only way to enumerate its use was to go into the villages and count the number of twigs, quantities of animal dung, etc. as they were used and make some sort of heroic assumptions about the homogeneity of the calorific value of the inputs and their conversion efficiencies. Given the lack of interest, the effort must have seemed scarcely worthwhile. The third reason for the lack of data is that there appears to have been a widespread assumption that TE use was falling so rapidly as to make measurement unnecessary. The final reason, doubtless influenced by the tunnel-vision of dualism, was that in any case TE was often thought to lie beyond the reach of government policy.

1.2 Reasons for the recent interest in TE

This situation of neglect changed dramatically in the 1970s for three reasons. The first was a major change in the orientation of development policies. By the middle to end of the 1960s there was a growing disillusion with the conventional development wisdom. Despite relatively high growth rates by the LDCs plus increases in the size of the modern sector, it was becoming clear that the majority of the populations of the LDCs were no better off and in many cases worse off. The trickle-down mechanism had failed (ILO,1977;Griffin,1974). The result was a growing emphasis on such ideas as redistribution with growth and meeting basic needs (Chenery et al, 1974, Ahluwalia, 1976, Singer, 1979). This was linked to the view that agricultural development was important not just for what it could supply to the rest of the economy but also for what it could contribute to the lives of those in rural areas:since the majority of the LDC populations lived in the rural areas if development meant anything it meant making such people 'better off'. The result of these reorientations was that attention turned to the traditional sector as being important and worthy of study. With this growth of interest in the traditional sector came a growing interest in the fuel situation in the traditional sector, namely TE. This was further stimulated by the growing problem of the 'fuelwood crisis' which began to emerge in the 1970s and an associated interest in environmental problems related to TE (Eckholm, 1979, Global 2000, 1982).

The second cause of interest was the rise in crude oil prices which began in 1971. This dramatically forced the whole issue of energy to the attention of LDC governments. The two oil price shocks of 1973 and 1979-80 were both disastrous for the LDCs. Their import bills rose sharply, creating balance of payments havoc. Two other complementary factors reinforced this payments problem. The rise in oil price coincided with a fall in the price of other primary commodities following the price boom of 1970-74 and in the middle of the 1970s international interest rates began to rise thus putting further strain on debtor nations trying to service their debts (Foley and Van Buren 1982). In 1970, the oil-importing LDCs faced a current account deficit excluding official transactions of $7.5 billion (current prices). By 1979 this has increased to $36.2 billion and by 1981 had reached $67.7 billion (World Bank). Between 1980 and 1982 for the twenty one major LDC borrowers their current account deficits increased from 12 percent of exports to 23 percent of exports (Morgan Guaranty). Effectively the oil bill was crippling the LDCs. Thus emphasis was turned towards saving oil imports which in turn meant considering all aspects of energy including TE although this interest was essentially academic and appeared to have little influence on policy.

The final reason for the growth of interest was the preliminary results of some studies, indicating that TE, its links with CE and its environmental impacts could no longer be ignored in any competent, comprehensive analysis of the present and future energy situation in the LDCs.

1.3 Results of recent data collection and analysis

There has been, and to a considerable extent there still is an acute shortage of information on the scale and nature of use of TE (see, for example, Asian Development Bank, 1982, p.103, Dunkerley, 1982, p.87, Global 2000, 1982, v.2, p.374, World Bank, 1979b, p.8). In the past this data shortage made impracticable any comprehensive and reliable quantitative analysis and hindered the development of appropriate policies. Recently, however, as interest has grown, more resources have been directed towards gathering and analysing information on TE sources and uses. The work has been undertaken by individuals, institutions and some governments (see, for example, Alam et al., 1983, Asian Development Bank, 1982, Desai 1978, 1980, Douglas, 1982,Earl, 1975, Makhijani and Poole, 1975, Sankar, 1977, World Bank, 1979a, 1979b, 1980; for summaries of much of the available work, see Global 2000, 1982, the annotated bibliography by Barnett, Bell and Hoffman, 1982, and also Hall, Barnard and Moss, 1982).

Even now the data has to be interpreted with great care. There is a wide range of problems associated with obtaining and preparing estimates of TE. Hughart (World Bank 1979a, p.34) points out a number of difficulties with data about animal dung and crop residues, beginning with the estimation of crop production levels and livestock numbers. Once these estimates are available it is then necessary to estimate: (a) coefficients relating residue production to primary production; (b) the energy content of different residues; (c) the availability of residues for energy purposes; and (d) the differential efficiencies of different fuels in different end-uses. In each case the estimate results from the aggregation of a set of sub-estimates which are likely to differ widely and for which neither the basic data nor those necessary for accurate weighting are easy to get. Similar problems arise with fuelwood availability data, with the added difficulty that a lot of fuelwood is not collected from the forests and trees recorded in official statistics but from trees and shrubs scattered around villages, houses and roadsides. Much of the fuelwood consists of mixed twigs and leaves with a variety of moisture contents and heating values.

Household surveys are widely used as the source of data on TE consumption but are not always as reliable or as useful as they might be (Barnett, Bell and Hoffman, 1982, pp.10-17, Hall, Barnard and Moss, 1982, p.13). The problems include: the seasonality of fuel supply and consumption; difficulties in measuring accurately different units of supply (e.g. headloads, bundles); the unsystematic unreliability of people's recollections of recent fuel use; intentional exaggeration or understatement of use by respondents who may wish to appear richer or poorer than they are or who may ,for a variety of reasons, be reluctant to disclose their methods of collection and sources of supply; failure to structure questionnaires so as to distinguish between different social, income or occcupational groups; and all the other classic problems of survey methodology. A further limitation of the single survey is that it provides no time-series data necessary for understanding the dynamics of the rural and urban TE situations, although this difficulty can sometimes be overcome through re-analysis of existing data from other sources.

Despite these reservations, interesting and useful information has begun to emerge from a number of studies, although it is not always a simple matter to bring it together and compare it. Table 1 is intended to provide a compact outline of data on domestic and non-domestic TE sources and uses and on the environmental impacts of TE production, collection and use.

Recent data confirms the actual and potential importance of TE use in LDCs. It is substantial, both absolutely and relative to CE use. In particular, it is the main source of energy for both household and non-household uses in the rural areas where 70 per cent of the people in LDCs live, and is extensively used by the poorer households in urban areas. Estimates of the share of TE in total world and LDC energy consumption vary considerably; one source offers estimates ranging from a share of TE in total LDC energy use of 30 per cent, right up to a high of 70 per cent (Global 2000, 1982, v.2, p.375), while another recent estimate puts this share at 43 per cent (Hall, Barnard and Moss, 1982, p.7). Fuelwood (including charcoal) is the major non-commercial fuel, with 90 per cent of the world's fuelwood being consumed in the LDCs. Worldwide, in 1974 the fuelwood share of TE was more than 80 per cent, with dung contributing about ten

TABLE 1: Summary Data on Traditional Energy

SOURCES	DOMESTIC ENERGY USES	AGRICULTURE, INDUSTRY, COMMERCE AND TRANSPORT ENERGY USES
WOODFUEL + twigs & leaves	Cooking and heating: wood is the most commonly used traditional fuel, the principal cooking fuel for 1/3 of world population (H,p.3), especially in rural areas and among the urban poor in LDCs. Average use in rural villages can easily approach 15 GJ/person/year, roughly equivalent to 1 tonne of air-dry wood (HBM, pp.14, 182-3). Open fires or simple stoves are used, with very low efficiency of 5-10% (ADB, p.117). Most cooking done by women and fuel collecting by women and children, from woodland, scrubland and roadsides (HBM, p.9). Widespread rises in commercial firewood prices have occurred in the last ten years (D & F, p.69).	Wood and charcoal widely used in a variety of mostly small-scale processes, including: baking, blacksmiths, brewing, brick-making, cement manufacture, food drying, curing and vending, metal extraction, pottery-making, rubber manufacture, sugar production, tea-curing and tobacco-curing, as well as steel-making (Brazil, Philippines) and railways (Thailand) on a larger scale (HBM, p.12; H, p.16). Although in most countries only 2-15% of fuelwood is devoted to these processes, in many these activities represent the fastest-growing use for wood (D & F, p.69). In rural Asian villages, non-commercial energy used in industries is a small proportion of the total energy used (ADB, p.113.) Wastes produced as part of the process are used as fuel by sawmills burning sawdust, bark and woodshavings (HBM, p.12). Wood-fired power stations are under construction in the Philippines (D & F, p.73).
CHARCOAL	Cooking and heating: charcoal is the second most commonly used traditional fuel, after wood, and in urban areas is used more than wood. Charcoal braziers may be 2 to 3 times as efficient as wood stoves, although 70-80% of energy value of wood may be lost in traditional charcoal-making in covered wood piles or simple earthen kilns (HBM, pp.9-10; H, p.14). Conversion of wood to charcoal more common as distance from forest increases and transport costs rise (estimates vary between 15 and 80 kms: E, pp.73-74; H, p.11). Charcoal is often bought for cash in urban areas.	
CROP RESIDUES & VEGETABLE 'WASTE' – stalks, husks from grain crops, cotton & nut waste, bagasse, jute sticks	Cooking and heating: often used where wood and charcoal are scarce. Main fuel source for domestic use in Bangladesh (B, p.615; H, pp.17-24). Availability tends to be seasonal and depends on harvest and competing uses, such as for animal fodder, housing construction and thatching, and soil conditioning (H, pp.20-21). Little or nothing is wasted, hence the term 'wastes' is inappropriate	By-products are used as fuel in some industries, e.g. sugarcane bagasse is used as a fuel for sugar production and the food-processing industry burns organic wastes (HBM, p.12).
DUNG	Cooking and heating: widely used as a substitute for wood and charcoal. With crop residues is estimated to be principal cooking fuel for more than 1/5 of world population (H, p.3). Between 0.5 and 1 billion people use dung to meet a part of their energy needs (HBM, p.10). This preempts its use as a fertiliser and soil conditioner, except when used in biogas digesters to produce methane (the slurry can still be used). Around 6 million biogas plants are used in China and around 80,000 in India (HBM, pp.83-87) but families and communities may be too poor to adopt them, while the landless poor may lose access to 'free' fuel (HBM, pp.130-31).	Apart from use in biogas digesters to produce methane, and agricultural use as fertiliser, dung is mainly a domestic fuel. In one Bangladesh village 62% of dung was used as a fertiliser, 13% was used as fuel and 25% was not collected or uncollectable (H, p.21).
HUMAN & ANIMAL ENERGY	Domestic work: human energy is used for tasks including cooking, clothes-making and washing, carrying of water, child care, etc., mostly by women. Fuel-gathering is also typically women's work and in areas where fuel is scarce, journeys of half a day or more may be required (HBM, p.9) and children may be withdrawn from school to search for fuel. In central Tanzania, providing a family's annual firewood requires 250-300 days of labour (D & F, p.69).	In LDCs much physical work is done by humans and animals that in developed countries is done by machines. This can be important for comparisons of energy-intensities (D2, p.62; D1). The output of a 40kW small diesel engine is equivalent to that of 1300 people or 80 bullocks in a working day (F & vB, p.6). Rural industry and commerce employ primarily human labour (and woodfuels) to provide mechanical energy. In agriculture human labour is used in soil preparation, planting, irrigating, harvesting, processing and transport, often with the aid of draft animals. Draft animals widely used in rural transport (e.g. bullock carts).
ALL TRADITIONAL ENERGY SOURCES	Traditional fuels are used for cooking by more than 1/2 of the world population of 4.5 billion in 1981 (H, p.3), so they are a major source of energy for domestic purposes especially in the rural areas where 70% of LDC populations live. The level and pattern of use varies widely both within and between countries, reflecting differences in demand, fuel-use practices and supply and relative prices of both commercial and non-commercial energy; within countries, variations depend on region, season, and income level (data in ADB, pp.105-109,319; HBM, pp.15,177-200, H, p.63, D2,pp.44-61). Ownership of fuel-generating resources (trees, land, animals) typically highly skewed, especially where high proportion of villagers are landless – distributive mechanisms depend on social relationships (e.g. patron/client relationships in Indian subcontinent) which can change or be changed over time (H, pp.25-27; HBM, pp.141-142; BBH, pp.2-5).	Wood and charcoal are widely used in small-scale industrial processes from food processing to manufacturing, and occasionally used in large-scale processes such as steel-making in Brazil and the Philippines. Usage is increasing even though it does not usually constitute more than 15% of total fuelwood use. By-products are often used as fuel in the same process. In LDCs human and animal physical work is significant although accounting for a relatively small percentage of total energy use.

TABLE 1: (continued)

SOURCES	ENVIRONMENTAL IMPACTS	COMMENTS AND STATISTICS
WOODFUEL CHARCOAL	Increases in local deforestation can occur where sustainable yields are exceeded by heavy and early cutting of trees for fuelwood (other contributory causes include expansion of agricultural land, demand for animal fodder and commercial logging). The removal of tree and vegetation cover can lead to soil erosion (and landslides in hilly areas such as Nepal) followed by siltation, causing disruption to water systems, e.g. siltation of reservoirs, riverbeds and irrigation canals, resulting in reduced availability of water for some and more flooding for others (G, pp.320-321). The water storage capacity of eroded soil is lost, so runoff increases flood potential and decreases usable water resources, lowering the groundwater table (G, p.379). Lowered soil fertility adversely affects agriculture and food production. The ultimate consequence of excessive wood gathering is often desertification. Fires and furnaces create pollution and fire hazards.	As statistics improve, the extent of rural energy supplies becomes better known. However, there is little understanding of the likely changes in future rural energy systems as requirements increase and the availability of fuels changes (BBH, p.10). Overall at least 25% of all LDCs are or presently will be experiencing fuelwood availability problems. There are two types of problem areas: (1) areas where wood is already scarce and other fuels are being used (most drier areas of Africa, much of S. Asia, PR of China and parts of Latin America); (2) areas where wood is now extensively used but receding forests will cause this to change - occurs mainly in densely populated rural zones and around cities with big populations where incomes don't permit the use of substitutes for wood and charcoal (H, pp.40-42,77). 90 million people in rural areas suffer acute fuelwood shortages, while 800 million are consuming fuelwood resources faster than they are being replaced. Projected to rise to 140 million people in acute scarcity and 2,200 million consuming above rate of replacement by year 2000 (F & vB, p.3). 90% of the world's fuelwood consumption is in the LDCs (G, p.375).
CROP RESIDUES & VEGETABLE 'WASTE'	Excess demand for woodfuel, charcoal and other fuels leads to increased substitution of crop residues, removing potentially valuable organic materials which contribute to the maintenance of soil quality (G, p.378).	The burning of crop residues and dung is an important loss of potential soil nutrients. The amount of nitrogen, potassium and phosphorus potentially available to LDCs from organic sources was estimated to be 7.8 times the amount actually applied in 1971 as chemical fertiliser, worth 16 billion dollars at 1973 prices (G, p.378).
DUNG	Scarcity of other fuels leads to increased substitution of dung, preventing its use as an organic fertiliser and soil conditioner. An estimated 150-400 million tons of dung are burned annually in the world, while the burning of about 70 million tons of cow dung in India wastes nutrients equivalent to 1/3 of India's chemical fertiliser use. The biogas digestion process kills pathogens affecting both animals and humans, so improving and reducing the spread of crop diseases, while the sludge is still usable as fertiliser (G, pp.377-378).	Although dung equivalent to at least 13% of the amount of energy provided by firewood is burned for fuel, estimates suggest that in many LDCs the resource base does not exist to make biogas generated from dung a major contributor to rural energy supplies (this includes Nigeria, Algeria, Egypt, Vietnam, Sri Lanka, Malaysia, Philippines, PR of China and Thailand)(H, p.43).
HUMAN & ANIMAL ENERGY	Increasing demands for animal fodder can contribute to the stripping of vegetative cover and so to the problems of deforestation and desertification.	Estimates of human and animal energy inputs into agriculture and other activities are crude. Energy of this form typically accounts for as much as 10% of total consumption in rural areas and can often constitute the only major energy input into agriculture (HBM, pp.16-17).
ALL TRADITIONAL ENERGY SOURCES	The environmental impacts of traditional fuel collection and use affect people both as producers and as consumers (P & P, pp.11-16). Excessive wood collection beyond sustainable yields can lead to deforestation and desertification, eventually resulting in further environmental damage and consequent loss of soil fertility, food and incomes. Burning of dung and crop residues also deprives the soil of valuable organic nutrients. Biogas generation has some beneficial impacts.	Overall Figures Biomass energy use in LDCs has been estimated at 43% of total LDC energy use of 92 billion GJ in 1978 (assuming 15GJ/person for rural populations and 8GJ/person for urban populations). Biomass energy use in developed countries is estimated t be 1% of total energy use of 208 billion GJ (HBM, p.7). Worldwide of the energy derived from wood, crop residues and dung in 1974, wood accounted for 83%, crop residues for 6% and dung for 11% (G, p.375). Non-commercial energy consumption in the Developing Member Countries of the Asian Development Bank accounted for about 40% of total energy use in 1970 and about 33% in 1978, and although its relative share has fallen, absolute consumption levels have risen. Even in countries where the non-commercial energy share is modest, the household sector in rural areas and poorer housholds in urban areas are heavily dependent on non-commercial fuels (ADB, pp.xxx, Annex 2).

per cent and crop residues about 5 per cent (Global 2000, 1982, v.2, p.375), although there are wide variations in these shares both within and between countries and regions. At the aggregate level too, there are wide variations. For example, the share of TE in total consumption has been estimated to be from 58 per cent to more than 65 per cent in Africa but only 33 per cent in the developing member countries (DMCs) of the Asian Development Bank, excluding India (Global 2000, 1982, v.2, p.375, World Bank, 1979a, p.2, Asian Development Bank, 1982, p.8).

Table 2 indicates the share of TE in total energy consumption for a variety of countries. The figures clearly illustrate the extent to which this aggregate share can vary. The existence of more than one estimate for several of the countries, and in two cases (Thailand and India) striking differences between those estimates, highlights the problems underlying TE data and the need for caution in interpretation.

TABLE 2: Percentage share of TE in total energy consumption of selected LDCs

Less than 10 per cent
Hong Kong 0.2 (ADB), Singapore 0.2 (ADB), Fiji 1.5 (ADB), Libya 5 (HBM), Republic of Korea 7.4 (ADB), Mexico 9 (HBM)
Between 10 and 30 per cent
Egypt 15-20 (HBM), Guyana 15 (HBM), Malaysia 19.1 (ADB), Morocco 21 (HBM), Thailand 22.8 (ADB) {63 (HBM)}, China 29 (HBM)
Between 30 and 50 per cent
Brazil 34 (HBM), Philippines 34.4 (ADB), India 40 (HBM) {54 (HBM), 57 (ADB)}, Bolivia 44 (HBM), Sri Lanka 46.2 (ADB), Indonesia 48.5 (ADB), Pakistan 49.6 (ADB)
Between 50 and 70 per cent
Vietnam 50.4 (ADB), India 54 (HBM) {57 (ADB), 40 (HBM)}, Thailand 63 (HBM) {22.8 ADB}, Papua New Guinea 68.6 (ADB), Gambia 69 (HBM)
Between 70 and 90 per cent
Bangladesh 71 (HBM), 73.5 (ADB), Afghanistan 73.2 (ADB), Kenya 75 (HBM), Burma 79.4 (ADB), Sudan 77,80 (HBM), Somalia 84 (HBM), Lao PDR 85.2 (ADB), Niger 88 (HBM)
More than 90 per cent
Tanzania 93 (HBM), Ethiopia 95 (HBM), Nepal 95.8 (ADB), 98 (HBM), Cambodia 98 (ADB)

Notes
The data relate mainly to wood and charcoal consumption, although some sources include animal and crop residues.
Sources
ADB is Asian Development Bank (1982, Table 5.1 (pp.106-107), Annex 2 (pp.280-291)). The data relate to 1978. HBM is Hall, Barnard and Moss (1982, Table 2.3 (p.18), Appendix A, Part Two (pp.185-205). Data from various years, mostly 1976- 1980.

Further data suggest that while the per capita consumption of TE varies considerably even between countries with similar income levels, aggregated groups of countries do appear to show an inverse relationship between the share of TE and income level (Asian Development Bank, 1982, pp.29-31), and there is said to be a general inverse relationship between the level of economic development and the use of fuelwood (Global 2000, 1982, v.2, p.375). Time-series data for the Asian Development Bank's DMCs (excluding India) suggest that between 1960 and 1978 the share of TE fell significantly in all but the low-income group of countries, with the decrease being steepest for the more affluent countries: overall the TE share fell from 52 per cent in 1960 to 33 per cent in 1978, while in India it fell from 63 to 57 per cent. Although the share of TE seems to have fallen in several countries, the absolute level of consumption rose in all but the more affluent (Asian Development Bank, 1982, pp.280-291). Fuelwood and charcoal consumption in LDCs before the 1973 oil price rises was estimated to be rising at between 1 and 2 per cent per year and is thought to have risen above 2 per cent since then; as a result it has been suggested that demand may grow in the future as fast or faster than LDC populations (Global 2000, 1982, v.2, pp.375-376). This would, of course, carry important implications for the future environmental impacts of TE, particularly if the use and substitution of dung and crop residues also continues to increase.

It is clear that the level and patterns of use of TE vary extensively within and between countries in response to a wide variety of factors influencing demand and supply, including tastes, fuel-use practices, the stock of energy-using appliances, relative prices of both CE and TE, location, season, income level and property ownership, fuel-gathering rights, privileges and practices, and the division of labour within the family. The explanation of the patterns of TE use clearly requires us to examine in some detail the important determinants of demand and supply. Moreover, given the diversity of consumption patterns it is evidently most unlikely that the current and future patterns of TE demand, supply and use can be successfully explained or forecast on the basis of a few broad generalisations.

Data suggest that a number of countries are or will be experiencing severe fuelwood shortages, leading to increasing explicit or implicit prices for fuelwood and charcoal (World Bank, 1979a, pp.39-42, Asian Development Bank, 1982, pp.115-117). This situation means that there are actually and potentially serious problems of fuel poverty, most notably in rural areas but also for the urban poor.

It should not be thought, however, that TE is only important for household domestic uses such as cooking and heating. It is also widely used in agriculture, industry and transport, as Table 1 suggests. There are many processes for which TE can be successfully used instead of or as well as CE. Even though in most countries only 2 to 15 per cent of fuelwood is devoted to these processes, in many these are thought to represent the fastest-growing use for wood (Deudney and Flavin,1983, p.69). Moreover, crop residues represent a potentially very important source of energy, sufficiently valuable for users to be willing to meet the costs of transporting them from distant locations. In a situation where there is a scarcity of foreign exchange, the opportunity to substitute TE for imported fuels is of considerable significance.

Conventional wisdoms

Recent research also suggests that some of the conventional wisdoms about energy/GNP ratios may be suspect. For example, it has often been assumed that energy consumption rises faster than GNP in the process of development, i.e. that the elasticity of energy consumption with respect to output is greater than one. However, Desai (1978, p.263) argues that this is incorrect and that,"when all forms of energy are brought into the reckoning, there is no evidence that development entails growing energy consumption." Furthermore Sankar (1977,p.235) claims that in India the energy/GNP ratio is lower in sectors where CE is used and this results in a decrease in overall intensity of energy use as the share of CE in total energy consumption increases. What seems more likely, therefore, is that the output elasticity of CE consumption may be greater than one in the process of development. This is an important distinction, implying different income elasticities of demand for CE and TE and substitution of TE for CE.

Environmental impacts

A third aspect of recent work is the finding that non-commercial fuel collection and usage can have significant effects on environmental quality and hence on the quality of people's lives. Moreover, these effects are by no means confined to the richer sections of the population, as has sometimes been suggested. People are affected both as consumers (for example, in terms of health damage and recreational and amenity losses) and as producers (for example, through loss of agricultural output and productivity through soil erosion, as well as through reduced ability to work because of impaired health (Coooper, 1981, Pearson and Pryor, 1978). As the dominant TE source, fuelwood not surprisingly is associated with the biggest environmental impacts. In particular, increases in local deforestation have occurred where sustainable yields are exceeded by early and heavy cutting of trees for fuelwood and other purposes. The removal of tree and vegetation cover can lead to soil erosion (and landslides in hilly areas), followed by siltation of reservoirs, riverbeds and irrigation channels, resulting in reduced availability of water for some but more flooding for others. Moreover, in some circumstances excess demand for woodfuel, charcoal and other fuels can lead to increased substitution of crop residues and animal dung, thus diverting them from valuable use as organic soil conditioners and nutrients (Global 2000, 1982, v.2, pp.320-321, 377-379). Impaired agricultural productivity seriously impairs the ability of the poorer sections to meet their basic needs.

Thus, recent research suggests that: TE is a major component of LDC energy; that it is used not only for household consumption, where it is essential for basic needs, but also for non-domestic production, and that this latter use is increasing rapidly - which carries important implications for situations where alternative fuels require scarce foreign exchange; that there are serious actual and potential supply problems in many areas; and that environmental impacts are too large to be ignored, especially because they are not confined to the more affluent sections of the population.

Increasing awareness of these points, added to the impact of higher oil prices and a desire to meet basic needs has led to a more active concern among both LDC governments and international agencies with formulating and implementing energy policies. Thus a number of countries are either operating a specifically formulated policy or are constructing such a policy, although Fritz (1981) claimed that out of 156 LDCs only 24 had either worked out a comprehensive national energy policy or had prepared the basis for one. Moreover, despite the new concern there is as yet little evidence of much detailed planning relating either to TE or to the interrelationships between CE planning and TE. Moreover, energy policies have been formulated with little or no systematic reference to environmental impacts from changes in CE and TE usage, even though these impacts are sometimes acknowledged elsewhere in the planning process. Thus, even for those countries with a policy, the orientation is still mainly towards the 'organised' or 'modern' sectors of the economy, while the 'unorganised' or 'traditional' sectors relying mainly on TE are rarely explicitly accounted for. Nonetheless, because of the linkages that can exist between the two sectors, the traditional sector is influenced by policies directed towards the modern sector, while the modern sector is clearly affected by what happens to the supply of and demand for TE.

It is, therefore, important to examine the linkages between CE and TE and to explore the related environmental impacts of energy use. In particular, it is vital to develop an approach which takes account of these linkages and so can help in the formulation of integrated energy policies.

PART TWO IMPLICATIONS FOR ENERGY POLICY

2.1 An examination of energy policy objectives in relation to TE and CE

Standard theory suggests that the government's overall aim is to ensure that the net social benefit obtainable from energy resources is maximised, through the attainment of appropriate levels of energy consumption and production now and for the duration of the government's planning horizon. The allocation of energy resources must be 'appropriate' in relation to at least four areas of policy concern : economic efficiency; financial viability or profitability; income distribution and basic needs objectives; and macroeconomic impacts (Rees, 1976).

Economic efficiency means, of course, allocative efficiency but also subsumes managerial and technological efficiency. The financial viability of energy institutions (especially those in the public sector) is of concern for two main reasons. Not only can their trading surpluses or deficits augment or deplete the public purse, but also it may be possible to encourage the pursuit of managerial and technological efficiency by setting appropriate financial targets along with controls on pricing policy. Energy policy decisions relating to prices and wages, the siting of facilities and choice of technology will carry implications for income distribution and basic needs policies. Moreover, energy policy can itself be used as an instrument of distribution policy, for example through the use of subsidised prices to help meet the basic energy needs of the poor. The macroeconomic effects of energy resource allocation carry potential implications for a government's macroeconomic policy objectives, while target variables such as employment, inflation,the balance of payments, real and nominal growth, can be affected by changes in the energy sectors.

Thus the allocation of energy resources should be both efficient and consistent with other objectives relating to profitability, income distribution, and macroeconomic policy. However, these four objectives may conflict. For example, macroeconomic policy considerations may dictate the use of instruments such as public expenditure controls or wage and price policies which will disrupt otherwise efficient investment,wage and pricing plans in the energy sectors. The main point here is that the balance of policy trade-offs may be very different between CE and TE. CE policy tends to give a relatively high weight to the efficiency, financial viability and macroeconomic objectives (especially the balance of payments), while basic needs receives a relatively high weighting in many TE policies. Insofar as CE policies based on one set of priorities have unintended impacts on TE, the consequences may well be contrary to the policy-maker's intentions. Ideally the decision problems resulting from any potential conflicts could be resolved with the aid of a 'social welfare function'. This would rank alternative allocations of energy and other resources according to relative societal valuations of the weights to be given to each objective and so enable the 'best' of the feasible outcomes to be chosen. Some form of explicit welfare ordering is clearly required for successful decentralised energy management. Without this, in however rudimentary a form, it is, as as Rees (1976, p.123) emphasises, impossible to specify decentralised rules (e.g. for pricing and investment decisions) which correctly take into account trade-offs between disparate policy objectives and so guide individual decision-makers to appropriate decisions.

In the same way as consistent energy policy targets cannot be formulated without reference to non-energy policy targets, so policy targets for individual energy sectors must take into account interrelationships between energy sectors. This suggests that traditional energy must be considered before CE targets can be regarded as appropriate, unless of course there are no interrelationships.

2.2 Arguments for and against exploring the links between TE and CE

An attenpted justification for ignoring the role of TE sectors might run as follows. The presence in a typical economy of the symptoms of market failure (imperfect competition, widespread externalities, uncertainty and non-lump-sum taxes), plus the fact that policy-makers are unwilling and/or unable to control these departures from first-best conditions, mean that the economy is strictly second-best. However, provided that the uncorrected 'deviant' sectors (in this case, the TE sectors) are not affected by decisions in the sectors controlled by the policy-makers (here, the CE sectors) then 'piecemeal' second-best arguments suggest that first-best policies, marginal cost pricing, for example, will nonetheless still be appropriate. Hence, it could be argued, CE policy can be drawn up without reference to TE.

The key issue here is the presumption that there are no signficant relationships of substitutability or complementarity between CE and TE sectors. However, the actual strength of such links between given fuels in particular countries is a question that can only be resolved through empirical testing of appropriately-framed hypotheses, such as that the demands for woodfuel and charcoal increase when the price of kerosene rises. Therefore, we can reject at once one argument that has been advanced, namely that there are insufficient data to permit thorough testing of the existence and size of the links, but nevertheless the very absence of such data means that the links between the sectors must be too weak to be of any account. Not only is the logic of this argument wrong, for if there are insufficient data there are indeed insufficient data, but also there is in fact some evidence of significant links in a number of countries.

Although the strength of the links is an empirical issue requiring more data and testing, there is a further reason for adopting the working hypothesis that the links exist. The size and importance of TE, established earlier, mean that where links exist a failure to takeaccount of them in CE planning could have major economic and environmental impacts. These impacts could be particularly significant in view of the central role of TE in meeting the basic energy needs of rural populations and of the urban poor.

As was suggested earlier, it is sometimes averred that the TE sectors lie completely outwith the reach of government control and thus do not themselves either permit or require any direct planning. However, this view results from a less than complete understanding of TE and from focussing on too narrow a range of policy instruments. Athough governments have little or no direct control over TE 'prices', they can use physical controls, can influence research, development and dissemination of improved appliances such as cooking stoves, biogas digesters, charcoal kilns and other appliances designed to save human or animal energy, can educate the public to increase awareness of the short and long-term environmental consequences of energy use, can finance or facilitate re-afforestation schemes, and can generally influence TE production and use by changing the legal framework to cope with the public good and common property resource problems that tend to lead to over-exploitation. So governments do have policy instruments at their command and need to decide whether and in what ways to use them. Hence, explicit policies for TE (taking into account links with CE, of course) can be developed. Of course <u>implicit</u> policies, in the sense of the usually unanticipated and unintended side-effects of CE policies, already exist.

To sum up the argument. As Munasinghe (1983, p.123) suggests, "Energy planning requires analysis at three levels: links between the energy sector and the rest of the economy; interactions between subsectors of the energy sector, and activities in each individual energy subsector." Here, of course, 'the energy sector' must include TE. Thus, we argue that a competent analysis will include a consideration of both TE and CE, the relationships between them, and their environmental impacts. And even though energy policy in practice is bound to be a good deal looser than the ideal of standard theory, this does not invalidate the argument for taking TE into account.

2.3 Strategies for developing imtegrated energy policies

One of the most difficult tasks for energy policy-makers is to ask the right questions. As economists, we seek economical ways of devising strategies for developing integrated energy policies taking account of the relations between CE and TE. The practical problem about TE is that it is both technically difficult and time and resource-consuming to gather and analyse good data. Therefore, it is important to identify the crucial areas where extra data is worthwhile and not to waste resources on data that yield little, either because the area itself is quantitatively insignificant or because it is unlikely to be responsive to or influenced by policy intervention. It is clearly not sensible to try to go out and measure anything that burns or moves. We suggest a two-pronged strategy that approaches this problem of how to ask useful questions from two perspectives. At one end is the augmented energy balance matrix, to be explained below, while at the other are the policy instruments themselves.

The augmented energy balance matrix

We begin with the augmented energy balance matrix shown in diagram 1.

The methodology behind energy balances is well known. An energy balance is a representation in physical terms of the production and use of energy and it facilitates the analysis of the components of change in energy production and use. The difference between the conventional approach and the approach used here lies in the addition of two extra columns representing TE (wood and 'other', although the 'other'column could be further disaggregated). Also two extra rows have been included to allow the conversion of useable final energy into useful energy. This has been done since the object is to examine policy options and obviously the increased efficiency of energy use by technological change or improved maintenance of the converting and using appliances is a policy option. Also, the age, type and condition of the present stock of appliances will influence the extent of substitutability between different fuels. In terms of TE, there are well-known efficiency-losses in the process of conversion to useable energy (for example, in charcoal-making and in direct burning of dung, rather than through the use of biogas digesters) and also in the transformation from useable to useful energy (for example, the use of open fireplaces and poorly-constructed stoves). As has already been pointed out, the relative structure of the components of Gross Final Consumption (GFC) and Useful Energy (UE) will vary enormously between countries. For example, energy balance equations for the industrialized countries ignore the columns of wood and other simply because they are neglible in the total GFC. However, as we have seen, for many LDCs these energy sources cannot be assumed to be negligible.

Each row of the diagram involves costs to the economy ranging from the foreign exchange cost of an imported drilling bit to the opportunity cost of labour used in collecting firewood. The last row provides benefits in the form of satisfaction from the use of useful energy. Indeed the energy balance matrix can also be represented in value as well as in physical terms; clearly both are essential for policy analysis. The augmented energy balance matrix (AEBM) itself provides only an accounting framework but it is one which, particularly with the addition of extra data, can lead to valuable policy insights. Elements in the matrix indicate points at which government may have the option to intervene in some way (some cells will, of course, have zero entries). The number of points of intervention should not be confused with the effectiveness of intervention. Thus one point of intervention may be worth ten others in terms of effectiveness. Moreover, the criterion of 'effectiveness' may itself take various forms.

As we have seen, in terms of theory, the government's objective will be to devise optimal policies that maximise the net social benefit obtainable from energy resources, subject to the relevant constraints In practice, of course, governments do not devise optimal policies (even in a second-best sense). Thus, at a more practical level it is possible to express the overall policy aim in a more direct way, in terms of target values of GFC and UE. The desired levels and patterns of GFC and UE are determined by the interplay of the policy-maker's broad objectives and by the actual and desired level of GDP, its structure and

AUGMENTED ENERGY BALANCE MATRIX[A]

	COMMERCIAL						TRADITIONAL		
	SOLID FUEL	CRUDE OIL	PET PRODS	NAT GAS	PRIMARY ELECT	ELEC	WOOD	OTHER[B]	TOTAL
PRIMARY ENERGY PRODUCTION									+ P
IMPORTS									+ M
EXPORTS									- E
CHANGE IN STOCKS									± CHS
TOTAL ENERGY AVAILABILITY									TEA
CONVERSION TO FINAL (USEABLE) ENERGY									- CFE
GROSS FINAL CONSUMPTION									GFC
TRANSFORMATION FROM USEABLE TO USEFUL ENERGY									- TUE
USEFUL ENERGY									UE

NOTES: (A) SOME CELLS WILL HAVE ZERO ENTRIES; (B) INCLUDES CROP RESIDUES, VEGETABLE 'WASTE', DUNG (AND ANIMAL & HUMAN ENERGY) AND CAN BE DISAGGREGATED.

the structural energy-output coefficients. Two problems can arise which provide the context for specific policy sub-targets. Suppose first that there is a shortage of UE or of the components of UE. The main consequence of this would be to inhibit the growth of GDP. Alternatively (and in a market context in parallel with the first problem) the cost of satisfying the requirements for UE will rise. This implies a diversion of resources from other uses (inhibiting GDP growth),a redistribution of income between sectors and groups and finally a political consequence. From this gap between the desired and actual UE level and pattern a series of energy policy sub-targets follow, such as increasing the level of primary energy and of its components, reducing exports or increasing imports (depending on whether there is foreign exchange constraint).

A crucial point is that the energy balance configuration is a matrix many of whose elements are interconnected. For example, if government policy is aimed at the CE columns then this will obviously affect those components. However, changes in these columns will also affect the items under TE which in turn may cause secondary effects in the CE sector and so on. However, to the extent that CE decisions shift demand and supply curves for TE, there will be changes in outputs and (implicit) prices for TE and consequent changes in environmental impacts. Moreover, the impact of these changes may feed back in turn to the CE sector, and so on through a complex multiplier process. One helpful way to visualise the full impact is to see the energy sectors as sub-sectors of a general equilibrium input-output system in which policy changes cause direct and indirect changes in other sectors and in environmental impacts, while the consequent induced income changes (in level and distribution) cause further multiplier effects on the level and pattern of energy demand until the entire system settles down to a new equilibrium in which both CE and TE outputs have changed (see Pearson, 1984, for further details of such a model).

Once it is accepted that there may be important interconnections between CE and TE, then the problem for the policy-maker is where to look. The important interconnections are going to be the ones which relate to strong linkages at strategic points. What using the augmented energy balance matrix (including making broad estimates of some of the potentially important relationships of substitutability or complementarity) does is to help the policy-maker to identify interconnections which, if they exist, are likely to be strategic. Existing studies of the elements in the matrix and of their interconnections can then be slotted into the energy balance matrix framework and can then be related to broader policy issues.

Thus the AEBM offers a helpful way of approaching the policy problem. It helps in the identification of potentially important areas and effective points of intervention, and thus might pinpoint a problem where a particular technical study and/or more data are needed. However, it is not efficient to investigate in detail every one of the admittedly complex relations underlying the eventual configuration of the AEBM. So, if the problem is turned on its head and looked at the other way round, then by examining the relevant policy instruments, this process will help to suggest other kinds of questions. These questions will involve not only investigating specific links between CE and TE, but also by looking at the available policy instruments in relation to the insights yielded by analysis of the AEBM, this again may suggest the minimum amounts of information needed to make an effective impact on the energy policy problem. the policy-maker would iterate between the policy instruments and the AEBM, and analysing the policy instruments would make it easier to trace the complex effects of a policy change on the AEBM. We now turn to the policy instruments themselves.

Policy instruments

The policy instruments are determined by the factors which influence the absolute size of the row totals and their component parts in the energy balance matrix. Eight of these factors can be identified which are simply the determinants of the supply and demand of the energy components.

The first factor is the physical availability of the energy resources which is in effect the resource base. In terms of the non-renewables this is determined by geography and geology. What is important here is not just the physical availability but awareness of that availability and access to it. This is because geography and geology are not amenable to policy decision whereas knowledge and access are directly the result of policy decisions in such areas as exploration and development. In terms of the renewables the resource base is amenable to policy influence, depending upon the relative time lags.

The second determining factor which allows policy influence is the costs of production of P in the matrix and its components. Here the interest is more in the economic cost than the accounting costs since by definition TE has no accounting costs but only opportunity costs which arise either from the collection costs or the fact that the energy source has substitute uses (Douglas,1982). In terms of the former one must come to terms with the surplus labour argument. If it is assumed that surplus labour in the sense used by Lewis (Lewis, 1954) exists then it may be argued the opportunity cost of collection is zero. This would be mistaken on two grounds. First the overwhelming body of empirical work suggests that there exists little or no surplus labour in the rural areas (Kao et al,1964). Second even if surplus labour did exist, to assume a zero value on the collection time assumes that leisure has no value. Moreover, most of the fuel collection for TE is done by women and children. The children may be withdrawn from classes, thus harming their accumulation of human capital, while the opportunity cost of the foregone domestic or other activities of the women may well be significantly diferent from zero. The opportunities to apply policy instruments in the area of CE to alter this variable are numerous, such as subsidies on factor inputs either directly or via exchange rate policies. Even in terms of the costs of producing TE, policy can play a role. For example the opportunity cost is expressed largely in terms of agricultural production foregone either because of reduced labour input or reduced inputs of fertilizer from animal and vegetable residues thus agricultural pricing policies will have an impact.

A third area which is a variant of the second is the costs of transforming primary energy into useful energy represented by the losses CFE and TUE in the matrix. There are two elements to these costs in both of the transformation stages (ie from primary to useable energy and from useable to useful energy). The first is the cost of the appliances involved which in the first transformation would cover the capital costs of such items as electricity turbines and catalytic crackers and in the second transformation would cover anything from the cost of car engines to the cost of the 'three stone fireplace'. The other cost transformation element arises courtesy of The Second Law of thermodynamics which decrees the existence of energy loss in conversion to useful energy. This can be large. For example, one study suggests (Makhijani, 1980) that in five regions the loss in the second stage transformation for TE can be as high as 94 percent. As with the production costs this is an obvious area of policy influence. To cite just one example, it has been suggested that in Sri Lanka the use of fuel efficient woodstoves (which may require government subsidy and or an education drive) could reduce fuelwood requirements by up to fifty percent (Kauffman, 1980). Technical change is clearly very important here.

The administrative and legislative environment in which the energy balances exist is the fourth influencing factor . This is directly shaped by policy and would include tax regimes, subsidy availability, physical rationing, the attitudes of the government to multinational companies etc. It would also include the ways in which property rights are established and enforced, since this affects the exploitation of energy resources and of woodland in particular. It is a commonplace that unprotected common property resources are subject to over-exploitation. Other externality problems are also influenced by the administrative and legal environment.

A fifth influencing factor is the incomes of the energy using groups. There exists a growing body of empirical evidence which suggests that the level and distribution of income is a major determinant of the level and pattern of energy demand (Julius, 1981, Asian Development Bank, 1982). This is hardly surprising since income affects not only the consumer's ability to buy the energy but also to buy the energy-using appliance. The availability of the appliance can be crucial. For example an increase in the price of kerosene means that people can switch to TE fuels since the 'three stone fireplace' is cheap. However an increase in the price of TE may not lead to a switch to kerosene unless the user can afford a kerosene-burning appliance. The influence of government policy on income levels and distribution needs no elaboration (Chenery et al, 1974, Sinha et al, 1979, Bigsten, 1983).

A sixth influence on the configuration of the energy balance matrix is the tastes and preferences of the energy users. Evidence suggests (Kauffman,1980) that the preference is to move 'upmarket' as soon as possible first to kerosene and then bottled gas. It is interesting to reflect that in much of the developed world moving 'upmarket' involves a reversion to TE in the form of open fireplaces. Outside of influencing these tastes via a propaganda campaign the role of government policy in this particular area is probably fairly limited. However, governments can, by making extravagant promises, encourage significant numbers of people to demand (both politically and in the market place) commercial fuels.

The seventh factor covers other non-price demand determinants not yet specified. Two are crucial. The first is the size of the population and its distribution between rural and urban areas given the predominance of TE use in rural areas, already alluded to. The second is more complex and can be termed 'technical specificity'. This refers to the possibilities of fuel substitution for given energy-using appliances. For example, while an LPG stove could easily run on biogas it could not run on kerosene or electricity. Thus if the consumer owns an LPG stove and the price of kerosene falls by 5 percent he or she is unlikely to switch to a kerosene stove. What magnitude of price change would induce him or her to shift would depend on the application of the 'bygones rule' (It might also depend on who makes the decisions in the household, the man or the woman; their interests and decisions would not necessarily coincide in a situation where one controls the resources while the other uses the appliance). Clearly both population and 'technical specificity' are areas which can be influenced by government policy.

The eighth influence is the final price of the energy source to the user. Obviously this will be heavily influenced by the previous seven factors. Indeed in a world of neoclassical economics the price would be determined by supply and demand and would not require separate discussion. However, in reality the final price may bear little or no relationship to a number of the other determining variables. In most of the LDCs the CE sectors are arms of the state. Thus most forms of commercial fuels are priced by administrative decision which may or may not bear any close relationship to the supply and demand determinants listed above.

The eight influences will determine the rates of substitution between the column components either economically or technically determined; the cross elasticities of supply and demand between the components and the price and income elaticities of supply and demand. Thus these factors will determine the configuration of the energy balance diagram and how it may change as the various influences alter.

Finally it is important to remember that as well as energy policy instruments, other macro and micro economic policies of the government will directly or indirectly affect the eight influences listed above. For example policies with respect to balance of payments may affect the exchange rates which will obviously affect relative costs and prices of energy sources, converting equipment and using appliances. Even the whole development strategy adopted by the government will carry enormous implications for energy consumption patterns (Diwan,1978).

2.4 An example of how incorporating TE could alter energy policy

An example will serve to illustrate how energy policy may change when TE is directly incorporated into policy. Assume that the policy target is to reduce the energy import bill in an effort to save foreign exchange. Consider two routes. A policy which incorporates TE and one which ignores it

First assume the government decides to reduce the import of oil products and accordingly imposes an import duty on imported crude oil. This shifts supply curves for oil-based products to the left and so increases product prices to final users. In the industrial sector this will encourage a reduction of oil use. This may be done by switching to a substitute fuel or, if a conservation path is followed, this may involve changing the stock of capital equipment in favour of new, more energy-efficient equipment. Both the substitute fuel and the energy-conserving equipment may have a substantial import content and so the import-saving policy will be muted.

In the household sector there is likely to be a substitution away from oil products both to other commercial fuel sources (some of which may be imported) or to local woodfuel supplies. The shift in the demand for wood and charcoal increases their 'price' which means in the rural areas some wood users switch to animal or vegetable residues which increases their price. The increase in the price of animal and vegetable residues is reinforced by the fact that as a result of the higher oil prices, artificial fertilizers also increase in price, with a consequent increase in the demand for animal and vegetable residues for fertilizers. The overall result is a growing problem of fuel poverty in the rural areas.

However, this is not the end of the story. The increased price of wood means that more will be supplied in the short run. The extra fuel may be gathered before trees and other plants reach maturity, so reducing the net present value of existing woodlands. In the long run the increased price of wood leads to more CE exploitation of woodland by more assiduous enclosure of previously open woodland or scrubland (and more careful collection of animal dung). A side-effect is to exclude people who once scavenged for wood (and dung), although there may also be a small increase in employment on the plantations. Moreover, the trees planted will be suitable for CE exploitation and will not be intended for fuelwood for the poor. The process of substitution may continue until the wood price reaches parity with the higher oil prices and there is a switch back to oil. If the government then decides to raise the oil import duty further, the whole cycle begins again. Thus the policy has fallen short of its objectives of reducing the import bill and in the process has exacerbated the problem of fuel poverty in rural areas, by not taking into account the links between TE and CE energy.

Consider also the influence of the policy on environmental impacts. There will be a reduction in impacts from oil-related processes and an increase in impacts from substitute commercial fuel-related processes (especially coal and coal-fired electricity). In rural areas the collection of extra woodfuel could result in certain circumstances in erosion, desertification, siltation and flooding. If there is increased use of dung for fuel, this diverts organic fertiliser from the soil at a time when oil-based fertilisers have become more expensive. This leads to a further loss of soil fertility and damage to soil productivity. The net effects of all these changes in urban and rural areas depends on the nature and extent of fuel substitution and so we cannot simply say whether there will be a deterioration in environmental quality. The point is, however, that we can predict that potentially serious changes in the level, pattern and distribution of environmental impacts (both spatially and across different income groups) may occur and they require to be given due weight in the planning process.

Now, examine an alternative policy route to reduce oil imports. Assume that in addition to raising import duty the government carries out R & D to improve (by simple low cost methods) the thermal efficiency of stoves and ovens using TE in the rural sectorand also improves charcoal kilns. It then carries out a programme of education coupled with subsidies to encourage the people to make the necessary changes and also begins a wood-planting programme which is highly labour-intensive. This greater conversion efficiency reduces the demand for woodfuel in rural areas offsetting to some extent the increase in demand as a result of the substitution from oil induced by higher oil product prices. Along with the eventually increasing supply of wood from the planting programme this helps to reduce the wood price below what it would otherwise have been. In urban areas this would make wood relatively more attractive compared with oil. Also in the rural areas, less animal and vegetable residues would be needed for energy than would have been the case, increasing its availability for fertilizer, thereby reducing the pressure of demand for artificial fertilizer and hence oil and gas inputs. Thus oil imports are reduced below what they would otherwise have been, rural fuel poverty has not been exacerbated and some employment has been generated.

Of course, we must emphasise that reality may well not be so generous. Much depends upon the relative sizes of the components in the augmented energy balance matrix together with the cross-elasticities and rates of substitution. In addition one source has suggested that economic analysis based on the assumption of transferability and interchangeability of resources may not be valid in the rural LDC context. This makes 'the energy problem in rural areas appear a great deal simpler than they really are' (Foley and Van Buren,1982.page 11). However, there is a considerable body of evidence (Griffin, 1974,Schultz, 1964, Sahota, 1968) which indicates that the LDC peasant is rational in his or her resource allocations, and there seems no reason to assume that energy resources would be treated differently. On the other hand there are serious barriers to the introduction of efficient woodstoves, in particular the low per capita incomes in the rural areas (Foley and Van Buren,1982). Nevertheless the point is clearly made that changing one element of the AEBM can produce multiplier effects which will be reflected in changes in other elements in the matrix and on prices, incomes and environmental impacts. While energy policy is aimed at only selected items, without considering its subsequent effects, it is hardly surprising that the end-result of the policy differs from its original intention. The actual divergence between policy targets and policy achievements depends upon the size of the effects and this is entirely a matter for empirical investigation.

Conclusion

Recent data show that TE is a significant energy source for both household and non-household uses and suggests that there may be important interconnections between TE and CE. If these interconnections exist it will be helpful for energy-planners to investigate them. But the problem remains of how to tackle this, given the known data difficulties and the shortage of time and resources available to policy-makers. Most of the economics needed to analyse the interrelationships is fairly well-known but it is important to economise in the analysis. For the policy-maker, the problem is which bits of the problem should be approached first. In this paper we have discussed a broad strategy which would attack the problem from two viewpoints: (a) by using the insights gained from working with an augmented energy balance matrix; and (b) by analysing the relevant policy instruments. Specific policies have intentionally not been suggested because they are essentially an empirical matter and can only be determined after the appropriate analysis. Moreover, the strategy itself has only been outlined here and clearly empirical work is required to put flesh on the skeleton.

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Note

A * in front of a reference indicates that it is a source referred to in Table 1 by the first letter of the author's name.

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