International Labour Review, Vol. 119, No. 5, September-October 1980

Energy policy and social progress in developing countries

C. BARON *

The depletion of fossil fuel resources became a matter of increasing global concern during the 1970s, a decade which concluded with the "second oil shock", an increase of over two and a half times in the average price of traded crude oil between January 1979 and June 1980. This article reviews the implications of energy scarcity for the developing countries in respect of social objectives such as employment generation and the alleviation of poverty. In particular it seeks to address the following questions: firstly, are the projections of a tightening world market for oil a sound basis for policy-making, and if so what implications do they have for economic growth in developing countries? Secondly, what are the employment and other social consequences of the energy policy options facing developing countries in the remainder of this century? And thirdly, what role can the ILO play in easing the transition to new energy producing and consuming technologies?

1. Projections of the world energy market

As in Europe before the industrial revolution, energy supply in low-income countries is distinguished by the predominance of non-commercial sources including animal power, human labour, firewood and crop wastes. However, in order to establish their urban centres, transport systems and manufacturing industries, developing countries need commercial energy—petrol and heating oil, coal, gas and electricity. Most are heavily dependent on imports of crude or refined oil for their supply of this commercial energy: indeed in 48 out of 74 oil-importing countries these imports account for 90 per cent or more of the total supply.[1] Because of this dependence on imports, the ratio of the value of energy imports to all

* International Labour Office. This article is a condensed version of a discussion paper prepared by the author while on study leave at the Centre of Development Planning, Erasmus University, to which he is indebted. The fuller paper is entitled *Energy, employment and basic needs in developing countries* (Rotterdam, Erasmus University, 1980).

merchandise exports is almost as high for developing countries as it is for the industrialised world—on average about 20 per cent in 1976 compared with 10 per cent in 1970.[2]

Thus the developing countries have a vital interest in the availability and price of oil, even though these are determined in a global market dominated by the big producers of the Middle East and the consuming countries of North America and Western Europe. Since the first major price increase in the winter of 1973-74 a plethora of projections of the future of this market have been published. Here, two major studies looking towards the end of this century and beyond are briefly summarised and reviewed: these present the conclusions of the Workshop on Alternative Energy Strategies (WAES)[3] and the World Energy Conference (WEC).[4] Both were published in the period 1977-78 and are authoritative and comprehensive works.

The WAES study estimates global demand for oil for the years 1985 and 2000, assuming high and low rates of economic growth and two levels of oil price. With each of these scenarios it was found that global "desired" demand will exceed supply to an increasingly serious degree in the period up to the year 2000. The WAES calculations indicate[5] that it will be difficult to balance supply and demand even if OECD governments implement vigorous policies of fuel substitution and conservation and develop nuclear power and coal production.

This suggests a serious situation; yet there are significant flaws in the WAES model. One of these is that no attention is paid to the balance of payments constraint, a factor likely to encourage the economic growth of countries with their own energy resources while retarding growth in others. Secondly, it assumes a traded oil price no higher than US (1975) $17.50 a barrel (and this only after 1985), a level already exceeded in 1979. Finally, the WAES group did not examine a *very* low growth scenario—i.e. a world economic situation of continuing structural recession—even though such a situation is conceivable unless strong measures are taken either to increase global energy supplies or to reduce demand by the application of more efficient energy-using technologies.

The judgement of the 1977 World Energy Conference was rather more optimistic although founded on somewhat heroic assumptions. The WEC Conservation Commission based its projections for the year 2020 on simple commercial energy demand: gross domestic product elasticities of 1.3 declining to 0.9 for the developing regions; and 0.8 declining to 0.4 for OECD countries. The fall in these elasticities over time reflects an assumption about continuing technological progress towards greater efficiency in energy use; the higher values assumed for the developing regions reflect the perceived need for low-income countries to establish relatively energy-intensive industries such as iron and steel, fertilisers and petrochemicals at an early stage in their development. The WEC calculations also assume perpetually increasing energy prices to curb demand

and considerable increases in the production of nuclear electricity and coal. These assumptions permit balance between energy supply and demand throughout the period.[6]

The estimates of energy supply in global models of this kind depend on expert opinions concerning world resources of recoverable oil. The extent of the latter is the subject of considerable controversy and confusion—there are many categories of oil, with varying costs of production. However, there seems little doubt that global supplies of cheap oil in relatively accessible places are being depleted. An increasing quantity will therefore be required from distant locations such as Siberia, the Arctic and the sedimentary basins of the developing world. Recovery operations of this kind entail considerable uncertainty and large capital investments, and long lead times are required before the investments bear fruit. When they do come on-stream the net cost of production is likely to be from ten to a hundred times higher than that of oil from the Middle East.

Alternative energy sources—coal mines, gas fields and nuclear power stations—are equally characterised by long gestation periods and by large capital investment and energy inputs in both construction and operation. For these reasons they are unlikely to become established on a globally significant scale until the world price of oil has remained high enough, for a period of some years, to render their exploitation profitable. The indications are that this "threshold" price may well be a good deal higher than even the present one. Despite optimistic newspaper reports in the industrialised countries concerning solar energy and geothermal, tidal and wind power, neither the WAES nor the WEC experts accord a significant role to non-conventional sources of energy supply in the year 2000.

These engineering facts of life imply that the OPEC cartel is not as dominating an influence on the world energy scene as it may appear. In the long term its existence is a symptom of the limits of current and future supplies of energy available at a low capital cost rather than the cause of increasing oil prices. And other geopolitical considerations are equally important contributors to the enormous uncertainties of the energy situation in the years to come. The extent to which the Western European countries succeed in implementing their declared policies of energy conservation will be highly relevant, as will be the degree to which the United States can define an energy policy consistent with both its domestic concerns and its global responsibilities.

2. The consequences of increasing oil prices for developing countries

In real terms (i.e. after deflating the nominal price by the factor of increase of world export prices of manufactured goods measured in dollars) the price of oil from the Persian Gulf is now about seven times its pre-1973 level. In itself this is a blow to hopes that developing countries may be able to continue to raise living standards at a more rapid rate than that achieved by the now industrialised countries in the course of their industrial revolution. The likelihood that oil prices will continue to rise to several times their present level implies that the year 2000 will be as fraught with difficulties as any other year—rather than the gateway to a utopian era that many international reports and political declarations tend to suggest.

Increasing oil prices attack the vulnerable developing economy via the balance of payments: a higher import bill is combined with reduced exports to the industrialised countries, the latter being themselves gripped by structural recession. Thereafter the malaise spreads, fairly rapidly through price inflation and in the longer term through "the decelerator" effect of lower imports of machinery and transport equipment. An article to appear in a later issue of the *Review*, by Ashok Desai, will examine the evidence on these effects, as revealed by four case studies carried out by ILO research associates in the countries of the Indian subcontinent. World Bank figures relating to the developing countries as a whole indicate that the average growth rates of GDP (except in OPEC capital-surplus countries) declined from 6.2 per cent per year in the period 1965-74 to 4.9 per cent in 1974-77.[7] With average population growth at about 2½ per cent per year, these figures imply a reduction of about a third in the growth rates of per capita GDP. But the impact varies considerably among countries, depending on their energy resources, trading position and many other factors. Some of those affected most seriously by increasing oil prices are the rapidly industrialising middle-income countries like Turkey and Brazil, which are reliant on imported commercial energy to ensure the growth of their industrial and transport sectors.

Looking ahead to a future in which increases in world oil prices will have to be regarded as more commonplace than in the halcyon years before 1973, it seems probable that each increase will tend to exacerbate income inequality both within and among importing countries because of the inherently regressive nature of any rise in the price of a commodity used by all income groups in society. However, in a particular economy the potentially deleterious long-term effects on income distribution may be obviated by government policy towards energy supply and demand. Indeed, as the following sections of this article try to show, the energy policy options faced by developing countries are more pregnant with social implications than a passing glance might suggest.

3. Energy policy options—the urban industrial sector

Increased domestic production of primary energy

The orthodox solution to the problem posed by the higher oil prices now facing developing countries is to increase the domestic production of primary energy in order to reduce the level of oil imports required. In this section the prospects for increasing primary energy supply in developing countries are briefly reviewed and some conclusions are drawn about the social implications of this strategy.

Among the international agencies and organisations concerned with development the World Bank is the strongest protagonist of the orthodox approach. In recognition of the difficulties which have hindered negotiations between the international oil companies and developing countries in the past, the Bank recently launched a programme[8] to accelerate exploration for oil and gas in approximately 35 such countries in which no oil or gas is now produced but there are good reasons to suppose that its recovery may be economically viable.

A few developing countries already produce coal in significant quantities. These include, most notably, India, the Republic of Korea, Turkey, Viet Nam, Yugoslavia and Zimbabwe. Some 20 other countries are known to possess exploitable reserves of coal but have not yet started production. A certain reticence regarding coal is understandable: it is a costly fuel to recover and transport, and without adequate transportation facilities there is little point in constructing coal mines.

Several technologies are available for electricity generation. Instead of oil-fired power stations developing countries may switch to coal-fired generation, nuclear plants, or geothermal or hydroelectric resources. Despite widespread enthusiasm for nuclear power in the years following the 1973 oil price increase, it is now generally recognised that this technology is inappropriate for low-income countries. The plants available for purchase are too large[9] for the grid systems of all but the largest of the developing economies and the costs of technology transfer—hiring skilled foreign engineers, training programmes, continuing maintenance, etc.—are very high, as are the initial construction costs and the foreign exchange costs of importing plant and machinery.

Hydro-power is the one energy resource (apart from sunshine) of which the developing regions enjoy a relative abundance. The World Energy Conference estimated that less than 10 per cent of the annual flow of water in these regions is at present harnessed in this way.[10] Hydroelectricity has significant advantages: it is environmentally clean, at least in the short to medium term, and the associated machinery has a longer lifetime than thermal generators, which are deteriorated by process heat. However, the investment costs per unit of electricity generated are relatively high and large-scale hydroelectric projects in developing countries have often caused political difficulties by concentrating capital resources and most of the income benefits in particular regions.

The broader social implications of increasing domestic supply by conventional energy technologies may be briefly summarised as follows. In the long run energy costs may be restrained by substituting domestic primary energy production for increasingly expensive imported oil—at least in countries possessing their own energy resources; but the capital costs of modern energy technologies are many times higher than those of refining imported crude oil. In general the labour force in the energy sector—with the possible exception of coalmining—is highly skilled but small in relation to output. Moreover, the construction of hydroelectric, geothermal and nuclear plants as well as conventional thermal generators tends to be capital-intensive and demanding of foreign exchange. Altogether the modern energy sector is a voracious consumer of the resources that are most scarce in the typical developing economy. Estimates by the World Bank[11] suggest that the proportion of gross fixed capital formation devoted to the power sector in these economies is likely to increase in the coming decade from the present level of 7-8 per cent to 10-12 per cent because of the forced shift away from oil-fired electricity generation towards more capital-intensive techniques. If this happens, the investment resources available for the creation of employment opportunities in other economic sectors, and possibly also investments in welfare services such as education and health, will be correspondingly diminished.

Conservation policy and employment

An alternative to pushing ahead with the expansion of energy supply is to seek to reduce the elasticity of demand with respect to national income through the more efficient use of energy. This interpretation of the term "conservation" may usefully be distinguished from curtailment, i.e. the reduction of petrol and electricity consumption by charging higher prices or by imposing power cuts and physical rationing. Curtailment is equivalent to a drop in living standards and may also bring about a deterioration in working conditions as factory lights are dimmed and air-conditioning is reduced. It is a political rock on which several governments have foundered in recent years, in countries at all levels of income. Conservation, on the other hand, can be regarded as a positive long-term policy implying economies in the requirements of the energy sector for capital and foreign exchange, care in energy use in the main consuming sectors and thus higher growth rates of output and employment than would be possible in the absence of such a policy.

Energy conservation in the positive sense in which it is intended here implies both the consideration of alternative choices of technology according to energy use, at a given point in time, i.e. choice in a *static* sense; and decisions about the direction of technological change and its energy use implications, i.e. the *dynamic* dimension of choice. These concepts and their practical implications for employment policy will be briefly examined.

Conservation strategy in the *static* sense may take account of the energy intensities of different products and industries. In some industrialised countries, in which there is detailed information on all the inputs to different economic activities, comprehensive calculations to measure energy intensity have been carried out.[12] These calculations include both direct and indirect energy inputs: for example, the manufacture and sale of a loaf of bread requires energy inputs (fertilisers, pesticides, tractor use) for grain cultivation, mechanical energy consumption for grain milling, process heat energy for baking and, finally, minor fuel inputs for the distribution of the product to food shops. It may be useful to give a few examples of the sort of results to which this type of comprehensive calculation gives rise. In the United Kingdom[13] in 1968 the products with the highest energy intensities per unit of value (kWh/£) included cement 415, organic chemicals 406, fertilisers 263, iron and steel 213, polishes 186, bricks, fireclay and refractory goods 177, aluminium 171, paints 149, paper and board 138 and granulated sugar 123. Rather similar results were obtained for the US economy by Wright:[14] energy-intensive industrial sectors included most branches of chemicals and plastics, certain branches of textiles and food, many building materials and metal processing of different kinds.

The concept of energy intensity could be useful in developing countries. Where adequate data are available, decisions may be taken in the planning of industrial development with a greater awareness of the consequences for energy demand in the long term. A related issue is the classic problem of the choice of techniques for making a given product. This can be reformulated in terms of energy inputs. Taking bread as an example once more, it has been established[15] that many small-scale bakeries offer a greater potential for employment generation than one large automated bakery producing loaves at the same unit cost. However, small wood-fired bakeries are several times more energy-intensive because of the inefficiency of the typical wood oven. The general hypothesis suggested by this example, that small enterprises using simple technologies may be profligate energy consumers, is pertinent to the many developing countries in which wood is in short supply, sometimes to such an extent as to threaten the material well-being of the poor. It is a hypothesis deserving further investigation; and, if confirmed, points to the need for practical assistance to improve the energy consumption characteristics of the relatively simple technologies typically applied in rural and small enterprises.

Can the energy intensity of economic activities be reduced by substituting labour for energy inputs? If this question could be answered positively the silver lining to the prospect of increasing international oil prices would be the comforting expectation that the structural unemployment endemic in developing countries might be steadily diminished by such substitution. Alas, the answer cannot be yes in practice. Human labour is very inefficient: the energy content of a barrel of oil is equivalent to the work which can be done by a healthy male adult persevering at hard manual tasks for 40 hours a week over three years. Thus, although human energy is still applied throughout the world, this is not because of the cost of oil or other forms of energy; rather it is due to the lack of savings with which the equivalent machinery can be purchased, or to the fact that labour (particularly family or child labour in developing countries) frequently has a zero opportunity cost, i.e. there is nothing better to do.

Energy conservation in the *dynamic* sense is a policy option resting on technological progress in the future as the key to the continuing reduction of the energy requirement per unit of income as income increases. Several studies examining technological progress from this point of view have been carried out in industrialised economies. One particularly authoritative study, by Leach and others, considers a possible low energy strategy for the United Kingdom.[16] This looks forward to the year 2020 and examines the energy requirement implied by two scenarios involving a doubling and tripling of per capita income in the intervening period. For the high growth scenario it is shown that if energy-saving technologies which already exist or are in an advanced stage of development were applied in industry, transport and commerce, and the residential sector, there would be no need to increase primary energy supply above the 1976 level. This result implies a reduction in the energy/income coefficient to a third of its present level over 40 years, a striking conclusion underlining the extent to which the energy input has been neglected in research and development activities during the recent decades of relatively inexpensive oil.

Some work by Rodberg[17] in the United States along somewhat similar lines analyses the additional employment generated as a consequence of energy conservation in the following way. An energy strategy is proposed for the period up to the year 2000 based on: the rigorous insulation of private residences and commercial buildings, combined with solar-powered heating; in industry, a specified set of more energy-efficient practices and the use of solar-powered machines; in transport, increased fuel efficiency in road vehicles; and in electricity generation, the application of photovoltaic cells, wind power and solar generators, particularly in small-scale private enterprises, agriculture and the residential sector, to reduce the demand for commercial energy. By implementing such a policy, conventional energy demand could be reduced by 37 per cent of its present projected value in the year 2000. A total of 2.17 million jobs would be created in the manufacture and installation of insulation equipment and small-scale energy devices, a larger number than the associated loss of jobs in the construction and operation of large-scale energy installations, estimated at 1.14 million. Other US studies confirm that conservation measures of the kinds mentioned are less expensive than investment in additional production capacity in nuclear power plants or similar energy installations. Of course, there will be a point of diminished returns when this ceases to be true, but that point may be some way off in the future. An analysis by Elliott[18] of the alternatives to the UK nuclear power programme arrives at conclusions similar to those of Rodberg: a conservation strategy to the year 2000 could generate 1.52 million man-years of work compared with the 0.66 million man-years of employment associated with the construction of nuclear reactors producing the same amount of energy.

These reviews of the alternatives to orthodox energy supply policy in the industrialised countries suggest that it may be equally useful to take a hard look at the scope for reducing commercial energy demand in the urban-industrial sectors of developing economies. Studies like those mentioned are not of course directly applicable, inter alia because residential energy needs are much less important in low-income countries. But their challenging approach and methodology may be relevant and merit some research directed towards the different economic circumstances in developing countries. For example, the transport sector is a major energy consumer in such countries: since rail freight haulage is known to be much more energy-economical than road haulage there may be a case for considering the extent to which transport systems can be designed to exploit this difference. Likewise, the high energy intensity of building materials such as cement, bricks, iron and steel and glass suggests that architectural design has a role to play in reducing energy demand in respect of both the construction and maintenance of buildings. One study [19] estimated that US office buildings being constructed in the late 1970s would consume only a sixth of the energy required in normal use by buildings completed at the beginning of the decade.

Another important question posed by these studies on the industrialised countries concerns the respective roles of energy pricing policy and government guidance in respect of technological decisions. Energy pricing is a highly political issue and has important consequences for income distribution. Moreover, at least in the short run, higher petrol and electricity prices are likely to lead to the curtailment of energy consumption, with the concomitant impairment of living and working conditions. In developing countries, therefore, the case is strong for government intervention to encourage the choice of energy-saving technologies, particularly by the provision of information to managers, entrepreneurs and consumers, and possibly by mandatory technical specifications for industrial equipment.

4. Energy policy for agriculture and rural development

With the exception of scattered enclaves of mechanised and chemical-intensive farming associated with the Green Revolution, the peasant farms and small enterprises in the rural sector of developing countries depend for their energy supply on the traditional non-commercial fuels—wood, crop residues, animal dung. Animal power and human labour provide the direct mechanical energy required in the cultivation of small farms. Kerosene and electricity have started to enter the rural economy but only to a limited extent in the typical developing country; and occasional reports suggest that this process has been arrested in recent years with the new constraints on oil consumption.

This section will review the potential of the so-called "renewable energy technologies" in rural areas and attempt to compare them with conventional sources such as animal power and electricity supply by grid extension and diesel engine generation. Before embarking on this comparison it may be useful to emphasise the immense changes brought about in the advanced economies during the past half century of cheap oil. Leach has examined the changing pattern of inputs of human and animal labour and fuels to agriculture in a variety of cultures throughout human history.[20] Fuel inputs are not essential if land is abundant: for example, the !Kung bushman of the Kalahari Desert is blessed with as much land as he desires and can survive, together with his family, by doing no more than two hours' work a day; his recreational life may therefore be rich, despite a monotonous diet of nuts, vegetables and such animals as he can catch. Globally, however, population growth reduced the availability of land and, as European economies began to industrialise, the application of more and more animal and human labour became essential to support the increasing proportion of the population living and working outside agriculture. More recently these inputs of mechanical energy have been augmented by energy embodied in man-made fertilisers. In the United Kingdom, for example, total energy inputs per hectare rose no less than 60 times in the half century from 1920 to 1970. Tractors were substituted for horses, fertilisers took the place of the traditional manure and compost and the number of agricultural labourers decreased as their skills were developed. By 1968 UK agriculture was applying as much energy per employee as heavy engineering industries.[21]

Renewable energy sources

Even before the oil price increase of 1973-74, progress in raising the productivity of agriculture in the Third World suffered many other constraints. These included the shortage and maldistribution of capital resources, inappropriate land tenure systems and institutional structures ill-suited to technological change. The 1973-74 oil price increase has probably exacerbated the problems of rural poverty coupled with low productivity and has certainly encouraged an increasingly articulate school of thought to conclude that if any progress is to be made towards the satisfaction of basic needs, more has to be done to improve the supply and use of energy at the level of the village itself. With this objective in mind many writers have enthused about the potential of simple energy technologies based on solar energy capture in one form or another. Conceptually such technologies are attractive because of their ecological innocence, drawing as they do on a constant flow rather than on the earth's dwindling stock of fossil fuel resources. W. S. Jevons, the distinguished economist who pioneered the analysis of the demand for coal, drew attention to this environmental consideration, even though writing at the height of the industrial revolution in England when the role of coal was of such evidently crucial importance: "... while other nations subsist upon the annual and ceaseless income of the harvest, we are drawing more and more upon a capital which yields no annual interest, but once turned to heat and light and motive power, is gone for ever".[22]

However, the implementation of the renewable technologies briefly reviewed below is by no means as poetic or simple as it is often made out to be: whatever benefits may be realisable in terms of better living conditions and higher agricultural productivity, the technical, economic and institutional constraints are formidable.

Biogas is perhaps the best known example of the new generation of non-conventional technologies. Fifty thousand biogas plants were operating in India and 4.3 million in China in 1977. They offer tangible benefits to households—especially to the womenfolk who might otherwise invest much time and effort in the collection of firewood—in the form of methane gas for cooking, lighting and space heating, with, as a valuable by-product, a rich slurry which can be used as fertiliser. However, the Government of India has reduced its support for biogas plants following investigations revealing that the main beneficiaries are middle-class families owning more than three cattle, the minimum required to work a plant. Moreover, biogasification is clearly not viable in developing countries where household cattle-rearing is not established in the culture.[23]

Windmills are the subject of considerable research; a variety of designs, shapes and sizes are available. Power captured by a windmill can be harnessed directly to drive irrigation pumps, or converted by a dynamo into electricity and subsequently stored in batteries. Windmill operating costs are low but initial costs are relatively high, especially taking into consideration the likelihood of low levels of capacity utilisation because of daily and seasonal variations in windspeed. Indeed the major difficulty about windmills is the sensitivity of their design to specific geographical locations: and even then a design that is optimal in one season may literally be a non-starter in another.

A number of small-scale energy technologies aim at the capture of *direct solar energy*, i.e. sunshine, as contrasted with the "indirect" solar energy embodied in running water, tides, winds and plants after photosynthesis. Among these technologies are solar driers to process foods in a simple way; solar stills to purify brackish water; flat plate collectors to provide hot water for domestic space heating, cooking and washing; solar irrigation pumps; and photovoltaic cell arrays combined with battery storage. Evidence about the usefulness of these devices is fragmentary. Flat plate collectors are certainly used widely in countries of the Levant and a market for them has also sprung up in parts of India. Solar-powered irrigation pumps are much more sophisticated in conception and have not so far proved particularly successful, although experiments are in progress in some 25 African countries. The utility of solar cookers is prejudiced by the practice in most cultures of eating *after* sunset, a drawback confirmed by a recent ILO review of appropriate rural technologies in West Africa.[24] However, Reddy and Prasad estimate that by using solar cookers only to preheat food during the day about a third of the firewood now used for cooking in a typical Indian village could be saved.[25] Photovoltaic cell arrays hold considerable promise if the price of the cells can be reduced to the extent projected by US government agencies; this would render the electricity produced by such arrays cost-competitive with electricity supplied to rural areas by grid extension. However, all these solar energy capture devices may well be more useful in towns, where manufacturing and repair facilities and substitute fuels are available: rural folk may not easily be convinced that the investment of their small savings in solar cookers or plate collectors is sound, especially if the level of insolation is subject to significant seasonal variation.

Finally, *fuelwood* is a renewable energy resource which is being reduced at a rapid rate in many developing countries. This situation may be remedied in several ways. Firstly, there is considerable scope for improving the efficiency of wood-burning stoves in all parts of the developing world. Secondly, afforestation programmes may ensure supplies of wood in the long term. Such programmes may concern either large-scale plantations—"energy forests" as they have been termed—or local village woodlots. In each case there are potential institutional difficulties. The wood produced in government-managed plantations may tend to be diverted towards industry and the urban middle class rather than to the rural poor who feel the increasing scarcity of firewood most keenly. Village woodlots, on the other hand, can be established only by well informed and well organised rural communities, and where land is scarce their establishment may be ill-advised unless steps have already been taken to improve the efficiency of wood-burning stoves.

Despite the gravity of the energy situation in the rural areas of low-income oil-importing countries, it is imprudent to advocate these small-scale renewable technologies too enthusiastically at present. The appropriateness of each is dependent on climatic conditions and cultural circumstances. The institutional implications of installing large numbers of non-conventional energy devices in a developing country are forbidding. Even in India, which has a well established civil service at the provincial (state) level, the dissemination of information on better firewood stoves, improved water pumps and the more efficient use of cattle dung has proved difficult; and the experience of China's "Great Leap Forward" of 1958 does not encourage any attempt to apply small-scale technologies extensively without adequate preparation in the form of planning, testing and training programmes. But notwithstanding these sound reasons for caution, research and development to improve the reliability and efficiency of renewable energy technologies is becoming increasingly relevant as world oil prices rise and the capability of governments to press forward along the conventional path of rural electrification is correspondingly diminished.

Conventional rural energy

Oxen constitute the most crucial source of power, especially at the peak period of harvesting, in many agricultural systems. Cattle are typically used for tillage, the grinding of foodgrains, the drawing of water and the movement of harvested crops from the field to the farm and onward to the points of processing and sale. The capability of cattle to provide a large amount of mechanical power at a given moment distinguishes this source of energy from others; only an expensive tractor, beyond the means of small farmers in low-income agriculture, can replace oxen. But the bullock is an inefficient converter of energy: although having a less fastidious palate than his owner, as much as half of his working capacity is typically expended in foraging for food.[26] The inefficiency of draught animals in developing countries is such that it has been estimated that their replacement by tractors would increase over-all commercial energy demand by only 2 per cent. Viewed in isolation this point appears somewhat academic: but its relevance to the basic human condition of peasant farmers and their families is emphasised by the historical experience in Europe, where the improved collar for draught animals which came into use in the ninth and tenth centuries is estimated to have increased their productivity five times over.[27] Recent work on rural transport by I. J. Barwell and J. D. Howe[28] emphasises the important contribution which could be made to agricultural productivity, at a relatively low cost, by better designed bullock carts and collars.

Rural electrification is conventional to the extent that it has formed an integral part of the modernisation of the rural areas of the industrialised countries in the past 50 years and is now spreading slowly in the developing countries. Electricity supplies can serve developmental objectives by raising agricultural productivity (mainly by providing power for irrigation pumps); by improving living standards (heating in the home, and lighting, both private and public); by encouraging the establishment of rural industries; and through these other effects discouraging migration to towns and cities.

Electrification programmes are politically important in many developing countries because of the tangible and immediate benefits evident to farmers and entrepreneurs, and the popular perception of the electric path and the appliances associated with it as heralding progress. But the total costs of capital equipment and fuel needed for central electricity generation, plus distribution by transmission lines, with unavoidable power losses, are high; they can be reduced only by high rates of capacity utilisation—which villages in rural areas cannot usually manage in the first few years following connection to the grid. Because of the high costs of electricity at the end of a grid extension the World Bank's policy on rural electrification is cautious—it is argued that diesel engine generation with battery storage may be economically more sensible for small communities off the beaten track.[29]

Some writers regard electrification in rural areas as largely irrelevant, whatever the unit cost, because it cannot replace animal power in cultivation and harvesting; and because there are usually more pressing needs in impoverished villages, e.g. for water, sanitation and cooking fuel, which a grid extension can do little to meet. Others maintain that electricity can be produced almost as cheaply by the new non-conventional energy technologies discussed above. However, this assertion is not particularly meaningful. It is certainly impossible to compare unit costs in rural electrification projects with those for electricity produced by biogas plants, windmills, etc., in the developing world as a whole. Even in the context of a specific country such a comparison is bedevilled by conceptual difficulties and the paucity of experience with small-scale non-conventional electricity generation. One country study which provides some concrete figures concerns Tanzania.[30] The following estimates are given for unit production costs of electricity (in Tanzanian shillings per kWh): grid extension in rural areas, up to 20 km from an existing transmission line, 0.58; diesel engine generation, 2.30; windmill generator, 1.50; photovoltaic cell array, 0.83-11.00, the lower figure corresponding to the US target for cell production costs in 1985; small-scale hydro-power, 0.26-0.97 depending on the system; and biogas plant plus generator, 18.2. (For purposes of comparison, the *consumer* price in Dar es Salaam is 0.88.) Judging by these figures biogas electricity is expensive; but this does not condemn the technology, because electricity generation is a particularly sophisticated form of energy output from such a plant and most users would be content with gas. The estimates for small-scale hydro-power are encouragingly low, but this is due in part to the assumption that villagers provide their own tools, materials and labour free of charge in the construction of dams and other earthworks. These figures may not be especially useful for the purpose of decision-making, however, because the grid extension costs are unlikely to reflect accurately the real cost to the Tanzanian economy of providing electricity in rural areas in the future.

Until small-scale energy technologies are demonstrated to be viable over extensive areas of several developing countries, data such as these must be treated with great caution. On the face of it they indicate that electricity from windmills, small hydro-electric plants and photovoltaic cell arrays may be cheaper than that from the diesel engine generators so common in Tanzania. But these technologies are not yet being implemented on a large scale in that country or elsewhere; thus the exercise of comparing production costs is likely to remain essentially academic until training programmes are established and the local manufacture of equipment is initiated.

5. Some implications for future ILO action

The fashionable phrase "the energy crisis" both dramatises and oversimplifies an exceedingly complex global situation arising from a tangled skein of economic, geopolitical and technological considerations and uncertainties. The term crisis can perhaps be used accurately in those parts of the developing world—for example, low-income Asia and Sahelian Africa—in which human existence is threatened in rural areas by the rapid depletion of firewood resources and reduced supplies of kerosene. Yet in these areas there are often other crises of equally vital importance—those of water supply and food production. Elsewhere the energy problem is best viewed not as a crisis but rather as a continuing process of technological choice and change on a grand scale in the next two decades and beyond, a process the more challenging because its inevitability is so apparent.

As indicated earlier in this article, the high capital intensity of the conventional energy sector means that energy policy has major implications for the growth of other sectors: the orthodox approach of planning energy supply without considering the possibilities for conservation in the positive sense may therefore be detrimental to social goals such as the alleviation of rural poverty and urban squalor. Thus to concentrate ILO energy-related activities exclusively on matters of concern to its tripartite constituents in the modern energy sector may not necessarily be consistent with the objectives of the World Employment Programme established by the 53rd Session of the International Labour Conference and confirmed by the 1976 World Employment Conference. Indeed, unless appropriate economic and technological choices are made in the coming decades in respect of both energy supply and consumption, many of the values for which the ILO stands, in developed as in developing countries, will be threatened. There are therefore good reasons for the Organisation to consider the extent to which it should concern itself with certain key aspects of the energy transition including, for example, training activities to promote energy conservation and assist the application of more efficient primary energy recovery and conversion techniques, and information dissemination to promote the application of small-scale renewable energy technologies. Some ILO projects already in progress reflect the need to move towards new technological solutions in order to match energy resources to social needs. Specific activities—other than those relating to the energy sector itself—include the preparation of training materials on conservation and on improved methods of charcoal burning; technical co-operation to promote reforestation and the creation of village woodlots;

and a project to assist the long-term planning of the transport sector, taking account of future energy scarcity, in an African developing country.

It is probable that the ILO will receive an increasing number of requests for assistance in the energy field in the years to come. In order to provide such assistance efficiently, a more secure data base is essential. It is apposite then to emphasise in conclusion the need for further research: our knowledge of energy use and its relationship to the growth of output and employment is very limited. Most of what is now known has been learnt in the past five years and concerns energy demand in industrialised rather than developing countries. Indeed, in most of the latter the first priority is the collection of data on end use. Beyond this, more research is needed on the social implications of different energy policies and technologies. Some of the more interesting issues for future research have already been mentioned. Others deserving of more attention, to give just a few examples, include the total energy intensity of consumption by different income groups in a society; the consequences for energy demand and employment of different modes of transport; and the relationship between price regimes for petrol and other oils and electricity, and the distribution of real incomes. Until more data on actual developing country experiences have been collected and analysed, the energy policy options discussed in this article will remain frustratingly open and untested as traded oil prices rise and the circle of constraints on progress towards social objectives closes further.

Notes

[1] D. G. Fallen-Bailey and T. A. Byer: *Energy options and policy issues in developing countries*, World Bank Staff Working Paper No. 350 (Washington, 1979), p. 9.

[2] World Bank: *World development report, 1979* (Washington, 1979), statistical annex.

[3] Workshop on Alternative Energy Strategies (WAES): *Energy: global prospects 1985-2000* (New York, McGraw-Hill, 1977).

[4] World Energy Conference (WEC): *World energy: looking ahead to 2020*, Report by the Conservation Commission of the WEC (Guildford and New York, IPC Science and Technology Press, 1978).

[5] WAES, op. cit., p. 238.

[6] WEC, op. cit., p. 208.

[7] World Bank, op. cit., p. 11, table 11.

[8] See idem: *A program to accelerate petroleum production in the developing countries* (Washington, 1979).

[9] See J. A. Lane: *Nuclear energy in developing countries* (Toronto, Ontario Press, 1978).

[10] A comprehensive survey of energy resources is contained in WEC: *World energy resources 1985-2020* (Guildford and New York, IPC Science and Technology Press, 1978).

[11] See E. Friedmann: "Financing energy in developing countries", in *Energy Policy* (Guildford), Mar. 1976, pp. 37-49.

[12] See for example D. J. Wright: "Energy budgets: 3. Goods and services: an input-output analysis", ibid., Dec. 1974; R. V. Denton: "The energy costs of goods and services in the Federal Republic of Germany", ibid., Dec. 1975; and R. A. Herendeen: *An energy input-*

output matrix for the USA (1963): a user's guide (Urbana, University of Illinois, Center for Advanced Computation, 1973). Alas, similar computations have not yet been made for any developing economy.

[13] The figures given here are based on P. Chapman, D. A. Casper and N. D. Mortimer: *Energy analysis of the census of production*, Energy Research Group Report, Open University (UK), 1975.

[14] Wright, op. cit.

[15] See C. Baron (ed.): *Technology, employment and basic needs in food processing in developing countries* (Oxford, Pergamon Press, 1980).

[16] G. Leach, C. Lewis, A. van Buren, F. Romig and G. Foley: *A low energy strategy for the United Kingdom* (London, Science Reviews, 1979). The authors assume that living conditions will improve in the UK up to the year 2025: for example, it is hypothesised that electrical appliances in the home will be owned in increasing numbers; and that house temperatures and hot water consumption will continue to increase. But the efficiency of appliances will also increase and some will be used less: for example, home cooking will decline because of the convenience of prepared foods. Insulation in housing could make a major impact on energy consumption in the residential sector. Likewise, in the commercial sector it is assumed that although there will be a considerable increase in office space, educational and health buildings, the energy intensities of all newly constructed buildings will greatly diminish. For example, the efficiency of solid fuel and gas-fired heating appliances is assumed to increase by 25 per cent by the year 2025. It is suggested that district heating could supply about 15 per cent of the total energy requirements of commercial and residential accommodation by the year 2010; and that solar water heating might supply 40 per cent of the hot water requirement in new buildings by 2025. In transport, it is forecast that although car ownership will reach saturation levels by the beginning of the next century cars will be smaller and their consumption per kilometre much lower than today. Fuel economies for all other kinds of vehicular road transport are also projected, in part owing to battery-powered cars, buses, coaches and light vans coming into use after 2000. In industry, the largest energy-using sector in the British economy, a saving of 50 per cent for space and water heating is regarded as a feasible goal by the introduction of fairly simple measures such as insulation and the application of heating and ventilation controls. A 15 per cent energy saving in the lighting industry is already possible by the use of more efficient lamps. Energy savings in the region of 30 per cent are possible in respect of all boiler plant used in industry. The energy requirements of fertiliser manufacture could be cut by 40 per cent and 37 per cent could be saved in the production of cement by substituting the dry for the wet manufacturing process.

[17] For the report by Leonard Rodberg, see *Employment impact of the solar transition*, A study prepared for the use of the Subcommittee on Energy of the Joint Economic Committee, Congress of the United States (Washington, US Government Printing Office, 1979).

[18] D. A. Elliott: *Energy options and employment* (Dagenham, North East London Polytechnic, Centre for Alternative Industrial and Technological Systems, 1979).

[19] Cited in R. Stobaugh and D. Yergin: "After the second shock: pragmatic energy strategies", in *Foreign Affairs* (New York), Spring 1979, p. 862.

[20] G. Leach: *Energy and food production* (Guildford, IPC Science and Technology Press, 1976).

[21] Ibid., pp. 9, 15 and 21.

[22] W. S. Jevons: *The coal question* (London, Macmillan, 1865), p. 412.

[23] See D. Hughart: *Prospects for traditional and non-conventional energy sources in developing countries*, World Bank Staff Working Paper No. 346 (Washington, 1979), which observes that there is some doubt whether the resource base in many developing countries is sufficient to permit any large-scale use of biogas in rural areas.

[24] M. J. C. Woillet: *Technologie appropriée: coopération entre les pays de la Communauté économique de l'Afrique de l'Ouest* (Geneva, ILO, 1980).

[25] A. K. N. Reddy and K. Krishna Prasad: "Technological alternatives and the Indian energy crisis", in *Economic and Political Weekly* (Bombay), Special Number, Aug. 1977, pp. 1465-1502.

[26] A. V. Desai: "India's energy consumption: composition and trends", in *Energy Policy*, Sep. 1978, pp. 217-230.

27 See G. F. Ray: "Energy economics—a random walk in history", in *Energy Economics* (Guildford), Mar. 1979.

28 See their contribution in UNIDO: *Appropriate industrial technology for low-cost transport for rural areas* (New York, 1979).

29 World Bank: *Rural electrification* (Washington, 1975).

30 See Tanzania National Scientific Research Council: *Workshop on solar energy for the villages of Tanzania* (1978).