

INTRODUCTION

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Rural energy is and continues to be primarily solar energy, available through photosynthetic conversion of crops (food and fodder), fuelwood, animal dung and agricultural residues. Over 80% of rural energy in the developing countries is derived from wood and animal wastes, and is primarily used for cooking and agriculture. Most of the energy used is non-commercial and produced by people themselves to meet their own needs. Rural energy, in other words, is not a commodity exchanged through a market, but a *use value*. Recognition of this characteristic is central to the task of rural energy planning and assessment.

Rural energy sources and the environment

Rural energy use takes place in the context of complex, interrelated physical, economic and social systems. Energy flows exhibit many interconnections. Most traditional fuel resources serve many purposes. Leaves and twigs may serve as animal fodder or fuelwood; the trees themselves may be harvested for fuelwood or building materials; residues from the trees may be spread or used as fertilizer. Crop and animal residues also have competing uses: new straw for animal feed, compost, fuel or soil nutritioner; and dung for fertilizer, fuel or feedstock. There is often a delicate resource balance within a rural area. Any resource adjustments – for example, forest clearing for agriculture, excessive wood cutting for fuel, etc – imply altered resource availabilities.

Fuelwood comes overwhelmingly from local sources, and this puts growing pressure on the trees, bushes and shrubs near the centres of population. Long

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before the demand for fuelwood leads to complete destruction of the tree cover, it can have a markedly degrading environmental effect. Excessive pruning of its branches may reduce a tree's capacity for growth; removal of the more easily felled younger trees may reduce the regenerative ability of the forest; excessive opening of the canopy through the removal of too many trees can render the forest susceptible to damage from wind and sun and can affect wildlife; the removal of all residues, even to the point of sweeping up the leaves, removes the nutrients that should return to the soil to maintain its fertility; removal of stumps, bushes and shrubs can destroy much of what remains of the soil's protective cover and binding structure. Eventually, the whole forest may disappear.

The removal of tropical forests has been estimated to occur at a rate of about 11 million ha/year. Most of this deforestation occurs (and will continue to occur) in the developing countries, whose humid tropical forests and open woodlands are steadily being felled and converted to farmland and pasture. This trend is impelled by several forces: the expansion of agricultural frontiers into forested areas in order to supply food as populations increase; the demand for fuelwood and charcoal; the demand for tropical forest products by industrialized nations; and the demand within the developing countries for paper and other forest-derived products as incomes rise.

In the developing regions where fuelwood is most needed (and demand will increase by 2000), situations have evolved where fuelwood has become quite scarce. Acute scarcity in 1980 involved about 90 million rural people in developing countries [3]. Minimum energy needs are not met, and energy consumption is below minimum levels. Such situations prevail in Africa, mainly in the arid and semi-arid areas south of the Sahara, in East and South-east Africa and in the mountainous areas; in Asia, in the Himalayas and the hills of South Asia; and in Latin America, mostly in the Andean Plateau and the arid areas of the Pacific Coast. Also, some 150 million people live in major urban centres situated in rural areas which already have a fuelwood deficit. Under prevailing ecological conditions and with expanding demographic growth, any large-scale forestry effort to improve the fuelwood supply is likely to be very costly and to offer only a partial solution to increasing energy needs. Deficits in 1980 involved 833 million rural people, in areas where populations are still able to meet their minimum energy needs, but only by harvesting in excess of sustainable fuelwood supply. Populations in such situations in Africa amount to 146 million, mainly in the savanna areas in West, Central and South-east Africa. In North Africa and the Middle East, 70 million rural people have a fuelwood deficit. In Asia, 550 million people in rural areas and small urban centres, mainly in the Indu Ganges plains of Central Asia and in South-east Asia, are affected. In Latin America, 82 million rural people are affected, mostly in the semi-arid and arid areas. An additional rural population of 800 million are living under conditions of prospective fuelwood deficit. (Prospective deficit situations are those where the availability of supplies exceeded demand in 1980, but where, if current trends of depletion of fuelwood resources continue, deficits will occur by 2000.)

The demand for fuelwood and charcoal, the higher prices of kerosene, the increasing demand for energy for rural industries and agricultural production, higher population and competing demands for forest products, have all generated a rural energy 'crisis'. This crisis can be understood only as an interaction of

natural, technological and social factors. Energy cannot be addressed as an isolated physical or technical problem but only in the overall broad context of development with its socio-cultural, economic, environmental and geopolitical dimensions.

Rural development and the environment

Environmentally sound development is seen as a process which is primarily directed towards: (a) satisfying basic human needs, starting with the needs of the neediest, in order to reduce inequalities between and within countries; (b) indigenous self-reliance through social participation and control; and (c) harmony with the environment [2]. The commitment to development, rather than to growth *per se*, as a socioeconomic objective has major implications with regard to energy targets for developing countries. The view that growth in GNP should be a byproduct rather than the basis of development releases policy makers from dependence on the 'correlation' (between per capita energy consumption and per capita GNP) as a source of energy targets.

Instead, per capita energy targets must be derived from development objectives, and in particular from the objective of satisfying basic human needs.

In terms of economic development, increasing energy supply means an increased capacity to produce the necessities and amenities of life – food, shelter, clothing, communications, health care, transport etc. In fact, economic development consists in large part of harnessing increasing amounts of energy for productive purposes. This can occur either by tapping increased amounts of energy resources or by making more efficient use of available energy resources through use of appropriate tools and machines or conservation techniques. The relationship between energy and economic development is a dynamic one, in which the amount, type, and speed of economic growth are mutually dependent variables of the quantity, kind, and price of energy available.

Rural development is a strategy designed to improve the economic, environmental and social life of a specific group of people – the rural poor. A strategy for rural development must recognize three points. First, the rate of transfer of people out of low productivity, agriculture and related activities into more rewarding pursuits has been slow. Second, the mass of the rural population in developing countries face varying degrees of poverty; their position is likely to get worse if population expands at unprecedented rates while limitations continue to be imposed by available resources, technology, and institutions and organizations. Third, rural areas have labour, land and at least some capital which, if mobilized, could reduce poverty and improve the quality of life. Since rural development is intended to reduce poverty, it must be clearly designed to increase production and raise productivity. Rural development recognizes, however, that improved food supplies and nutrition, together with basic services such as health and education, can not only directly improve the physical well being and quality of life of the rural poor, but can also indirectly enhance their productivity and their ability to contribute to the national economy.

There is a growing consensus that successful development requires a firm agricultural foundation and that the basic quality of life must be improved for – and with the participation of – the poor majority of people living in the countryside. If

this can be done, the rural poor may have reason and ability to reduce their birthrates, they may increase their food production and consumption, and they may no longer be forced to flee to already overcrowded cities. Carefully and persistently pursued, a fully integrated rural development programme could provide a sound basis for the manufacturing and service sectors of a self-reliant and thriving national economy.

Needs of integrated rural development

Among the needs stemming from a programme of integrated rural development is energy for agriculture and small-scale industries. Agriculture requires inputs such as fertilizer and pesticides which are produced from oil and natural gas. It also requires human and animal labour and machines. Mechanical equipment powered by fuel or electricity is immensely more efficient and productive than humans or animals. Water is another essential agricultural input that is most efficiently used if controlled. Water management requires energy, and the major proportion of electricity used in developing country rural areas powers irrigation pumps. There is thus scope for alternative technologies for irrigation in rural areas. Production of adequate food and provision of the raw material basis of agro-industries depend on higher levels of crop production. These in turn depend on irrigation and thus on energy supplies.

The success of any rural development programme depends primarily on a thorough understanding of the perception of the rural community, of the concepts of 'development' and of 'improving the quality of life'. It also depends on the acceptability of programmes and technologies to the rural population. Strategies for rural development that may appeal to decision makers (living far away from rural areas) may not be so attractive to the rural community. Development cannot be instantaneous, and any approach that does not take into consideration the socio-economic implications cannot be very successful.

Energy policies for rural areas should not be imposed in ignorance of local preferences and customs. Traditional cooking and eating habits, for example, are essential considerations when so much of the fuel produced in rural areas is used for cooking. The community focus in anthropological research and attempts to develop cooperative movements in farming may not prove successful. The same is true in the area of energy. In tree planting programmes, for example, it may sometimes be easier to interest the individual rather than the group.

Strategies for integrated rural development

In many developing countries rural electrification has been promoted as the solution to meet rural energy demand. Electricity was perceived as a symbol of modernization and progress. However, electricity from the main grid system is beyond the purchasing power of most of the rural poor and is not a suitable form of energy for cooking, agriculture, fertilizer or pumping, without expensive capital outlay which is beyond the reach of most rural people. In any case, the weak demand leads to very low load (utilization) factors, ranging from 1% to 14%, which render this energy supply uncommercial. This can be illustrated by a

comparative costing of conventional, diesel and renewable technologies for supplying electricity to a remote village in Tanzania.

Bearing in mind that rural energy strategies must be a part of an integrated rural development strategy, the formulation of rural energy plans must be based on the socio-economic and environmental conditions prevailing in the area under study. For example, in locations exclusively dependent on human and animal labour at present, utilization of energy should as a first step be directed towards improvement of the basic living environment using simple devices. This should be followed by the application of energy to improve agricultural productivity. Energy can then be provided for small-scale industrial and community level uses.

The starting point, therefore, must be that human beings, draught animals and non-commercial fuels supply the bulk of the energy needs of villages in developing countries. As a first step, major improvements can be effected in the productivity of human and animal labour and in the efficiency with which non-commercial energy is used. The productivity of human and animal labour can be increased by exploiting the mechanical advantage of what are known in physics as simple machines – levers, pulleys, wheels, etc – which do not require inputs of harnessed energy. For example, a better way of using human energy is pedal power, which could be used for such purposes as water pumping, corn grinding and transport (using bicycle-drawn trailers, etc). Similarly, the productivity of draught animals can be enhanced by creative engineering on the devices which transform this animate energy source into desired end-uses. Simple designs of mud cooking stoves permit doubling or trebling of the efficiency with which the heat produced by the combustion of non-commercial fuels is used in cooking. This means that the same quantity of non-commercial fuel used in the village can satisfy double or treble current energy needs for cooking.

Further steps in an appropriate rural energy plan would aim at harnessing locally available renewable sources of energy to promote rural development. Renewable energy sources (eg biomass, solar energy, wind energy, microhydro-power, etc) can be harnessed individually or in combination to meet specific energy requirements.

Integrated energy systems

There has been the temptation to convert different renewable energy sources into electricity and so integrate them into all-electric systems with transmission lines and electrical equipment. The temptation is increased because the electric system is well established in the developed countries, and most of the technologies and equipment are available off-the-shelf, or almost so. But there are serious disadvantages: the capital costs of electrical equipment are almost certain to exclude families below the poverty line. Also, totally different domestic lifestyles are suddenly demanded by an all-electric system. The system can also suffer from substantial efficiency losses, which occur in two ways. First, there are the losses associated with energy conversion. For example, transforming biogas into electricity may yield only 25% conversion efficiency, so that direct use of biogas for cooking may be far more efficient than converting it to electricity which is then used for cooking. Second, energy comes in various grades; electricity and mechanical motion correspond to the highest grade, waste heat the lowest; and

fossil fuels are of intermediate grade. The grading of energy sources leads to a simple rule-of-thumb – ‘Don’t use a higher grade energy source than the task deserves’. For example, it is wasteful to use high-grade electricity for medium-temperature heating, which is what is required in cooking.

These points about electric systems can be illustrated by the results of a joint project undertaken by the Ceylon Electricity Board and UNEP. In that project, an experimental rural energy centre has been built at Pattiypola village using wind power, biogas and solar energy [1]. Each of these energy sources is used to produce electricity which is then stored in a battery bank, converted and distributed to a number of houses in the village. Theoretically, the Pattiypola energy centre should produce about 60 000 kWh/year. However, allowing for losses associated with charging and discharging the main battery bank, conversion and distribution (which amount to about 50%), would reduce the output of the centre to about 30 000 kWh/year. Irregular supplies of dung for the biogas plant and other factors led to a further reduction of output to about 20 000 kWh/year. This can only meet the requirements for lighting of 50 households, for water pumping to meet their needs and for street lighting (30 lamps each of 80 W, for six hours daily).

The above considerations do not mean that electricity should be excluded from rural energy strategies. On the contrary, lighting, communication and a number of other activities at the heart of rural development, require electricity. The question is where this electricity will come from. In some cases, it may prove convenient (and economical) to connect a rural area to the main electric grid system; in other cases, it may be more appropriate to use decentralized generating units. It is therefore necessary to study and compare various options, from the socio-economic, technical and environmental points of view, before deciding on how to introduce electricity in a rural area.

In all cases, it should be noted that no single energy technology, whether electricity, biomass, wind, solar energy, etc, can meet all the energy requirements of rural areas. There will have to be a ‘mix’ of sources, each component (or more) of which should be designed to match a specific energy-consuming task(s).

Optimum energy mixes for rural areas should be determined using a ‘matching’ process, which identifies the energy systems best suited for local energy requirements and which use the most appropriate and economical local resources. Matching is carried out by assessing the energy requirements of a village, by assessing local conventional and renewable sources of energy, and then by selecting the energy systems which best fit the energy requirements.

Details about the different rural energy centres will be given in the following chapters. There is much that we can learn from the pioneering experiments of these centres. Successful experience may be adopted after necessary adaptation to local conditions. The reasons for unsuccessful experiments can be analysed and well understood. Effort should be made to avoid making the same mistakes.

References

- 1 Ceylon Electricity Board and UNEP, *The Pattiypola Energy Centre*, UNEP ERS-6-82, 1982. See also Chapter 1 in this volume, ‘An integrated rural energy system in Sri Lanka’.

- 2 M. K. Tolba, *Development without Destruction*, Tycooly International, Dublin, 1982.
- 3 E. El-Hinnawi, Margaret R. Biswas and Asit K. Biswas, *New and Renewable Sources of Energy*, Tycooly International, Dublin, 1983.