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LIMITED
ID/WG. 282/100
17 October 1978
ENGLISH

08777

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

INTERNATIONAL FORUM ON APPROPRIATE INDUSTRIAL TECHNOLOGY

New Delhi/Anand, India 20—30 November 1978

WORKING GROUP No.11

APPROPRIATE TECHNOLOGY FOR RURAL ENERGY

ENERGY FOR RURAL REQUIREMENTS,
Discussion Paper

id 78-7121

Energy for Rural Environments*

Issues and Considerations

Note prepared by the secretariat of UNIDO

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Energy for Rural Requirements*

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* This Note has been largely based on the background documentation on the subject, which is attached.

INTRODUCTION

1. The conventional energy supply systems, which have evolved in reponse to or in conjunction with urban-based industrialization programmes, have proved to be inadequate in relation to the integrated needs of the rural population in developing countries. Even the little "trickle-down" benefits, which have reached the rural sector, have not been equitably distributed either geographically or between different income groups. Rural energy supplies for agriculture, irrigation and transport involving substantial grid-subsidies in most cases, have benefitted mainly plantation and other large-scale agricultural interests. The pattern of energy development in developing countries over the past 30 years, for example, has been described as "urban islands of energy-affluence amidst vast oceans of rural energy-deprivation". Only about 12 per cent of the total energy produced is distributed for rural use. Distribution of even this small percentage of the total energy generated has been highly inequitable.

2. Thus the conventional energy systems based on centralized energy production has failed to yield adequate power in relation to the micro-economic needs in developing countries and has not, in most cases, met the specialized demand requirements of agriculture and rural and small-scale industries. The problem of rural energy supply, therefore, calls for a new approach and a new planning strategy, deliberately oriented to the specialized needs of integrated rural development. In other words, integrated rural development has to be sustained by an integrated rural energy system, which would be expected to encompass all the facets of the rural energy supply problem and to result in optimum matching of the needs with energy availability. The emphasis could be placed on local renewable resources, which can result in technologically sound decentralized options.

I. RURAL ENERGY NEEDS

3. When properly used, small - perhaps intermittent - amounts of energy can be of critical value to the rural economy. The inability of developing countries to produce relatively small increments of energy, is a major bottle-neck to development programmes, particularly in the rural sector where needs are much simpler. Although by itself, provision of such amounts

of energy is not a sufficient condition for improvement in economic and social well-being, it is a necessary condition. Its efficacy, of course, is bound up ultimately with other economic, social and political changes and energy supply is so important that provision of appropriate energy technology presents a singularly opportune "point of entry" for rural development programmes.

4. The cumulative impact of effective use of even small amounts of energy in a rural area can be considerable. Agricultural productivity, rural-based industries, health, communications, educational opportunities - all leading, perhaps, to a slowing down of rural exodus - could benefit from the availability of even low-power devices. Estimates of the amount of energy required to provide subsistance vary with specific circumstances. Thus per capita levels of energy consumption ranges from 11,000 kgce in North America to between 5 per cent to 10 per cent of that in developing countries, even when non-commercial energy is included. Several studies concur that approximately 300-400 kgce/cap/annum would coincide with minimum provision of food and shelter in a rural agricultural setting.

5. According to the initial findings of a study of the Overseas Development Council of the U.S.A., the standard of living is correlated directly wit' energy consumption. The study concluded that a three-fold increase of the current average energy consumption in developing countries to 900-1000 kgce/cap/annum would be required to ensure a minimum adequacy for human life. A target of 2000 kgce/cap/annum, which was the world average in 1973 and corresponds to the energy consumption of GNP/cap/annum of US$1,600 per year, would, therefore, be quite reasonable and appropriate.

6. On a global perspective, it would appear that most of the developing countries are below this threshold of subsistance, if one considers only the commercial energy consumption. However, the bulk of the energy for the domestic sector now comes from non-commercial energy sources. Non-commercial fuels, such as wood and dung represent a substantial portion of the total world energy use - about 8 per cent. According to an estimate, in energy terms, wood and dung represent one-fifth of the total world oil, four times the world hydro-power, sixty times the total world nuclear power. In developing countries, non-commercial energy represents a very significant portion of the total energy use.

7. The quantity of dung burnt as fuel represents 20 to 25 per cent of the total dung production and a destruction of plant nutrients to that extent. According to an estimate, in India alone, 60-80 million tonnes of dried cowdung, 300-400 million tonnes of wet, freshly collected manure, are burnt as fuel. The plant nutrient and organic matter thus wasted equal more than a third of India's chemical fertilizer use.

8. Non-OPEC developing countries account for 49 per cent of the world population but consume only 9 per cent of its commercial energy. Although commercial energy consumption of these countries has been increasing rapidly, it is still substantially below the subsistence level and only about 20 per cent of the world average in 1973. The combined commercial and non-commercial energy consumption, which ranges from 480 kgce/cap/annum for agricultural non-exporters to 1600 kgce/cap/annum for industrialized developing countries, leaves some 75 per cent of the world population at or below the energy consumption level which is necessary to provide basic human needs. In formulating estimates of rural energy requirements, national governments may take into account:

(a) the basic needs comprising household or domestic and social or community requirements;

(b) needs for agricultural operations including agro-processing, storage, etc.; and

(c) needs of village and small-scale industries.

9. The quantitative and qualitative shifts in energy requirements due to increase in population and the structural changes in the economy due to intensification of agriculture and dispersal of industries would need to be adequately provided for in any long-term rural energy planning.

10. In 1977, estimates of developing countries' rate of energy consumption growth based on GNP projections, ranged from 3 to 4 per cent. Due to growing foreign exchange difficulties and rising cost of fossil fuel, it is certain that the developing countries will find it increasingly difficult to maintain their imports of fossil fuel in future. If the oil imports of developing countries are not to increase and if growth is to be maintained, then energy must be secured from alternative sources. The present energy supplies which are based largely on non-commercial energy sources will not be in a position to sustain the vastly expanded rural requirements. 1/

1/ For a detailed discussion of energy demands in developing countries and the future trends thereof, see background papers: ID/WG.282/46, ID/WG.282/66 and ID/WG.282/86.

II. ENERGY SOURCES AND TECHNOLOGICAL OPTIONS

11. Commercial energy consumed in developing countries is overwhelmingly provided by petroleum products. Rising foreign exchange costs of fossil fuel and capital equipments have, however, severely restricted the ability of the developing countries to maintain their future energy development programmes at levels achieved in the past. There is, however, no doubt that petroleum products will continue to play a vital central role in commercial energy consumption of developing countries. This fact is sometimes lost in the current discussions on the alternative sources of energy. Nevertheless, developing countries must plan for a transition to a non-fossil fuel future. By starting now, industrial and agro-industrial opportunities within developing countries can be identified and seized and new technologies produced in as well as for developing countries, when options of feasible, renewable energies are available.

12. It is, however, important to note that generalized economic studies and models for rural areas are no more useful in real situations than purely technological studies. A village on the Mediterranean coast, where there is wind, solar energy and perhaps abundant rain, is radically different from a village in the rain-forest that has water but little wind or a village in India that, at certain times of the year, may have neither. Any attempt to find a universal model for all these situations will be so full of theoretical generalities as to be of little value to the specific micro-economies to which solutions must be applied.

13. A wide range of technological options are available to the developing countries; but only a few may be of immediate relevance to them in terms of suitability in relation to needs, capital cost, the absorptive capacity of the rural population and availability of technological hardware.

14. Much debate at present centres around which alternative technologies are most appropriate for the rural areas of the developing countries. Background documents provide a general over-view of the present status of the technologies developed so far for use of various alternative energy sources.

15. Alternative energy technologies are site-specific and thus are not as easily evaluated outside their context of use as are other technologies. Nevertheless, there is much agreement, based on experiments and social response, that suitable technologies for production of mechanical and electricity energy from biological wastes, solar, wind and water are available

and can be adopted for wide-spread application in rural areas in most of the developing countries. General geoclimatic conditions, levels of technological development and economic circumstances of the develeloping countries are also favourable to the application of one or the other, or a combination of all the technologies in the rural situation of these countries. In view of the decline of availability of non-commercial energy, which comes mainly from wood and farm wastes rather than from planned generation, these options are considered most appropriate and may be used, wherever feasible and necessary, in conjunction with diesel or micro-hydroelectric back-up.

16. Background documents provide a general overview of the state-of-the-art of various alternative energy technologies which are at different stages of development and application. However, the scope of this paper is primarily concerned with the problems of utilization of renewable sources and small-scale technologies in rural environment of developing countries and particularly to those technologies which are of immediate relevance to the developing countries and which would be expected to contribute to the improvement of the quality of rural and village life in situations where conventional fuels and power systems have not yet penetrated or are too expensive to become a significant factor in the foreseeable future.

17. The above considerations limit our discussions mainly to four technological options based on:

(a) bio-gas - for production of methane;
(b) water energy - for production of
    (i) electrical and
    (ii) mechanical power;
(c) wind - for production of mechanical energy; and
(d) solar energy - for use as direct heat.

Bio-Gas

18. The process of anaerobic fermentation of farm-wastes and human night-soil for production of methane gas to be used as fuel has great potentialities in the rural areas in developing countries. It would, however, be most attractive if installed to serve community needs rather than those of individual families. Village-based plants could utilize farm wastes from smaller holdings as well as human night-soil more effectively. The technology available is most attractive not only because of its simplicity

but also because of its low cost. A family size unit would cost between US$200 and US$300. However, a family-oriented programme would reach at best about 10 per cent of the rural population. It would seem desirable, therefore, to use this technology primarily for community use. The greatest relevance of this technology to the rural areas in developing countries is that it is capable of producing fuel gas (methane) without destroying the manurial properties of farm wastes.

Water - Mechanical Power

19. Water-wheels of many types and variations have long been used to produce mechanical power in different parts of the world for irrigation, grain milling, sugar-cane crushing and other simple utilities. The hilly terrains of Africa, Asia and Latin America contain streams which have the world's highest hydro potential. Water-wheels installed as community plants have great potential in rural areas of developing countries.

20. Water - electrical energy: In conjunction with dams and control sluices, water-wheels or turbines can also be used to produce cheap electricity-energy. Once the discharge and storage data is known and the energy need of a particular population concentration is assessed, it is possible to select appropriate hydro-power devices from a wide range of such devices now available.

21. In China, 20,000 to 35,000 micro-hydro units, averaging 34 KW each were in operation in 1973. For the Chinese villages involved, use of such small-scale hydro-power units, which represents 20 per cent of the total national hydro-power capacity, is significant for irrigation lighting, small-scale industries, etc. In 1974, hydro-power accounted for nearly 50 per cent of the total rural electric power consumption. Tanzanian experiments with micro-hydro power generation show that such installations were cost-competitive in relation to large-scale systems.

22. According to an estimate made by US Overseas Development Council, for villages with demands for 0.2 to 10 KW based on water sources capable of generating 8 to 25 ft falls and flows of 70 to 1000 cft per minute, there are turbines at a cost of US$3,000 to US$3,500 for the smallest units to US$12,000 to US$15,000 for the largest units. Larger units can be installed to serve the purposes of a group of villages also.

Wind - for operation of windmills

23. For areas with suitable wind regions and, particularly, in coastal areas, windmills can be installed to produce mechanical energy which may be used for such simple purposes as irrigation, grain-milling, sugar-can crushing, etc. Traditionally, windmills have been in use in China, Iran, the European Mediterranean and Northern Europe for a variety of purposes. Windmills intended to be used for simple purposes like water-pumping, irrigation, grain-milling, sugar-cane crushing, etc. can also be locally fabricated using local materials.

24. In developing countries, there has not been any systematic national policy, integrated applied R+D or local manufacture of windmills, although fragmented efforts for design and prototype fabrication have been made. Only Argentina has been manufacturing windmills on a commercial scale. Cloth-sail windmills are fabricated in Greece while Ethiopia, India, Kenya, Thailand, United Republic of Tanzania and Upper Volta have done some applied R+D and prototype fabrication.

Solar Energy - for production of heat energy 1/

25. The sunshine map of the world shows that the developing countries occupy a favourable position in regard to availability of solar energy. The current applications of solar energy that seem appropriate for use in rural areas, depending on local conditions, include:

(a) heating of water for domestic and industrial/commercial use;
(b) seed drying and dehydration of agricultural products for preservation;
(c) evaporation of sea water for salt production;
(d) water distillation; and
(e) for storage refrigeration (in a limited way).

26. Of the developing countries, only India and Mexico have so far developed national policies on R+D problems. At present technologies are available for immediate application in developing countries only for grain drying, dehydration of certain agricultural produces, water-heating, production of salt from sea water or inland brines.

Storage

27. Nearly all renewable sources of energy are more or less intermittent in their character. Storage of energy must, therefore, be an integral part

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1/ Attention is drawn to the UNIDO document, Technology for Solar Energy Utilization, Development and Transfer of Technology Series No. 5 - ID/202, which will be available at the meeting.

of R+D for development of technologies based on these sources. Techniques of storage vary - it can be stored in electrical, mechanical and thermal forms (apart from nuclear form, which, however, may not be of relevance in prevailing socio-economic contexts of the developing countries).

28. There are few effective and satisfactory storage systems for short-term application in rural areas. Without development of suitable technologies for storage of energy from non-conventional sources it is unlikely that any substantial and sustained impact would be achieved in the prevailing rural energy supply position in the rural areas in developing countries. But absence of satisfactory technologies for storage of energy need not hold up available energy technologies for production of energy, which in any case, is limited at present, as long as continuous demands for energy can still be met from other energy sources.

III. PROBLEMS AND CONSTRAINTS

29. Broadly, problems and constraints of any strategy for rural energy development featuring decentralized, integrated energy systems have two main dimensions - (a) technological and (b) institutional, including social.

30. In its technological dimension the problem is one of identification of available technologies, testing these for suitability to the local situations and for acceptability in relation to their costs and technological capacity of the people in the villages to operate, maintain and repair the hardware involved. The technological problems of adaptation and innovation to match the available technologies and hardware with the local circumstances may prove to be a serious constraint to many developing countries in implementing their programmes. But these problems will need to be divided into manageable proportion in terms of (a) what is available for immediate application and (b) what needs further research and development. Technologies are available, even in many developing countries for simpler applications of both direct and indirect solar energy. In regard to the first category of cases, the critical technological problem is one of providing the appropriate software for actual use in primary consumption of the energy made available from alternative non-conventional sources. The essential distinction between generation of energy from non-conventional sources and its actual application has to be constantly kept in view so that, due to an excessive

preoccupation with the problems of developing energy supplies from alternative sources, the equally important technological problem of creating the necessary conditions for mass application of alternating energy supplies is not relegated to the background.

31. Thus, in respect of the first categories of technologies, the technological problem to which R+D has to address itself to immediately, would be to ascertain, for example, why the low-cost smoke-less stoves designed in India or the bio-gas and solar technologies well established in a number of developing countries have failed to persuade the village population in the past. It was observed that the smoke-less stove designed for use in rural areas in India consumed more fuel and, therefore, the poor preferred to put up with a little smoke, instead of spending more on fuel. Similarly, bio-gas and solar energy technologies, although cheap, have failed to secure mass-scale application on account of the inadequacies of the software available. The problem here is one of 'taking the energy into the kitchens' of the individual families. The software now available for actual application of their energy supplies for domestic needs would need further development to improve their appeal for individual families. Thus, the R+D programme appropriate for the specific situation of developing countries must represent an integrated approach involving not only the problems of development of alternative energy supplies, but also those of providing the appropriate means and gadgetry for actual use of such alternative energy supplies in preference to the conventional energy supplies. Some of the technologies now available and in use would, however, need further investigation and adaptions before their extension in rural areas.

32. A related technological problem to reckon with would be one of fabrication of requisite hardware. This problem, too, will need to be simplified into manageable proportions in terms of (a) what can be fabricated within the villages using locally-available materials and (b) what needs commercial production outside the villages. There are technologies involving the use of simpler hardware which can be readily fabricated within the villages. These may be extended to the villages for widespread application without any loss of time. There are, however, technologies involving use of hardwares which have to be fabricated outside the villages on a commercial scale. Production of such hardwares will have to be encouraged through a scheme of subsidies, incentives and assistances as well as guaranteed sale initially.

Suitable institutional arrangements would be required to organise and sustain commercial production of the necessary hardware.

33. Institutional problems constitute the real constraint not only to the development of appropriate technologies, but also for their extension to rural areas. Technologies which are of immediate relevance to the rural population in developing countries are now available and, while improvements may be required in individual cases, especially to reduce production costs, by and large, hardware for harnessing alternative energy sources is relatively well-known and reliable. What is required is, therefore, an appropriate institutional infrastructure capable of planning and implementing a co-ordinated programme at all levels and also to mobilize community support for it at the micro-economic levels where it would need to be implemented.

34. An adequate institutional framework that would be needed would include institutional capacities:

(a) for survey of energy potentialities and planning;

(b) for R+D in order to identify appropriate technologies, adaptation of available technologies to suit local conditions, innovations and development of prototypes;

(c) field-testing of prototypes for suitability as well as social compatability;

(d) for rural extension and social mobilization;

(e) for training of villagers in operation, maintenance and repairs as well as for local fabrication of hardware;

(f) for promotion and encouragement of commercial production of hardware;

(g) for operation of schemes of financial incentives, subsidies and assistance for both (a) adoption by villagers and (b) commercial production and marketing; and

(h) for sustaining the programmes at the village level.

35. In many developing countries the requisite institutional apparatus either does not exist or is inadequate in relation to the task involved. The existing machinery for energy planning in developing countries which have evolved in response to the strategy of rural electrification based on centralized schemes, have tended to be biased against schemes based on decentralized systems using non-conventional energy supplies, like bio-gas, solar, wind, water, etc. energy. The new strategy calls for a different approach which would need to be compartmentalized

according to the sources of energy supplies and yet integrated and co-ordinated to create the needed import in the rural areas. The planning machinery, R+D structure, extension and training agencies, manufacturing capacity and community institutions will all have to be established, augmented and re-oriented both technologically and culturally to the new strategy of decentralized integrated energy development. The new strategy will need an integrated institutional approach involving political will to support it consistently, the institutional arrangements to implement it and involvement of the people to sustain it.

IV. POLICY IMPLICATIONS, CHOICES AND PRIORITIES

36. Integrated rural development featuring increase of agricultural production, encouragement of rural and small-scale industries, expansion of employment opportunities and provision of basic needs for civilized existence in the rural areas in developing countries, requires a need-oriented energy policy aimed at provision of energy in quantities, variations and at points it is needed.

37. Nearly 90 per cent of the energy now consumed in the rural sector comes from non-commercial sources, mostly wood. This has led to large-scale deforestation and a critical dislocation of the ecological balance leading to erosion and soil run-off with consequent disastrous effects on agricultural productivity and production in developing countries. This cannot go on. Alternative sources of energy must be found to reverse the present trend. Use of animal power should also be considered.

38. While developing countries should continue to explore for oil, gas and coal, it is an urgent imperative to reduce dependence on these sources. This implies an important policy issue involving a choice or re-allocation of priority inter se, between rural electrification systems based on (a) centralized systems and (b) decentralized but integrated systems supplemented by central power grids.

39. The need for devising an alternative energy system has stemmed from a realization that centralized energy systems and rural electrification schemes based on these systems, have proved to be inadequate and unavailing in relation to the actual rural requirements. First, electricity is only one form of energy at present required for rural purposes. To the extent that rural electrification does not meet non-electrical rural energy needs, it is inadequate. Secondly, rural electrification

based on centralized systems have tended to be inequitable in regard to distribution of power between different regions and villages and even within them. Regions in the immediate vicinity of large power-plants, larger villages and the more affluent sections of the rural population have, between themselves, derived a disproportionate share of the benefits. Thirdly, rural electrification through extension of central grid is highly capital intensive and may be prohibitive to those developing countries which do not already possess the requisite engineering and technical expertise and infrastructure to execute such schemes themselves, and the requisite manufacturing capability to produce the necessary wherewithal like cables, transformers, transmission towers, etc. and, instead, have to import them. Fourthly, population concentrations and micro-economies in many developing countries are widely scattered and separated by long distances. Apart from high cost of transmission and transmission losses, this makes for a low load factor which renders rural electrification most uneconomic, particularly in relation to reliable energy alternatives that may be available locally. Fifthly, lead time involved in establishment of the infrastructure required for rural electrification is much longer as compared to that for establishment of suitable decentralized local systems using locally available energy resources. Thus, for example, in about 25 years, from 1950/51 to 1975/76, only about 30 per cent of the villages in India has been covered under the rural electrification scheme despite the fact that the requisite hardware for rural electrification as well as engineering expertise are available within the country.

40. The foregoing considerations, perhaps, suggest that in energy planning for rural areas much greater emphasis would need to be given to self-sufficient local systems involving maximum possible use of solar, wind, water and biological energy than on the "trickle-down" benefits of centralized systems. In some cases this may even involve suitable "phasing" and postponement of centralized rural electrification schemes in order to liberate more resources for implementation of quick-maturing decentralized schemes. This is not to suggest that planning for rural energy supply has to be separated from planning for national energy supply. All that has been suggested is that rural energy supply should not be contingent on centralized energy systems but should be separately planned for and integrated, wherever possible, with centralized systems.

41. Reconsideration and re-allocation of relative priorities of centralized and decentralized rural electrification schemes may, in most cases, seem to imply a choice between the criteria of cost-efficiency and social welfare as a basis for decision-making. In view of the prevailing level of total per capita energy consumption in the rural sector, the overwhelming negative factors operating against expansion of energy supplies based on conventional sources, and the close interrelationship between energy consumption and economic development, the developing countries would be perfectly justified in taking deliberate decisions to develop energy supplies based on non-conventional energy sources, whatever the cost. However, in actual practice, the choice involved would be not between the two polar alternatives of social welfare and cost-efficiency but in respect of a combination of both these alternatives. Clearly there are a number of trade-offs, and where the balance lies is determined by public policy and its specific circumstances. Efforts will have to be made to ensure that the costs in absolute economic or commercial terms are as low as possible and comparable to the traditional conventional sources of energy.

42. Any scheme for development of alternative energy sources for meeting rural needs, will have to be supported by a deliberate policy of incentives and disincentives. On the one hand, use of non-conventional commercial energy supplies will have to be consciously encouraged through a scheme of financial incentives, subsidies and assistance, not only for application of alternative technologies, but also for commercial manufacture of the requisite hardware. On the other hand, continued use of conventional non-commercial sources of energy will have to be deliberately discouraged through a rational scheme of disincentives. Financial subsidies and incentives extended to decentralized community level schemes are likely to benefit the more vulnerable sections of the rural community for whom these may be intended whereas grid subsidies now given on rural electrification schemes benefit mainly the more affluent sections of the rural population.

43. Based on the above and other related considerations, which necessitate a re-orientation of the strategy for rural energy supply, developing-country governments might devise overall energy policies that include the following objectives:

(a) reduction of dependence on energy imports;

(b) reduction of existing gap between industrialized countries and developing countries per capita energy consumption - by increasing energy availability - from the existing levels of about 300 kgce/cap/annum to at least 1600/2000 kgce/cap/annum - within the next ten years;

(c) reduction rural/urban energy consumption difference;

(d) increasing reliance on renewable sources of energy, priority being given to development of bio-gas, solar, small-scale hydro-power systems, wind and water; and

(e) technological adaptations and innovations, with special attention to experiences of other developing countries and to the local raw materials, through continuous R+D.

44. For accelerated growth of the rural sector, be it agricultural operation of small-scale and agro-based industries located in the rural areas, energy needs to be provided in adequate measure in the form of electricity. Electrical energy is more versatile, efficient and convenient than any other form of energy. While bio-gas, solar, wind and water energy technologies now available do provide an alternative to the conventional mechanical energy and fuel supplies and would need to be exploited to the maximum extent, there can be no let-up on efforts to develop electrical energy supplies to meet the growing demand. Reliance on rural electrification schemes based on centralized systems to provide electrical energy for rural requirements is bound to push the time-horizon of actual supply of such energy indefinitely. While, therefore, the existing on-going centralized power schemes should, resources permitting, be completed expeditiously, local schemes for power generation based on hydel resources and diesel would need to be given an adequate priority in the new energy strategy.

45. Small-scale energy technologies in the present state of the art cannot be expected to yield dramatic results immediately. Nevertheless, these need to be pursued as an end in themselves. When conventional sources of energy are becoming increasingly uncertain and limited, any increment in supply of energy from alternative sources, however modest, would contribute to the growth potential of an economy emerging from the semi-subsistence strait-jacket.

46. As we have seen, 90 per cent and even more of the energy now consumed in the rural sector comes from non-commercial sources, mainly wood, and for domestic purposes. About 90 per cent of the population of the developing countries depend only on firewood for cooking. At least half of the

timber cut is used as fuel. The firewood crisis goes about unnoticed because it lacks the photogenic visibility of a famine; but it is a portent of the dustbowl future. The fast-multiplying rural population has stripped the nearer forests, avenue plantations and farm lands of trees, leaving the landscape bare. People of most of the South-Asian countries are now using cowdung as fuel.

47. Few, even among the rural rich, have taken irreversably to alternative energy supplies like coal or kerosene and even if they have, they would still revert to wood if supplies are available in sufficient quantities as fuel. To ask the rural population to switch over to biogas or solar cooker, merely in the name of saving trees, would be wrong and unavailing. Perhaps the least expensive and most immediately practicable measure for the benefit of the largest number would be to have an energy forest in every village. For decades we have been denuding forests without caring to replant. It is time that this sin is atoned by building permanent forest belts wherever possible. Fast growing fuel wood forests can be planted on village commons, boundaries of fields, road and railway sides, banks of canals, etc. Application of the principle of production forestry to remote forests can produce higher increments per unit area.

V. PLAN OF ACTION FOR FUTURE

48. It follows from the foregoing considerations that the future plan of action would need to have both national and international dimensions.

49. At the national level, action programmes may include:

(a) assessment of actual rural energy needs at the national level;

(b) strengthening of the machinery for national energy planning;

(c) identification of alternative resources and technological possibilities;

(d) formulation of a comprehensive national policy on utilization of various non-conventional and renewable energy sources through decentralized systems;

(e) formulating a scheme of fiscal and monetary incentives, subsidies and assistance for encouragement of the use of alternative energy technologies as well as for commercialization of processes and prototypes as well as of disincentives for continued use of conventional non-renewable energy sources;

(f) intensification of applied R+D efforts in terms of extensive trials of available technologies and hardware to test them for suitability;

(g) extension of appropriate technologies and related hardware for widespread application;

(h) establishment of adequate extension agencies in the field for propagation of approved technologies and for training of cadres of villagers in the operation, maintenance and repair of the hardware used;

(i) training of villagers wherever feasible for local fabrication of hardware utilizing local materials;

(j) identification of rural-based community institutions to support and maintain the alternative energy technologies as well as to manage production and distribution of energy at the base level;

(k) establishment of a network of rural technology centres, which would be responsible for demonstration and training for application of appropriate technologies, including alternative energy technologies, in rural areas; and

(l) formulation and implementation of a planned afforestation programme with special emphasis on programmes for development of energy forests.

50. Although much of what is needed to be done to plan for a non-conventional fuel future for the rural areas of developing countries has to be done by these countries themselves, there is considerable scope for interaction and co-operation between developing countries for their mutual advantages. The fact that most of the developing countries share the same or similar geo-climatic conditions makes it not only possible but also desirable for them to co-operate with each other, share each other's experiences and even develop co-ordinated R+D programmes. Such co-ordinated R+D programmes may be developed on both bilateral and multilateral bases.

51. UNIDO and other UN agencies can play a positive role in promoting technological co-operation among developing countries in the field of alternative energy programmes. Action programmes of these agencies may include the following elements:

(a) establishment of a comprehensive data bank in respect of alternative energy technologies and, to start with, water- and solar energy-based technologies which are of immediate relevance to developing countries;

(b) evaluation of available technologies to identify appropriate technologies for developing countries;

(c) assessment of R+D gaps - both technical and infrastructural - in developing countries with a view to extending compensatory assistance for augmenting R+D capabilities in such countries;

(d) promotion of continuous bilateral as well as multilateral exchange of information between developing countries;

(e) actual participation in R+D efforts in developing countries for dealing with specific technological problems;

(f) establishment of regional research centres to co-ordinate regional programmes as well as to study common problems of the countries in specific regions in regard to development and testing of prototypes, formulation of specifications and standards to facilitate commercial production of hardware etc;

(g) organization of seminars and symposia at frequent intervals on specific common technological problems with a view to developing co-ordinated programmes; and

(h) assist in institutional transfer of technologies from developed to developing countries.

VI. CONCLUSION

52. Rural energy planning will have to be an integral part of the comprehensive national energy plan and not something external or consequential to it. Important policy issues to be reckoned with would include a choice between a centralized and a decentralized energy strategy or a reallocation of priorities inter se in terms of their relative cost-competitiveness. Coinciding with these poles of the policy continuum are broader development approaches, which emphasise either rapid growth and expected spread of productivity to rural sectors or distribution and social welfare objectives. Since both these objectives are equally important in the specific context of the developing countries, a combination of these objectives would be both relevant and necessary. The relative weight that may be given to the one or the other of these objectives would depend on specific situations and will be largely determined by the overall development goals.

53. The developing countries might devise their overall energy policies based on the needs of integrated rural development and the options provided by renewable alternative sources of energy. While they might, if

resources permit, continue with their large-scale production and distribution schemes, these schemes should not interfere with the priorities assigned to decentralized rural energy systems based on wind, water, farm and human wastes, solar and other renewable sources.

54. The historical separation between centralized and decentralized systems has become irrelevant to the special contexts of the developing countries. They need to be meaningfully and structurally integrated so as to be able to serve a total national purpose viz. integrated rural development. It is again not a question of which particular sources of energy can be used to generate energy in a particular situation but a question of how all available sources of power can be harnessed to the best advantage of specific micro-economies. In a situation of scarcity, "technological fixations" become irrelevant. There is again no such thing as over-planning for power. Supply of power creates its own demand if supply is available in the form, in quantities and at prices it is needed. In fact, demand for energy increases geometrically when the base level is of a low value.

55. Suitable technologies for use of alternative, renewable energy sources are now available although the present level of development in respect of some of these technologies indicate further research and development work mainly to reduce costs. Future development of energy supplies to rural areas in developing countries will, therefore, depend on the political options exercised by these countries now with regard to their development goals and priorities and the institutional infrastructure established to achieve these goals.

In preparing this **Note**, material contained inter alia in the following documents have been used:

1. **Energy for Rural Requirements - ID/WG.282/46.**
2. **Planning of Rural Energy Systems: Issues and Perspectives - ID/WG.282/66.**
3. **Appropriate Technology for Rural Energy Supply in Developing Countries - ID/WG.282/86.**

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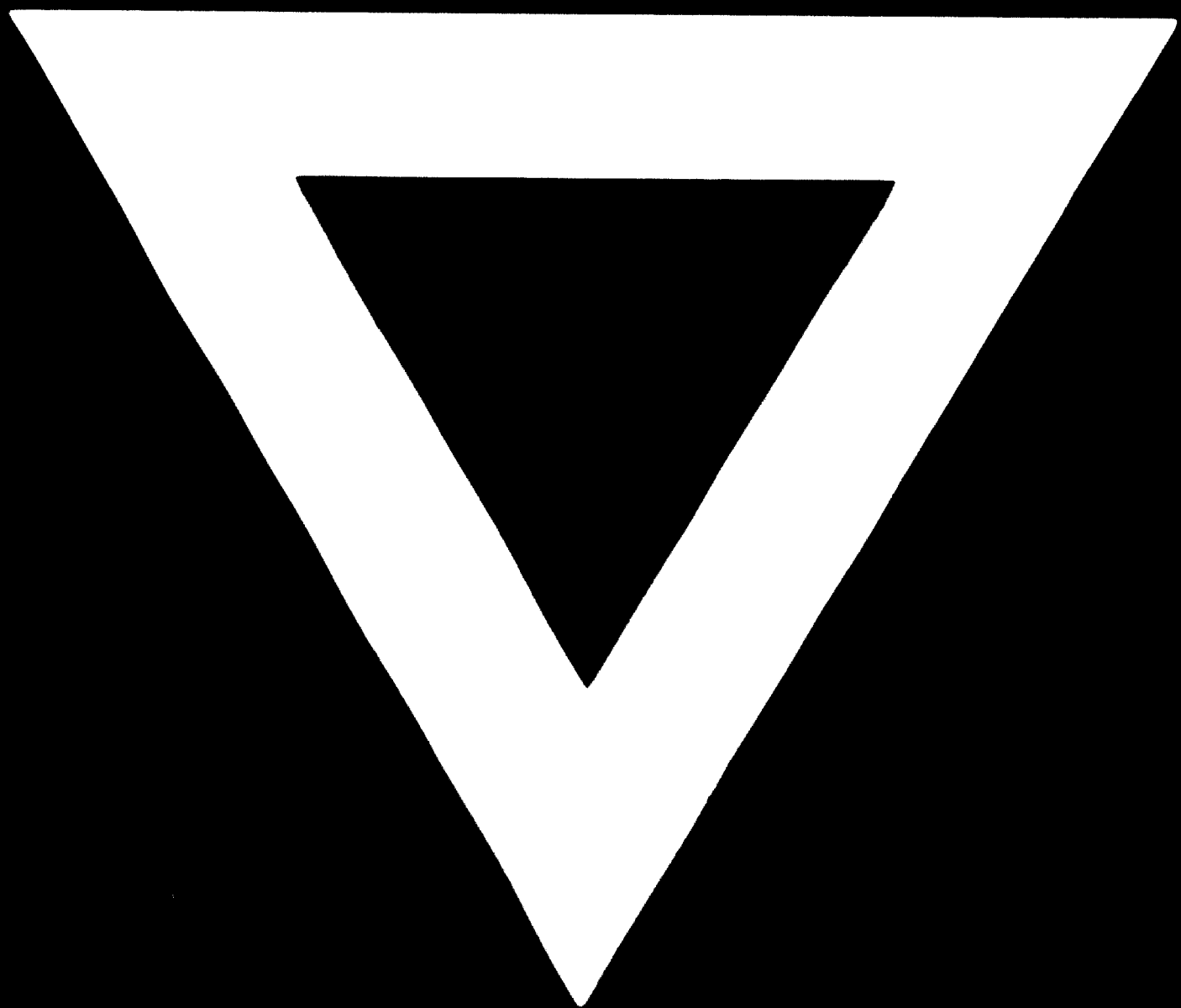

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