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Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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APPROPRIATE TECHNOLOGY FOR RURAL ENERGY

ENERGY FOR RURAL REQUIREMENTS

Background Paper

ENERGY FOR RURAL REQUIREMENTS

by

Intermediate Technology Development Group (ITDG)*
United Kingdom

* This paper was prepared by P. D. Dunn on behalf of ITDG.

Abstract

The Paper discusses the energy use and needs in the rural areas of developing countries and summarises the sources of energy and the current state of the art in energy conversion. Most emphasis is given to the problems impeding the implementation of new energy sources and conversion devices. Some successful developments in this field are described and some guidelines laid down for future programmes.

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(1) INTRODUCTION

The main impetus of development programmes so far has been directed towards the construction of large capital plant - steelworks, chemical works, roads, dams, airports and power stations. These are undoubtedly an essential component of development but are by no means the whole story. One result of such programmes has been the growth of a dual society, islands of development, usually in the towns, populated by a highly educated elite but surrounded by a stagnant rural sea. It is in the rural areas where most of the population live, typically 70-80 per cent, and here the pattern is not of growth but of decay, lack of development, mounting unemployment and drift to the towns.

The problem of achieving rural development is now recognised as a major development goal.

A Source of Energy is one of the basic physical human needs and is an essential component in any development programme.

At present the only significant use of energy by very many people living in the rural areas is for cooking. The principal fuel is wood and in some areas dried dung. Wood is being consumed at a greater rate than it is produced locally and many parts of the developing world are experiencing a severe and continuing shortage. The 'Firewood crisis' is more real and urgent than the 'Oil crisis'. As with the developed sectors other energy needs are largely satisfied by the Fossil Fuels. There are two needs

(i) To find alternatives to firewood for cooking, or at least to reduce the rate of consumption by more efficient use.

(ii) To increase the energy/capita availability in rural areas to enable other developments to be initiated.

It should be stated at the outset that development can only be successful if it is seen as a total solution to community needs and it is highly desirable that an energy programme should be set up within a more general programme content.

Currently in the developed world there is considerable interest in "Alternative" or "Renewable" energy sources. This has arisen for several reasons, the increase in oil prices, concern over the fossil fuel reserves, and to some extent a feeling that the renewable energy resources will be ecologically more acceptable. The only real criterion, however, is the economic cost of power from the various sources. The technical developments arising from this programme are most valuable in providing information and ideas for satisfying the rural energy needs in the developing countries. However, some caution must be exercised. Very little is really new, the Romans were well aware of small hydro power plant, the Persians have traditionally airconditioned their homes by the air tower, and produced ice by the 'ice wall'. Wind power has a long history and is still widely used.

Fossil Fuel is perfectly satisfactoy as an energy source for the people in the rural areas. They do not use much of it because they cannot afford to. It does not help them to be offered a solar heat engine which they cannot afford in place of a diesel engine which they cannot affort either. Cost, though important, is not the only criterion in considering a new technology. The availability of suitable operating and maintenance skills is important. Also material requirements, e.g. elastomer rubber for sealing flat plate collectors can be obtained cheaply at any hardware store in the U.S.A. but might be quite unobtainable in a developing country.

What is required is to increase the energy availability/capita in the rural areas. The universal availability of renewable energy offers this possibility. The diffuse nature of solar radiation or wind and its variability is often not important, e.g. where water is to be pumped. Simple designs are required for equipment which can be made locally, at an economic cost, to satisfy local needs. This solves only part of the problem, the dissemination of information, the encouragement of local manufacture and the stimulation of a local market constitute the major obstacles to implementation. These issues are discussed more fully in the paper and some suggestions are made for possible programmes.

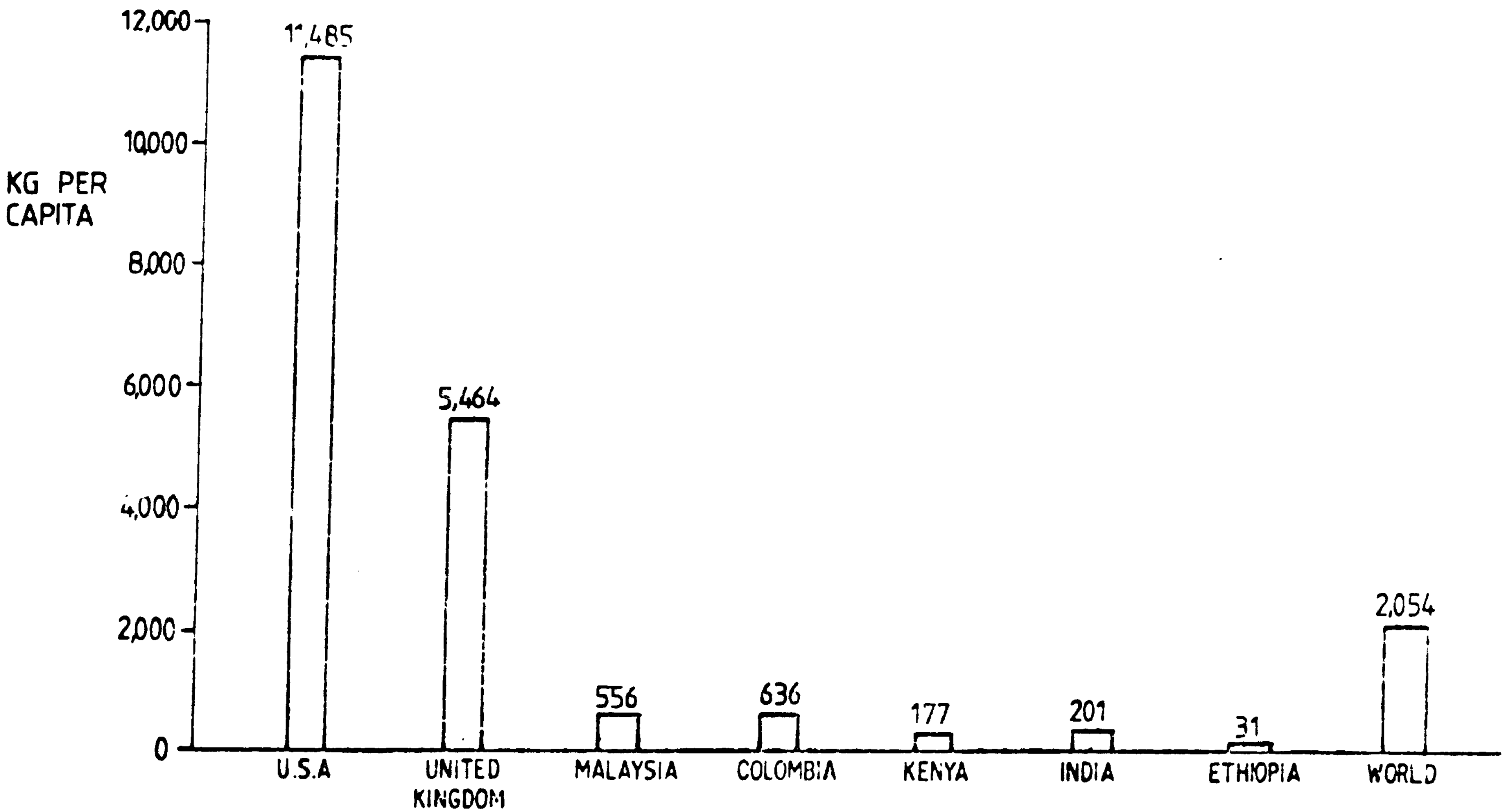
BACKGROUND TO ENERGY USE

The present world annual rate of commercial energy consumption is around 8.0×10^9 t.c.e. or an average of 2.0 t.c.e. per capita per year. This average conceals very wide variations in consumption between countries. Fig.1. There are also considerable variations within individual countries. Fig.2. Almost all the worlds' energy needs (7.6%) are at present met by fossil fuel. The current annual rate of increase is 3.5% corresponding to a doubling time of 20 years. The greater part of the increased demand over the past two decades has been provided by oil and natural gas. There is an approximately linear relationship between Energy consumption per capita and GNP per capita. Fig.3. This is not surprising since a high GNP per capita is accompanied by an increased use of manufactured goods, transport, environmental comfort standards, all requiring energy. It is, however, interesting to note from Fig.4 that this relationship has to some extent been broken by some of the most developed countries following the oil crisis and the subsequent conservation programmes which have been set up.

In principle, different energy sources are broadly interchangeable in their natural form for most applications. An important exception is the transport sector where it is difficult to see any alternative to the liquid hydrocarbon fuels in the next few decades. These can, however, be produced from other energy sources for example from coal by hydrogenation or by fermentation of biomass.

In discussing energy matters, it is usual to quote only commercial energy sources. In fact, non-commercial fuels such as wood and dung represent quite a significant faction of the total World energy use - about 8 per cent. Table I.

FIG. 1 PER CAPITA USE OF ENERGY



Source: U.N. Statistical Yearbook 1975

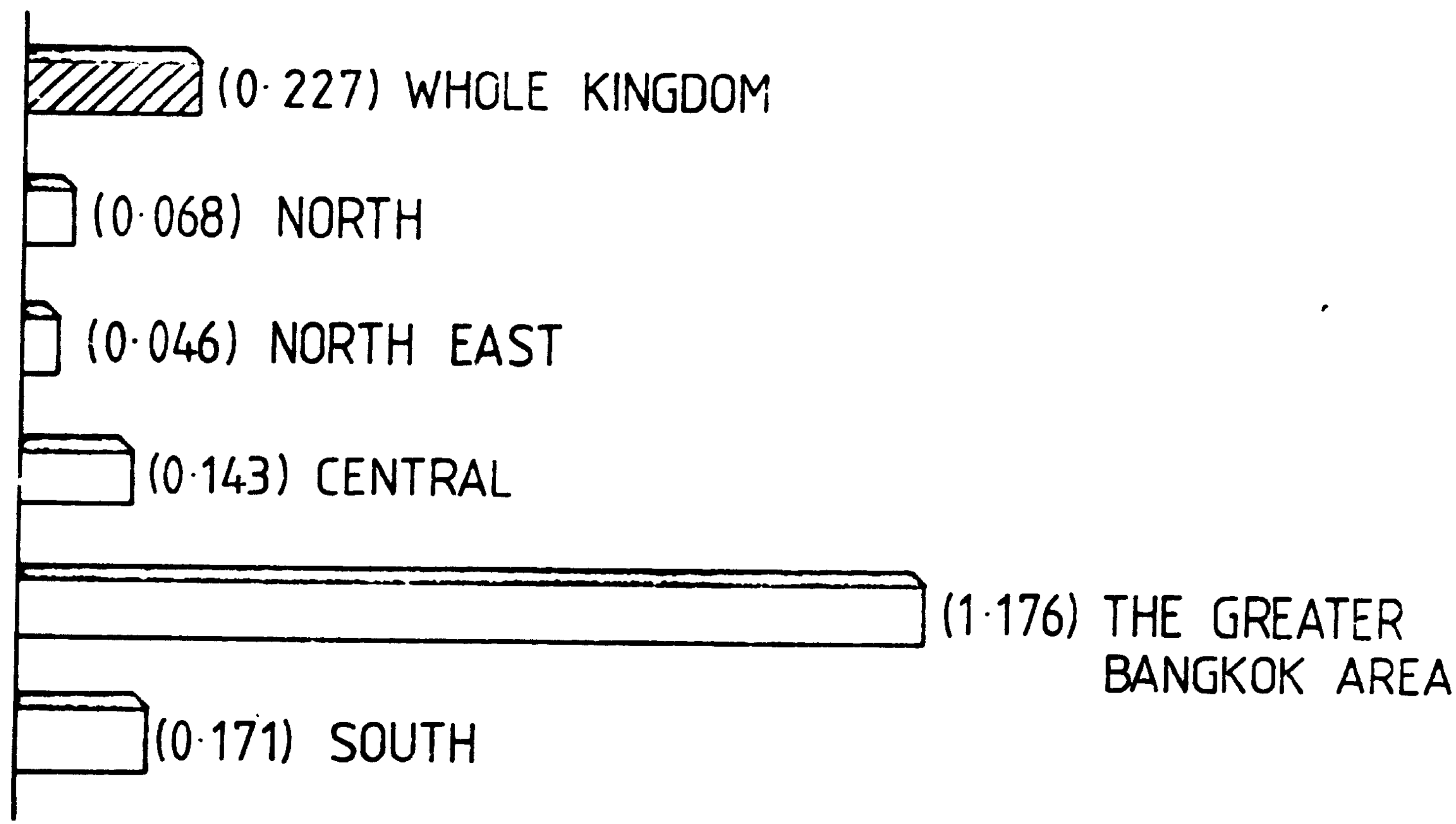


FIG 2 ENERGY CONSUMPTION PER CAPITA
(T.C.E. / YEAR)

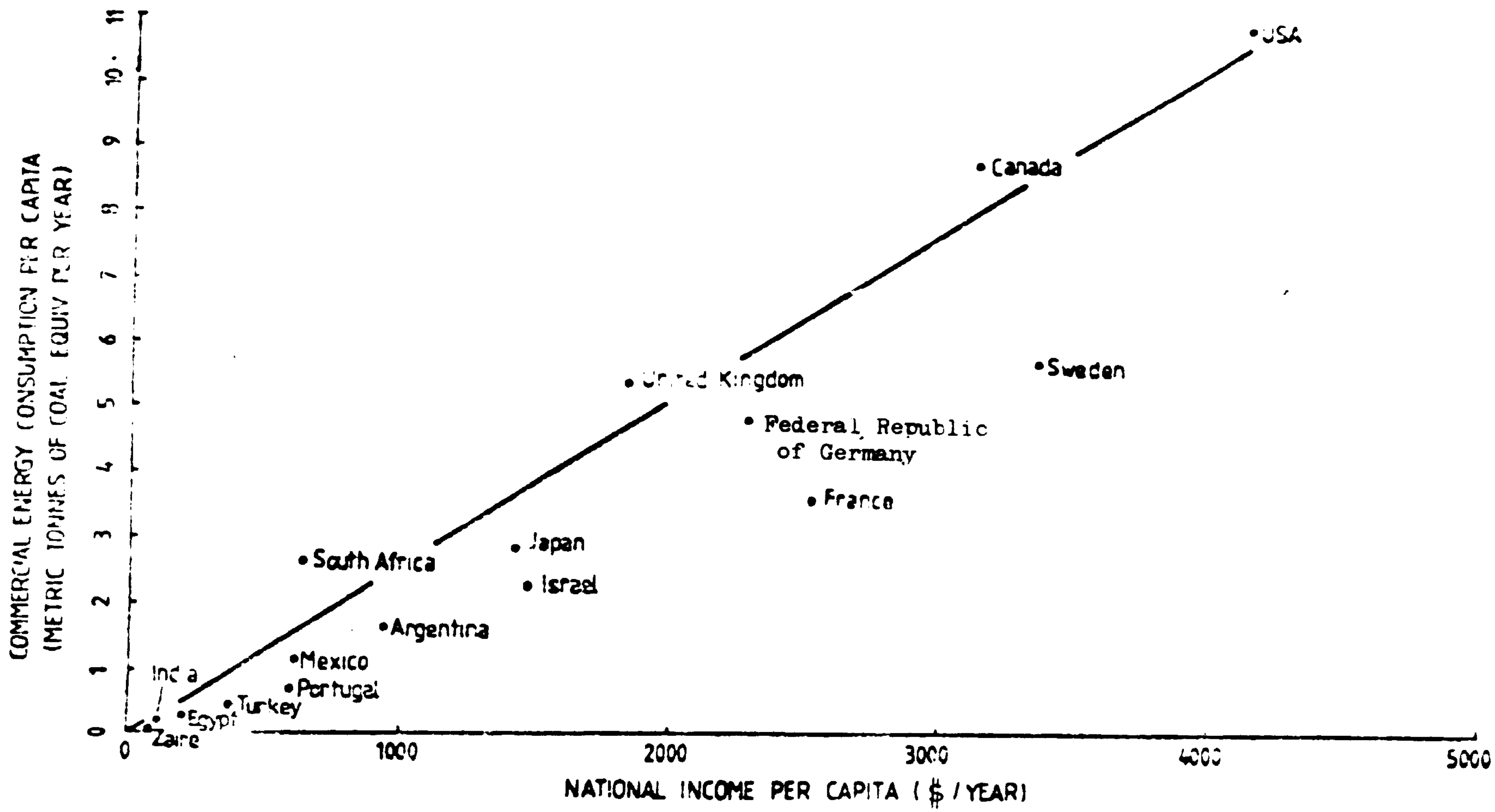


Fig. 3 National Income per Capita versus Commercial Energy Consumption per Capita
Source: United Nations Statistical Yearbook 1969

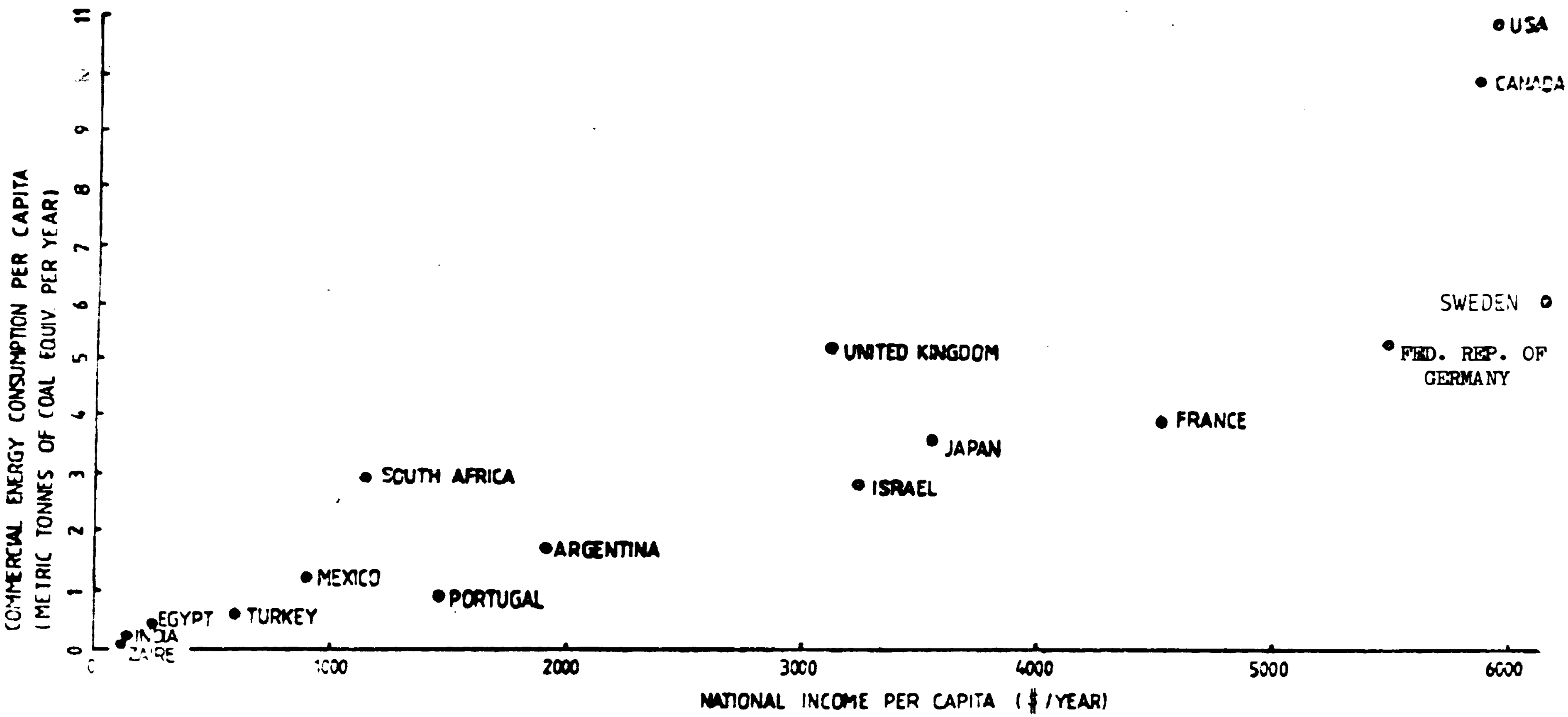


Fig. 4 National Income per Capita versus Commercial Energy Consumption per Capita
Source: United Nations Statistical Yearbook 1976

TABLE I (1)

Coal	Oil	Gas	Uranium	Hydro	Geo	Wood	Dung	Waste
32.5	38.3	19	0.13	2.0	.01	6.6	1.2	0.13
92%						8%		

We see that wood and dung in energy terms are one fifth of the total World oil, four times the World hydro power, sixty times the total World nuclear power, so non-commercial energy is certainly not negligible and, in fact, in the developing countries, it represents a very significant faction of the total energy use. This is brought out in the comparison between the energy input to the Sudan and the U.S.A. respectively. Table II.

TABLE II (2)

SUDAN		U.S.A.	
Oil	38%	Oil	46%
Fire-wood/charcoal	57%	Gas	31%
Bagasse	2.2%	Coal	18%
Hydro	1.8%	Hydro/Nuclear	5%
Muscle	0.6%		
0.2 tce/cap/yr.		11.2 tce/cap/yr.	

The way in which this energy is used is strikingly different between the two countries. Table III.

TABLE III (2)

SUDAN		U.S.A.	
Domestic 61% Industry 7%	68%	Commercial/ Domestic	19%
Transport	20%	Industry	26%
Agriculture	7%	Transport	25%
Electricity	5%	Electricity	25%
		Non Energy Use	5%

Non commercial energy sources, mainly wood, provide the major portion of the energy supply in a number of countries. For example, in the Sahelian countries. Table IV.

TABLE IV (3)

Population, National Income and Commercial and non-Commercial Energy Consumption

Country	Population millions (1974)	National income per capita US$ (1973)	Commercial energy consumption per capita (1974) (kg coal equiv.)	kg coal equiv. per capita	Percentage of total energy
Upper-Volta	5.9	70	14	235	94
Chad	3.9	70	17	270	94
Niger	4.4	90	31	190	84
Mali	5.5	70	24	170	86
Mauretania	1.2	190	112	130	53
Senegal	4.3	270	184	185	50

With industrial growth, total national energy consumption will increase so the percentage contributed by the non-commercial energy sources will decrease. Table V illustrates this for India where energy consumption has increased from 43 x 10^6t.c.e. in 1953/54 to 131 x 10^6 t.c.e. in 1971. However, the importance of the non-commercial fuels for the rural sector remains unchanged.

TABLE V (4)

Energy Consumption, Commercial and non-Commercial

Millions of tons of coal equivalent	1953/54	1960/61	1965/66	1970/71
Commercial energy	43	71	104	131
Non-Commercial energy	127	147	164	183
Total	170	218	268	314
Percentage shares Commercial energy	25	33	39	42
Non-Commercial energy	75	67	61	58
	100	100	100	100

The non-commercial energy contribution for India is largely firewoo' and charcoal but dried cow dung is also significant, Table VI, and accounts for between 1/4 and 1/5 of total dung production. It represents a serious loss of fertiliser.

TABLE VI (4)

Estimated Consumption of Non-Commercial Energy 1970/71

	Original Units million tons	Million tons coal replacement	Percentage
Firewood and charcoal	126	120	65
Vegetable wastes	39	37	20
Dried cow-dung	68	27	15
Total	233	184	100

(3) RURAL ELECTRIFICATION

Most developing countries have a rural electrification programme. Very extensive use of small hydro plant is reported from China. By 1973, 60,000 installations of average power 36kw and total capacity 1800 MW had been installed, other countries have extended the electricity grid to the rural area. Extension of the grid to rural areas is restricted by high investment costs, low load factor and lack of infrastructure. The smaller villages are particularly neglected. Table VII

TABLE VII (5)

Villages electrified in India (1971/72)

Inhabitants	Number of Villages	Electrified	Percentage
0 - 499	349,995	39,924	11
500 - 999	118,602	32,378	27
1000 - 1999	65,101	27,775	42
2000 - 4999	26,400	18,179	96
5000 - 9999	3,404	2,739	80
10000 -	774	710	92

In a particular village electricity is often only used by the more wealthy members.[6] Rural electricity is for lighting and to some extent for powering machines. One consequence of village electrification in India has been extensive use of electrically operated water pumps.

TABLE VIII

Number of villages electrified and irrigation pumpsets/tubewells energized

	Number of villages electrified	Percentage of total villages	Number of Energized Pumps
1950/51	3,100	0.5	21,000
1955/56	7,300	1.3	56,000
1960/61	21,700	3.8	198,000
1965/66	45,100	8.0	509,000
1970/71	104,900	18.7	1,619,000
1974/75	165,500	29.2	2,633,000

(4) ENERGY TRENDS IN DEVELOPING COUNTRIES

Traditional fuels - wood, charcoal and dung, are extremely important for the rural areas whilst oil and bottled gas is also being used increasingly for lighting and cooking. Transport fuel is still largely oil. Electricity generation on a large scale is by oil, using steam and gas turbines and, to some extent, hydro power. Small scale electricity is generated by oil and petrol internal combustion engines.

An important energy input in developing countries is concealed in the use of fertilizer and also in agricultural mechanisation. These trends have been accelerated by the new high yield varieties of grain, sometimes known as the "Green Revolution".

Table II is typical of the developing countries and we see that it is characterised by a heavy dependence on oil, very significant use of wood with an important contribution by hydro-power, but with very little nuclear contribution. We should distinguish between the energy-rich developing countries whose time-scale for adopting alternative energy sources is two or three decades and the energy-poor developing countries, such as the Sudan, who need the alternatives now.

(5) ENERGY NEEDS IN RURAL AREAS

Energy requirements in rural areas tend to be small scale, certainly less than 100 kilowatts for a village and usually less than 10 kilowatts for an individual installation. The energy is used as shown in Table IX.

TABLE IX

Agricultural Machinery
Crop Processing
Pumping
Desalination
Small Industry
Electricity (Domestic, Schools, Clinics)
Refrigeration
Domestic (Cooking, Water heating, Space heating/cooling)
Transport

In selecting an energy source or converter, a number of criteria must be borne in mind. These considerations include the following -

(i) Power level - whether continuous or discontinuous

(ii) Cost - Initial Cost

Total Running Cost including fuel, maintenance and capital amortised over life

(iii) Complexity of Operation

(iv) Maintenance and availability of Spares

(v) Life

(vi) Suitability for local manufacture

(vi) is of particular importance in most situations

(6) SOURCES OF ENERGY

The Sources of Energy are listed in Figure 5
Muscle power is given first because of its importance in the rural areas. As in the developed countries, the fossil fuels currently provide most of the energy used, and will continue to do so for the next two or three decades. Geothermal and tidal energy have little significance at present, though geothermal energy may prove to have value for large installations in the future in some areas. Solar energy, both direct and indirect, has considerable potential in supplying rural energy needs. The disadvantages of low power density and variability are often not serious in these situations since power requirements are low and supply continuity may not be necessary. Wave energy is not likely to be used generally though there may be local situations which are suitable. An example of this is given by Bott in a scheme designed for Mauritius.[7]
Nuclear energy sources are included for completeness but are unlikely to make any effective contribution in the rural areas other than in providing base load electricity for the grid.

Having listed the sources of energy we should now consider the various methods for converting these energy forms to the form required by the particular application. Some important energy conversion devices are given in Fig.6 Fig. 7 indicates the approximate power ranges of these converters. In practice these forms will be heat, for cooking etc., mechanical shaft power for driving machinery and pumps to provide lighting. Conversion to electricity is convenient for transmission, and for use with motors or lights. The principal practical problem with electricity is that of storage. Batteries are too expensive for all but small scale storage requirements. Most applications require only a few h.p. An exception is the generation of electricity for village use where up to 100 kw may be employed.

Human
Animal

Non Renewable

Fossil Fuels — Coal, Oil, Natural Gas

Nuclear — Fission, Fusion

Tidal
Geothermal

Renewable

Solar — Direct

Indirect — Wind, Waves, Hydro, Vegetation

Vegetation
- Direct
- Fermentation
- Animal Dung — Fermentation

FIG 5 SOURCES OF ENERGY

FIG 6 METHODS OF ENERGY CONVERSION

MUSCLE POWER		MAN
		ANIMALS
I.C. ENGINES		
	RECIPROCATING	PETROL - SPARK IGNITION
		DIESEL - COMPRESSION IGNITION
		HUMPHREY WATER PISTON
	ROTATING	GAS TURBINE
HEAT ENGINES		
	VAPOUR (RANKINE)	RECIPROCATING* STEAM ENGINE
		ROTATING STEAM TURBINE
	GAS (STIRLING)	RECIPROCATING*
	GAS (BRAYTON)	ROTATING GAS TURBINE
	ELECTRON GAS	THERMIONIC
		THERMO ELECTRIC
ELECTROMAGNETIC RADIATION		
	PHOTO DEVICES	
HYDRAULIC ENGINES		
	WHEELS, SCREWS, BUCKETS	
	TURBINES	
WIND ENGINES		
	WINDMILLS	VERTICAL AXIS
		HORIZONTAL AXIS
ELECTRICAL/MECHANICAL		
	DYNAMO/ALTERNATOR	
	MOTOR	

*Can be constructed using a water piston

SOME FACTORS INHIBITING THE USE OF ALTERNATIVE ENERGY SOURCES

(10) The major problems which are preventing the greater application of alternative energy converters are not technical, though of course technical difficulties and problems exist in some areas, and there is considerable potential for the development of new designs.

The factors preventing the more widespread adopting of new energy techniques include lack of information on possibilities, the absence of markets, the lack of manufacturing expertise, distribution networks and installation, servicing and maintenance skills. All these factors interact.

If progress is to be made it is essential that integrated programmes are initiated in which all aspects of the implementation problem are covered. Also, though energy is an essential component of development, it is very desirable that an energy programme should be seen in the content of an overall community development plan.

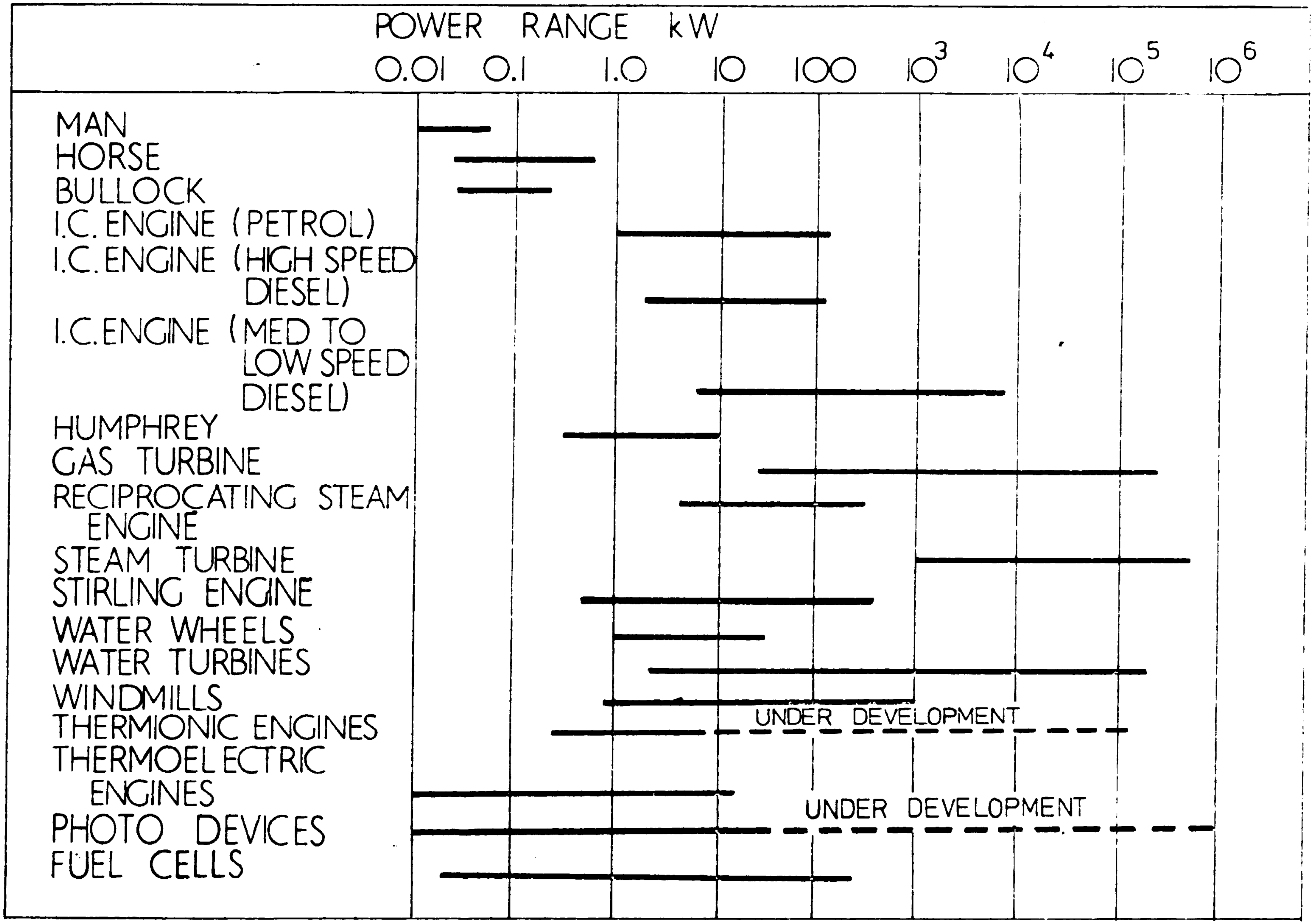
First of all, what criteria should we try to satisfy ? These fall under two heads -

i) Micro - The benefits to the individual - if these are not positive, he clearly won't wish to do it

ii) Macro - The general community should also benefit. It is not a desirable development if jobs are lost, whatever the advantages to the individual. Desirable factors include import substitution, job creation, build up of technical skills and industrial capabilities.

Whilst some subsidy may be necessary initially, new development should be economically viable in the longer term. The alternative is merely to produce isolated pockets of development which have no impact on the mass of the community. To be effective, development must be both appropriate and largely self help. Designs which satisfy some of the rural energy needs have been known for many years though there are still some technical problems. The major requirement is to arrange for the greater use of these equipments.

FIG. 7 POWER RANGE OF ENERGY CONVERTERS



What is needed to achieve this is -

1) Market surveys to establish needs and criteria
2) Design for local manufacture
3) Encouragement of local industry
4) Market development, including public awareness and acceptance
5) Development of technical skills at graduate, technician and school level.

Let us look at some of these factors

First the typical equipment development route which proceeds as follows -

Identification of a need, provision of a solution, design of equipment, construction, testing, assessment of performance, paper read to conference and the apparatus consigned to a "Museum" in the Institution. This applies to much development work, not only in energy. Too little thought is generally given to the take up of new designs by industry. In rural development we are concerned with small local markets and, usually, small local manufacture and special efforts and arrangements are necessary if new equipment is to be introduced.

Why does the small entrepreneur not take up new ideas ?

Firstly, he may not know about them and even if he does, he may not have access to a market, if it exists at all. Even when these inhibiting factors do not exist, the small entrepreneur suffers from three areas of difficulty -

1) Lack of management skills, including organisation, financial control, planning and marketing
2) Shortage of capital
3) Technical problems and lack of expertise

These problems and possible ways of overcoming them are discussed more fully in Appendix A.

New ideas do not disseminate readily in rural areas. One approach is to set up, in association with a village, examples of new devices in the proper village environment. For example, a methane generator or a windpowered pump. It is important that the local man should feel personally involved. This enables the product to be tested under realistic conditions and, if successful, it is sometimes possible to use the local man on a part time basis, as a paid field worker, to encourage the use of the equipment in the locality.

Universities and Colleges can make an important contribution in several ways, by introducing the idea of alternative energy into their courses to make students aware of its possibilities and importance, to develop equipment suitable for local use, to use their facilities and where available, agricultural extension services, to take this information to the villages. This is by no means a one-way traffic. The courses are enriched by new and topical teaching material, practical project ideas arise which can be of great value in teaching programmes.

(11) SOME SUGGESTIONS FOR A FUTURE PROGRAMME

(11.1) 1) Design for local manufacture

Many designs suitable for local manufacture are now becoming available, for example, from the Intermediate Technology Development Group and other similar organisations. It is essential that such designs should be properly tested before they are released to the potential manufacturer and this has not always been the case in the past. Designs which appear suitable for local needs and which are realistic in terms of cost should be selected and prototypes made and tested locally.

(11.2) 2) The encouragement of small industry

The small entrepreneur suffers from a number of difficulties which include finance, management and technical aspects. Local resources can be used to overcome these difficulties. As an example, one can cite the Product Development Centre at Kumasi. The successful designs arising from (1) could be manufactured by local small industry.

(11.3) 3) Education and Training

At professional level there is a need for specialist Masters Courses, for example, in alternative energy. More relevant material can be included in undergraduate courses and project teaching is a particularly good way of introducing these designs. Much the same applies to technical training and at schools there is a need for syllabus changes to build up public awareness.

(11.4) 4) Market development

Government can help here by, for example, making it a requirement of planning permission for hotels, that solar water heaters should be incorporated. Governments can also place bulk orders for water heaters for school canteens and hospitals in order to build up a market for this equipment. Suggestions for field testing were given in the previous section.

(11.5) 5) Research and Development

Research and Development Institutions should pay far more attention to the take-up of their designs by Industry. University research should be much more concerned with the appropriateness of its studies to local needs.

(11.6) 6) Energy saving

The energy implications of new developments should be examined. For example, the increased fertiliser requirement of new crops should not be overlooked. Alternative methods of providing fertiliser such as the azolla/blue green algae combination for wet rice in conventional fertiliser.

(11.7) 7) Agricultural Extension Networks

Existing arrangements could be used to disseminate new ideas and techniques in the energy field.

(11.8) 8) It has been stated earlier in this article that fossil fuel is probably the most convenient and suitable fuel for the rural areas. It is well worth considering how its availability could be increased, for example by subsidy.

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APPENDIX A

SETTING UP OF SMALL INDUSTRY

(A.1) There are several strong reasons for encouraging the development of a rural industry which manufactures equipment specifically designed to satisfy local requirements and which makes use of local skills and materials. Apart from the drain on foreign currency resulting from the import of goods from outside the country, problems arise in the servicing, maintenance and repair of such equipments. Spares are often difficult to obtain and maintenance skills are lacking. Also, though such equipment has been well designed for its original purpose, it does not necessarily fully satisfy local needs and practices. Technologies do not readily transplant. The creation of work places is of immediate value in opposing the drift from the rural areas by providing new job opportunities. Perhaps the greatest value of the growth of such industries is in the resulting education and training of the rural people, thus providing a means for developing their skills and experience on a continuing basis. At the outset it should be said that entrepreneurs are born and not made. What is required is an environment which provides them with encouragement and support in order to enable their activities to prosper. Their motivation is of course profit. It is found that the reasons why entrepreneurs encounter difficulties in building up their businesses fall under three headings -

(i) Managment skills, including organisation, financial control, planning and marketing

(ii) Capital

(iii) Technical problems and lack of expertise

We will treat these three items in turn. Firstly the problems of management. A typical case might be that of a small one or two man traditional carpentry business. The craftsmen would normally serve their immediate local area and often the work will be commissioned on a one-off basis. The owner will probably have little appreciation of estimating, pricing, work planning, ordering of materials, etc. He may not keep even the simplest of accounts and have little idea of whether he is making a profit and certainly not know which lines are most profitable. These small businesses may well have craftsmen of high skill or skill potential, They will, however, be restricted to traditional practices, tools and locally available traditional materials. In order to expand such a business, it is necessary to seek a wider market. This will have a number of consequences, for example, new lines will have to be developed and it will be necessary to introduce simple quality control of the products. Such considerations and changes will require help and guidance from outside the firm. Secondly, there is the problem of the availability of capital for expansion of the business, new building, new plant or as working capital.

Most developing countries have finance and banking arrangements set up for the development of small industry. In practice, however, the situation is not so easy. Before lending money, a bank must assure itself that the recipient has some financial credibility and it is often difficult for a bank clerk, who does not generally have suitable industrial experience, to assess the potential of the client and the technical and commercial viability of a new project. The result is that frequently the request is turned down. What is required is for the case to be properly put together and presented to the bank in terms it will understand. Thirdly, is the question of technical skills. The local craftsman may be aware of a method or an equipment but not of its suitability for his particular job. He needs answers to such questions as how much better will a new technique be than the traditional method? Will the use of the new technique justify the cost of the equipment? How will he obtain the training to use the new equipment?

To take an example, let us suppose that a traditional village blacksmith is considering the purchase of a gas welding set. All three types of difficulty arise. How will he obtain the money? How will the loan be repaid? Where will he buy the equipment and to what specification? Finally, who will show him how to use it in his own business? Sometimes the technical level of the problem can be surprisingly simple. For example, in a small foundry in South Vietnam we found a high wastage rate which was readily improved by a simple modification to the mould. In the same area we visited a one-man firm engaged on the production of pump pistons and impellers from light alloy using a very simple home made equipment. The feed material was war surplus made to a high military standard and available in quantity. The quality of the product was quite acceptable but the owner wished to increase his output and standard by installing a commercial diecasting plant. He was fully aware of the commercial range of equipment available and had carefully considered his needs before making a choice. His only problem turned out to be the one mentioned previously, that of convincing the bank several hundred miles away in the capital city of his financial viability and the security of their investment.

(A.2) ORGANISATIONAL SOLUTIONS

(A.2.1) C.o.S.I.R.A., U.K. [21]

In the U.K. a government supported organisation C.o.S.I.R.A. has been in existence for this purpose for the past forty years. C.o.S.I.R.A. or the Council for Small Industries in Rural Areas, is set up to assist small firms in the rural areas of England and Wales. It is restricted to businesses employing not more than 20 skilled persons and situated in country areas or towns of population less than 10,000. Agriculture, horticulture, and the retail trades are excluded.

The Council offers advisory services, including management advice, technical advice, experimental facilities, and specialist training courses. It also publishes a register of specialist engineering firms which is supplied to larger industrial organisations to make them aware of the availability of these skills in the rural areas. The Council operates an Industrial Loan Fund for the purchase of buildings or plant and for working capital. A network of full time local advisers is maintained, also voluntary local committees consisting of local business and professional men provide advice based on experience and local knowledge. The range of activities helped by C.o.S.I.R.A. range from traditional crafts, thatching, blacksmithing, pottery, to the most modern high technology including high vacuum equipment and the manufacture of computer core stores.

REGIONAL DEVELOPMENT CENTRES

(A.2.2) In many developing countries the local University or a local Research Institute may represent the only source of physical science or biological science expertise or engineering know-how. The sociology and economics departments of Universities can also provide valuable assistance in local development programmes. Other local resources include banking and the local branch of the Ministry concerned with small industry development. There is a need for a centre to co-ordinate these resources and to act as a communication and interpretive link between them and the small entrepreneur.

A centre should also provide some specialist knowledge and also a workshop facility. T.C.C. at Kumasi is a good example of such a centre.

 As far as the University is concerned, this is not a one-way traffic since projects arise which are useful in providing projects for undergraduates and later to M.Sc. and Ph.D. students. Involvement with industry by university also goes some way to rebuttal of a charge often made of "ivory-tower".

(A.2.3)

TECHNOLOGY CONSULTANCY CENTRE, T.C.C. KUMASI, GHANA

The Technology Consultancy Centre was set up in January, 1972, as a department of the University of Science and Technology, Kumasi, in order to strengthen the links between the Institution and industry and to help to promote industrial development. The centre was intended to act as a link between professionally qualified personnel in the Institute and particularly the local entrepreneurs. The permanent staff is small in number, initially consisting only of the Director, Assistant Director, one or two research assistants and clerical support. More recently the numbers have been increased by the addition of more research assistants who act as trainee project managers on specific projects.

One initiative shown by the Centre has been to secure a contract from a manufacturer of hand tools in Europe for the supply of a large quantity of wooden handles. There is a woodworking tradition in the area around Kumasi but the one/two man type businesses would neither be able to supply the quality nor, an individual business, the numbers required. By breaking the order down into smaller subcontracts and by providing help on simple jigs it was possible to meet both the quantity and quality requirement.

In addition to its work with the local entrepreneurs, the Centre has set up a number of production units within the Institute departments. The subjects include soap-making, bolt-making, broadloom weaving and others. In the case of soap-making a small factory has been set up some miles from the Institute campus. With this exception the production units have not resulted in the work being taken up by local business, probably due to the higher capital cost nature of the work.

A further Institute activity has been the provision of advice to Government departments and larger industry.

Whilst it is early to draw conclusions from the results of the Centre, the preliminary results give grounds for encouragement. Other Centres of a similar nature to that at Kumasi have been set up, for example, the Appropriate Technology Group A.T.G.S.L. in Sri Lanka and the Appropriate Technology Development Centre, A.T.D.A.

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