PROCEEDINGS OF THE SYMPOSIUM ON "ALTERNATIVE SOURCES OF ENERGY-MEASUREMENT OF EFFICIENCY" HELD ON 28TH DECEMBER 1981

Chairman : PROF P.V. SUKHATME
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It is well known that agriculture as an enterprize is not only highly energy intensive but also that it requires energy in various forms like human energy, animal energy and energy for operating/ running of machinery like tractor, pump sets etc. With the introduction of modern technology in agriculture involving high yielding variety seeds, higher levels of fertilizers and plant protection chemicals and improved management and cultural practices, the requirement of energy in the last category is increasing rapidly. The main sources of energy for this purpose are coal, oil and natural gas, electricity and bio-gas while some other sources which are presently used to a limited extent are wood, agricultural waste, nuclear, solar, wind etc. Most of these sources are nonrenewable, dependent as they are on fossil fuels. Great emphasis is, therefore, being laid on adoption of improved strategy for optimum utilisation of the available resources.

An important aspect of the final choice in favour of any particular source of energy is its efficiency of energy conversion for practical purposes. Apart from the search for new and renewable sources of energy which, it is hoped will solve the impending energy crisis, measurement of efficiency of various sources would also be an important component. The efficiency aspect may be considered in a 'Systems' approach or a 'Sectoral' approach. Thus, in the coal system, coal may be used directly as fuel or transformed to a liquid or gaseous form or it may be used for generating other sources of energy like electricity. In the Sectoral approach, say the Transport Sector, the choice from different alternatives like diesel, coal, electricity etc. would, apart from availability, depend upon the benefit cost ratio which in turn would involve efficiency of energy convension of different sources. In the Rural Sector similarly, where mostly the conventional sources of energy are used, the choice or the evaluation of different sources of energy appears to be still more difficult. For instance,

the total amount of animal power available in India is even greater than that of all the power houses in the country but the energy conversion of animal power seems to be rather poor today and concerted efforts would, therefore, need to be directed to bring about an improvement in a better efficiency of animal power, for example, by improving the design of bullock cart or designing simple tools and implements for fuller exploitation of the vast resources of animal energy in the rural areas.

It is in this context that the symposium on 'Alternative Sources of energy measurement of efficiency' was organized to focus attention on the important aspects of quantitative measurement of efficiency of alternative sources of energy so as to improve and optimise the availability and utilisation of the scarce energy resources.

In all, 6 papers were presented at the Symposium. The extended summaries of these papers are given below:

Solar Thermal Applications

BY

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The pattern of consumption of fuel in India today is significantly different from that of the developed countries. Being predominantly a rural society non-commercial fuel like firewood, Cow-dung, and agricultural waste has formed a major source. It has been estimated that the household sector consumed about 40.3 MTCR of Coal, Oil products and electricity in 1978-79. In rural areas, non-commercial fuels supplied 80 per cent of the energy requirements while in urban areas, they contributed 51 per cent of the energy requirements. It is estimated that in the 2000, 35.80 Twh of electricity, 12.95 million tonnes of Kerosene and 3.31 million tonnes of LPG will be required for the household sector alone. Similarly, the agricultural sector will need 28.0 Twh of electricity, and 5.26 million tonnes of diesel at the same time.

In the rural areas the main energy requirements can be classified as follows:

(*a*) 95-250°C Heat (Cooking)
(*b*) <95°C Heat Water heating, drying etc.

(*c*) >250°C Heat (Poultry, brick making, smithy etc.)
(*d*) Mechanical work in mobile equipment
(*e*) Mechanical work in stationary equipment
(*f*) Lighting

In the Industrial sector on the other hand, 85% of the total thermal energy is consumed at a temperature below 140°C (1976-77) and of the total requirements below 200°C, the break is as follows :

Fuel Consumption for Applications below 200°C in Industry (1976-77):

Coal	20 million tonnes
Oil	2.5 million tonnes
Electricity	5.4 TWh

A number of these requirements can be met with non-conventional sources of energy. Solar energy which is available in India in fairly good meausure offers a viable alternative. Extensive work has led to the development of :

Solar water heaters, Solar air heaters for heating of buildings, drying etc., Solar stills, Solar Cookers, Solar refrigeration and Solar passive buildings.

One of the main problems with these technologies has been the high initial cost of installation. Also, even though one expects these systems to be relatively trouble free, there are problems both in their manufacture, operation and maintenance. Considerable work is underway to solve these problems.

Another significant problem associated with the use of solar energy arises due to the intermittent nature of solar energy. It is imperative that if solar energy has to serve as a reliable source, it should be possible to store the excess energy available during the day for use during the night and other non sunny days. This has proved to be difficult as well as prohibitive in cost so far.

The paper discusses briefly the problems associated with the various solar devices under development in the country, the achievements and their present day Status.

Demand for power in agriculture

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Energy is an essential input for the agriculture sector. It is directly used for tilling of land, lifting of water for irrigation

purposes, harvesting and transporting of agricultural produce. Indirectly, the agriculture sector consumes energy in the form of fertilizers which are an energy intensive product. Electricity has played a very important role in the overall growth of the agriculture sector. The share of power consumption in agriculture has been growing faster over the years as compared to the share of the total commercial energy consumption by the sector. The sharp increases in oil prices have also provided an added incentive for an increasing number of electricity based equipment like pumpsets. The present paper is an attempt in working out the requirement of electric power for the agricultural pumpsets in the year 2000 A.D. The future requirements of electricity have been worked out by using the data on the growth in the number of pumpsets, utilisation of electricity per pump, average size of a pump and the distribution of diesel and electric pumps by correlating it with the gross value of output (at constant 1970-71 prices) of the agriculture sector. The total requirement of electric energy for agriculture sector has been estimated as 43 billion kwh. in 2000 A.D. against 13.5 billion kwh. in 1980. Attention has also been drawn to the need for conservation of power and suitable suggestions have been made for an optimal utilisation of energy in the agricultural sector.

On optimising efficiency of energy use sourcewise and activitywise

BY M.N. DAS
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Given an activity consuming energy there may be more than one source of energy which can be used. As a matter of fact most of the energy based activities can use several alternative sources of energy. For cooking, coal, firewood, gas and kerosene are the alternative source of energy. For railway traction, electricity, coal and diesel are the main sources. For generation of electricity, hydropower, coal and gas are the main sources of energy. These are but a few examples and their number can be multiplied. There are cases where for a given activity, use of certain type of energy becomes evident in a given situation. But there are many cases where such decision about a source is not as straight forward. In such cases for any objective decision suitable study of efficiency of alternative source of energy based on economic and convenience consideration is necessary. To take a relatively simpler example, for cooking in lower middle class families what source of energy is most economic and convenient in rural or semi-urban areas?

An answer to the question cannot possibly come from theoretical consideration or notional pronouncements. To get an objective answer it is necessary to collect appropriate data on cost, consumption, distribution system, family size etc. and then subject to these data to proper analysis so as to obtain appropriate indices which can be used to compare the efficiencies of alternative sources of energy and for cooking.

The problems of measurement of efficiency of alternative sources of energy is far from simple for major and more complex activities. For each such activity, the indices have to be properly defined, the data needed for working out such indices have to be specified, arrangement for maintenance and collection of such data has to be made and finally these data have to be appropriately analysed. As an activity can be performed with different alternative sources of energy, so also a given source of energy can be used for different alternative activities. This consideration makes the problem of measurement of efficiency of alternative sources of energy more complicated and widens the scope of connected studies. A further problem that arises is how to optimise the efficiency of use of a source of energy taking into account its various uses and also the competition among different sources of energy for specific use.

At present there is possibly no organised institution where study of efficiency of energy use is being undertaken. Some studies are perhaps being conducted at present in a limited way in the planning commission where such information is needed for planning purposes. In the wake of energy crisis it has become necessary to look into energy use more closely and apply suitable control so as to ensure optimum use of each major energy source keeping in view the national economy, public service and some social considerations. Appropriate arrangements are necessary to establish research cells in major generating units of energy and also in major activity centres where energy is used in bulk. These cells have to be entrusted with the planning for and collection of appropriate data in routine manner and analyse them without time lag. It may also be necessary to undertake *adhoc* studies for specific problems. Electricity and coal are the major sources of energy in the country. In the Central Electricity Authority office as also in the various State Electricity Boards, lots of data are being collected in regard to generation and consumption of energy. But possibly no retained studies are being undertaken on them with the objectives indicated

earlier. It is high time that suitable research cells are established in such organisations to probe into the data they collect and also to fill up gaps in data needed for specific studies.

Energy from animal sources in Agriculture and Rural Households-Measurement of Efficiency.

BY B.B.P.S. GOEL & K.B. SINGH

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Energy is an essential input in every economic activity and has become the most limiting factor in modernisation and development. In the present paper role of energy from animal sources has been considered for meeting the energy needs in country's agriculture and rural household sector. An attempt has been made to examine (*i*) the availability of bullock power vis-a-vis its requirements for meeting the various agricultural needs (*ii*) the possibility of meeting the fuel needs in rural households through gobar/biogas and (*iii*) how the efficiency of these alternative sources should be measured in relation to that of commercial sources of energy ?

The total requirement of energy for 172 million hectares of cropped year, including 28 million hectares irrigated by sources other than canal, comes out to be 8644 million H.P. days against the availability of 18000 million H.P. days from working animals showing a surplus of 9356 H.P. days. Some direct studies undertaken to estimate the extent of utilisation of working animals have also shown serious under utilisation of animals in the country. It has been suggested that fuller utilisation of animal energy in agriculture will not only save petroleum and electricity for industrial purposes but will also provide more employment in the rural areas. During the lean period for agriculture surplus animal energy can also be utilised in agro-industries and rural transport. Suitable studies to measure the efficiency of animal energy *vis-a-vis* energy from other sources in terms of productivity or profitability need to be undertaken.

Rural households in India are the largest consumers of energy as fuel for cooking and lighting, with a rural population of about 550 million the energy needed for cooking annually is of the order of 125×10^{12} kilo calories. About one half of this can be met through gobar/biogas from dung, agricultural waste and human excreta. There are about 250 million head of bovines in the country. With an annual production of 2.28 tonnes of dung per animals the total dung production is estimated to be around 570 milllon tonnes.

At present 2/3 of the dung production is used for manure and about 1/3 as dung cakes as a result of which a large part of the potential energy and nutrients for the soil are being wasted. By proper management viz by digesting of the entire cow dung in gobar gas plants the utilisation efficiency of energy can be increased substantially. The gas that would be available will be sufficient to meet about 50% of the fuel required for cooking and also provide an additional supply of 1.05,0 45 and 0.60 million tonnes of N,P and K respectively to the soil through the residual slurry which will help in increasing crop production.

There should be an integrated programme for proper management of drought and dairy animals with the twin objectives of meeting the energy needs in agriculture and rural households and raising the nutritional standard of the population. The disposal of dung and human and crop waste, management of gobar gas plants and supply of biogas/compost to the people in rural areas should be managed by village Panchayats on the pattern of management of sewerage disposal and water supply by municipalities in the urban areas.

Energy Octopus and the Solar Barn.

BY

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The rapid depletion of fossil based fuels like petrol, coal etc., in the world and the environmental damage caused by their prolonged consumption have lead to a vigorous search for alternative sources of energy. The oil embargo of 1973 and subsequent large increase of OPEC (Organisation of Petrol Exporting Countries) oil prices added new dimension to this problem. At present the known sources of energy in the world are (*i*) Fossil fuels (*ii*) Nuclear energy (*iii*) Solar energy (*iv*) Geothermal and Oceans thermal energy (*v*) Hydro energy (*vi*) Wind energy (*vii*) Tidal energy and (*viii*) Bio-energy.

The fossil fuel mainly consists of coal, oil, natural gas and peat. It is expected that the demand for coal would increase at some 6 percent per annum, and for oil at about 4 percent per annum. If these rates of growth are achieved, the country would have to produce some 400-500 million tonnes of coal per annum by the year 2000 compared to about 100-110 million tonnes now.

The growth in oil consumption in recent years has been of the order of 7 to 10 percent and to restrict the growth to4 percent per annum in next two decades, would call for very strict measures to contain oil usage. Even at this rate, we need to import 40-50 million tonnes of oil per annum by turn of the century compared to 20 million tonnes during 1981 in the form of crude and petroleum products.

The nuclear energy which is modern, un-limited and low cost source of energy could not make much thrust for fears associated with safe disposal of atomic waste and dangers of nuclear weapon proliferation.

The alternative sources of energy which are renewable include the solar energy, tidal energy, wind energy and the energy from bio-mass. Solar energy holds a great promise as it is available in abundance. From the total solar radiation entering the earths atmosphere, 30 percent is reflected back, 10 to 15 percent is absorbed by atomosphere, 5 to 10 percent reflected from ground, 20 percent accounted for evaporation and 30 percent is supplied to the ground and re-radiated.

Only less than I percent of the solar energy is spent on photosynthesis, wind, ocean currents etc. The major problems with solar technology development are:

(*i*) Technology is new and there is lack of Knowledge on what it can do and how it can be used;

(*ii*) Solar products and equipment are not readily available on an extensive scale;

(*iii*) The equipment initial cost is high probably because the technologies are still being experimental and no economics of scales can be realised.

Another source of energy is heat from oceans water. 70 percent of the earths surface is covered with water and ice. Oceans receive solar energy and act as solar energy reservoirs. Energy also can be obtained from ocean waves, tides and tidal currents, ocean winds, ocean currents, salinity gradients and ocean geothermals etc. Attempts are also being made by research organisations to harness wind energy by erecting wind mills etc. However, the limiting factor for promoting wind energy utilisation is the lack of reliable data on wind speeds for the open country side.

Bio-mass is a renewable cheap source of energy. 95 percent of the energy needs of our rural population is being met from traditional

sources of bioenergy like wood, animal dung and crop residues. To provide cheap bioenergy for rural population in India attention is to be paid to the following problems.

(*i*) The maintenance of growth of forests.
(*ii*) Growth of plants suitable as biomass energy in areas not suitable for crop production ;
(*iii*) The growth of aquatic variety of plants ;
(*iv*) Utilisation of crop residues.
(*v*) Optimum utilisation of wood resources ;
(*vi*) Improvement of technology for biogas production by using animals and vegetable wastes, weeds;
(*vii*) Encouragement of quick growing trees.

It is estimated that coal to the order of one and half million tonnes is being consumed in the country for curing F.C.V. Tobacco. A solar barn has been constructed at Central Tobacco Research Institute, Rajahmundry, in collaboration with National Industrial Development Corporation Limited in which mature tobocco leaves can be cured using mainly solar heat during day time and coal during night time. The results indicated the following advantages over conventional type of barn.

(*i*) A clear 40 percent saving in the consumption of coal ;
(*ii*) A reduction in the cost of curing to Rs. 0.21 from Rs.0.49 per one Kg of green leaf of F.C.V. tobacco ;
(*iii*) Considerable reduction in the time taken for curing

Attempts are being made to replace the use of coal in the night with briquetts prepared out of coal dust, paddy husk, saw dust and other agricultural wastes.

Bio-Fertilizers Alias Alternate Fertilizer Energy Strategy

BY
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Planning for the alternate sources of energy is adire imperative, all the more so for the Third World countries, whose low per capita energy consumption ever so results in low productivity. To feed their mounting millions, we have to devise ways and means for

providing them with cheaper and easily available energy, so that their agricultural production could be significantly boosted. But the hefty rise in the fertiliser prices have already led to a considerable decline in fertilizer consumption and this downward trend could virtually sound the death-knell of the green revolution. The only answer and a snaer one too, lies in our evolving an Appropriate Agricultural Technology that demand lesser inputs, more so the imported fossil fuels and makes do with the existing resource potential in a given million. Furthermore, we must equally look into more efficient ways of using energy rather than go on with the squadermania that often marks the energy consumption patterns in most of the LDCs.

On the one hand, we have the growing deficiency of our Indian soils make us look for more chemical fertilizers, while on the other hand, our fertilizer industry, the 4th largest inthe world, is chronically short in meeting the farmers' demands. Our present per capita fertilizer consumption of 36 kg/ha (1981) is very much on the lower side of the inputs but then increasing this level by a more one kg extra nitrogen for all the gross cropped area 160 million ha, would require putting up an additional area plant of 2,30,000 tons capacity at a cost of Rs. 150 crores. By the year 2000 AD, as pointed out by Vaccharajani our fertilizer gap will be over 13 million tonnes and it would necessitate setting up new fertilizer factories at a cost a Rs. 24,000 crores. Financial resources apart the very logistics of the technical input and skilled manpower poses a serious problem on the LDCs.

Hence, the remedy lies in our looking within, exploring the untapped or grossly underutilised resources, esp. the Organic Matter (OM) for its most optimum advantage. Besides saving on costly fertilizers, the use of OM not only enriches the soil but also helps improve the plant uptake of the fertilizers, whose major proportion gets leached away. And the Indian subcontinent has over 1000 million tons of animal wastes, besides nearly 500 million tons of agro-industrial residues which could very substantially bridge the yawning gap in fertilizer demand and supply. Biological Nitrogen Fixation is yet another wonder-formula that does not cost so much. It has been estimated that BNF presently fixes 175 million tons of N per annum in the universe. Apart from the leguminous crops and fodders which add N from to the soil by taking it from the abundantly available atmospheric N, microbial agents like Rhizobium, Azospirillum, azotobacter and blue green algae (BGA) help fix N directly around the root zone of the plant. These latter can easily fix around 20-40

kg N per ha, besides significantly boosting crop productivity. And all these organic fertilization techniques offer the additional major benefit of increasing the soil humans and also reducing the loss of the soil microglora all of which go to add to the enrichment of soil on long-term basis. Already, the reports monitored at IRRI, Manila show that one can manage to get higher yields without adding any chemical fertilizer at all. In USA, this organic farming or Echo-Agricultu re is being increasingly taken up by the farmers and the 'Health Foods' so produced bring extra dividend in the market.

China and Japan have long been dependent on these organic resources for fertilization of land. As long back as 1910, the Japanes paddy yields were 3.3 tons/ha almost double the present Indian yield rate.

As such, it will have to be a strategy of 'Multiple Nutrients' for the Third World countries. This would mean the judicious blending of organic matter, green manures and microbial inoculant alongwith reduced dosage of chemical fertilizers. This conjunctive use of the old and the new practices would help save crores of ruppees now being spent on import of fertilizer Rs. 925 crores in 1980-81, as also the petroleum-based feedstockes like Naphtha and fuel oil for the indigenous fertilizer industry.

This Alternate Fertilizer Energy strategy is basically an Optimal Resource Management Strategy, wherein many of the so-called wastes are duly put to productive uses, besides the fact that we also make the most optimum use of the animal and under-utilised man-power, which the LDCs have in super-anundance. This would, also provide mass employment in the countryside and lead to far greater distributive justice, than has ever been possible with the earlier planning models. In fact, this proposed Bio-Fertilizer stiategy would usher in a Green Revolution that echoes forth from each and every hamlet, rather than being confined to a select band of farmers. This way, it would also check the regional imbalance, since the poorly-endowed areas, in conventional terms would be in a position to mop up these unexploited organic resources, withou calling for the long distance import of fuels and fertilizers and also without asking for too much of infrastructural investment in the backward areas.

After presentation of papers, the Discussant of the Symposium, Dr. Ashok Desai, gave a review of the work and studies available on the subject. According to him, the measurement of efficiency of alternative sources of energy could be considered at different levels,

viz. primary energy, final energy and useful energy. Indian agriculture was quite efficient in the utilisation of energy, from the concept of useful energy. However, in terms of gross energy, Indian agriculture was rather poor. It was also well recognised that agriculture was far more energy intensive than any other enterprise, although energy needs of agriculture were mainly met from agriculture itself. With increased energy needs for irrigation, the number of pump sets increased substantially in the past few years. But there was no decline in the use of animal power for this purpose showing that there was no competition between animal devices *vis-a-vis* other devices run by electricity/diesel. In fact, the number of diesel pump sets had increased more or less in the same ratio as electric pump sets in the recent past despite apparent rise in the current prices of soil. This was mainly on account of three reasons. First, the real prices of diesel has actually declined. Secondly, due to shortage of electricity diesel pumps are more dependable. Thirdly, due to improvement in technology, diesel pump sets are portable and more handy to use. Taking similar energy need for ploughing, there was a sharp rise in the use of tractors mainly because the demand of fodder for purposes other than feeding draught animals has gone up. It was being diverted for milch cattle to meet the increase demand of milk.

He thus, advocated collection of relevant and reliable data for detailed and in-depth study of causal factors, so that the efficiency of alternative sources of energy could be measured in proper context.

From the foregoing discussions, the following points emerged for further studies and investigations :

(1) Collection of data regarding consumption of commercial, non-commercial and animal energy for agriculture, rural households and rural transportation;

(2) Determination of energy needs for crop production, post harvest technology and transportation;

(3) Estimation of likely changes in the pattern of rural consumption of different fuels with growth of agricultural production and socio-economic changes;

(4) Investigations of possibility and potential of integration of various energy sources for different farming systems;

(5) Investigations for developing criteria for measurement and evaluation of alternative energy sources particularly in the agricultural sector.

(6) Studies for objective assessment of different technologies based on alternative energy sources with the help of data on initial cost, running cost, distribution system etc;

(7) Studies for developing high efficiency low HP engines which could lead to a saving of as much as 50 per cent of the oil consumption;

(8) Studies for developing solar pump with low initial cost and negligible maintenance cost;

(9) Studies for developing techniques for measurement of direct and indirect energy consumption; and

(10) Studies for determining the relative efficiency and adequacy of bio-fertilizers as alternative to the chemical fertilizers by using organic matter or crop wastes so as to reduce pressure on chemical fertilizers which are imported or require imported ingredients.