Proceedings of the Symposium on "Rural Energy Scenario in 2000 AD"

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A Symposium on "Rural Energy Scenario in 2000 AD" was organised during the 51st Annual Conference of the Indian Society of Agricultural Statistics, on December 7, 1997 at Saurashtra University, Rajkot (Gujarat). Dr. Padam Singh, Sessional President welcomed the distinguished Chairman and invited speakers (Scientists) from Central Institute of Agricultural Engineering, Bhopal and Sardar Patel Renewable Energy Research Institute. Vallabh Vidyanagar, Gujarat and introduced the Chairman to the delegates attending the Symposium.

The chairman in his opening remarks described in brief about the importance of the research in the field relating to energy in agriculture. He further gave a glimpse of the rural energy scenario in the near future.

In all 6 papers were contributed for the Symposium out of which 5 were actually presented. The broader topics covered were statistical aspect of estimation of energy utilisation in agriculture; electrical energy scenario in agriculture and prospects of power from renewables; renewable energy for rural development; renewable (agricultural residues) source of energy for agriculture. The sixth paper which could not be presented was on demand forecast for bio-fuels in rural households.

The presentation of papers were followed by discussions and questions in respect of the results presented by the participants. At various points of time, Chairman himself clarified various queries.

Chairman also thanked the various speakers and hoped that the deliberations would be of immense benefit to the agricultural scientists.

The following recommendations emerged out of the Symposium:

(i) The estimation of energy utilisation as well as energy output- input ratio should be worked out on per ton of produce in place of per hectare basis.

(ii) It was stressed that there is a strong need of involvement of agricultural statisticians right from planning stage till the analysis in the research projects taken up by scientists working in agricultural engineering discipline as well as scientists engaged with research relating to energy in agriculture.

The summaries of the papers presented and discussed are as follows:

Estimation of Energy Utilisation in Agriculture

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Agriculture, on which about 80% of the population of the country is dependent, contributes more than 40% to the GNP of the country. Basically, agriculture is an energy conversion process. Agriculture is a seasonal industry where demand of energy fluctuates throughout the year. In modern times commercial energy sources such as coal, oil, natural gas and electricity have been the foundation inputs for modernisation of agriculture and development of industries. Coal, oil, natural gas and fossil fuels are non-renewable whereas solar energy, biomass, wind energy and draft animals are renewable.

Energy : Basic Concepts

The unit of measurement of energy is joule, which is represented by the letter J. One Joule of energy is approximately equal to the energy required to lift a mass of 100 grams to a height of 1 metre above the surface of earth. Joule is actually a small unit of energy, so to express bigger values of energy, the bigger units of energy like kilo joule (1 KJ = 10^3 J), mega joule (1 MJ = 10^6 J), giga joule (1 GJ = 10^9 J) and tera joule (1 TJ = 10^{12} J) etc. are used. The commercial (or trade) unit of energy is kilo-watt-hour (1 KWh = 3.6×10^6 J).

Classification of Energy on the Basis of Source

On the basis of source, the energy can be classified as direct and indirect energy. The energy sources, which are direct in nature but can be subsequently replenished are grouped in this category. The energies which may fall in this group are human beings, animals, solar and wind energy, fuel wood, agricultural wastes etc. Direct energy sources which are not renewable (at least in near future, say next 100 years) are classified in this category. Coal and fossil fuels examplify non-renewable direct sources of energy.

The indirect sources of energy are those which do not release energy directly but release it by conversion process. Some energy is invested in producing indirect sources of energy. Seeds, manures (farm yard and poultry), chemicals, fertilisers and machinery can be classified under indirect sources of energy. Again, on the basis of their replenishment, these can be further classified into renewable and non-renewable indirect sources of energy.

Seed and manure can be termed as renewable indirect sources of energy as they can be replenished in due course of time. The energy sources which are not replenished come under non-renewable indirect sources of energy. Chemicals, fertilisers and machinery manufacturing are the non-renewable indirect sources of energy.

On the basis of comparative economic value the energy may be classified as commercial and non-commercial. Each and every source has some economic value. Some energy sources are available comparatively at low cost whereas others are capital intensive. The energy sources which are available cheaply are called non- commercial sources of energy whereas the ones which are capital intensive are called commercial energy sources. Human labour and bullocks examplify the category of non-commercial source of energy. The energy sources like petroleum products (diesel, petrol and kerosene oil) and electricity, which are capital intensive examplify commercial sources of energy. Considering the fact that most of the commercial sources are also non-renewable and to some extent are imported in India, efforts must be made to conserve such sources of energy.

Results :

Various estimators making use of ratio-type and regression methods of estimation at various stages of sampling were used to work out the estimate of total energy utilisation as well as average energy utilisation per hectare alongwith percentage standard errors. The estimate of energy utilisation on per hectare basis for various above mentioned crops ranged between 6079 MJ and 17088 MJ with percentage standard error less than 7%, while for sugarcane crop it was significantly higher mainly because this crop comparatively consumes good amount of inputs. The percentage contribution of first stage and second stage components towards sampling variance was also worked out and it was observed that the first stage component contributed significantly as compared to second stage component. The sample sizes (number of villages) required for estimating the energy utilisation for varying levels of precision for various crops were also worked out. The estimates of energy output-input ratios for various crops ranged between 6.72 and 15.46 and these were estimated with a high precision. Estimates of energy utilisation for various crop-rotations e.g. Maize-Wheat, Paddy-Wheat, Fodder- Wheat, Fodder-Fodder and Sugarcane on per hectare basis were obtained between 15723 MJ and 28848 MJ. The estimates of energy output-input ratios for these crop-rotations ranged between 6.64 and 14.01.

Electrical Energy Scenario in Agriculture and Prospects of Power from Renewables

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One of the most important indicator of economic development is the electricity generation, it's constant availability to users and the extent of utilization. Also, electrical energy has been proved to be the clean and most convenient for various uses. Because of it's utility, electricity utilization is constantly increasing for economic development of India. The percentage share of electricity consumption has touched the level of 17.6% out of total commercial energy supply, 184.1 million tones of oil equivalent in 1990-91. The total electricity generation for our country was 324050 GW hr. in 1993-94 against the installed capacity of 76753 MW.

Agriculture is one of the prime sector for Indian economy contributing nearly 33% for Gross Domestic Product during 1995-96. Quality of rural life in India is highly dependent on utilization of commercial energy sources. Commercial energy source for agricultural sector includes electricity, diesel, fertilizer and tractor power. The contribution of commercial sources to total energy for agriculture sector is nearly 9% of total energy in flow (291 million tonnes of oil equivalent in 1990-91) to Indian economy. Agricultural sector is becoming more and more oriented towards the electrical power as the sector is progressing to consume the higher share of electrical power. The present scenario of power use in agriculture sector shows that share of electrical energy utilization in 1980-81 was 17.8% which has increased upto 29.7% in 1993-94.

Various rural activities consuming the electrical power are lighting and pumping, etc. Viewing the importance of rural development, the Indian government established "Rural Electrification Corporation" in 1969. With the concerted efforts of Corporation, nearly 85.8% villages has been electrified by 1994-95. Also, the population of electrically energized irrigation pumps/tube wells has increased upto 10.3 million in 1993-94 from 1.6 million in 1970-71, with growth rate of 17% per annum. The electricity consumption reached 30.16 GW because of increase in irrigation pumps and the electricity consumption is nearly 25% of total energy input to farm sector.

Though the progress of rural electrification seems to be very attractive, but it has not solved the problems of Indian farmers. The most common problems for our villages is erratic and irregular electric supply with fluctuating voltage. The possible may be the shortage of electricity generation, improper maintenance of transmission network and high transmission losses, etc. These problems forces the farmers to opt for a power generation system based on conventional fuel. The use of conventional fuel for electricity generation undoubtedly causes environmental pollution because of toxic emissions. Therefore, scientists are exploring the power generation system based on renewable energy sources. The various options to provide electrical power through renewable sources to rural life are wind power, solar energy, biomas, etc.

Solar energy is also one of the best renewable options as it is clean, cost free, pollution free, widely available and decentralized energy source. On an average 4-7 kWhr/m^2 per day solar intensity is falling on the surface for 250-300 sunny days per annum. Around 492 $\times$ 10^9 kWhr electricity may be produced by harnessing solar energy at 10% overall efficiency, if only 1% of our area is utilized for this purpose. Solar photovoltaic is exciting technology having fairly large scope in India. The electricity generator by Solar Photovoltaic system can be used for electricity production in remote and distant villages. There are nearly 100,000 villages still to be electrified and over 70 million households need the electrical connections. Over 300,000 Solar Photovoltaic systems aggregating to about 22 MW have been installed and total Solar Photovoltaic pumping system installation were 463 as on Jan., 1995.

Biomass is the main source of energy in the country as it contributes about 40% of the total energy consumption. Fire-wood, cow dung and agricultural residues provide nearly 80-90% of total energy consumed in rural areas for the subsistence activities of cooking and heating considering agricultural residues, agro industrial by-product and waste land energy plantation, the total exploitable potential is of 17,000 MW. India has tremendous potential of biomass which is yet to be utilised efficiently. As per an estimate, India has total crop residue availability of 357.5 MT which is equivalent to 260 MT of coal.

The gasifiers has large potential for decentralized power generation in addition with various thermal applications. India Gasifier programme launched in 1986 has achieved installation of about 1600 gasifier with total capacity of 32 MW ranging from 3.5 to 500 KW gasifier systems. Dual fuel (gasifier and diesel) operating engines also offers tremendous fuel saving potential. The replacement of diesel in dual fuel operation has been obtained upto 60-70%. Besides gasifiers programme, the Indian government is promoting the installation of biomass combustion-based power projects. The total installed capacity of biomass power projects was 34.00 MW upto Jan. 1996 and around 70.00 MW capacity is under implementation.

One recent development in electricity generation technology that has attracted the attention of global community, is the Fuel cell. The technology converts the chemical power of gaseous fuel, such as hydrogen, carbon mono-oxide and methane, in to electrical energy. The usefulness of fuel cell further enhances if the gaseous fuel input is generated from available biomass. As an estimate, India may have 88,200 million k Whr of electrical power using the available agro residues through fuel cell technology. Presently, the technology is only at laboratory stage.

The energy scenario of rural India can easily be augmented utilizing the renewables. The achievements of renewable programme in India is not desperate but there is long way to go.

Renewable Energy for Rural Development

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Energy consumption is very closely related with the industrial, agricultural and socio-economic development of a country. In India, dependence of agricultural sector on commercial sources of energy, such as coal, petroleum products and electricity has gradually increased during the past three decades of post-green revolution period. The commercial energy consumption in agricultural sector increased from 2.1 million ton oil equivalent during 1984-85 to 7.7 million ton oil equivalent during 1994-95. The share of agricultural sector in total commercial energy consumption of all the sectors in India has reached up to 9.8% from a low of 3.0% during 1953-54. About 90% of the total energy consumption in rural sector is contributed by non-commercial sources of energy such as fuel wood, crop residues, doing. However, commercial energy sources like electricity, diesel, fertilizers, pesticides, etc contributed nearly 87% to total energy consumption in production agriculture.

The environmental implications of burning fossil fuels accelerated the pace of development of renewable sources of energy in the country. Renewables also termed as non-conventional energy sources have emerged as an indisputable alternative for power generation. Besides, these are more environment friendly. To ensure proper focus on the problem, Government of India created Department of Non-conventional Energy Sources during 1982 which was later converted to a full fledged Ministry. Status of the important renewable energy sources (wind, solar, biomass) is as follows:

Wind Energy:

The government has taken major initiatives for establishment of wind farms in different parts of the country. Potential windy regions have been identified and several incentives are being extended to the industrial sector for this purpose. The installed capacity now stands around 825 MW and is expected to grow rapidly. The target for the IX Plan period is 20,000 MW. Application of wind-diesel hybrid system can be a viable alternative for the isolated remote villages.

Solar Energy:

Solar thermal systems such as domestic cookers and domestic and industrial water heaters are already being used in good number. Solar air heater for drying and space heating and solar distillation are the other potential thermal applications. Solar photovoltaic system may, however, contribute significantly to meet power requirement for water lifting, agro-industries and domestic activities in rural sector in future as decentralised energy system.

Biomass:

Availability of biomass (Agricultural residues) for energy purpose will increase in future. Chemically agro-residues are not much different from wood. But their density is very low. Densification of agro-residues produces a material which would replace wood in different conversion technologies and thus protecting the limited forest resources. Bioconversion (aerobic and anaerobic) and thermochemical conversion of biomass to produce liquid, gaseous and solid fuels may offer a viable alternative to the commercial energy in rural sector. Already about 25.2 lakh biogas plants have been installed. The gas produced is primarily being used for rural domestic cooking. 20 million improved cook stoves have been available in rural areas to help conserve fuel wood. Technology for power generation through biomass gasification have been developed and will be put to practice shortly.

The Indian Council of Agriculture Research launched an All India Coordination Research Project on Renewable Sources of Energy for agriculture and agro-industries during 1983. The mandate of the project is to study and conduct pilot level field trials on integrated technology of Renewable Sources of Energy for their appropriate applications for production agriculture, post-harvest operations, animal raising and rural living singly or in combination with other sources of energy. The project comprises five different activities viz. solar energy biogas technology, producer gas technology, wind energy and ORP on integrated energy & nutrient supply system and is operating at 15 different locations in the country. Fifty one technologies have been developed. The important technologies which have been commercialised includes PV Powered ultra low volume sprayer, folding two-step asymmetric reflector solar cooker, solar papain dryer, 125.1 capacity built-in storage type solar water heater, solar community cooker, 10 KW down draft gasifier (Kalyan gasifier), 5 & 10 KW jai Kissan open core throatless gasifier, PAU Janta biogas plant, PAU Katcha-Pacca drum type biogas plant, batch type biogas plant for willow dust and biogas plant for kitchen wastes, water hyacinth, banana stem etc. Besides, integrated energy & nutrients supply system has been developed and demonstrated for an adopted village (Islamnagar) near Bhopal.

Conclusions:

Since economic growth, social development and human welfare is closely interlinked with energy consumption, a well planned strategy for increasing energy availability and reducing dependence on petroleum fuels (particularly for the rural sector) should assume national priority. Technological developments will play a crucial role in reshaping our energy policy. Renewable energy technologies particularly related with conversion and utilization of biomass may significantly contribute in meeting the energy and nutrient requirements of the rural sector.

Agricultural Residues - a Renewable Source of Energy for Agriculture

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The total foodgrain production in India has recorded a growth rate of 2.5% during the last four decades. This was possible as a result of increased energy inputs in terms of use of quality seeds higher doses of fertilizers, and plant protection chemicals coupled with assured irrigation. The animate power has been supplemented by tractors, power tillers, diesel engines and electric motors.

Electrical energy is one of the major commercial energy input in the production agriculture. Power situation in India is becoming worst day by day. Power deficit during peak period is 22% and otherwise 7%. Prices of other commercial fuels like diesel are rising exponentially.

Agricultural Residues (AR), by products of the production agriculture, has tremendous potential as a renewable source of energy for Agriculture. In Gujarat, per year availability of agricultural residues is around 24 MT which has a potential to generate around 950 MW. Energy plantation on the waste land can provide 15000 MW power. Animal dung of 200 lakh cattle population of the state can generate biogas having potential to generate 933 MW.

Thermochemical and biological routes are major one for converting agricultural-residues into gaseous, solid and liquid fuels which can be used for energy and power applications in agricultural sector. Under thermochemical conversion route comes combustion, pyrolysis and gasification technologies. Direct combustion based devices like improved chulhas, furnaces and boilers have been developed and are in commercial use.

Pyrolysis involves heating the biomass in the absence of air. It gives charcoal (upto 35% wt), combustible gas (35% wt) and fuel oil (30% wt) as the by products. Agricultural residues based charcoal has good potential for domestic, community and industrial heat applications.

Gasification generates a combustible gas called as Producer Gas (P Gas) through partial combustion process. The reactor is called as gasifier. The P gas burns like LPG. It can be used for domestic, community and industrial heat applications with efficiency more than 60 per cent. About 3 kg of waste saves one liter of fuel oil. P gas, after purification can be used to operate IC engines on dual fuel mode with diesel replacement upto 70%. 4 to 5 kg of wood is required to save one litre of diesel. The gasifier technology has tremendous potential for reducing the dependence of agriculture operations and village community on commercial energy for meeting their heat and power demands to a considerable extent.

Anaerobic digestion of Agricultural residues and other wastes like cattle dung can generate biogas which can be used for heat applications and running IC engines. Slurry is a good manure.

Energy Use Scenario in Production Agriculture in India

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Energy is central to national development process and to provide major vital services that improve human condition - fuel for cooking, light for living, motive power for transport and electricity for modern communication. In agricultural sector, its use is in every form of inputs – seed, fertilizer, agro-chemical for plant protection, machinery use for various operations, housing, transport and processing.

About 50 per cent of total energy supply in India has been from non-commercial renewable energy resources as firewood, agro-waste and dung cake with annual consumption of about 250 million tonnes. Actual consumption of these energy sources increased from 1051 PCal in 1960-61 to 2554 PCal in 1987-88, however, their share in total gross energy consumption declined from 69.7% to 44.4% during the same period due to increased availability of commercial energy sources. Coal provides about 40% of total energy use in India followed by petroleum products.

Energy Use in Rural Home

In Indian rural households, energy needs are inseparably linked with the activities generated by agriculture. The main activities include preparation of food, livestock raising, heating, making provisions of fuel and water, home maintenance and family care. The pattern of energy consumption for the activities vary according to climatic conditions, economic development, prevailing social practices and readily available and economically viable energy sources. Most of the energy are derived from non-commercial sources as human and biomass. Scarcity of fuelwood in many areas compel local people to remain highly dependent on seasonal agricultural waste and animal dung which would have otherwise found better use in agriculture. Such uses also precipitate a number of environmental problems like resource depletion, soil erosion, deterioration of agri-ecosystems and increases social costs. Commercial energy use is mainly governed by the extent of its availability and economic viability.

Some important features of household energy consumption in study areas in three States are:

- the average annual energy consumption in rural household was about 96,000 MJ/household.
- 78 to 92% of total energy (128 to 648 MJ/day per family, depending upon family size) used for various household activities is met through non-commercial energy in the form of firewood, dung cake and agro-wastes.
- Large farm households generally use 40% more firewood and about 5 times more dry dung cakes per year than small and marginal ones.
- Commercial energy use was mainly for lighting of the households.
- About 39% of annual consumption of kerosene is during rainy season. In typical villages in South India, nearly 80% of kerosene is used in lamps, 16% for igniting cookstoves and only 4% in kerosene stoves.
- Human energy use was 7% of total energy consumption out of which about 82% was contributed by women.
- Among household operations, cooking alone consumed 81-94% of energy.

Conservation of cooking energy is thus an imminent need, particularly in areas where a shortage of traditional fuel is leading to commercialization of wood, or substitution of firewood with animal dung and crop residues which have alternate vital uses.

The Energy Availability Scenario

In order to achieve the production target of 230 million tonnes of foodgrains by the turn of the century, and assuming that the available energy is used for its production, the average specific energy availability on all India basis would be of the order of 8,452 MJ/t of foodgrain as compared to present level of 8,146 MJ/t.

It is estimated that if the full potential of tractor, power tiller and stationary engine are put in use by the farmers, the demand of diesel oil in agricultural sector will increase by about 1.8 times from its present level. With the foodgrain production targets before the country, the demand of all type of energy sources used in production agriculture is to rise further. This Coordinated Project since its inception has endeavored to conduct research on energy in the context of its increased demand resulting from modern technological inputs to agriculture and necessitated due to increase in demand of food, feed and fibre on account of population pressure and rising standard of living.

Energy Demand

Under tight energy policies, the energy demand is normally to be met through better utilisation of non-renewable energy sources and exploiting renewable energy sources. Availability of energy and matching technology for amelioration become crucial factors in such case. Renewable energy sources seem to be quite substantial, but unless the unit cost of production (as compared to non-renewable sources) is brought down, their utilisation would be low. The system would thus remain largely dependent on non-renewable energy resources. Lack of investment capacity, inadequate technical literacy and poor infrastructure compel inefficient use of non-renewable resources.

Under the given situational factors, it may be difficult to increase energy intensity beyond moderate means in all regions of the country within short term since poor farmers will not have requisite absorptive capacity. Owing to lack of integration of the different diversified situations into location-specific technology standards, it is difficult for the system to improve efficiency to the desired level. On the other hand, specific situations remain untouched by high level technology owing to lack of absorptive capacity and effective demand generation. Proper energy management planning at macro as well as micro level is necessary for best use of available resources.

Energy management in agriculture requires a scientific database on energy use pattern in various production sub-sectors of agriculture, which can help in analyzing the pattern of uses to identify the critical areas of operation, areas of low-efficient usage, the pattern of resource use, effect of technology on energy use and evaluate various options to support the decision making processes on future energy demand and supply for best use of resources. Information on the above at micro level had been generated through some isolated studies, but their assimilation is difficult due to lack of homogeneity.

Demand Forecast for Bio-fuels in Rural Households

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Bio-fuels are the dominant source of energy in rural India. In a survey done in India by the NCAER in 1978-79, it was estimated that biofuels accounted for over 90% of the heating energy used by the rural households. The major bio-fuels used are firewood, crop wastes and dung cakes. Firewood alone accounted for more than 55% of the total bio-fuel consumption. The survey also showed that the rural households consumed over 125 million tonnes of bio-fuels in 1978-79. Of these 67 million tonnes were dung cakes and 30 million tonnes were crop residues. The balance of 79 million tonnes was firewood made up of 20 million tonnes of logs and 59 million tonnes of twigs.

A number of factors affect the level of energy consumption. Two of the most important among these are income and population. To take care of the effect of population increase the following procedure is adopted. The likely average household energy demand is projected for the year 1999-2000. This figure is multiplied with the projected number of households in 1999-2000 to arrive at the demand for total energy in that year. To estimate the average household energy demand for any future year, the income effect is to be taken into consideration. In order to gauge the effect of a rise in real (household) income on average energy consumption, it is necessary to know the income elasticity of demand for energy.

In the absence of data on energy consumption at different levels of income, the following procedure is adopted to forecast the average household heating energy demand for 1999-2000. Between 1978-79 and 1992-1993, the average household heating energy demand grew at 1.9% per annum. This growth may be attributed mostly to the increase in the annual average household income between 1978-79 and 1991-92. It is assumed that the period between 1992-93 and 1999-2000 also, the average household energy demand would grow at 1.9% per year. This essentially means that the income effect is taken to be the same in the two periods under consideration.

The demand for average household energy for heating during 1999- 2000 estimated as above comes to 1550 kgcr.

Population Projections

The rural population of India was estimated at 628.7 million in the 1991 Census. The growth rate between 1981 and 1991 was estimated at 1.8% per year. The census report also reckoned the growth rate for the rural and urban areas put together at 2%. The projected rural population in 2000 was estimated at 744 million.

Some of the recent surveys done by the NCAER, indicated the average household size in the rural areas to be 5.7. Using this average size, the estimated number of rural households in 2000 comes to 130.5 million.

With an average household heating energy demand of 1550 kgcr, the demand for heating energy in rural households in 1999-2000, is estimated at 202.4 mtcr.

Pattern of Fuel Consumption

The next step in the exercise is to apportion this total energy demand between different fuels. It is assumed that the fuels used would be soft coke, kerosene, dung cake, firewood, crop wastes and bio-gas. Commercial fuels like LPG and electricity and other non-conventional energy sources are not considered as their share in the total energy demand is likely to be insignificant.

Adjustment for Improved Efficiency

The estimates have not made any allowance for any likely increase in the efficiency of fuel use in the future. Under the National programme of Improved Chulhas, fuel efficient wood stoves are propagated in the rural areas. Till the end of 1994, around 15 million chulhas were constructed. The last few years saw additions of around 2 million chulhas a year. If this trend continues, by 1999-2000, around 30 million chulhas would have been installed in rural homes.

These chulhas are smokeless and fuel efficient. It is claimed that an improved chulha is three times as efficient as a traditional chulha. If this is true and when all the 30 million chulhas are used in 1999-2000 then a dent would certainly be made in the demand for bio-fuels.

However, recent studies by NCAER show that the improved chulhas installed by the rural households are only 40% more efficient than the traditional chulha. Further hardly 50% of the chulhas are operational. Faulty construction and poor maintenance were cited as the major reasons for the poor performance. The study also noted that around 20% of the existing chulhas become nonfunctional each year. As a result the new constructions mainly replace the ones that go out of order each year leaving very little for net addition to stock. It is unlikely that this system would improve in the near future. Based on these, it is estimated that out of the 30 million chulhas only 9 million would be in use in 1999-2000.

On the basis of a 40% higher efficiency, it is estimated that an improved chulha would save fuels capable of yielding useful energy of around 620 kgcr. For the 9 million chulhas in operation, the total saving would be to the tune of 5.5 mtcr. In terms of firewood, it is around 7 million tonnes. Thus the total demand for firewood after allowing for likely improvement in the efficiency of use of fuels would be around 175 million tonnes in 1999-2000.