5.0 INTRODUCTION

Traditional methods of cooking are carried out at efficiencies estimated at 10-15 %.

The prospect of an increase in energy consumption as economic development proceeds focuses its attention on the efficiency of fuel use. The fuel efficiency for fuelwood is more or less fixed in the form it is used. The way efficiency of fuel use can be increased with using fuelwood when the cooking device and the cooking medium efficiency is increased.

Many a time, energy consumption habits may reflect an efficiency defined by local preferences. This can be seen in the problems with the introduction of more efficient stoves (using biomass or other commercial fuels) had to face, which required unfamiliar methods of cooking, new types of utensils, and not matching the needs of the users as was observed by Cecelski, Dunkerley, and Ramsay [1985]. The traditional ways of burning wood for cooking and heating generally are inefficient. In a study in Indonesia by Arnold and Jongma [1979], it was found that on the usual types of fuelwood stove 94% of the heat value of the wood was wasted and simple improvements in wood preparation (making charcoal, briquettes, charcoal-powder balls, etc.), in some design (for example, the stove ASTRA developed in Bangalore) and cooking pot design (using aluminum pots instead of clay ones), reduced the
consumption of fuelwood for cooking by 70%.

The aspect of efficiency and conservation of wood resources go hand in hand. Transforming wood into charcoal can be seen as a means of extending the wood-based fuel base. Though the properties of charcoal vary with the wood raw material, and particular woods have to be used for charcoals for certain special purposes, almost all woods can be converted into charcoal. But its low-conversion factor tends to make charcoal making unprofitable, when the cost of growing (or procuring) of wood has to be taken into consideration.

5.1 CHARCOAL VERSUS FUELWOOD

Charcoal is produced by a partial chemical reduction of wood under controlled conditions. The yield of charcoal by weight is usually about 20-30% of the dry weight of the wood used, and the yield by volume is about 50%. There are some advantages and disadvantages associated with the usage of charcoal and wood. They are that it is almost smokeless, radiates high proportion energy, it can be ground and used with standard equipment, its calorific value is similar to high quality coal, and, it has various industrial uses.

But charcoal use has a few disadvantages as well, like, its low bulk density necessitates special transportation, it is easily broken, and care has to be taken during combustion to ensure that there is free circulation of air because of the danger of carbon
mono-oxide poisoning.

On the other hand, there are advantages of using fuelwood, because, it is the cheapest fuel available, not only per ton, but also per unit of heat, it burns safely and easily if properly dried, there is no special storage facilities are required. But fuelwood is a fuel which is not only inefficient, it has some other disadvantages as well, like, it is a very carbon-intensive fuel, forests and other trees around human habitation become depleted, and, the calorific value is lower than that of other fossil fuels.

5.2 FUEL EFFICIENCY

The delivered energy content of a fuel measures the potential heat available form it. The fraction of the energy utilized defines the efficiency of the end-use device. Efficiencies are usually defined in terms of delivered energy but can also be given on a primary energy basis.

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\text{Efficiency for a end - use} = \frac{\text{Energy utilized for the task}}{\text{Energy delivered to conversion device for task}}
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This is the utilized energy efficiency, expressed as Percentage Heat Utilized (PHU). When any fuel is burned, its energy is usually transferred to the end-use task in several stages. There are, various measured of efficiency. The three basic ones, as enumerated by Leach and Gowen [1987] are –
a. **Combustion Efficiency** (C.E.) - It allows for energy losses in the combustion process and heat that does not reach the point where it could be transferred to the final task.

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\text{Combustion Efficiency} = \frac{\text{Heat generated by combustion (MJ)}}{\text{Delivered energy of fuel (MJ)}}
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b. **Heat Transfer Efficiency** (H.T.E.) - It allows for energy losses between the combustion outlet and the end-use task, especially heat transfer and radiation losses.

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\text{Heat Transfer Efficiency} = \frac{\text{Energy absorbed by end-use task (MJ)}}{\text{Heat generated by combustion (MJ)}}
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c. **System or End-Use Efficiency** (S.E.) - It is the product of the Combustion and HTE, or the overall efficiency. It is often referred to as conversion, gross, thermal and end-use efficiency.

Percentage of Heat Utilized (PHU) is the energy utilized and expressed as a percentage of that available at any stage in the energy conversion process. The overall PHU is commonly referred to as appliance efficiency.

The long-run solutions to the shortages of domestic fuel in developing countries, mainly in the rural areas involve both an increase in the supply of fuel and a reduction in demand. Both these can be ‘managed’ by improving the usage efficiency either by preparing wood before use (drying or making charcoal) or by using
improved, less fuel using stoves.

When one has to make a distinction between efficiency of fuel in purely technical terms and economic efficiency of energy supply and use, a distinction between the concepts of energy intensity, energy saving and energy rationalization is necessary. **Energy Intensity** is the consumption of energy per unit of product output or GDP, **Energy Saving** represents a reduction in this intensity; and **Energy Rationalization** is a combination of energy savings and switching from higher cost to lower cost fuels [Hume; 1988].

Thus, fuel conservation (or improvements in the efficiency of energy conservation), and improvements in conversion which lead to increased quality or productivity, or to improved working conditions, can be treated as one option for economizing fuelwood use in the rural areas.

**5.3 COOKING APPLIANCE EFFICIENCY**

There are two facets of fuel efficiency, especially fuelwood efficiency. One is, the efficient use of fuel itself by various 'preparations' of the fuel, the other is efficiency of use, that is, efficiency of the appliances through which the fuelwood is used. In this are included the technological and economic aspects of stoves and vessel usage and their design. Appliance efficiency is simply a measure of the effectiveness with which heat is transferred from the fuel when the appliance is being used with a
particular end in view. The efficiency of an appliance can be defined as the amount of heat in the original fuel which is directly utilized in the cooking task. In controlled conditions (or tests in the laboratory), this is usually measured by taking the total amount of heat absorbed by the cooking pot and its contents over a period of time and expressing it as a percentage of the total amount of heat released from the fuel; this is referred to as the Percentage Heat Utilized (PHU).

A variety of factors can distort the performance figures, and make comparisons misleading. For example, the moisture control of fuel can have a great effect on the amount of useful energy that can be derived from it [Vimal & Bhat; 1989]. The majority of stove design work in recent years has been concentrated on improving the efficiency with which fuel is used for cooking. The aim in all the cases is to find methods of countering the main ways in which energy is lost from a cooking fire.

In many places in rural areas, it is a common practice to cook over open fire, with the 'three-stone-stove', where there is a substantial loss of energy. A simple way to upgrade its performance may be by providing people with means to cut down on the loss radiant heat and protect it against wind or draughts. Apart from the simplest method of constructing 'surrounds' for open-fire cooking, it was observed by Anderson and Fishwick [1984] that the use of aluminum pots, whether on open-fires or on mud or metal stoves, add 5-8 % to the efficiency with which the task is
Some reasons for the poor response for improved stoves was found by Cecelski, Dunkerley and Ramsay [1985]. The reasons given were the defects in the stove design itself. In many areas, its improper use and also, the stoves which were designed to be smokeless were not suitable to many users, who preferred a certain level of smokiness to reduce the insect pests and maintain thatched roofs.

Moisture Content Dry Basis (MCDB) refers to the ratio of the weight of water in the fuel to the weight of dry material. Moisture Content Wet Basis (MCWB) is the ratio of the weight of water in the fuel to the total weight of fuel. Both are expressed as percentages. Heating values of biomass fuels are often given as the energy content per unit weight or volume at various stages as 'green', 'air-dried' and 'oven-dried' material. The basic reason for the adoption of improved stove is the long-term solution to the shortage of domestic fuel in developing countries, which involve both an increase in supply of fuel and a reduction in demand. The main aim for undertaking improved stove programme was not solely for fuel economy, but also on improved health by reducing the quantity of smoke produced.

5.4 THE EARLIEST IMPROVED STOVES

The first controlled laboratory tests to be carried out on an
improved stove were those conducted by Theodorovic in 1954 in Egypt. The stove was an adapted version of the 'Hyderabad Smokeless Chula' developed in India. In the experiment carried out, it was found that on an average the improved stove used 16% less fuel than the traditional stove, for boiling one liter of water and 28% less for boiling two liters of water.

Next came the stove developed by Singer in 1961. Next series of development of improved stoves was in 1970s, when in 1976, the 'Lorena' stove was developed in Guatemala. It had a chimney and its ability to reduce the quantity of smoke was a major advantage.

5.5 NEW DEVELOPMENTS IN STOVE DESIGN

The new series of stoves use metal sheets and they are in many instances, portable and they use generally charcoal or coal, though they can also use wood chips and wood cut in a particular size to fit the fire chamber. In Africa, there is 'Jiko', which is normally made in the form of cylinder about 25 cm. in diameter and 15 cm. high, and has a perforated metal grate at almost its mid-height. A very similar stove is used in India, which is called angeethie. It is used in areas where coal or charcoal is in use, as the use of wood in these stoves does not give equal amount of heat required for cooking the whole meal [Foley & Moss; 1985].

In the rural areas, using fuelwood and other agricultural wastes,
fixed 'mud' stoves are more popular. They are built on the floor of the dwelling and in some cases, they are directly made in their final shape and placed in the cooking area. One main shortcoming of the mud-stoves is that they are not very durable. The heat of the fire causes them to crack. They are also very vulnerable to water spilling on them. Because of this problem, one innovative idea is that of making a ceramic ‘stove-liner’ which is then covered on the outside with a mixture of sand and clay.

The success or failure of an improved stove depends completely on the acceptable by the people for whom it is designed, and whether it satisfies all their needs, with minimum changes in their traditional ways of cooking.

Apart from these local and specific requirements for an improved stove, the financial context is also very crucial as far as acceptance by the poor people is concerned. The success or failure of any improved stove programme depends on the various factors ranging from cost to fuel availability, fuel efficiency, to acceptance because of social and cultural factors.