

# Charcoal production and use in Africa: what future?

*P. Girard*

*With mounting urbanization, African populations are increasingly shifting from fuelwood to charcoal for domestic cooking and heating.*

Urbanization and economic development are bringing about changes in consumption patterns and increases in household income in developing countries, which in turn are leading to major changes in the household energy sector. A pronounced shift from fuelwood to charcoal, especially in Africa, has raised concerns among environmentalists and those responsible for forest development and management.

This article describes the trend towards increased use of charcoal in Africa, identifies the resource issues and highlights some of the requirements for the sustainable development of this sector.

## SHIFT FROM FUELWOOD TO CHARCOAL

In general, energy consumption in rural areas of Africa is still low and is limited almost exclusively to fuelwood. However, energy consumption and the type of fuel used by households evolve as countries develop. A survey carried out for World Bank's Energy Sector Management Assistance Programme (ESMAP) in 45 cities in 12 countries between 1984 and 1993 (Waddams Price, 2000) showed that a decrease in the use of woodfuel and a shift to petroleum products is clearly related to improvement in incomes, as well as to new policies and programmes established by governments.

Energy consumption and fuel types are also influenced by high migration flows and the high growth rate of urban populations. Although migrants to cities keep their rural habits and traditions for several generations, the pressures of urban life (modernization of housing, lack of time, etc.) are rapidly swinging many towns from fuelwood to other fuels such as liquefied petroleum gas (LPG) or kerosene. Urban women interviewed during household energy surveys in Ethiopia, Chad, Madagascar, Mali, the Niger and Senegal did not like to cook with wood because they found it

difficult to kindle, awkward, dangerous for children, smoky and messy (Madon, 2000). Charcoal is perceived to lack most of these negative effects, and it is priced more competitively than LPG and kerosene, which are still too expensive for many people (Foster, 2000). A study in Dar-es-Salaam, United Republic of Tanzania, for example, clearly showed charcoal used in energy-efficient stoves to be the cheapest fuel per unit of energy (Foster, 2000). It is therefore often used prior to the adoption of other more expensive modern fuels.

The urban shift from fuelwood to charcoal is illustrated by the case of Bamako, Mali, where in 1990 over 85 percent of families used wood as their everyday household fuel. The figure is under 50 percent today, and in 1997 charcoal (which had previously been kept for such special uses as tea-making and barbecuing) replaced wood as the primary fuel in Bamako (see Figure). The low level of household income is probably the only factor holding back the shift to fossil fuels, LPG and petroleum.

Most striking is the increasing use of charcoal in average-sized towns, and sometimes even in rural areas. For example, a recent survey of household consumption in all towns in the northern region of Mahajanga, Madagascar, showed that charcoal was the main domestic fuel used (CIRAD, 1999). The figures reveal a trend of increasing charcoal consumption when compared with a 1992 survey realized for the World Bank by the Household Energy Planning Unit of the Ministry of Energy and Mines (CIRAD, 1992).

With urbanization, the charcoal sector has acquired considerable economic weight. Work carried out under ESMAP in the Niger and Mali since the late 1980s has shown that this mainly informal sector accounts for an annual turnover of several million dollars for a number of African countries. In terms of employment, if not in financial terms, its importance is comparable to that of cash crops (Matly, 2000).

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### PRESSURE ON FOREST AND TREE RESOURCES

Globally, the use of woodfuels has been growing in line with population growth, so that the annual growth in demand is between 3 and 4 percent depending on the country (Amous, 2000). During the past two decades, a better understanding of wood energy systems has led to the recognition that supply sources are more diversified than was once assumed, including not only forest areas but also trees outside forests. Thus the alarmist predictions of the 1970s of a "fuelwood crisis" in which supply sources would not be capable of meeting the demand have proved unfounded.

Nevertheless, in places where high fuelwood and charcoal consumption and weak supply sources put strong pressure on existing trees resources (because of high population density, low income and/or severe climate conditions), deforestation and devegetation problems are still of great concern.

### MUST CHARCOAL BE A CAUSE FOR CONCERN?

The shift from fuelwood to charcoal, even if it lasts only a few decades, could have major ecological consequences if it is not kept under control. However, since charcoal stoves are more efficient than wood stoves, the ratio of primary energy to usable energy is almost the same as with fuelwood. Thus with adequate supervision, management and support, the shift does not need to disrupt present levels of resource use.

One great concern, however, is that charcoal, unlike fuelwood, is most often produced from forest resources. Thus the use of forest biomass for charcoal making could still represent a threat to the future of the resources in local terms, especially in certain situations with high demand (for instance the periphery of large urban zones with low resources) and lack of proper forest management practices and regulations.

With adequate forest management, supervision and control practices, however, the growth of charcoal use does not have to have a serious impact on forested areas that supply consumption centres. Work carried out in the Niger and Mali, for example, indicated that control of the resource by the people living in the charcoal production areas can lead to proper management of the resource while improving local people's incomes (CIRAD, unpublished documents, 2001).

Despite some successful examples like these, many African governments, concerned about the potential threat of charcoal to forest resources, have launched programmes in the past two decades to encourage substitution of charcoal with other fuels (particularly LPG and kerosene) through subsidies and provision of equipment to households. Despite the effective distribution of equipment (in Dakar, Senegal, over 60 percent of families were equipped to use LPG), these programmes have not succeeded, in part because African cities do not always readily take on urban habits (Matly, 2000).

However, substitution programmes have also had the negative effect of creating unemployment in forest areas when charcoal production was discouraged. The lack of employment led to increased migration towards urban and peri-urban areas and accentuated the demand for fuelwood and

even more charcoal, as these are the main source of affordable energy for poor people.

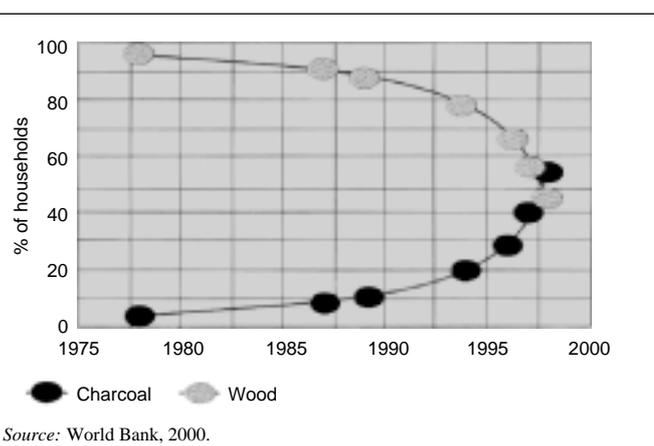
Banning the production and/or marketing of charcoal, as has sometimes been done (for example in Mauritania and Kenya), has proved counterproductive: bans do not in fact reduce production, but simply drive producers underground, thereby precluding proper control of production procedures (FAO, 1993).

The sustainable production and use of charcoal through proper management and planning of supply sources, together with rational trade and marketing infrastructures and efficient use, can also have a significant positive impact by helping to conserve resources, reducing migration from rural or forested areas and improving people's incomes. However, the necessary interventions for long-term solutions are not easy to implement, especially for poor tropical countries that lack the necessary financial resources, institutional capacity and skilled personnel.

### SOLUTIONS FOR SUSTAINABLE CHARCOAL USE

Charcoal is often traditionally made from species that yield a dense, slow-burning charcoal. These species are slow growing and are therefore particularly vulnerable to overexploitation. There is thus a need to encourage diversification and the use of

*Use of wood versus charcoal as fuel in Bamako, Mali*



### Average qualities of traditional charcoals in Togo compared with charcoal from plantation eucalyptus

| Type of charcoal               | Volatile matter (%) | Ash (%) | Fixed carbon (%) | Higher heating value (kJ/kg) | Density (%) | Friability (%) | Moisture recovery (%) |
|--------------------------------|---------------------|---------|------------------|------------------------------|-------------|----------------|-----------------------|
| Average savannah               | 17.2                | 5.8     | 77.0             | 30 190                       | 0.58        | 11.1           | 5.10                  |
| Average cleared wood           | 23.5                | 5.1     | 71.4             | 29 320                       | 0.49        | 19.1           | 6.37                  |
| <i>Anogeissus</i> spp.         | 19.0                | 9.6     | 71.4             | 28 570                       | 0.65        | 11.7           | 4.18                  |
| <i>Eucalyptus torelliana</i>   | 19.0                | 3.8     | 77.2             | 30 600                       | 0.36        | 13.3           | –                     |
| <i>Eucalyptus tereticornis</i> | 15.7                | 3.1     | 81.2             | 32 480                       | 0.44        | 18.1           | –                     |

Source: Girard, 1987

plantation species or species producing less dense charcoal. While less dense charcoal may have different physical properties, there is no difference in energy terms, as shown in the Table. Since charcoal is marketed by volume (piles, sacks, etc.), a heavier product gives consumers the impression of buying more. Although dense charcoal does indeed hold more energy by volume, this is not the case by weight.

Where the use of alternative species for charcoal making is promoted, it is necessary to re-evaluate the processes involved in the charcoal production and utilization chain. One necessary adaptation is the design of energy-efficient charcoal stoves, as most of the stoves currently used are not really suitable for charcoal from light-weight species, burning it too quickly and vigorously for consumers' needs.

When charcoal comes to be used as cooking fuel in a given country, the speedy introduction of procedures encouraging the use of light charcoal (sale by weight, quality-based prices, control over the species used, etc.) could limit overexploitation and encourage production from plantation species, to the considerable benefit of the environment and consumers. Professional training and supervisory measures could also help reduce the current pressure on species that yield dense charcoal.

#### A NEED-BASED APPROACH IS ESSENTIAL

In industrialized countries a large number of more efficient and rational technical solutions are being developed to enable carbonization processes to conform to environmental and energy norms and to improve

carbonization yields because of increased wood prices. The basic goal is to produce more charcoal using less wood.

The solutions are many. These include batch-type retorts where wood is carbonized by an external source of heat; metal kilns equipped with vapour incinerators; and Lambiotte-type continuous retorts where wood is introduced at the top of the kiln and the charcoal is extracted from the bottom, with the vapours burned to meet the heat requirements of the process. All of these require a large investment and are usually unaffordable for small-scale charcoal makers in tropical countries.

Most traditional or improved traditional charcoal production techniques give good yields, with relatively low capital investment, if they are efficiently used. However, they are labour intensive.

Many charcoal projects have not achieved the hoped-for results because they have considered only the energy aspects of the technical process and ignored the social and economic aspects. However, considerable economies could be achieved in the sector, as shown in the Box.

Many sawmills produce great amounts of waste, which is often simply burned for disposal or very roughly carbonized. Semi-industrial charcoal making processes with incineration of pyrolysis gases and heat recovery could provide a satisfactory way of optimizing sawmill by-products, since such mills have the necessary technical and human resources (FAO, 1985). There are some examples of this kind in the humid tropical zone (e.g. Côte d'Ivoire, Brazil).

The choice of technology must always be governed by analysis of the socio-economic context. A set formula should never be applied, even if it has had excellent results in another context.

Although globally charcoal consumption could be expected to decrease in the near future, locally or in specific countries (developing and developed) it may still increase as a result of new industrial "green



Traditional charcoal mound in West Africa (Guinea)



*A semi-permanent low-cost "Subri-fosse" type metal kiln in Madagascar was designed to carbonize offcuts from sawmilling*

*Metal kilns equipped with vapour incinerators (shown here in France) can help reduce environmental pressure by increasing charcoal yields, but they tend to be unaffordable in developing countries*



energy" market opportunities under development. Therefore forest services and energy agencies should give particular attention to charcoal and its sustainable production and use. Effective actions might include, among others:

- the establishment of forest management programmes to avoid deforestation by overharvesting of species suited to charcoal production;
- professionalization of the sector, whereby charcoal makers would produce charcoal as their main activity and occasional charcoal production by non-professionals would be discouraged, through apposite policies and training programmes;
- providing charcoal makers with a range of suitable technical methods from which to choose, rather than a single "best" technical solution;
- the promotion of charcoal from residues and forest plantation timber, through pricing and appropriate policies.

If charcoal making is regarded as a source of supplementary income or as women's work, investment in training will be less likely, and less labour-intensive methods – which are also the least productive – will be preferred, limiting possible improvements. The education and training of forest planners, extensionists and charcoal makers, and the implementation of more sustainable charcoal making technologies,

may be determining factors in improving working conditions in the sector, as well as environmental impacts and energy effectiveness.

Charcoal is part of a range of fuels for domestic use that needs to be incorporated into any programme to rationalize energy resource use in tropical countries. Rather than seeing it as the forester's public enemy, planners need to understand the problems and to implement suitable solutions to make the best possible use of charcoal. ♦

### Some figures regarding economic and environmental issues

Mass yields from a Casamance kiln and a well-managed traditional mound kiln are about 25 percent. In other words, 1 tonne of wood will give 250 kg of charcoal. With poorer techniques, however, yields often do not exceed 15 to 20 percent, in other words about 150 to 200kg from 1tonne of wood. Many charcoal makers, for example, use green wood, and the energy needed to dry it is provided by part of the load, reducing yields to 15 percent.

The carbon content of wood and charcoal is 50 and 90 percent respectively, giving the following carbon equivalents:

- 1000kg of wood → 500kg of carbon;
- 250kg of charcoal → 225kg of carbon;
- 150kg of charcoal → 135 kg of carbon.

When a tonne of wood is carbonized, 365 kg are released into the atmosphere with a poorly managed technique and 275 kg with improved methods. Improved technique thus prevents the emission of 90kg of carbon per tonne of carbonized wood, equivalent to 300kg of carbon or 1.1 tonnes of CO<sub>2</sub> per tonne of charcoal consumed.

For the city of, Abidjan, Côte d'Ivoire, which consumes about 300000 tonnes of charcoal per year, the annual savings amount to:

- 330000 tonnes of CO<sub>2</sub> emission avoided;
- 800 000 tonnes of wood not consumed as a result of the increased yield.



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## Developments in charcoal production technology

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Humans have produced and used charcoal as fuel for cooking and grilling since the Stone Age, and for producing metal implements since the Bronze Age. In developing countries charcoal is still widely used by urban and rural people as a smokeless domestic cooking and grilling fuel with a high heating value. In developed countries there is an increasing demand for charcoal as a barbecue fuel. Large amounts of charcoal are used in copper and zinc production as well as in the production of precious metals.

Heating wood in the absence of air results in the production of charcoal, volatile tars and a mixture of gases. The relative amounts of these three types of products depend on the equipment used and on the characteristics of the original wood. The moisture content is an especially important parameter. Dry wood produces more charcoal than wet wood.

In domestic or barbecue applications the remaining tar (or volatile) content of the charcoal is important. The higher the fixed carbon content, the lesser the tar and the lesser the smoke during combustion. For metallurgical applications the ash content and the size and crushing strength of the charcoal are also of importance.

### Traditional charcoal production

Until the beginning of the twentieth century virtually all charcoal was produced by traditional methods. Wood was put in dug-out earth pits, lit and covered with earth. The combustion of part of the wood produced enough heat to carbonize the remainder. Alternatively, heaps of wood were covered with earth and sod and lit through openings in the earth cover (earth kilns). Those openings could be judiciously opened and closed and new ones could be made to control the introduction of air. This method allowed somewhat more control over combustion and carbonization than the pit method. Both techniques persist to this day in many developing countries, mainly because they are cheap. However, they often produce very low yields (typically 1 kg of charcoal from 8 to 12 kg or more of wood), inconsistent quality (because it is difficult to maintain uniform carbonization) and environmental pollution from the release of tars and poisonous gases.

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**Improved traditional charcoal production: a Brazilian-type brick kiln in Cuba**



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**Improved charcoal production using a metal kiln, Senegal**

**Modern industrialized charcoal production in the Netherlands meets strict emission standards**



M.A. TROSSIERO

### Improved traditional methods

In the 1970s and 1980s, efforts were made to improve traditional charcoal making by equipping earth kilns with chimneys made from oil drums (Casamance kilns) and by introducing small-scale steel or brick kilns. These methods all rely on partial combustion of the wood charge to provide the heat necessary for carbonization; therefore yields depend heavily on the moisture content of the wood. With good practice, yields of 1 kg of charcoal from 4 to 5 kg of air-dried wood are possible. Yields of 1 kg of charcoal from 6 to 8 kg of wood are more common. The advantage of processes using a solid cover (metal, brick or concrete) stems from the hermetic seal such a cover provides, which minimizes the effect of poor supervision and gives more consistent results. Steel and brick kilns are less labour intensive than (improved) earth mounds. However, they may be less accessible to small-scale traditional charcoal makers because of their higher costs. Improved traditional small-scale methods should be encouraged in most cases.

### Industrial production technologies

The industrial demand for charcoal in the twentieth century elicited new larger-scale technologies mainly aimed at improving yield and quality. Different types of batch-wise operated brick or metal kilns or continuously operated retorts were designed, which considerably increased yields (typically 1 kg of charcoal from 5 to 7 kg of wood) and produced a much more uniform charcoal product with a higher fixed carbon content. Many factories of this type are still in operation today in Europe as well as in North and South America. However there is a persistent problem with pollution. Charcoal factories emit large amounts of smoke, soot and tarry particles and a foul odour, and they are considered a menace to health.

### New high-yield, low-emission systems

The current trend in charcoal production aims at improving the environmental performance of equipment while maintaining and/or improving charcoal yield and quality. Steel vessels or retorts are filled with pre-dried wood and placed in a ceramic brick-lined carbonization furnace heated to 900°C. The tars and gases produced as the wood heats up are led to a separate high-temperature combustion chamber. The flue gas from this combustion chamber is used to heat the carbonization furnace, and the remaining heat from the furnace is used to pre-dry the wood. The very good heat management of this type of equipment makes it possible to produce 1 kg of charcoal from 3 to 4 kg of wood.

Because of the very high temperature of the combustion chamber, all particles, tars and gases are completely combusted. In the Netherlands, equipment of this type has been certified to meet strict emission standards for combustion installations. Emissions of tars, carbon monoxide and nitrogen oxide as well as smell components are well within the legal limits.

The new high-yield, low-emission charcoal factories have higher investment costs than the old-fashioned brick or steel kilns or retorts. However, in many cases the improved yield more than compensates for the higher investment, so the improved emissions come as a no-cost bonus. As a result, this relatively new technology has spread in the past two years, not only in the environment-conscious countries of the European Union (France, the Netherlands), but also in Eastern Europe (Estonia) and in developing regions (China, Ghana, South Africa). A carbonization factory for the production of charcoal from municipal waste wood is under construction in Singapore.