When an African city runs out of fuel

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Ouagadougou, capital of Upper Volta, has a critical situation. Surrounding tree cover is disappearing. Imported oil is out of the question. Wood and charcoal will have to come from distant places. Ivory Coast forests may provide the answer.

Part I: supplying Ouagadougou

Ouagadougou is a typical example of an urban centre whose inhabitants use almost exclusively fuelwood as energy for cooking their food. A rise in population and the rapid disappearance of the forest resources from which the city drew its supplies have, however, caused a growing imbalance between consumption and availability. Fossil fuels and, in particular, oil which might have been able to replace wood to a certain extent have become so expensive that their use has practically ceased. Moreover, they represent a heavy burden on the country which must import all such fuel, and an increase in their consumption cannot be encouraged. The situation is critical because the tree cover around nearby towns and villages is rapidly disappearing, and a solution must be found very quickly.

The effect of present and future reforestation programmes, insufficient to re-establish the balance, will not be felt for several years. Moreover, they are hindered by a very serious shortage of financial, material and human resources. The alternative sources of energy proposed are still scarcely reliable, not easy to use and too expensive to be of much help in the near future.

Without neglecting the development of plantations and research into alternative sources of energy, two immediate steps might considerably modify existing trends and make it possible to restore this balance:

- promote, on a very large scale, the use of stoves capable of more efficient combustion of both fuelwood and charcoal, thus saving the maximum possible energy produced by these fuels; and pursue research in this field to obtain ever higher caloric yields;

- import a sizable proportion of supplies from wood resources outside the country,

e.g., from the Ivory Coast, already processed so that they would be cheaper to transport than wood.

These two measures could have a rapid and noticeable impact. To them could be added a more efficient utilization of the local resources, precluding wastage during felling and dressing.

This study deals with the wood-based energy requirements of Ouagadougou and the possibility of the fuelwood surplus of the Ivory Coast helping to meet them.

Only the consumption of energy for cooking is considered here. Wood is by far the main energy source for this activity, which covers also the brewing of "dodo" the local beer - and bread-baking. Electricity and bottled gas are used by only a very small part of the population owing to their cost and the investment required. In addition, gas has the reputation of being dangerous. Oil, which was being increasingly employed for cooking because it was easy to use, relatively low-priced and did not require too much investment, has been hit by steep increases in price. Hardly anyone now uses it for cooking, and it serves mainly for lighting. Solar energy and biogas have been introduced but are still at the strictly experimental stage, although a few installations are in operation. Obviously, they will have little impact on the consumption of wood products in the near future. The use of charcoal is relatively limited but is slowly increasing. This growth rate is faster than that of the population because charcoal has been adopted by certain ethnic groups and social strata whose relative importance is growing.

Consumption of energy

Surveys aimed at determining the fuel consumption of a given population often produce diverging results. The causes of these differences are well known but it is not easy to eliminate them. In the case of Ouagadougou, there have been numerous surveys, but some doubts remain as to the accuracy of their findings. However, it is possible to extract from all the existing data values that may be adopted as working hypotheses.

We shall assume, then, that in 1980 the population of Ouagadougou was 260000 and the daily consumption of fuelwood per inhabitant 1.2 kg (1 m^3 = 2 steres = 700 kg). Hence, the annual consumption of fuelwood per inhabitant is 438 kg and the total annual consumption of fuelwood 114000 tons. The daily supply required is 312 tons. The amount necessary for marring "dolo" about 15 percent - is included in these figures.

No recent survey has dealt with the consumption of charcoal. The last estimates date from 1974 or 1975 and give a figure of 905 tons/year for Ouagadougou. In 1978 the Investment Centre of the FAO/World Bank Programme adopted, in calculating the profitability of the projected forest plantations, a rate of growth in charcoal consumption of 9 percent per year. No new element makes it possible to either confirm or invalidate this figure, so it may be taken as it stands. Charcoal consumption in Ouagadougou in 1980 can therefore be estimated at about 1500 tons/year, or a per caput consumption of 5.77 kg/year. The equivalent in fuelwood of this charcoal is about 7500 tons/year, which should be added to the annual consumption of fuelwood.

Supplies

At present, supplies of wood come solely by road from the wooded savanna formations existing in the region. The wood is cut either during clearing for crop-growing or expressly for the processing of fuelwood for sale. In both cases, the work is done by the peasants and provides them with a by-no-means negligible addition to their income.

The distance to be covered to find wood is now 70-100 km along the main roads. Off these highways, a little wood is still to be found within a more reasonable distance but the difficulties of transport are then much greater. Light lorries (3.5-ton or more) are increasingly replacing

vans and donkey-drawn carts, which had in turn replaced donkeys, bicycles and human bearers. Carts now, in fact, take five or six days to transport about 450 kg of wood. The constant lengthening of the distances over which supplies have to travel is due to the disappearance of trees from an increasingly wide radius around the city; the latter's consumption greatly exceeds the production of the remaining stands that encircle it and the production is itself decreasing as the trees disappear.

If one accepts the figures mentioned in some reports, the standing volume of the intact natural stands in the Ouagadougou region is 20-25 m^3/hectare and annual production about 0.5-1 m^3/hectare, which represents a potential yield of 500-700 kg/ha/year. In these circumstances, to meet the present needs of Ouagadougou it would be necessary to fell 7000-8000 ha of intact stands each year, or to manage, according to the principle of sustained yield, a forest of 200000-300000 ha. These figures, although approximate, give an idea of the size of the problem. Applying the same kind of calculation to the wood-fuel plantations which, according to existing information, produce 2-3 tons/hectare/year, the city would need 30000-40000 ha of plantations in full production. However, there are only 5000-6000 ha of plantations around Ouagadougou, of which only 1500-2000 ha are about to come into production. It is difficult to know at what rate the projects under way will be implemented but they are greatly inferior to requirements. The increase in the population of Ouagadougou alone would call for the production of 30000 ha, to be planted *now*.

Since charcoal can be transported over longer distances, it can come from stands more remote and harder to reach. It does, however, represent a loss of energy that must be taken into consideration when wood is rare and precious. Charcoal-making can be justified only when there are surplus wood resources in regions too far away for economic transport.

Production and marketing

It is essentially the peasants who produce firewood, recovering it from their fields when there is a surplus over family needs or extracting it directly from nearby stands. Felling and dressing are done by means of the local axe which is not a very efficient tool. There is, therefore, wastage because the trunks are cut too high, the big trunks and branches are not logged and the chips from the felling and dressing are often left lying. The loss may represent 5-10 percent of the wood, but the abandoned trunks and large branches may represent a loss of 10-30 percent. This calls for study and more appropriate working methods and tools: two-man saws or bow-saws, sledgehammers and wedges, etc. These methods and tools could at least be used on sites being cleared for reforestation where they could serve as models.

The wood felled by the peasants is cut into lengths of 1 metre, split when necessary and possible, and carried to the side of the road or track where it is stacked to form the load of a cart or lorry. The wood is then bought in this form by a middleman who is often the transporter. The price paid is about F CFA 2-2.50/kg. Once transported, this wood is resold at F CFA 9-11.50 and more per kilogram, according to whether an entire load is delivered, it has been split or, finally, whether it is sold in small quantities. To these variations in price are added those caused by the rainy season, since this is the crop-growing season and the peasants no longer have the time to prepare the wood. There is thus a shortage on the market. It should also be noted that, traditionally, long lengths of wood are preferred, so short pieces have less value.

Charcoal is made in small pits which produce about 80-100 kg at each charge, every 24 hours in the best conditions. This charcoal, transported by bicycle, is sold in town in sacks of about 17 kg, at a price of F CFA 35/kg, to retailers who charge F CFA 60-65/kg for small piles. Prices are, moreover, rising constantly. The marketing of charcoal, as of wood, poses the problem of the profit margins that the retailers allow themselves. The Centre technique forestier tropical (CTFT) has carried out experiments and charcoal-making trials. Production

reached more than 3000 kg, for which the retailers offered F CFA 15/kg. The charcoal was sold to a hotel at F CFA 45/kg. The traditional charcoal maker does not buy the wood. He collects it himself and the taxes he pays are minimal. Investments are very low: a bicycle for transport, old metal sheets to cover the pits, a few tools and sacks. The producer price is some F CFA 10-12/kg, including the work of the charcoal-maker at the wage rate for manual labourers. During its trials with a Mark-V kiln, the CTFT obtained a cost price ex works of F CFA 25/kg. This price needs to be confirmed, since it was based on experimental charges and a very approximate estimate of certain factors.

FUELWOOD DESTINED FOR OUAGADOUGOU over long distances

Table 1. Wood energy: kWh produced in Upper Volta by 1 kg of wood or its equivalent in charcoal according to the yield of the stove

Type of stove	Heat efficiency	Useful per kg of wood or equivalent	
	Percent	kcal	kWh
Open stove	3	129	0.15
Average stove	5	215	0.25
Average stove	8	344	0.40
Kamper model	10	430	0.50
Earth, improved	28	1204	1.40
Charcoal, earthenware	28	437	0.50
Charcoal, improved	35	546	0.63

Table 2. Economics of different fuels: cost price of 1 kWh produced in Upper Volta from various fuels according to their heat yield

Fuel	Price [1]	Calorific value	Equivalent	Price [1] per kWh	Heat efficiency	Cost price [1] per kWh
	F CFA/kg	*kcal/kg*	*kWh/kg*	*F CFA/kg*	*Percent*	*F CFA/kg*
Wood	11.50	4300	4998	2301	3	76.80
					5	46.00
					8	28.75
					10	23.00
					26	8.85
Charcoal	65.00	7800	9048	7184	28	25.66
					35	20.52
Oil	105.50	12000	13920	7583	50	15.17
Bottled gas	480.00	12000	13920	34782	60	57.47
Electricity				110/kWh	76	144.75

[1] Prices charged In Ouagadougou, April 1980.

Table 3. Production of plantations for Ouagadougou (1981-90)

Year	Area under production [1] (1000 ha)	Production (1000 tons)
1981	2.0	5.0

1982	2.3	5.7
1983	3.5	8.8
1984	5.4	13.6
1985	6.5	16.4
1986	8.9	22.4
1987	11.4	28.4
1988	13.7	34.4
1989	16.1	40.2
1990	18.5	46.2

[1] Production would start at the age of 7 years.

Energy balance

The gross energy produced by a kilogram of very dry wood is 4300 kcal. This wood, used in a traditional stove with a heat efficiency of 5 percent, supplies 215 useful kcal and 215 x 0.00116 = 0.25 kWh. The same kilogram of wood will produce 0.2 kg of charcoal which can supply a gross energy of 0.2 x 7800 = 1560 kcal. This charcoal, used in a traditional earthenware stove with a yield of 28 percent, therefore supplies useful energy of 437 kcal and 437 x 0.00116 = 0.50 kWh (see Table 1). On the basis of an average annual consumption of 438 kg of wood used in a stove with a yield of 5 percent, the energy consumed is 109 kWh/person/year. If the wood is burnt in a stove with a yield of 10 percent, 219 kg of wood suffice to obtain the same energy. If to this we add the consumption of charcoal used in a stove with a yield of 28 percent, that is, 5.77 kg/person/year, the energy consumed per person per year amounts to 109 + 14.6 = 123.6 kWh. If charcoal is used instead of wood in a stove with a yield of 28 percent, the 109 kWh can be obtained with 43.6 kg of charcoal, the making of which has required 218 kg of wood.

In financial terms, these results give the following figures. To produce the 23.6 kWh necessary for food preparation, it is necessary to have: wood-burning stove, 5 percent yield, 467 kg at F CFA 11.50 - F CFA 5300; wood-burning stove, 10 percent yield, 234 kg at F CFA 11.50 - F CFA 2650; charcoal-burning stove, 49.4 kg at F CFA 65 - F CFA 3200.

Seeking efficiency

It may be objected that the yield of 28 percent is not always obtained with charcoal-burning stoves, but the traditional "three stones" ovens have a heat efficiency closer to 3 than 5 percent. Furthermore, the price adopted for wood is at half-wholesale while the price for charcoal is at small retail.

The most obvious conclusion is that efforts must concentrate on a more efficient use of wood, and that large-scale use of charcoal does not involve additional expense for the population. Earthenware charcoal-burning ovens are easy to make and reasonably priced, as are those made with old sheet metal. As things stand at present, the use of charcoal results in a lower consumption of wood at the outset. However, an important point was overlooked - the people's food habits, hence their cooking methods. This is by no means the least of the problems.

Table 4. Ten-year supply plan (1980-90) for Ouagadougou

Year	Theoretical consumption	Contribution from plantations	Deficit to be covered	Number of improved stoves to be built	Cumulative amount of wood saved	Production targets	Charcoal imports	Wood equivalent of charcoal	Amount production to be covered by natural

				annually					forests
	1000 t	*1000 t*		*1000 t*	*1000 t*	*1000 t*	*tons*	*1000 t*	*1000 t*
1980	121.5		121.5	500	0.8	120.7	-	-	120.7
1981	131.2	5.0	126.2	2000	4.0	122.2	1500	15.0	107.2
1982	141.7	5.7	136.0	3500	9.7	126.3	3000	30.0	96.3
1983	152.9	8.8	144.1	5000	18.0	126.1	3600	36.0	90.1
1984	165.2	13.6	151.6	7000	29.5	122.1	4800	48.0	74.1
1985	178.5	16.4	162.1	8500	43.5	118.6	6000	60.0	58.6
1986	192.7	22.4	170.3	9500	59.1	111.2	6000	60.0	51.2
1987	208.1	28.4	179.7	9500	74.7	105.0	6000	60.0	45.0
1988	224.7	34.4	190.3	8500	88.7	101.6	6000	60.0	41.6
1989	242.9	40.2	202.7	7000	100.2	102.5	6000	60.0	42.5
1990	261.2	46.2	215.0	5000	108.4	106.6	6000	60.0	46.6

Note: The theoretical consumption comprises that of fuelwood plus the equivalent in wood of the charcoal consumption. The overall theoretical consumption per Inhabitant is considered as stable.

Developments in energy requirements

At present, oil is still, theoretically, the cheapest fuel (see Table 2) but its abrupt price fluctuations and likely supply difficulties have led people to distrust it, and it is difficult to reverse acquired habits. Wood, therefore, remains and will remain for a long time the most preferred cooking fuel. Charcoal, however, can easily replace wood since it is convenient and clean and its price is competitive, even advantageous if one considers the caloric yield. It would gain much wider diffusion if small earthenware stoves were put on the market. Accordingly, we shall base our forecasts for the coming ten years on fuelwood and charcoal as energy sources, and assume that the consumption of wood or wood equivalent per person will not increase despite an estimated economic growth of 1.1 percent per year.

Starting with a population of 260000 inhabitants in 1980, and adopting the United Nations rate of growth estimated at 8 percent per year, the population of Ouagadougou will exceed 500000 before 1990. Taking the present consumption of wood and of the wood equivalent of charcoal - 467 kg/person/year - total consumption by then will be 261200 tons/year as against today's 121500 tons. The present reforestation programmes, however, are far from being able to meet these goals and, even if vigorously carried through and extended, will serve merely to ease the pressure.

Therefore, we are left with two possible measures applicable in a relatively short period of time: economizing on wood through the use of more efficient stoves, and procuring wood fuels from distant but abundant resources. Hence, the proposal to make charcoal in the Ivory Cost and transport it to the Ouagadougou market in order to fill in the gaps and help reverse the present trends. The respite thus gained would make it possible to reconstitute the tree cover, manage the forest resources and re-establish an ecological balance in the region.

Plantations

According to current information, the plantations intended to supply wood for Ouagadougou covered a total of 8970 ha at the end of 1979 but not all the information agrees. Present programmes provide for the plantation of an additional 2400 ha/year, at least up to 1983. These plantations should produce, under local conditions, an average of 7 stares/ha/year, or about 2.5 tons of fuelwood (see Table 3).

Use of improved stoves

Research work, started a few years ago, resulted in the designing of a stove made from earthenware bricks faced with stone, provided with a chimney and suited to the cooking habits of the local housewives. Several models exist and research is continuing. However, a German Forestry Mission has already started to promote these stoves and has taught a certain number of masons how to build them in a few hours. More than 500 stoves have been built so far and they seem to have won acceptance from the women who use them. They sell at about F CFA 3000 for the simplest model. The trials show that a fuelwood saving of about 50 percent is possible when they are correctly used. This requires a certain amount of practice. Obviously, improvements are expected to make the stove easier to use, sturdier and more heat-efficient.

To evaluate the effect that the adoption of improved stoves could have on consumption and to determine the number that would have to be built each year to obtain the desired effect, we shall take as a basis a fuel saving of 50 percent and a stove for an average family of 7.5 people. A family consumes at present 7.5 x 438 = 3285 kg of wood. The adoption of an improved stove could reduce this consumption to 1643 kg of wood per year. The construction of 1000 stoves would, therefore, result in a saving of 1643 tons of fuelwood per year. Bearing in mind the heat efficiency of charcoal cookers, a ton of charcoal equals 10 tons of wood. Thus, the introduction of 1000 tons of charcoal on the Ouagadougou market would result in a saving of 10000 tons of locally produced wood.

Table 4 shows how a programme for the construction of improved stoves, combined with the creation of plantation forests and the import of charcoal from distant resources, could relieve the pressure on natural forests, lowering their contribution to Ouagadougou's supplies from the present 121500 tons to 46500 tons in 1990, while still coping with the increase in population. The number of stoves needed and the amount of charcoal to be imported can be adjusted according to the effect desired and the results obtained. The table shows that reasonable imports of charcoal could decisively lower the quantity of wood removed from natural forests to a level compatible with the forests' survival and equilibrium.

In the second part of our report we shall discuss the import source of charcoal as well as the economic feasibility of its production and transport.

WEST AFRICANS PREPARING TO HAVE E. THEIR NOON MEAL the fuel is at least as important as the food

Part II: Fuelwood from the Ivory Coast

Only fuelwood in easily accessible areas at acceptable distances from the prospective consumption centres is considered. This is unmarketable surplus wood under present conditions. It is usually burnt or abandoned, according to whether the ground has to be cleared or not.

The Ivory Coast has a long-term reforestation programme aiming at a minimum of 4000-6000 ha/year. This reforestation is carried out by a State company, SODEFOR, which manages and is accountable for all the plantations. At present, the programme is partly financed by the World Bank, and is executed in blocks of some 1000 ha in four reserved forests. During the next stage, the plantations will be extended to two other forest reserves. Once deforestation is completed, it is planned to recuperate an average of 50 m^3 of logs per ha. After this operation, a minimum of 60 m^3/ha of firewood will remain, which may be gathered. This represents at least 100 stares/ha. Some large logs and stumps are left lying because it is too difficult to dress them. Clearing for growing industrial crops such as oil palms, hevea, fruit, coffee or cacao is, in principle, to end around 1985 and is limited at present to 100000 ha/year.

Considering the types of forest where such clearings will take place, an average of 50 steres is expected to become available from each hectare. This represents 5000000 et/year up to 1985 at least, but certainly 100.0000 et/year will be easily obtainable. More than 35000 ha have been reforested to date in the Ivory Coast. SODEFOR takes over when its possibilities permit. At present, it manages more than 20000 ha and must carry out, every year, thinnings over 2500-3000 ha. The programme of work envisages an average production of 40 steres of firewood per hectare. A minimum of 100000 steres are, therefore, available each year. This fuelwood has at present no outlet and this holds up the thinning programmes.

In the region of Bouaké alone - apart from the thinnings already mentioned - it should be possible to gather 60000-80000 steres from already mature teak and cassia plantation without prejudicing local supplies. In this same region of Bouaké, it has been estimated that about 590000 m^3 of wood, not used at present, could be recuperated from fallow land.

Waste from wood industries now reaches 300000-400000 m^3 per year but three quarters is already used, either in boilers, or for making charcoal or particle board, or as firewood for the people living near the factories. Since the Ivory Coast's policy is to become self-sufficient as regards energy, it advocates the full use of such waste. Therefore, this resource is not reliable as it may dry up rapidly.

This brief but far from exhaustive review shows that there are very large amounts of unused wood, either burnt or abandoned, available in the Ivory Coast. Of the amounts quoted, at least 1000000 tons are relatively accessible.

Charcoal-making and cost price

The only economic way of channelling this resource toward potential consumption sites is to turn it into charcoal on the spot. Whatever plans the Ivory Coast government agencies may have for using the energy contained in wood waste, the amount available leaves no doubt about the possibility of supplying external markets. The quantities mentioned above, representing only a part of the available supply, once carbonized in metal or brick kilns or even in pits, could guarantee an annual production of 125000-150000 tons of charcoal. Although the yield in charcoal and byproducts is much greater when using retorts, these are not taken into consideration because of the investments and transport of wood entailed.

In the light of experience acquired and results already obtained, steel kilns of the Mark V type or similar, used in batteries of four, which permit good productivity while ensuring great flexibility in utilization, are chosen. Batteries of two kilns give a lower, though still acceptable, financial yield. Larger batteries may be more profitable but require more organization. It is better to group several relatively independent units. The standard unit of four Mark V-type kilns is operated by a team of five men. The kilns have a capacity of 6 steres each. The necessary tools consist of a chainsaw, axes, machetes, bow-saws, log turners, lugs and scratches. To these might be added a Tirfor or similar apparatus.

The parameters selected for the calculations are as follows. Each kiln is amortized in three years, the present purchase price being estimated at F CFA 525000. It is made locally and is of good quality. It completes 10 carbonization cycles per month. Estimated output of each cycle is 500 kg of charcoal obtained from 6 steres of dry wood. The chain-saw must be of sufficiently robust make and of a size adapted to the wood selected. The present purchase price is F CFA 210000 and the amortization period is 1.5 years. The cost of the tools is estimated at F CFA 52000 and the amortization period, one year. Interest on the money invested is calculated at 10 percent per year, which is the same rate allowed at present in the Ivory Coast to small firms for amortization. The teams servicing the kilns collect the wood already felled, dress it, transport it to the kiln and pack the product into sacks. They must be experienced and have received thorough training. They earn the wages of a qualified worker

at the level corresponding to the responsibilities they have to assume. Average wages are F CFA 26200 per month, plus social welfare charges amounting to 21 percent of this salary.

Investments amount to: four kilns at F CFA 525000 each, or F CFA 2100000; one chain-saw at F CFA 210000; tools, F CFA 52000 - a total of F CFA 362000. Annual interest on the average investments amounts to: for four kilns, F CFA 46667; for one chain-saw, F CFA 11667; for tools, F CFA 5200 - a total of F CFA 63534. The battery of four kilos will complete 40 cycles per month, using 240 steres; it will produce 20 tons of charcoal per month, hence 240 tons per year. The wood, before dressing and collection, costs F CFA 80/st. This is the price paid by charcoal-makers in the region of Abidjan. Purchase of wood therefore represents 240 x 12 x 80 = F CFA 230000/year. Salaries and social insurance amount to 26200 x 5 x 12 x 1.21 = F CFA 1902120/year. Forestry taxes and the licence have been calculated at the 1976 rate, no more recent data being available. They amount to F CFA 1/kg and F CFA 18000/year respectively. This represents F CFA 258000/year (see Table 5).

Table 5. Cost price for an annual production of 240 tons of charcoal in the Ivory Cost

	F CFA	
1) Amortization: Kilns	700000	
Chain-saw	140000	
Tools	52000	
		892000
2) Interest: Kilns	46667	
Chain-saw	11667	
Tools	5200	
		63534
3) Purchase of wood	230400	
4) Salaries and social insurance	1902120	
5) Forestry taxes	240000	
6) Licence	18000	
7) Overall coats 20 percent on 3) and 4)	426504	
		2817024
Total.....	3772558	

or F CFA 15700/ton at the kiln, without profit. Allowing a profit of 30 percent to the producer, the price Is F CFA 20400/ton, without packing. However, bagging Is the responsibility of the charcoal-making team.

Table 6. Cost price of charcoal from the Ivory Coast delivered to Ouagadougou

	Lower Ivory Coast (Basse Côte)	**Bouaké**	
		F CFA/bag	
Plastic bag (25-kg)	Road + rail	1028.75	980.00
	Road	1345.50	1211.75
Paper beg (10-kg)	Road + rail	386.50	367.00
	Road	513.00	459.70
Jute bag (25-kg)	Road + rail	938.75	890.00
	Road	1255.50	1121.75

Note: These are the cost prices of charcoal from Basse Côte and Bouaké calculated for an average distance.

Transport and costs

The study of the cost price of transport is based on the following data. The destination point is Ouagadougou in Upper Volta, and two areas of charcoal production have been considered: the Basse Côte (the southern part of the Ivory Coast) and the region of Bouaké. Six departure points have been chosen in the Basse Côte, corresponding to the various reforestation and thinning sites of SODEFOR. These are the forest reserves of Mopri near Tiassalé, Irobo in the Rubino region, Téné and Sangoué near Oumé, Bouaflé on the Bouaflé-Daloa route, and Séguié between Agboville and Tiassalé. In the region of Bouaké, we have selected the area lying within a radius of 60 km around the town.

Two transport methods have been explored. The first is by road to the nearest railway station, then transfer to truck, transport by rail and unloading onto lorry at the station of Ouagadougou. The second involves transport by road, without transshipment, from the production site to Ouagadougou and unloading into a warehouse. The distances from the production sites to the nearest railway stations range from 15 to 220 km. Transport by rail covers distances ranging from 1070 km for Agboville to 830 km for Bouaké. As to transport entirely by road, distances vary from 820 to 1185 km. The schedule of charges selected is that fixed by the Ministry of Transport; road transport for various goods, maximum price authorized: F CFA 26/ton/km. This rate is subject to discussion according to the possibilities of return loads or the establishment of contracts. It applies in general to loads of 20-25 tons. Since charcoal is bulky, it would be advantageous to use custom-built bodies. If transport is to be organized efficiently, lorries with a useful charge of 10 tons, with a trailer also of 10 tons, with custom-built bodies, are preferable.

Rail transport rates for charcoal, coke and fuelwood, minimum load 18 tons per truck: Rubino-Ouagadougou, F CFA 13140/ton; Agboville-Ouagadougou, F CFA 13327/ton; Dimbokro-Ouagadougou, F CFA 12268/ton; Bouaké-Ouagadougou, F CFA 11079/ton. A tax of F CFA 245/ton is also levied at the border. There are trucks of 28, 30, 35 and 40 tons. The costs of loading, transshipment and unloading are estimated at F CFA 150/ton/operation.

The application of these rates to the distances considered, according to the method of transport adopted, gives the following figures. *Road + rail*: prices range from F CFA 13770/ton to F CFA 17060/ton, with an average of F CFA 15310/ton. Upkeep represents F CFA 450/ton, giving an overall average price of F CFA 15760/ton. *Road*: prices range from F CFA 26200/ton to F CFA 30840/ton, with an average of F CFA 28100/ton. Upkeep amounts to F CFA 300/ton, giving an overall average price of F CFA 28400/ton.

Transport in bulk presents great disadvantages and is not easy to arrange for the quantities produced by small units. Also, custom-built vehicles must be provided. Transshipment is difficult and entails considerable loss. The only packaging possible, therefore, is bags. If the bags are non-returnable, the cost price is high, but return of the empties always poses problems.

Three types of bags have been studied. *Jute sacks bought second-hand*: used sacks that have already served for the importation of goods. They can be found at Abidjan at a unit price of F CFA 35. It remains to be seen whether they can be obtained if they are used as non-returnable packaging. A sack holds about 25 kg of charcoal. *Plastic bags*: manufactured by various factories in Abidjan. The prices indicated are of the order of F CFA 125/bag (74 x 120 cm and 1/10th mm thick). A bag holds about 25 kg. It can be sealed with a welder. *Paper bags*: cost price of bags for cement is about F CFA 20 per unit in Abidjan. This type of bag holds 10 kg of charcoal.

Table 7. Charcoal in the Ivory Coast: summary cost analysis

Cost of production, unpacked [1]	Cost after profit, unpacked [2]	Cost with non-returnable packaging [3]	Cost delivered at Ouagadougou, road + rail [4]	Cost delivered at Ouagadougou, road [5]	Margin [6]
F CFA/kg					
Production in Lower Ivory Coast (Basse Côte)					
15.70	20.40	22.40	37.71	-	27.29
15.70	20.40	22.40	-	50.80	14.20
Production in Bouaké region					
15.70	20.40	22.40	35.73	-	29.27
15.70	20.40	22.40	-	45.45	18.55

[1] Includes amortization and Interest. - [2] Profit of 30 percent on production cost. - [3] The prices shown are those for charcoal packed In 10-kg paper bags. For packing In 25-kg jute bags, subtract F CFA 0.60/kg. For packing in plastic bags, add F CFA 3/kg. In all cases, the calculation applies to non-returnable bags. - [4] The cost of transport is calculated on the basis of average rates: F CFA 15760/ton from Basse Côte and F CFA 13384/ton from Bouaké region for the road + rail combination. - [5] Average charge for transport entirely by lorry: F CFA 28400/ton from Basse Côte. F CFA 23050/ton from Bouaké region. - [6] The margin represents the difference between the cost price delivered at the Ouagadougou storehouse or to lorry at the station, and the retail selling price, which at present Is F CFA 65/kg. This margin should In principle cover the costs of marketing.

Cost price of charcoal delivered at Ouagadougou

These cost prices for charcoal delivered at the destination point are based on the use of non-returnable bags.

The cost price for charcoal delivered at Ouagadougou - either at a warehouse or to a lorry at the station - varies according to the type of packaging and the means of transport adopted (see Table 6). The road-rail solution is undoubtedly the most advantageous, but there may be a problem of availability of trucks. Similarly, jute sacks appear to be the most economic type of packaging, but there may be supply difficulties. Paper bags are easily found and can be produced in different sizes: 5-, 10- and 20-kg.

Overall assessment

Current retail prices on the Ouagadougou market are F CFA 65/kg for charcoal and F CFA 11.50-13/kg for fuelwood. Comparison of these prices with the cost price for charcoal from the Ivory Coast delivered at Ouagadougou shows that the operation is feasible (see Table 7). Production would be by small units, but the entire operation would have to be rigorously organized. The report makes no suggestions about the choice of formula: cooperative, State company or private enterprise.

Transport by rail entails regular availability of trucks; 6000 tons/year represent one loaded wagon per day. Transport by road is subject to competition, to seasonal variations in the availability of freight, and to difficulties in using the vehicles fully loaded. The creation of a special transport unit would ensure regular supplies at a more advantageous price. These 6000 tons/year correspond to about one lorry per day, which would require a fleet of 4 to 7 vehicles. The margins shown in Table 7 are relatively large but probably not enough to afford the use of existing commercial channels; distribution channels, therefore, would have to be

modified.

The relatively large influx of charcoal to replace fuelwood on the Ouagadougou market will also provoke some changes in the population's habits; this is why more research as well as more efforts at education are necessary, to facilitate the shift from wood to charcoal for cooking. Making charcoal in the Ivory Coast to supply Ouagadougou may create problems in the field of investments or in setting up companies - such problems must be clearly defined and solved in advance. The briquetting of charcoal, preferable to other less advantageous alternatives (densification), offers good possibilities because it uses a considerable part of the waste from charcoal-making such as dust and the debris that accumulate while it is being handled. The import of charcoal from regions rich in forest resources is an acceptable solution help considerably to modify present trends while being very flexible.

A study of the surplus resources of fuelwood in the Ivory Coast shows that the amounts available for the preparation of charcoal are much greater than probable requirements, even in the long term. The calculations of the cost price of charcoal-making and the costs of transport show that charcoal could reach Ouagadougou at a price which would make the operation economically viable. The making of charcoal as well as its transport and marketing will have to be well organized. Whether these operations are handled by a government body, a private company or cooperatives, they will have to be controlled, so as not to become monopolies. These things should be clearly understood. Independently of energy savings, of the importation of charcoal and of the utilization and extension of plantations, there must be an improvement in the utilization of natural stands to ensure that as little wood as possible is wasted during logging. This improvement could be achieved through better methods, more appropriate tools, and training the work force. Finally, it is essential to manage the reserved or protected forests in order to make them play their part in wood production and to broadly expand their potential.

A judicious combination of these various measures - in particular, saving fuel, importing charcoal and creating more plantations - could lead within ten years to a considerable decrease in the demands made on the natural forest, thus enabling it to regenerate itself. According to the suggestions put forward in this study, it would be possible to reduce the pressure on natural forests by lowering the demand for fuelwood from today's 114000 tons to 45000 or 50000 tons within ten years, and yet satisfy the needs of a population twice as large.

Obviously, what could be done for Ouagadougou could also be done for other towns and villages.

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