Report No. 5730-BUR

Burkina: Issues and Options in the Energy Sector

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BURKINA

ISSUES AND OPTIONS IN THE ENERGY SECTOR

JANUARY 1986

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ABSTRACT

Burkina (formerly Upper Volta) is a landlocked country in the Sahel belt of West Africa. Agriculture and livestock are the main economic activities, and around 90% of the population lives in rural areas. Population pressure on agricultural and fuelwood resources is most acute in the central Mossi plateau, an area which includes the capital city, Ouagadougou. The trend towards desertification in this area could be slowed down by a combination of (a) improved woodstoves; (b) transport of fuelwood from surplus areas; (c) natural forest management and rural forestry; and (d) substitution by kerosene. However, the only long-term solution is an acceleration of the present migratory flows towards the south and west. Burkina imports petroleum products from the Ivory Coast and from other sources via Togo. The Government should take advantage of this flexibility to ensure that all products are purchased at least cost. Electricity generation is based on imported petroleum and on agro-industrial residues. In the longer term there is scope for developing hydro sites for both irrigation and electricity generation, possibly in conjunction with interconnection with the larger electricity systems in the region. The main requirement for successful energy planning in Burkina is donor support for the Government in a massive effort involving institutional strengthening, R&D and pre-investment appraisal of fuelwood-related projects, both to increase supply and evaluate fuelwood substitutes. This is essential to ensure that increasing amounts of concessionary resources can be absorbed in fuelwood-related investments over the coming decade.

CURRENCY EQUIVALENTS

US$1.00 = CFA.Franc 450

This was the exchange rate at the time of the mission (September, 1984). It is the rate used in the report unless otherwise stated, in which case the rates are as follows:

1978	US$1.00 = 225.6 CFA.F
1979	US$1.00 = 212.7 CFA.F
1980	US$1.00 = 211.3 CFA.F
1981	US$1.00 = 271.7 CFA.F
1982	US$1.00 = 327.6 CFA.F
1983	US$1.00 = 345.0 CFA.F

CONVERSION FACTORS

	m^3/toe	ton/toe	kcal/kg
Butane	1.97	0.91	10,800
Gasoline	1.32	0.97	10,500
Jet fuel	1.24	0.99	10,300
Kerosene	1.24	0.99	10,300
Gas oil	1.19	1.00	10,200
DDO (Industrial diesel oil)	1.11	1.00	10,200
Fuel oil	1.09	1.02	10,000
Fuelwood			4,000
Charcoal			7,000
Straw			2,500
Bagasse			3,500
Agroindustrial Residues			2,000-5,000

1 tonne of crude oil equivalent (toe) = 10.2 million kcal
1 m^3 of fuelwood = 2 steres = 800 kgs.
1 kWh = 223 gr of fuel oil
1 kWh = 250 gr of diesel oil
1 GWh = 84.3 toe in net value.

ABBREVIATIONS

GWh	gigawatt hour
ha	hectare
kg	kilogram
km	kilometer
kWh	kilowatt hour
l	liter
m^3	cubic meter
MW	megawatt
toe	metric tonne oil equivalent

ACRONYMS

BUMIGEB	Bureau des Mines et de la Géologie du Burkina (Mining Directorate)
DAFR	Direction de l'Aménagement Forestier et du Reboisement (Forestry Services)
GOB	Government of Burkina
IBE	Institut Burkinabè de l'Energie (National Energy Institute)
MET	Ministère de l'Environnement et du Tourisme (Ministry of Forestry and Tourism)
MPDP	Ministère de la Planification et du Développement Populaire (Planning Ministry)
SEBHY	Société d'Entreposage Burkinabè d'Hydrocarbures (Petroleum Storage Company)
SONABEL	Société Nationale Burkinabè d'Electricité (Power Utility)

This report is based on joint work with Burkina officials in September 1984 and on discussion of the draft report with the Government in October 1985. The main contributors to the report were: D. Craig (mission leader), U. Weimper (economist), M. Muller (researcher), G. Madon (fuelwood/household energy consultant), E. Ferguson (improved cookstoves consultant), P. DuBrule (petroleum consultant), M. Petcu (electricity consultant), P. Duiker and J. Trouvé (organization and training, International Labour Organisation). The I.L.O. financed the participation of Mr. Trouvé. J. Gorse (forester) supervised the work on fuelwood. D. Craig and M. Muller wrote the report.

TABLE OF CONTENTS

ANNEXES

MAPS

OVERVIEW

Energy Strategy

1. After a period of satisfactory economic growth during the 1970s (1.5% per capita per year), the Burkina economy has encountered increasingly difficult conditions since 1980. Debt service payments reached 20% of current budget expenditure in 1984; workers' remittances and aid disbursement have slowed down; and a renewed drought has reduced grain output and hit the livestock sector especially hard. The Government is in the process of reviewing policy and investment options in key economic sectors in order to prepare a 1986-91 Plan which will promote economic recovery and sustained growth in the longer term.

2. Agriculture is the lifeblood of the Burkina economy. This sector directly accounts for 80-90% of employment and exports and around 40% of GDP. Burkina's agricultural resource base is increasingly threatened by erosion and the loss of soil fertility caused by the use of fuelwood, crop residues and dung as household fuels. The most important part of the Government's energy strategy will be the measures taken to relieve the pressure of household energy on the agricultural sector.

3. Burkina's principal energy requirement is for household cooking. This accounted for nearly 90% of primary energy consumption in 1983 (Annex 1: 1983 energy balance). The other main requirements are: (a) liquid fuels for road transport and, to a lesser extent, for rail; and (b) fuels for industry and for electricity generation. At present there is no alternative to petroleum products in the transport sector other than low-percentage blends of ethanol in gasoline. In industry, bagasse and other agro-industrial residues are already the main source of energy for both process heat and electricity generation. In the public supply system, electricity generation is totally oil-fired.

4. Burkina has a very limited resource base to meet these needs. Domestic biomass (fuelwood and agricultural residues) cannot continue to satisfy the requirements of household cooking. Agro-industrial residues have some potential to further reduce industrial, consumption of oil, by more efficient use of bagasse in the sugar industry, for example. Hydro resources are limited; of the two multi-purpose hydro schemes which could help to reduce the consumption of fuel oil for electricity generation in Ouagadougou, one is already under development. Since there is no serious prospect of discovering exploitable reserves of fossil fuels or petroleum in the medium term, more efficient use of fuelwood, agro-industrial residues and imported petroleum products will remain the key elements of Burkina's energy strategy for the foreseeable future.

5. Burkina is a member of the West African Monetary Union (WAMU, the CFA franc zone). Membership of the union means that the balance of payments is not an absolute constraint as it is in many other African countries. However, WAMU membership also imposes strict limits on the

size of the Government's budget; this in turn means that nearly all investment expenditure is externally financed (88% in 1984) and that this expenditure has to be managed by a small and efficient corps of public servants. A su.cessful energy strategy therefore requires clear decisions on how best to use: (a) a limited volume of managerial talent and manpower in the public sector; (b) a limited supply of concessionary investment resources in the energy sector; and (c) available foreign exchange resources, particularly for the purchase of petroleum products.

6. The mission proposes the following guidelines for making these decisions:

(a) Wherever possible, the Government should use pricing and the legal environment to ensure that individuals, companies and other non-Government entities take the main responsibility for investing in efficient energy systems and managing them. This applies to manufacturing and marketing of improved woodstoves; management of natural forest cover and growing of trees; import, storage and distribution of petroleum products; and, in some circumstances, generation of electricity for the public supply system.

(b) Within the energy sector, allocation of staff and their training should be focused on increasing Burkina's ability to identify, evaluate and implement projects which relieve the pressure of desertification.

(c) Burkina's energy sector investment strategy should move away from the present emphasis on maximizing the medium term drawdown of concessionary resources in readily identified projects (e.g. in the electricity subsector); the emphasis should be redirected towards preparing for investments in agriculture/household energy. This means substantial pre-investment work with the support of technical assistance.

(d) Energy projects should be directed at achieving high economic rates of return rather than at saving foreign exchange at low economic rates of return. There needs to be a small group of public servants (energy planners) whose task it is to evaluate the economic costs and benefits of proposed energy projects.

(e) Petroleum product imports should be increased in all instances where this is the most economic option. The most likely cases are kerosene, as a fuelwood substitute, and fuel oil, as an alternative to hydro investments for electricity generation. The emphasis should be on reducing the per-unit cost of petroleum products (by lowering the costs of procurement and transport) and on increasing the efficiency of their use.

7. On the basis of these guidelines the mission has identified a short-list of top priority activities requiring the Government's immediate attention.

Immediate Priorities

8. As part of the next five year Plan, the Government envisages a significant reinforcement of its improved woodstove dissemination program. This activity is of the highest priority. Stove promotion should concentrate on the rural areas of the Mossi plateau and on three urban areas: Ouagadougou, Koudougou and Ouahigouya. Government resources should be allocated between the "improved three stone" and "Ouaga metal" stoves on the basis of cost-effectiveness. The present channels for craft production and retailing of unimproved metal woodstoves should be encouraged to add the "Ouaga metal" stove to their range. There should be an evaluation of the scope for marketing a kerosene stove which is both more efficient and adapted to local cooking requirements. This should then be used as the basis for a demonstration project to promote maximum penetration of kerosene stoves in urban areas (para. 2.65-2.90).

9. The recent effort to increase city-gate collection of fuelwood taxes should be reinforced and the new licensing system should be monitored to ensure that it achieves its objectives, i.e., to direct commercial cutting by independent loggers as much as possible to specific exploitation zones. Permanently-managed logging areas should be developed in fuelwood-surplus areas to relieve pressure on the Mossi plateau. The Government should vigorously pursue its program of forest protection, but with increasing management responsibility for villagers. Individual/community multi-purpose tree planting should be promoted through a more extensive national network of tree nurseries (para. 2.37-2.52).

10. The Government will have to give serious consideration to promoting accelerated migration from the most densely-populated parts of the Mossi plateau towards wood-surplus areas (para. 2.115).

11. Arrangements for importing, transporting and storing petroleum products should be reviewed. Under the present market conditions it is probable that competitive procurement terms could be negotiated with the SIR refinery in Abidjan. Preparations for such negotiations should begin immediately. The Government should also request access to the Ivory Coast's maritime petroleum receiving facilities in the event that not all products can be competitively purchased at SIR. At the same time, Burkina should continue to import a small proportion of its requirements through other ports and in particular through the proposed Togolese storage facility (STH) in Lomé (para 3.35-3.43).

12. Regardless of the outcome of these arrangements the Government should act vigorously to maximize the use of the RAN railway for transporting petroleum products from Abidjan to Burkina and to improve the quality of service on the RAN (para. 3.44-3.53).

13. The Government should review its methods of intervention in petroleum subsector. Direct intervention by the Government should be minimized in favour of more extensive use of the private sector; a

possible exception is where prices are set by government-to-government negotiations, for example with the Ivory Coast or with Algeria (para. 5.29).

14. There should be an immediate review of the SOPAL project to produce ethanol as a gasoline extender. The economic costs and transfer prices of the inputs (molasses, steam and electricity) should be identified as part of an energy audit of the SOSU-BF sugar complex. The Government should check that it is economically worthwhile to commission and operate the plant under these conditions. The arrangements with the oil companies for transport, storage, blending and distribution should then be established for both investment and operating requirements (para. 3.32-3.34).

15. The electricity demand forecasts underlying SONABEL's supply planning should be revised downwards. The following levels are indicative of likely demand in 1995: (a) 149-173 GWh/year (around 42 MW) for Ouagadougou/Koudougou, and (b) 53-60 GWh/year (around 13 MW) for Bobo-Dioulasso/Banfora (para. 4.75-4.81).

16. For supply to Ouagadougou, the existing fuel oil plant (Ouaga 2) should be restored to normal availability as soon as possible. Once the Kompienga hydro scheme is commissioned, the next increment of capacity will be needed by 1994. For Bobo-Dioulasso, new fuel oil fired diesels are scheduled to meet the need for new capacity in 1986 (para. 4.82-4.95).

17. The electricity utility (SONABEL) should review its system expansion plans for Ouagadougou to take account of the possible commissioning of the Bagré multi-purpose hydro project. The viability of interconnection with Ghana should be compared with further thermal development; the best timing of these projects should then be established — as from 1994 (without Bagré) or as from 1997 (with Bagré). The decision to proceed with the Bagré project depends on factors which are external to the electricity subsector, since electricity generation by itself only accounts for a minor part of the economic benefits required (para. 4.82-4.85).

Policy Measures

18. The mission has identified a number of policy measures which are needed either in support of the priority actions listed above or to create a suitable framework for longer term energy planning. The measures cover energy sector organization (private and public), manpower and technical training, pricing and financial management.

19. The urban fuelwood supply chain is now regulated by a system of licenses and price control on cutting, transport and sales. The system has only recently been put into effect and the Government does not exclude the possibility that it could be improved. One of the possibilities to be investigated would be (a) to reduce the scope of the

licensing system, (b) to further increase fuelwood taxes, and (c) to eliminate price control on retail fuelwood sales (para. 2.43).

20. The Government should ensure that the fabrication and marketing of "Ouaga metal" improved woodstoves remains as competitive as possible. At present, large numbers of craft metalworkers produce a scrap-metal stove of low combustion efficiency. These are then sold as a normal retail item. The Government should take advantage of this reservoir of skills and distribution networks to launch the new improved cookstove models (para. 2.82-2.88).

21. The Government should investigate ways of using the resources of private companies to manage the petroleum subsector — for example by means of competitive tendering, joint venture companies and management contracts. The Government could arrange for the management of strategic stocks (to average around 45 days' consumption) by the oil companies, under price control provisions designed to give a reasonable rate of return on working capital (para. 3.54-3.58).

22. In order to encourage private generation of electricity for public supply, the Government should: (a) define SONABEL's marginal costs as a basis for establishing the tariffs at which SONABEL will purchase privately generated electricity in each of the main centers; (b) make legal provision for future private sector sales in centers not currently served by SONABEL (para. 4.69-4.70).

23. In the public sector, energy planning could be improved by a number of minor organizational measures: (a) A small energy planning unit should be created within the Ministry of Planning. (b) Fuelwood supply-related activities should be coordinated through an interdepartmental working group which would include Environment & Tourism, Agriculture & Livestock and other departments working in social and rural development; within the forestry service a multi-disciplinary planning and project monitoring group is needed. (c) There should be one government agency responsible for overseeing oil company implementation of a national petroleum procurement, transport and stockpiling policy. (d) A single organization should be responsible for implementation of all major hydro projects (para. 5.22-5.25).

24. Implementation of the proposed household energy strategy requires a major reallocation of manpower in related agencies: (a) Additional staff should be assigned to lower level positions in the forestry service. A higher proportion of staff at all levels should be assigned to work on fuelwood-deficit regions. At the same time a higher proportion of forestry staff should be trained in extension methods and assigned to field positions. This should be backed up by a program of training agricultural extension workers to work in natural forest management and rural forestry with the technical support of foresters. (b) IBE staff and work priorities should be reoriented to support a large-scale improved cookstove program for both wood and kerosene stoves (para. 5.32-5.34).

25. For the other components of the proposed energy strategy, there are several manpower and technical training requirements: (a) A small nucleus of staff should be trained for the role of overseeing petroleum procurement arrangements and for implementing an improved system of petroleum price control. (b) The SONABEL training center should extend the range of staff categories covered by its programs. (c) The Government's architectural and building services personnel should be trained in the selection and operation of airconditioning systems (para. 5.35-5.36).

26. In addition to the proposed increase in woodfuel taxes, pricing and financial management could be improved in the other energy subsectors: (a) The present LPG pricing distortions should be eliminated either by removing LPG from price control or by revising the official price structures to allow full cost recovery on both LPG and LPG bottles. Petroleum transporters should be encouraged to use rail from Abidjan to Burkina by an incentive in the official price structures. Petroleum price control mechanisms should be improved; the Government should also reduce the extent of "earmarking" and establish greater budgetary control over petroleum tax revenues. (b) Low voltage electricity tariffs should be simplified. The structure of medium voltage tariffs should be revised to more accurately reflect SONABEL's peak and off-peak costs of generation. The present system of uniform national tariffs should be abandoned as soon as the smaller centers account for a significant proportion of total electricity sales (para. 5.41-5.44).

Investment Requirements

27. Gross fixed investment in Burkina was expected to be around 60 billion CFA.F in 1984. Public investment will account for approximately 90% of the total and an estimated 93% of public investment will be financed by donors. On the assumption that the annual growth rate of total fixed public investment will lie somewhere in the range from zero to 3.5%, total public investment resources available over the next decade will be between 600 and 700 billion CFA.F in 1984 terms. It is estimated that the energy sector (including forestry) has traditionally absorbed 4-6% of externally-financed investment; if this share were maintained the energy sector would have access to 24 to 42 billion CFA.F of investment resources over the coming decade (para. 5.59-5.64).

28. The mission has judged it feasible to treble Burkina's capacity to absorb new fuelwood-related investments over the coming decade compared with the previous decade. This investment program would have to include large components aimed at strengthening the management, planning and research capabilities of the forestry service in particular. This rate of investment implies a total of at least 40 billion CFA.F in the period 1986-1995. The mission has designed a "minimum" investment program of both supply and demand-related projects to fit within this envelope (para. 2.105-2.112).

29. The actions proposed to improve fuelwood supply are:

(a) Improved management of village forests in selected areas of the Mossi plateau; 975,000 ha, or 25% of the natural forest cover in the provinces concerned, for a total cost of about 6.6 billion CFA.F.

(b) Improved exploitation of bush fallows; 2,350,000 ha, or 50% of the bush fallow area in the provinces concerned, for a total cost of about 9.4 billion CFA.F.

(c) Establishment of permanent logging sites on 300,000 ha in the wood-surplus areas in the South and East; total cost around 22.5 billion CFA.F.

(d) Development of mini-nurseries to allow each family to plant two trees per year; with a 50% survival rate, 1.4 million trees (2,800 ha-equivalent) could be planted in each of five woodfuel-deficit zones by 1995; total cost around 0.5 billion CFA.F.

30. The actions proposed to restrain fuelwood demand are:

(a) Large scale marketing of improved woodstoves; 50% penetration in urban areas and 30% penetration in rural areas by 1995; 500,000 stoves in use by 1995 and 800,000 stoves disseminated over a ten year period; total cost of government support for this program should be less than 1 billion CFA.F over the decade to 1995.

(b) Promotion of kerosene as a fuelwood substitute in middle to high income households; 15% penetration in urban areas and 10% penetration in semi-urban areas; 140,000 stoves marketed over a ten year period; total cost of government support for this program could be 0.1-0.2 billion CFA.F over the decade to 1995; additional kerosene imports in 1995 would amount to 12,000 toe or 7% of total "base case" petroleum imports in that year.

31. In the absence of these projects the national fuelwood deficit will rise to around 1.5 million cu.m./year by 1995, with the deficit being concentrated in the heavily-populated Mossi plateau. At a cost of around 40 billion CFA.F over the decade to 1995, the wood supply management projects proposed by the mission would make a significant contribution to maintaining Burkina's agricultural resource base and would at the same time reduce the fuelwood deficit by around 0.2 million cu.m./year by 1995. For a further 1 billion CFA.F of government support over ten years, the fuel conservation and substitution measures proposed by the mission could result in fuelwood savings of 0.2-0.3 million cu.m./year through the introduction of improved woodstoves and a further 0.1-0.2 million cu.m./year through switching to kerosene. The savings from introducing of improved woodstoves are highly uncertain; they depend on the mix mudstoves (10-20% efficiency) and metal-stoves (25-30%

efficiency) and on the extent to which conservation is reinforced by rising fuelwood prices. Savings from improved woodstoves will be negligible unless the stoves are a success in the marketplace.

32. Even if these ambitious "minimum" targets are met by 1995, the annual fuelwood deficit will still only be reduced by around 40%; the balance will be supplied by continued deforestation and by increased use of crop residues and dung for domestic cooking. Both imply continued desertification. Projections beyond 1995 indicate that the process of desertification is irreversible in the most densely-populated parts of the Mossi plateau. The proposed measures should be accompanied by a policy of promoting accelerated emigration from the Mossi plateau (para. 2.113-2.115).

33. The Government is in the process of developing an investment program which is considerably larger than the mission's "minimum". In particular, there are much higher 10-year targets for rural forestry and improved woodstoves. Rural forestry is called upon to plant the equivalent of 140,000 ha over the period 1986-95 at a total cost of 3 billion CFA.F. At the same time it is envisaged that the national improved woodstove program will disseminate at least two stoves to each household in Burkina, i.e. a total of 1.8 million stoves at an estimated total cost of 4 billion CFA.F. If these very ambitious "maximum" targets were met, the projected fuelwood deficit would be eliminated by 1995 (para. 2.116-2.117).

34. The mission has used its revised load forecasts to examine a number of elecricity investment scenarios out to the year 2000. For Ouagadougou, it is expected that the existing fuel oil capacity will be restored to normal availability as soon as possible and that the Kompienga hydro scheme will be commissioned at the end of the eighties. Under the revised load forecasts, no new capacity is then required for Ouagadougou until 1994. At the same time, the needs of Koudougou can be met by a 30 kV interconnection with Ouagadougou at the end of the eighties, with back-up from a new fuel oil unit two or three years later. With these constraints, the only significant investment planning decision to be made for Ouagadougou/Koudougou is how to meet the need for additional power and energy in the mid-nineties. The principal options are: (a) additional fuel oil fired diesels, (b) electricity imports via an interconnection with Ghana, and (c) the Bagré multi-purpose hydro project (para. 4.82-4.87)

35. For Bobo-Dioulasso, continued thermal development is most likely to remain the least-cost option until the mid-nineties. At that point it may become worthwhile to import electricity via an interconnection with the Ivory Coast. This decision will determine whether the link between Bobo-Dioulasso and Banfora should be at 30 kV or at 132 kV (para. 4.88-4.95).

36. In order to illustrate the range of possible electricity investment requirements over the coming decade, the mission has compared low and high capital-cost system expansion scenarios for

Quagadougou/Koudougou and Bobo-Dioulasso/Banfora. All scenarios include: (a) committed investments such as Kompienga; (b) thermal development in Bobo-Dioulasso until the early nineties, (c) a low level of continuing investment in distribution extensions. For both groups of load centers the minimum capital-cost option is additional thermal development in the mid-nineties; total investment requirements over the decade from 1985 amount to 47 billion CFA.F. This investment represents an unavoidable minimum, since it consists of the lowest capital-cost options for meeting electricity load growth in existing centers.

37. An alternative, more capital-intensive scenario for the mid-nineties consists of: (a) the Bagré multi-purpose hydro scheme, for supply to Ouagadougou; and (b) interconnection with the Ivory Coast, for supply to Bobo-Dioulasso/Banfora. The investment cost of these capital-intensive options is around 76 billion CFA.F over the coming decade, of which possibly 8 to 12 billion CFA.F could be attributed to the irrigation component of the Bagré dam. The Government should accord the highest priority to establishing whether or not the higher level of investment is economically warranted in the present economic climate, e.g. lower load forecasts, stagnant fuel oil prices (para. 4.96-4.99).

38. The mission's assessment of total investment requirements for the energy sector (fuelwood and electricity) over the coming decade is therefore 88-107 billion CFA.F, where the upper estimate excludes costs attributable to the irrigation component of the Bagré dam. This range represents a substantial increase over the amounts and proportions of public investment which have traditionally been allocated for the energy sector, and the lower level of investment represents what the mission regards as an essential minimum for both forestry and electricity. It will be important to explore in the context of the Government's formulation of an overall public investment program during 1985-1986, the tradeoffs which might be required in other sectors to put into place an energy sector program targetted at achieving at least the minimum level of investment defined by the range (para 5.63).

Technical Assistance

39. Donor support is required, not only for fuelwood and electricity investments, but also for technical assistance in two general areas: (a) institutional strengthening, and (b) pre-investment investigations. The need for this assistance is most urgent in the household energy subsector, since the recommended rate of investment will not be achieved without a major effort to define specific projects and reinforce the implementation capability of the institutions concerned. The second priority is to reinforce the Government's ability to regulate petroleum operations as an alternative to direct intervention. The third priority is to review electricity investment plans in the light of changed circumstances in the energy sector.

40. The mission recommends that these activities be phased over three years in an energy sector action program. Three of these activities require immediate implementation, either because of their economic

importance (reduced wood consumption, improved petroleum procurement) or because of timing considerations (restoration of generating plant). The remainder are listed in approximate order of priority and should be progressively implemented over the three years 1986-1988.

41. Immediate Implementation: The mission recommends that the Government seek immediate donor support for:

(a) Design and implementation of a household energy project consisting of: (i) a component to support planning and regulation of fuelwood production and supply to urban areas; (ii) a component to expand commercial production and marketing of the "Ouaga metal" stove; and (iii) a demonstration project to promote maximum penetration of kerosene stoves in urban areas (para. 2.65-2.104).

(b) Petroleum supply planning consisting of: (i) expert assistance to prepare for an approach to the SIR refinery concerning future supply arrangements; (ii) training of a nucleus of government personnel to devise and supervise a national petroleum procurement, transport and storage strategy to be implemented by the resident oil companies; (iii) review and improvement of price control arrangements for updating of petroleum cost structures (para. 3.35-3.65).

(c) Assistance to SONABEL to evaluate and implement the measures required to upgrade the existing fuel oil capacity at Ouagadougou to normal availability (para. 4.28).

42. Other Projects, 1986-88: The mission recommends that the Government then seek donor support for technical assistance for:

(a) Evaluation of (i) medium term options for major interconnections with the larger grids in the region; and (ii) the role and timing of additional thermal capacity (para. 4.83-4.85).

(b) A review of arrangements for introducing ethanol as a gasoline extender in the Bobo-Dioulasso distribution area (para. 3.32-3.34).

(c) Design and implementation of procedures for selecting energy-efficient airconditioning systems for buildings (para. 4.47-4.56).

(d) Creation of a small energy planning unit in the Ministry of Planning to complement and reinforce the present activities of the Institut Burkinabè de l'Energie (para. 5.18-5.20).

43. Detailed terms of reference for the above technical assistance projects are being prepared to provide the Government of Burkina with an effective instrument to channel the assistance from the donor community towards priority needs in the energy sector. This activity is being financed by the joint UNDP/World Bank Energy Sector Management Program (ESMAP).

I. ENERGY AND THE ECONOMY

Economic Background

1.1 Burkina is a country of 274,000 square km located in the heart of West Africa. Like its neighbors in the Sahel, Burkina is extremely poor, with a per capita income of US$210 in 1982, and is heavily dependent on agriculture. This sector directly accounts for 80-90% of employment and exports and 38% of GDP, while services contribute 45% of GDP and industry only 17%. Average life expectancy is 44 years and literacy is less than 20%.

1.2 Harsh geoclimatic conditions and poor soil resources are the major causes of this extreme poverty. The main natural constraints are (a) a landlocked situation, with main port access located over 600 kms from the country's southern border; (b) low and highly variable rainfall with averages ranging from 1000 mm per annum in the southwestern Soudano-Guinean zone to less than 500 mm in the northeastern Sahelian zone; (c) generally shallow and poorly structured soils which are easily depleted by traditional methods of cultivation; and (d) a poor natural resource endowment limited to some mineral resources (zinc silver, phosphorus) but without any significant energy resources.

1.3 The total resident population was estimated at 6.6 million in 1984 with a growth rate of 2.06% per year. Because of dryness in the North and endemic diseases in the South, over half the population is concentrated on the central Mossi plateau, which has led to its deforestation, overcultivation and loss of soil fertility. The impoverishment of this region has triggered (a) spontaneous resettlement to the south and the west which are being progressively freed from riverblindness and (b) emigration to the coastal countries, mainly the Ivory Coast (0.6% of the population each year).

1.4 In spite of its modest resource endowment Burkina's development performance during the 1970s was reasonably good by Sahelian standards, with annual GDP growth averaging 3.9% (1.5% per capita). These good results, achieved in spite of the major 1973-74 drought, are generally attributed to: (a) conservative financial policies, well within the guidelines of the West African Monetary Union of which Burkina is a member; (b) a relative absence of pricing and other policy distortions; and (c) major inflows of foreign aid and remittances from emigrant workers. These inflows of foreign savings financed a large resource gap and a high level of investment, both averaging 20-25% of GDP in the second half of the 1970s.

1.5 The situation has deteriorated since 1980. The authorities have steadily increased the Government's debt by contracting foreign loans on non-concessionary terms to finance increases in public sector salaries, expenditure on equipment (e.g. military) and payments arrears of public utilities. Service payment on internal and external debt

reached 20% of current budget expenditure in 1984, mainly because of the expiry of grace periods on foreign concessionary loans. Concurrently, workers' remittances and aid disbursement have slowed down. The crisis is aggravated by a renewed drought that has reduced grain output and has hit the livestock sector especially hard.

1.6 The Government reacted to this difficult situation by instituting a policy of budgetary austerity in 1984 and by launching a special program of rural self-help. However, it is still necessary to design a workable strategy for economic growth in the long term, to review policy choices in key sectors and to strengthen Burkina's investment capability. The current drafting of the 1986-1991 Plan offers the opportunity to undertake such a review.

Key Energy Issues

1.7 An overview of total and sectoral energy consumption in Burkina is presented in the 1983 energy balance (Annex 1). Primary energy supply was about 1,542,000 tons of oil equivalent (toe) in 1983, or 230 kilograms of oil equivalent (koe) per capita, which is one of the lowest levels in the world. Over 91% of primary energy requirements are met by domestic biomass energy, mainly fuelwood (84%), followed by crop residues (7%). The remaining 8.4% of primary energy requirements are met by imported petroleum products, of which about 30% are used in Burkina's thermal-only power generation system. These major sources of primary energy, fuelwood and petroleum products, are both associated with supply and financing problems which have serious consequences for the economy as a whole.

1.8 The current overcutting rate of wood resources for agricultural clearing, livestock grazing and fuelwood consumption is leading to rapid depletion of the sparse forest cover. Some 150,000 to 160,000 hectares of forest are degraded every year in Burkina, with associated land erosion and decline in soil fertility. The increasing scarcity of fuelwood is leading to greater use of crop residues and dung for household cooking; this in turn causes accelerated desertification. The situation is particularly worrisome on the densely populated central Mossi plateau.

1.9 However, in spite of the urgent need for corrective action, investments in the forestry sector have been minimal so far. Only 2.3% (880 million CFA.F) of externally financed investments, which accounts for about 90% of all fixed capital investments in Burkina, was allocated to forestry in 1981. In the same year, the electricity subsector, which represents only 0.6% of final energy demand, received over twice as much financing as the forestry subsector.

1.10 Imported petroleum products are the only source of primary energy supply to the modern sector other than agro-industrial residues. Petroleum imports are placing an increasing burden on the balance of payments. Although consumption of refined products is only 19 koe per

capita, which is a little over one fifth of the average of commercial energy consumption in Sub-Saharan Africa, energy import dependence amounted to 22% of total fob merchandise imports in 1983 and absorbed almost 45% of total recorded export earnings. These percentages have more than doubled since 1980 even though petroleum imports have dropped by 7% in volume over the same period. The increase mainly reflects product price increases as a result of a significant devaluation of the CFA franc vis-a-vis the U.S. dollar.

Energy Consumption

Overview

1.11 Final energy consumption patterns are presented in Table 1.1 below. Final energy consumption by sector is dominated by the residential sector (including home-based craft activities). Households consume 91.4% of net domestic energy supplies, while the balance is divided up between transport (4.6%), industry/agriculture (3.6%) and the public sector (0.4%). This distribution reflects the dominant role of traditional, often non-commercial energy, mainly fuelwood. This is used almost exclusively by households for cooking and craft activities, and generally with very low combustion efficiencies.

Table 1.1: STRUCTURE OF FINAL ENERGY CONSUMPTION (1983)
(Percent)

Sector	Biomass	Petroleum	Power	Total
Households	97.7	12.7	33.2	92.7
Transport	-	70.6	-	3.9
Industry	2.3	9.8	62.0	3.0
Government	-	6.9	4.8	0.4
Total (%)	100	100	100	100
('000 toe)	1,688.6	97.6	9.3	1,786.9

Source: Mission estimates.

1.12 The sectoral distribution of final consumption of imported energy presents a totally different picture. Transport is the major consumer of petroleum products, accounting for 70.6%, followed by households (12.7%), industry (9.8%) and the public sector (6.9%). This distribution reflects the low level of industrialization in Burkina and the insignificant use of petroleum products for residential purposes such as cooking and lighting.

1.13 Industry, including small-scale industry and agricultural water-pumping, stands out as the largest electricity consumer with 62% of total sales, while households and administrative buildings consume

respectively 33.2% and 4.8%, mainly for air-conditioning and lighting in urban areas.

1.14 Industrial energy consumption is concentrated in the largest industries: SOVOBRA and BRAVOLTA (breweries), SOSU-BF (sugar mill), CITEC (food oil processing), SOFITEX (cotton ginning), VOLTEX (textile plant) and SAP (tires). Together, they accounted for over 80% of value-added and employment in the modern industrial sector in 1980, the last year for which precise data is available. The joint gas-oil, diesel and fuel-oil consumption of these industries amounted to over 80% of total estimated consumption of these fuels in 1983, and their electricity demand is almost equal to total sales to the industrial sector. Altogether, their primary petroleum energy requirements (including fuel equivalent of electricity consumption) absorbed close to 20% of total petroleum product imports in 1983.

1.15 In energy terms, the modern industrial sector in Burkina consumes almost three times more biomass, totalling 37,000 toe, than net electricity and petroleum products together. Biomass energy consumption is concentrated in a few specific industries, the sugar and the food oil industries as well as in the millet mills. The main industrial biomass energy sources are bagasse (84%) and other agro-industrial wastes (16%).

Historical Trends

1.16 Biomass energy consumption appears to follow population growth, with little variation in types and quantities of fuels used. While it is believed that the drought in the north of the country has caused households to switch from fuelwood to straw and manure to some extent, no reliable supply data is available to confirm this belief.

1.17 Petroleum consumption (including fuel for power generation) has evolved in a much more drastic and erratic way over the past decade. Total internal consumption jumped from 54,000 toe in 1972 to 140,000 toe in 1982. But petroleum consumption actually fell by 12% in 1983 and total imports were reduced to 123,000 toe. By 1984 both per capita consumption of petroleum products and commercial energy intensity, measured in toe per million CFA.F of GDP, had dropped back to their 1979 levels. The sharp contraction of the petroleum import growth rates is a result of (a) a sluggish and erratic GDP growth since 1980 along with a persistent crisis in the industrial and commercial sectors; and (b) large petroleum price increases since 1980 due to ex-refinery price hikes and the depreciation of the domestic currency.

1.18 Electricity demand, which represents less than 1% of final energy consumption, has followed the same pattern as petroleum demand over the last decade. Generation grew by 15% per annum between 1972 and 1980, rising from 37 to 113 GWh. The growth rate fell to 3.4% between 1980 and 1983 when generation reached 125 GWh. Finally, an absolute decline in generation was recorded in late 1983 and in 1984, especially in the large load centers.

1.19 Petroleum imports consisted mainly of gasolines (40%) in 1983, followed by gasoil for transportation (20%), diesel (15%), fuel oil (15%) and kerosene (10%). A review of the evolution of consumption patterns since 1972 shows that (a) the share of gasolines in total demand has remained unchanged; (b) the growth of the kerosene market for residential uses has lagged far behind the growth of the other petroleum products in the 1970s but has resisted the economic downturn since 1980; and that (c) a large increase in fuel oil consumption relative to diesel has taken place mainly because of SONABEL's switch from diesel to fuel oil for thermal power generation in Ouagadougou, and to a lesser extent because of increased fuel oil consumption in the breweries.

Energy Resource Base

1.20 Burkina has a limited energy resource base. Its main domestic energy resource is biomass, including mainly fuelwood but also crop residues and manure. Fuelwood is by far the largest single domestic source of energy. Natural forest extends over 15.5 million hectares (56% of the country's land area) and is supplemented by man-induced forest resources, including bush-fallows and forest parks which cover 8.8 million hectares. While gross yearly fuelwood production reaches 8.6 million m^3, poor accessibility and unbalanced forest/population ratios limit net sustainable fuelwood production to around 2.8 million m^3. Since annual fuelwood consumption amounts to around 5 million m^3, particularly concentrated on the deforested central plateau, overexploitation is leading to rapid destruction of the remaining forest resources in fuelwood-deficit areas.

1.21 Non-wood biomass energy potential, including crop residues and animal manure, totals about 1 million toe per year. It is estimated that about 50,000 toe of this potential (mainly millet straw) is currently used as household fuel. This proportion should not be allowed to increase significantly, since competing uses for the biomass as mulch or animal feed are generally of higher economic value. The scope for converting these wastes to other energy forms (briquettes, biogas, etc.) is limited by collection costs, which are very high even when the waste is geographically concentrated, and by various technical and socio-economic constraints. Another potential source of biomass energy is bush grass.

1.22 An estimated 180,000 tons of agro-industrial wastes are potentially available every year for energy conversion. Half of this potential is bagasse -- a sugar cane residue obtained after crushing -- which is burnt in the boilers of the SOSU-BF sugar mill in Banfora during the six-month season for cogeneration of process steam and electricity. CITEC, a food oil processing plant in Bobo-Dioulasso, also burns some 20,000 tons of cotton seed and karite wastes in its main boiler. At both SOSU-BF and CITEC there are energy investment options for achieving full self-sufficiency in energy and some scope for generating surplus electricity for sale to the public supply system (Annex 13).

1.23 The GOB has launched a project to transform molasses -- a by-product of the sugar industry -- into ethanol which can be used as a gasoline extender (Annex 7). In general, significantly increased use of wastes other than molasses (such as brewery residues and cotton cakes,) for energy purposes is not advisable since this would displace their present use as feedstuff or fertilizers.

1.24 Burkina's mineral energy endowment is little known. Coal shales have been discovered at Kasimoro, between Kaya and Ouagadougou. Preliminary sampling revealed that the shales have a calorific content ranging from 600 to 900 Kcal per kg. In spite of the marginality of these resources, the GOB is looking for external assistance to estimate the size of the shale resources, test the shales in adapted prototype boilers and study the possibility of using the shales for thermal power generation.

1.25 In geological terms, the western and northern part of Burkina are a border part of the sedimentary Taoudeni basin in Mali, which is believed to contain oil. However, the Burkina part of the basin is relatively shallow (2000 m), whereas most oil deposits are found below 3000 or 3500 m; there is no serious prospect of discovering exploitable reserves. The GOB is seeking assistance to carry out an aero- and electromagnetic as well as radiometric survey over a 41,000 km^2 area. This survey would map the region from a geological point of view and give an indication of the area's potential resources in oil, uranium and other minerals.

1.26 Landsat pictures suggest that there are peat deposits in the Dedougou-Noura area. French geological consultants are about to undertake a program of peat investigations within the framework of a regional project financed by the member countries of the Conseil de l'Entente.

1.27 No systematic inventory or classification of Burkina's hydroelectric potential has been completed to date, and no site has yet been developed. The hydro potential is severely limited by the adverse meteorological and hydrological conditions. The total technically exploitable potential is estimated at 800 GWh (200MW) in an average year. The main sites are at Noumbiel (80 MW), Bagré (16 MW) and Kompienga (15 MW). The two latter sites are in advanced stages of design (para. 4.63). The development of Noumbiel appears less likely for technical reasons (para. 4.69). A recent study identified several mini- and micro-hydro sites, mostly in the Banfora area. A more comprehensive and exhaustive survey of the sites is necessary to determine the potential for economic development of these small sites (para. 4.68).

1.28 In view of the scarcity and cost of conventional energy sources in Burkina, the development of the country's solar and wind potential appears to be attractive. Development activities in this area are under the technical supervision of the Institut Burkinabè de l'Energie (IBE). Burkina's solar potential is considerable and varies between 1,800 and 2,100 kWh/m^2/year for an average of 3,500 hours of sunshine. Local testing has identified several promising solar technologies, such as

photovoltaic pumping and solar water heating, and these are being promoted by the GOB within a national program. The only study of the country's wind energy potential dates back to 1948. Despite a low average wind speed of around 3 m/s, several Savonius-type windmills are being operated.

1.29 The mission recommends that IBE's renewable energy research/promotion program include: (a) a low level ongoing activitiy for a range of solar applications, and (b) monitoring-only of international developments in wind-powered water pumping. This should be accompanied by a reallocation of resources to substantially increase the level of support for improved cookstove programs, both for wood and for kerosene.

Institutional Framework

1.30 In August 1984 a ministerial reorganization allocated the principal economic and financial functions among five ministries: (a) "Promotion Economique" (economic development), (b) "Ressources Financières" (finance/income), (c) "Budget" (finance/expenditure), (d) "Planification et Développement Populaire" (planning), and (e) "Commerce et Approvisionnement" (commerce). The GOB energy agencies need to maintain links with all five ministries to ensure adequate coordination with the government's recurrent budget and with national plans and other investment activities. A sixth ministry, "Relations Extérieures et Coopération" (foreign affairs and aid relations), is involved in national investment planning through its role in negotiations with external donors.

1.31 A number of ministries are directly responsible for energy sector functions. "Environnement et Tourisme" is responsible for the management and development of national forests as well as for the dissemination of improved woodstoves. The Bureau of Mines and Geology of Burkina (BUMIGEB) within the Ministry of Commerce regulates oil and mineral exploration and monitors petroleum product imports. The same ministry sets petroleum product prices which are then administered by the Caisse de Peréquation (Equalization Fund). The "Ministère de l'Equipement" has technical supervision of SONABEL, the electric power utility. The "Institut Burkinabè de l'Energie" (IBE), under the jurisdiction of the "Ministère de l'Enseignement et de la Recherche Scientifique" (education and scientific research), has the legal mandate to promote the use of renewable energy and to advise on overall energy strategy.

1.32 Energy sector activities are in some cases only a part of broader projects or programs. This is particularly true of hydro-electric development since these projects generally have an important irrigation component. Coordination is required with the "Ministère de l'Agriculture et de l'Elevage" (agriculture and livestock) and the "Ministère de l'Eau" (water) as well as with a number of special purpose authorities. Other ministries with important linkages to the energy sector include "Transport et Communications" and "Essor Familial et

Solidarité Nationale" (family welfare), the latter for its role in dissemination of improved woodstoves.

1.33 In the private and para-statal sectors the principal energy trading entities are: (a) the oil companies, in various wholly private and joint venture arrangements with the GOB (para. 3.12); and (b) SONABEL, the State-owned power utility. Fuelwood cutting, transport and marketing are in the hands of small private operators.

II. FUELWOOD/HOUSEHOLD ENERGY

Issues

2.1 This chapter examines household energy options for Burkina and the role of traditional household fuels (fuelwood, crop residues, dung) in the process of desertification.

2.2 The following options are reviewed: (a) increasing the supply of fuelwood; (b) improving the efficiency of fuelwood use; (c) switching from fuelwood to other fuels.

2.3 The chapter focuses on incentives, such as relative prices, and the principal constraints to change: household incomes, foreign exchange requirements, the legal framework, and institutional capability to plan and implement projects. A program of investments and institutional strengthening is then proposed for the decade to 1995.

2.4 Special emphasis is placed on: (a) regional differences within Burkina and the need to concentrate scarce investment resources on projects in the severe deficit areas of the Mossi plateau; (b) the need to manage the GOB's fuelwood-related activities (investments, R & D, extension work, subsidies) in a way which allows resources to be re-allocated as required to achieve the best returns.

Key Recommendations

2.5 Urban Fuelwood. (a) The current effort to improve city-gate collection of fuelwood taxes should be reinforced. (b) Taxes on commercial fuelwood should be increased. 1/ (c) Villages should be given increased property rights over wood resources in their immediate area. (d) Commercial cutting by independent loggers should be directed and controlled. (e) The feasibility of transporting wood by road or rail from permanently managed logging sites in surplus areas within Burkina should be evaluated. (f) The appraisal of projects which involve removal of forest cover (especially damsite clearance, e.g. Kompienga, Bagré) should include an appraisal of woodfuel markets.

2.6 Rural Forestry. (a) Individual/community multi-purpose tree planting should be promoted through a national network of tree nurseries. 2/ (b) The GOB should define a program of natural forest

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1/ Fuelwood taxes were increased from 150 to 300 CFA.F/stere in April 1985.

2/ Since the assessment mission in September 1984, a national forest nursery program has been prepared for implementation during the 1986-90 Development Plan.

protection giving increasing management responsibility to villagers. (c) The role of fuelwood supply from bushfallows should be investigated as the basis for designing a management program. (d) R & D should be strengthened, both at a national level and within a regional framework, and focus on development of suitable technical packages for the above activities.

2.7 Institutions. (a) The GOB should create an interdepartmental working group to improve coordination among government agencies involved in forestry, agriculture, livestock and water. (b) A multi-disciplinary environmental planning and project monitoring group is needed within the general secretariat of the Ministry of Environment and Tourism. (c) A higher proportion of forestry staff should be allocated to fuelwood-deficit regions; a higher proportion should be trained in extension methods and assigned to field positions. (d) Land tenure systems and forestry regulations should be reviewed and revised to promote village commitment to forest protection.

2.8 Improved Woodstoves. (a) The GOB should aim to have at least 500,000 improved woodstoves in use by 1995. 3/ (b) Stove promotion should concentrate on the rural areas of the Mossi plateau and on three urban areas: Ouagadougou, Koudougou and Ouahigouya. (c) The "improved three stone" stove and the "Ouaga metal" stove should be promoted as alternatives in both urban and rural areas; government resources should be allocated between these two components on the basis of cost-effectiveness. (d) The present channels for craft production and retailing of unimproved metal woodstoves should be encouraged to add to their range the "Ouaga metal" stove, the manufacturing and distribution of which should be monitored. (e) Research and development of cost-effective local stoves should be continued.

2.9 Kerosene. (a) There should be a preliminary assessment of the scope for marketing a kerosene stove which is both more efficient and adapted to local cooking requirements. (b) The market potential of kerosene as an alternative to fuelwood should be investigated for middle to high income groups and promoted to the extent allowed by Burkina's ability to finance the foreign exchange requirements.

Donor Support

2.10 Improved Cookstoves. It is recommended that the GOB seek immediate donor support for: (a) a substantially expanded program to promote improved woodstoves in fuelwood-deficit areas; (b) support to local artisans for commercial production and marketing of the "Ouaga metal" stove; (c) design and implementation of a demonstration project to promote maximum penetration of kerosene stoves in urban areas.

3/ The national improved woodstoves program has recently adopted a target of 1.035 million stoves in use by 1990 and 1.800 million by 1995.

2.11 Fuelwood Production Planning. It is recommended that the GOB seek donor support for strengthening of the forestry service and for key pre-investment studies: (a) establishment of a multi-disciplinary project planning and monitoring group within the general secretariat of the Ministry of Environment and Tourism, leading ultimately to preparation of forestry Master Plans in the 10 to 15 provinces with the most severe fuelwood deficits; (b) design of an action plan to improve the management of bush fallows; (c) appraisal of fuel markets for wood from damsite clearance for the Kompienga and Bagré hydro projects.

2.12 Urban Woodfuels Supply. It is recommended that the GOB seek technical assistance to improve its regulatory control over the supply of woodfuels to urban areas. Project components could include evaluation and establishment of the following systems: (a) a statistical system to monitor woodfuel supply to urban areas; (b) increased woodfuel tax collection capacity; (c) systems to direct independent loggers to specific exploitation zones; and (d) transport of fuelwood from surplus provinces to fuelwood-short urban areas.

2.13 Fuelwood Investments. The fuelwood production planning activities described above would lay the basis for a series of investments in natural forest management and rural forestry. The mission estimates that up to US$100 million could be absorbed in such projects over the next decade (para. 2.105). It is recommended that donors accord the highest possible priority to financing these projects.

Household Energy

Demand

2.14 Households make almost exclusive use of fuelwood for cooking, lighting and heating, and family-based craft activities, even in urban and semi-urban areas. A recent survey found, for example, that an urban dweller consumes a monthly average of 37.5 kg of firewood but only 1 kg of charcoal, 0.02 kg of LPG, 0.7 liters of kerosene and 1.2 kWh of electricity. Household consumption of fuelwood is the largest single item in Burkina's 1983 energy balance (Annex 1). The approximate structure of household consumption of final energy in that year is presented in Table 2.1.

2.15 Fuelwood remains a "free good" for the vast majority of households in Burkina. Over 93% of rural families gather their wood requirements themselves in village forests and bush fallows. Marketing of wood is limited to the cities, where 96% of households buy their wood requirements, and to a lesser extent to the semi-urban areas where 80% of households purchase their wood rather than gather it. The low rate of urbanization in Burkina means that only 10%-15% of national fuelwood

consumption is commercialized; the remainder is not traded. Conservation and substitution strategies need to be different in these two subsectors.

Table 2.1: HOUSEHOLD ENERGY CONSUMPTION
(1983, tonnes oil-equivalent)

Fuel	Consumption	Structure
Wood	1,584,000	96%
Crop residues	50,000	3%
Charcoal	7,300	..
Electricity	3,098	..
LPG	355	..
Kerosene	12,017	1%
Total	1,656,770	100%

2.16 In areas where fuelwood is traded, the key factors affecting the future demand for fuelwood are: (a) the delivered price of fuelwood compared with other commercial cooking fuels; (b) the efficiency and cost of cookstoves for wood and other fuels, (c) household incomes and cash purchasing power. In areas where fuelwood is not traded, the comparison with fuel alternatives such as crop residues and dung is likely to be more important.

Relative Prices

2.17 With present fuel prices and typical stove efficiencies, the cost of cooking energy delivered to the pot is approximately the same for wood and charcoal, but much higher for other fuels: from twice as much for kerosene to five times as much for electricity. There is therefore no incentive to switch away from woodfuels until these relative costs change in favor of other fuels. In the longer term the real costs of both petroleum and electricity are unlikely to stay permanently below their present levels. In combination with the GOB's policy of full-cost pricing, this means that consumer prices for these alternatives to fuelwood are unlikely to decline.

2.18 On the woodfuel side, there are two opposing forces: (a) increasing fuelwood prices and (b) decreasing cooking costs as a result of introducing improved woodstoves. Surprisingly, the price of wood has been relatively stable over the last five years. Average retail prices of chopped wood in Ouagadougou remained at about 14 CFA.F/kg between 1980 and 1984 while the price paid to producers stayed at around 4 CFA.F/kg. Over the same period the combined cost of transport and tax increased from 3.8 to 6 CFA.F/kg, thus squeezing the wholesale and retail margins. Charcoal prices have also stagnated at around 58 CFA.F/kg. Annex 4 gives data on woodfuel prices.

2.19 This price stagnation is probably due to increased wood sales by rural households looking for secondary or cash incomes and to the

development of low-cost specialized woodlogging businesses (para. 2.39). It seems unlikely that increasing transport costs for fuelwood can continue to be absorbed without increasing the price to the consumer. The cost of increasing the fuelwood transport distance by 150 km, for example, is equivalent to 50% of the present retail price. Increased taxes on fuelwood will add to the upward pressure on retail prices.

2.20 At the same time, the introduction of improved woodstoves could reduce the amount of fuelwood required to cook a meal by up to 30%. In this report it is assumed that fuelwood price increases will approximately offset improvements in fuelwood combustion efficiency. This will leave the cost of energy delivered to the pot more or less unchanged for most urban fuelwood consumers. This is the basis for assuming a constant demand for cooking energy per person as the "base case" in the analysis which follows. In the absence of reliable survey data, the same assumption is applied to rural consumers.

Household Incomes

2.21 In the event that improved woodstoves fail to penetrate fuelwood-deficit areas in sufficient numbers, the real cost of cooking energy will almost certainly rise as a result of increasing fuelwood transport distances. It is estimated that a typical household in Ouagadougou already spends between 3,000 and 5,000 CFA.F/month on wood, that is 15% to 25% of a typical cash income. This suggests that most urban households do not have the purchasing power to maintain their fuelwood consumption in the face of rising fuelwood prices. The only alternative is less cooking, i.e. a painful reduction in basic welfare.

2.22 In fuelwood-short rural areas, the alternative to increased fuelwood collection time is either less cooking or increased use of crop residues or dung for cooking. Crop residues are already used in many areas as a supplementary fuel for several months of the year. In some circumstances there may be a surplus of crop residues and dung over and above what is required as fertilizer. However, their use as cooking fuels becomes dangerous as soon as it starts removing essential fertilizer inputs from the crop cycle. It appears that an increasing percentage of agricultural land in Burkina is now crossing this threshhold into a phase of accelerated desertification.

2.23 In urban areas and in fuelwood-short rural areas it is evident that households would be prepared to spend a high proportion of any additional income on increased cooking. The introduction of more efficient woodstoves has the same effect as reducing the price of wood. The income made available by this price change will to some extent be spent on increased cooking. An improvement in combustion efficiency may therefore result in a lesser reduction in fuelwood consumption. While the full cost reduction represents a very real improvement in basic household welfare, it is essential that desertification projections not be rigidly linked to combustion improvement. This restriction can be relaxed if fuelwood prices rise more rapidly than the efficiency improvement, as is assumed in this report.

2.24 In the absence of income distribution data, it has been assumed that there are very few urban households with a sufficiently high income to switch to kerosene. Better data on income is essential for the GOB's energy planning in order to ensure realistic targets for fuel substitution.

Taxes and Subsidies

2.25 Fuelwood prices are determined by the cost of cutting and transport and do not include a component for economic cost of the wood itself, i.e. the cost of reafforestation or, in its absence, the cost of deforestation in terms of decreasing soil fertility and desertification. While taxes on fuelwood can and should be increased, they are likely to remain well below the level required to bring the delivered price up to the full economic cost of supply. Unrealistically high tax levels would also tend to promote smuggling and other forms of avoidance. Fuelwood consumers will therefore continue to be indirectly subsidized by a significant price distortion. This economic fact-of-life should be explicitly recognized in any discussion of subsidies on stoves or reduced taxes on alternative cooking fuels.

Fuelwood Balance

Resources/Consumption

2.26 Burkina has large forest resources. Based on landsat pictures, the recent national forestry inventory estimated the natural forest cover (NFC) at 15.6 million hectares in 1976 4/, or 56% of the country's total land area. However, most of these resources consist of dispersed tree formations. Dense woodlands and savanna woodlands cover only 2% of the country's area while tree savanna and shrub savanna represent respectively 4.3 and 10.5 million ha (Annex 2).

2.27 These natural forest resources are supplemented by significant man-induced forest cover. While this category includes tree plantations, which total only 18,500 ha in Burkina, it mainly consists of agrosylvo-pastoral formations (forest parks and bush fallows) which cover 8.8 million ha or 32% of the country's total area. The traditional land-use system is based on shifting rain-fed agriculture, and extensive pastoralism alternating with lengthy fallow periods. A protective canopy of some trees is kept on the fields to provide fruit, fodder for animals, to maintain and improve the soil fertility and occasionally to supply fuelwood.

4/ These figures do not accurately reflect the 1985 situation; the estimates have not been updated due to the lack of funds.

2.28 A regional breakdown of Burkina's forest resources reveals that they are extremely unevenly distributed. While the natural forests cover 56% of the national territory and bushfallows 32%, the latter represent over 70% of the area in some heavily populated provinces of the central Mossi Plateau. This imbalance is further compounded by the low average productivity of bush fallows (0.20 to 0.30 m^3 per ha per year) compared with that of the natural forest (0.56 m^3/ha/year). Conversely, 80% of the country's stumpage volume is concentrated in the southern part of the country, far from the main consumption centers, sometimes in areas plagued by river blindness. "Accessibility" is therefore low.

2.29 Nationwide, wood production in Burkina is well above total fuelwood consumption. The annual increment of the natural forest cover (NFC), bush fallows (BF) and forest parks (FP) reaches 10.3 million m^3. Total consumption, on the other hand, is around 5.1 million m^3 (or 0.76 m^3 per capita per year), indicating an apparent surplus. However, in practice, the availability of fuelwood is well below the current consumption level. Availability depends (a) on the accessibility of the resources, since wood resources in Burkina are concentrated far from the large consumption centers in sparsely populated areas which lack appropriate access infrastructure to exploit the resources economically, and (b) on the rate of local consumption. When these factors are taken into account, sustainable available yearly production of wood is reduced to 3.5 million m^3; the consumption deficit therefore reaches 1.6 million m^3, mainly concentrated in the deficit areas. Some 1.3 million m^3 of clearance wood, logged mainly for clearing additional agricultural land and bush fallows for wood supply to urban areas, covers most of the consumption gap, but at the expense of existing resources which are depleted at an ever increasing rate. This deficit is concentrated in the Central provinces as indicated by the accompanying map. Annex 3 shows the specific fuelwood balances by province and their expected evolution.

Desertification: Causes and Trends

2.30 There are four main causes of destruction of the natural forest cover and of desertification in Burkina. Some 150,000 to 160,000 ha of forest are destroyed each year, under the combined pressure of (a) persistent drought, (b) clearing and degradation because of the need for agricultural and pastoral land, (c) the lack of individual commitment to tree protection and (d) overcutting of wood to supply the large and growing consumption centers.

2.31 The harsh natural conditions prevailing in Burkina have steadily worsened over the last decade. Recurrent drought conditions have hit the northern part of the country and especially the Sahel region where the prolonged drought has irreversibly destroyed considerable areas of forest. The national forest inventory has determined that in the three Sahelian provinces, the average tree death rate is 8.6% p.a. which is 2.6 times higher than the country's average. The drought has drastically reduced (by 20 to 40%) the natural productivity of tree formations.

2.32 Increased encroachment for agricultural and livestock purposes is inevitable as long as population increases without a parallel improvement in agricultural and livestock production. These land needs are therefore met either by agricultural and pastoral colonization or by shortening of the fallow period. Large agricultural projects also entail major clearing of forest formations. Many of these projects focus on agricultural production and, unlike traditional agrosylvopastoral practices, neglect conservation aspects.

2.33 Bad forestry management practices have been triggered by uncertainty about land-holding rights and therefore long-term ownership of the forest cover. Moreover, the policing role of the forestry services has reinforced the villagers' loss of interest in forest cover protection and development through sound management practices. However, on August 4, 1984, new land use legislation was enacted. According to the forestry services, this should foster improved commitment of villagers to forest protection and management. Moreover, a rural forestry program has been underway since 1979 to sensitize populations to the need to protect forest resources.

2.34 Rapid urbanization has led to commercialization of wood supplies, over-exploitation of peri-urban wood resources and eventually their destruction with associated damage to the ecosystem. Degradation patches can appear in forest rich areas under the pressure of concentrated urban demand. The desertification process is compounded when the rural areas themselves are in a fuelwood deficit situation. This is the case on the central Mossi plateau which also includes the country's largest urban centers.

2.35 As a result of these four factors, three of which are due solely to population pressure, it appears that 10% of Burkina's forest resources will be eliminated between 1983 and 1995. The average productivity of the natural forest cover will fall by 20%, and total natural production of wood will fall from 10.3 million m^3 in 1983 to 8.3 million m^3 in 1995. At the same time, population will grow at an average of 2% per year, bringing consumption to 6.9 million m^3 in 1995. As a result, the woodfuel production deficit will be multiplied by three over the coming decade and will reach 25% of consumption in 1995.

2.36 This analysis of current trends points to the urgent necessity to improve wood supply and limit wood demand growth on the Mossi plateau. Forestry strategy therefore should focus on improving the situation in the most endangered provinces, the ones belonging to categories I and II (Annex 3). The GOB is fully aware of the urgent necessity to slow down the desertification process. In April 1985 it launched a massive forest protection program entitled "The Three Struggles", intended to reduce the impact of (a) bush fires, (b) uncontrolled grazing, and (c) over-cutting of fuelwood.

Forestry Strategy

2.37 The limited financial and human resources of Burkina's forestry services severely constrains the subsector's investment absorptive capacity. Given this constraint, the GOB's fuelwood supply strategy should be aimed at (a) relieving the pressure on forest resources surrounding the major urban areas by developing alternative sources of supply, and (b) implementing a wide-ranging rural forestry program on the Mossi Plateau.

Supply to the Cities

2.38 Urban and semi-urban wood consumption takes a heavy toll on nearby wood resources, thereby creating desertification belts around the cities. Commercial fuelwood for urban consumption is transported over distances of up to 100 kms. Some 20 to 50% of fuelwood supplies to the larger urban areas and 70 to 80% of semi-urban supplies are gathered in nearby forests, savannas and fallows within a radius of 40 km. These farmers or specialized woodcutters then transport the wood into the city by foot, on bicycles or with donkey-carts. The increasing scarcity of supplies has compelled the supply system to rely more and more on motorized means of transport; presently over 50% of the wood supplies for major urban areas is brought into the cities by pick-up trucks and large-body trucks.

2.39 Two fairly recent developments in fuelwood supply have been accelerating the rate of deforestation around urban areas. First, it appears that in recent drought years, farmers have been increasingly overexploiting their meager forest resources in order to raise a cash income. It has been reported that wood quantities sold by farmers living close to Ouagadougou have tripled between 1975 and 1981. A second cause for concern is the increasing share of wood production provided by independent woodloggers who sell their output to large truck transporters. These independents often destroy entire forest areas by uncontrolled clearfelling.

2.40 The Government has been aware since the mid-1970s of the need to relieve the pressure on forest resources surrounding urban areas. Some 16,000 ha of plantations of fast growing trees have been developed, of which 2,800 ha are peri-urban operations. Two-thirds of these state-managed plantations are located on the Mossi plateau with the express purpose of providing the large consumption centers with timber and fuelwood. However, yields achieved are variable because of several factors, including the climate, choice of soil and species, as well as insufficient maintenance. This has led to relatively low productivities (1.5 to 6 m^3/ha/year). The cost per hectare planted ranges from 200,000 to 300,000 CFA.F.

2.41 Besides industrial plantations, other options should be considered to increase fuelwood supplies to the cities while protecting the surrounding forest base. These options include (a) control of wood

exploitation and marketing, and (b) transport of wood from surplus areas. Despite the potential for lowering transport costs, charcoal is not a viable option for Burkina. Even with the most efficient carbonization methods available, the switch from wood to charcoal cooking involves an increase in wood consumption. The economic cost of this increased consumption outweighs the potential gains from lower transport costs.

2.42 Control. There is an urgent need for the forestry services to better control exploitation and marketing of fuelwood for consumption in urban areas. Such a control program, for Ouagadougou as a first priority, must include:

- improving the data collection and analysis system on wood exploitation areas and methods. A large amount of information could be derived from using existing data on the cutting permits delivered to transporters;

- devising a system to direct independent woodloggers toward specific areas and training them to use efficient methods which permit regeneration of the natural forest cover;

- training farmers to exploit their bush fallows and forest parks more efficiently; and

- reinforcing the collection of forestry taxes on products entering the large urban centers. The "exploitation tax" is levied only on commercial wood/charcoal activities, since wood-cutting for personal consumption is a traditional user right. The tax was increased in 1985 for the second time since 1954, and is now 300 CFA.F per stere. It is estimated that the forestry services should have collected about 250 million CFA.F in 1983 but it is believed that only a very small proportion of these taxes were actually collected.

2.43 As a step towards rationalizing fuelwood exploitation within the framework of the "Three Struggles" program launched in April 1985, a new system has been introduced to control urban fuelwood supply. The new system controls cutting, transport and marketing of fuelwood in the large urban centers by means of: (a) a network of wholesale, semi-wholesale, and retail traders licensed by the government and given official concessions well as annual sales quotas; (b) a monopoly on road transport granted to special vehicles, to facilitate monitoring of quantities transported; (c) monitoring of woodcutters to ensure that they take their annual quotas only in specific logging areas; (d) fuelwood price control, both at the supplier and consumer levels with the object of fostering fuelwood conservation and interfuel substitution; and (e) an increase in the forestry tax in conjunction with a more comprehensive collection mechanism, thus increasing revenues for the forestry service.

2.44 Transport. Marketing conditions permitting, transport of wood should be organized from surplus provinces (categories III.1 and III.2 in

a first phase and category IV.2 in a second phase) to Ouagadougou and the other urban centers of the Mossi plateau. Preliminary transport cost calculations indicate that hauling wood could be viable over distances of up to 200 km. Additional costs are estimated at 6,600 CFA.F per cubic meter of fuelwood assuming that (a) transport distances would increase on average by 150 kms and that (b) better transport management (back loading, training of drivers, use of trailers) would lower transport costs to 50 or 60 CFA.F per tonne-km. However, a substantial amount of additional infrastructure may be required. This additional transport cost would increase the final retail price of wood by around 8 CFA.F/kg; taking it to 23 CFA.F/kg. This price increase would be close to the increase observed over the decade 1970-80.

2.45 The following main sources of supply should be considered:

(a) "Permanently managed logging sites" located in the well-stocked surplus regions. The most promising reserved or unreserved forest stands would be defined and then managed directly by the forestry department or, socio-economic conditions permitting, by nearby villagers. 5/ In the latter case the government agencies involved in rural production (agriculture, livestock, forestry) would provide guidance and technical services and participate in the development of basic infrastructure such as access roads, fire breaks etc.

(b) The mission recommends reviewing the scope for recovering wood that will be produced by damsite clearance for the Kompienga and Bagré projects; markets would include: (a) transport to Ouagadougou as wood or charcoal and (b) local consumption. It is necessary to carefully plan the marketing of this "non-traditional" wood so as not to depress the traditional commercial network. Wood recovery should be systematically investigated for all agricultural and hydro-electric projects.

Rural Forestry

2.46 A regionalized rural forestry program should be designed, particularly for the provinces located in categories I and II, with special emphasis on villagers' participation in forest protection and on coordinated multi-sectoral actions.

2.47 Improved Management of Forest Resources. There is an urgent need to foster an increased commitment by villagers to protecting the residual forest cover on the Mossi plateau. Managed forest areas should be defined and managed wherever possible by the villagers for both soil

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5/ The Forestry Service has expressed a strong preference for managing these sites themselves, either by a "Régie" system with the support of a national forestry fund which has yet to be created, or through state companies.

protection and fuelwood production. Intervention from the forestry and other rural services would be minimal and would focus on extension and training, such as protection methods, including fire-breaks, liberation cutting, grazing control and early burning/bushfire control. Such a program would require finding adequate incentives for villagers and in particular giving them as much responsibility as possible for the management of the natural forest cover and ownership of the forest products. Land tenure and forest regulations therefore need to be reviewed.

2.48 Bush fallows and forest parks have become major sources of fuelwood supplies on the Mossi plateau, both for the villagers and for the urban population. However, little is known about the current productivity of bush fallows and forest parks and about the exploitation methods used by villagers. In a first stage, it is therefore essential to develop a better data base on the role of bush fallows for supply of fuelwood, building poles and non-wood products. In a second stage, an extension program should be designed to rationalize and increase production from these multi-purpose tree/shrub formations. This multisectoral and participatory approach should rely on existing extension services and requires close coordination among agricultural, pastoral and forestry development structures. Wherever possible, such agro-forestry activities should be integrated as components of existing or planned rural development projects.

2.49 Both the natural forest protection program and the bush fallow/forest parks program are experimental, both from a social and technical point of view. For this reason they should be carried out as a series of pilot projects which would test the implications of these new forms of forest management before launching larger scale operations.

2.50 Tree Planting. Rural tree planting by the forestry services has been underway for several years and it now needs to be reoriented and intensified. The forestry services have set up one national tree nursery in the Oubritenga province and some 90 regional nurseries. In addition, close to 150 village tree nurseries have been created as components of village reafforestation projects. While this program has been significant, several fuelwood-deficit provinces still have no nurseries. The mission suggests that the Forestry Service expand and coordinate a national network of nurseries at the provincial level. These nurseries would provide seedlings to villagers but would mainly focus on training villagers to develop their own mini-nurseries. Over time this would shift the responsibility for tree planting from the central forest services to the local communities and preferably to the families themselves. This effort could be supported by the newly created seed service which could provide seeds and undertake necessary research.

2.51 Since 1979, village woodlot programs, mainly state-managed, have taken an increasingly important role in Burkina's tree planting promotion policy. Some 750 ha have been planted per year, mainly on the Mossi plateau, with an average of 1 to 2 ha per village per year. These efforts have been successful but their cost remains high (200,000 to

250,000 CFA.F/ha) because of the need for protective fencing and of the extension costs incurred for sensitization of villagers. These high costs are inherent in such programs aiming at a base scale technology transfer to the local population.

2.52 Amenity plantations (shade-trees, road-side tree plantations) as well as open field tree plantations should be established on a family/community basis. The latter would include, inter-alia, live-fencing, wind breaks, shelter belts, thickets and groves. Such plantations would be multi-purpose; they would not only produce fuelwood but also non-wood products such as gum, resins, medicines, fruit or animal fodder, all of which makes them more attractive to villagers. The plantations would also have an important soil and crop protection function in most cases. They would be scattered over cropping and grazing areas and could be considered as integrated agro-forestry activities. Open field tree/shrub/bush planting techniques should be disseminated in coordination with the existing rural and pastoral extension services.

Research

2.53 There is a need to create a strong national forestry research structure (e.g. the Directorate of Forest Seeds) and to promote its activities in close collaboration with other research centers, in particular the Centre Technique Forestier Tropical (CTFT) which comes under the jurisdiction of the Ministry of Higher Education. The research activities of this structure should focus on the concrete concerns embodied in the forestry strategy implemented by the Forestry Services.

Institutional Aspects

Institutions

2.54 Institutional strengthening of the forestry services is required in two areas. First, there is a need to increase their operational capability by improving basic infrastructure (provincial directorates, outposts, nurseries) and logistical services. Second, there is a need to improve coordination (a) within the Service between the central planning unit and the regional implementation services, and (b) between the forestry services and the agencies involved in rural development.

2.55 The Ministry of Environment and Tourism is formally responsible for formulating and implementing Burkina's forestry policy. The main entities involved in forestry are the Direction de l'Amenagement Forestier et du Reboisement (DAFR, Reafforestation Directorate) and 13 regional Forestry Directorates. The DAFR designs forestry policy, manages financial and human resources allocated to forestry and programs the individual projects, while the regional Directorates implement projects and enforce regulations. The regional Directorates are not

under the jurisdiction of the DAFR but report directly to the Secretary General of the Ministry.

2.56 In order to be efficient, such a system requires careful coordination of project programming so as to translate overall policy into work programs at a provincial level. The mission recommends setting up within the General Secretariat of the Ministry of Environment and Tourism a planning unit which would centralize appraisal, programming and monitoring of all environment related projects. This unit would define regional priorities, monitor project programming at the regional level, assess project work and disseminate information, both within the Ministry of Environment and Tourism and to other Ministries. The unit would be staffed with a multidisciplinary personnel skilled not only in sylviculture but also sociology, engineering and economics. This planning structure would be strengthened by the creation within the DAFR of specialized support services (including Inventory and Statistics, and Forestry Economics).

2.57 The forestry services also need to strengthen coordination and communication with the other agencies involved in closely related development areas. The present lack of coordination between the ministries involved in rural development has resulted in various inconsistencies, including overconcentration of projects in certain areas and poor scheduling of project implementation. The planning unit within the DAFR would ensure communication with regional extension services, integrated rural projects and village organizations. This multisectoral approach is essential for all new social/rural forestry projects.

2.58 Beyond simple coordination of project implementation among ministries, there is a need for high level integration of policy-making on land-use and land-tenure systems. The mission recommends strengthening the coordination process between the Ministries of Enviornment and Tourism, of Agriculture and of Water, all three involved with forestry issues, and if necessary, to create a permanent structure to ensure this coordination. While energy is only one of several areas of concern in these ministries, one of the functions of the working group would be to provide inputs for national energy planning.

Manpower

2.59 The forestry service staff has doubled over the last ten years, reaching 351 at the end of 1983. However, several structural problems hamper the efficient use of these resources. The distribution of staff among qualification levels is inadequate. Senior level staff (engineers and controllers) are almost as numerous as lower level field staff (technicians and rangers). The reorganization of the Dinderesso forestry school, with USAID financing, will allow training of 40 rangers per year instead of 10 and therefore help restore the staffing balance within the forestry services. However, the school is costly; annual recurrent costs per student are around US$3,000.

2.60 Spatial allocation of staff is uneven from two points of view. First, the distribution between central and provincial services does not match the requirements for operational and extension staff: only one-third of all engineers and one-fifth of controllers are working within regional directorates. Second, the staff (not including engineers) to population ratio varies among the provinces by a factor of five, ranging from one agent per 13,000 residents to one agent per 60,000 residents.

2.61 It is therefore necessary to better allocate staff (a) among provinces and (b) towards operational positions, and to provide them with adequate training in extension work and project management. However, an improvement in staff allocation is only a first step, since the numbers of staff will still be insufficient to efficiently carry out extension and monitoring work in the field. Agricultural extension staff should be trained for forestry work with technical support from foresters.

Land-tenure and Forestry Regulations

2.62 In order to induce a wholehearted commitment by the rural population to forest protection and development, land tenure and forestry legislation will have to offer suitable economic incentives. A new land tenure decree came into force in August 1984 which endows the State with the sole right to land ownership. Land use rights, however, can be granted to individuals. This legislation needs to guarantee long-term tenure since individuals are motivated to plant and grow trees only if they are certain that the long-term wood production will be their property.

2.63 The forestry legislation enacted in 1935 has tended to strip the villages of their traditional stake in protecting nearby vegetation. A return toward customary law, which involves exclusive management of natural forest resources by local village communities would limit uncontrolled commercial exploitation, overclearing, overgrazing, overcutting and uncontrolled bushfires.

2.64 The impact of the new land and agricultural reform on forest management and sensitization of villages should be carefully monitored.

Demand Management

Conservation

2.65 Fuelwood is mainly consumed for residential purposes and in particular for cooking which accounts for 75% to 90% of wood utilization, depending on the region. Cooking generally takes place on traditional open three-stone fires which offer a very poor thermal efficiency, estimated to range between 8% and 15% according to fire tending practices. Non-improved metal stoves ("foyers malgaches") are used to some extent in urban areas; their efficiency is also very low. In

principle, substantial savings of fuelwood could be achieved through widespread use of efficient woodstoves.

2.66 The economics of improved woodstoves are reasonably well established in Burkina. For a wide range of cost/combustion efficiency combinations, improved woodstoves are a better investment than any known means of increasing the supply of fuelwood. They are also an economically viable way of reducing the loss of agricultural output caused by declining tree cover and reduced fertiliser input from crop residues and dung. However, since investment resources are limited, the GOB should focus on high-return (high efficiency, low-cost) models of woodstove where possible.

2.67 In assessing the cost of woodstoves, the GOB should recognise the real economic cost of extension work by public servants. While the cost of extension inputs per stove will probably fall as the programs gather experience, the GOB must be prepared to reallocate resources away from projects where costs remain high. The manpower available in the Public Service is likely to remain limited and a stove program on the scale required would absorb an unreasonably high proportion of the resources available for extension work. For this reason alone there has to be a concerted effort to harness existing private sector mechanisms for stove production and marketing.

2.68 Despite the fact that fuelwood prices are well below the full economic cost of supply, some models of improved woodstove are clearly financially worthwhile for urban consumers of commercial fuelwood. However, in fuelwood-short rural areas it is not clear to what extent improved woodstoves are considered worthwhile in terms of reduced fuelwood collection time. Since rural households account for the bulk of the national fuelwood deficit, it is essential to determine the conditions (particularly price) under which improved woodstoves can be successfully marketed to these households.

2.69 While cash availability is often a problem, particularly in rural areas, households can generally tap private sources of credit to purchase small capital items. To date, improved woodstoves have only been made available at subsidized prices through institutional channels. Full-cost stoves should be commercially marketed in both rural and urban areas to determine the demand with present prices, incomes and sources of credit. This test would then provide the basis for a decision on how to allocate government resources between direct subsidies (to reduce stove prices) and indirect subsidies (the present system of extension work).

2.70 These micro-economic considerations are used below to evaluate the effectiveness of the GOB's improved woodstove programs, both past and proposed (i.e. accelerated dissemination). While it is essential that these programs should be cost-effective, the macro aspects are no less important. The donor resources required to fund a national program (para. 2.110) are minimal compared with other proposed energy sector investments (para. 5.62); yet the potential benefits of reduced desertification and lower household cooking costs are enormous.

2.71 Strong Government commitment and good institutional coordination have fostered rapid initial development of improved woodstoves in Burkina. Between 1979 and 1984, some 7000 improved woodstoves, mostly of the heavy fixed type, were disseminated in the country. The fixed two-pot stoves were heavily subsidized by free extension work inputs. However several of the fifteen or so models being disseminated proved to use more wood than the traditional three stone fire. In order to put an end to this confused situation, the Improved Woodstove Unit (SFA, Service des Foyers Améliorés) within the forestry service and the Institut Burkinabè de l'Energie (IBE) were given the mandate to direct and coordinate all woodstove activities.

2.72 These new institutional arrangements have already achieved major results, since 7000 stoves were distributed during the 1983/84 campaign alone. The newly created interministerial commission for improved woodstoves could provide coordination and support across all government agencies to promote an accelerated woodstoves dissemination plan.

2.73 The IBE has developed stove models which are adapted to local conditions and which could be candidates for large-scale dissemination. Two one-hole models have been retained: the portable "Ouaga metal" stove and the "improved three-stone" stove. They offer an end-use efficiency improvement of 10-30% over the traditional three-stone stove. Since its construction is relatively simple, artisans can manufacture the metal stove in 40 minutes for a competitive price ranging from 1000 to 1300 CFA.F. Several minor technical problems, such as the lack of stability for traditional "tô" should be solved shortly by the IBE. Tô is the traditional Burkinabè dish, usually made with millet flour and varying accompanying sauces. The improved three-stone stove, on the other hand, is a fixed installation in "banco" (a mixture of mud and straw) which can be constructed and maintained by the stove users themselves with no cash costs. A third type of improved woodstove is under review at the IBE. These ceramic stoves are presently too fragile, heavy and costly to compete with other models.

2.74 Since suitable standardized improved woodstove models are now available, the GOB now needs to accelerate the dissemination program under the leadership of the SFA and with the technical support of IBE. Several policy proposals have been drafted recently by the SFA within the Forestry Services and by the Interministerial Commission. The task at hand is tremendous. With a population of 6.6 million, the number of households in Burkina is probably around 800,000. Each household needs two improved woodstoves since the traditional tô is cooked in two different pots, one for the cereal and one for the gravy. Assuming that the average lifetime of a stove is two years, 800,000 improved woodstoves would need to be disseminated each year in order to cover the national market. This is one hundred times the present rate of diffusion (7000 in 1983/84).

2.75 The conclusion to be drawn from this preliminary calculation is twofold: (a) initial diffusion efforts must be concentrated in priority wood deficit zones, defined earlier as the urban/semi-urban areas and the

rural areas of the Mossi plateau; and (b) government-sponsored dissemination projects must lead as quickly as possible to a self-sustaining system requiring no subsidies.

2.76 The following improved woodstove dissemination objectives have therefore been set for implementation during the next five-year Development Plan 1986-90: (a) All households in the deficit provinces should have two improved woodstoves each by 1990, that is a total 685,000 stoves. The provinces concerned are Bam, Bazega, Bulkiemde, Gnagna Kadiogo, Kuritenga, Namentenga, Oubritenga, Passore, Sanmatenga, and Sourou. (b) Fifty precent of households in the surplus provinces (Gourma, Tapoa, Kossi, Mouhoun, Comoé, Houet, Kenedougou, Nahouri, Ganzourgou, Sanguié, Zoudwéogo, Oudalan, Séno, Soum) should use improved woodstoves by 1990, that is a total of 350,000 stoves. The new stove program should concentrate on two areas of activity. First, individual construction of improved three-stone stoves should be promoted through a continued demonstration program in rural, mainly deficit, areas. Second, the development of private manufacturing and marketing channels for metal woodstoves should be organized for commercial fuelwood users primarily in urban and semi-urban areas. The system should, however, remain flexible enough to offer a choice between fixed and portable stoves in both rural and urban areas.

2.77 The Improved Three-Stone Stove. The SFA and IBE have carried out an evaluation of the 1983/84 campaign that disseminated some 5,900 improved three-stone stoves in 11 provinces. This evaluation indicates large variations in dissemination results among the provinces. In particular, the Sanmatenga province (near Kaya) had much better results than other provinces. Better progress seems to be dependent upon the following factors:

(a) Coordination - There should be one main coordinator for each province, in charge of monitoring the work program, and coordinating field work performed by the various extension agents (CDR, women's association, forestry agents ..);

(b) Work program - A detailed work program should be set up for each province with specific targets in terms of numbers of villages, their characteristics (for example, villages suffering from a lack of water or good "banco" or who migrate to the fields for part of the year are not good candidates), and of percentage of households to be trained in order to ensure self-sustaining dissemination.

(c) Sensitization with efficient marketing techniques.

(d) Training and monitoring - The choice of motivated village representatives to be trained is critical and should be done in cooperation with existing village organizations. Sociological monitoring is essential to better understand the dissemination process within the village and therefore to adapt methods to their needs. Monitoring should be more than a counting of

stoves built, but should also include quality control in order to correct technical mistakes in construction and to teach maintenance methods.

2.78 Improved three-stone stoves are more adapted to rural than to urban areas. In urban areas many families rent their houses, move often and therefore want stoves which are easily portable. The building material is often not available in the cities and has to be brought in from rural areas; this can bring the stove price to a higher level than the metallic stove. Nonetheless, part of the urban population is interested in mudstoves and these should be made available through some form of marketing or extension services.

2.79 The dissemination program for improved three stone stoves within the 1986-90 Development Plan will rest on the principle of the training of women to build their own improved stoves. Training sessions of extension workers in techniques of sensitization and stove-building will therefore be organized at the national, regional and provincial levels. Human resources involved will include (a) at the national level, six managers each in charge of five Provinces; (b) a coordinator per Province, i.e. thirty coordinators; (c) one full-time extension agent and one part-time forester per one or two Departments (depending on whether the department belongs to a surplus or deficit zone); and (d) two women per village or sector, numbering a total of 5,000 women.

2.80 If the teams succeed in placing stoves in every household (one stove for every four to six people) the direct cost per stove could be as low as 1300 CFA.F per stove. If the success rate is the same as in the best component of the 1983/84 program (Sanmatenga: 40 stoves per village) the direct cost per stove will be around 4500 CFA.F. A comparison with the full delivered cost of a metal stove (1000 to 1500 CFA.F) indicates the importance of achieving rates of penetration which are even better than at Sanmatenga. If these rates fall below target the GOB will have to consider shifting resources towards promotion of metal stoves in rural areas.

2.81 Costs could be reduced by the systematic integration of improved woodstove components into rural or social projects. It would be useful to evaluate staff availability and training requirements for stove dissemination within the extension services of the Ministère du Développement Rural (Rural Development) and the Ministère de l'Essor Familial et de la Solidarité Nationale (Family Welfare and National Solidarity). Such an approach could be cost-effective and promote an integrated approach to extension efforts in interrelated areas such as nutrition, health, fuel-saving and cooking habits. The new Interministerial Commission for Improved Woodstoves could be the catalyst for such an approach.

2.82 <u>The Ouaga Metal Stove</u>. The Ouaga metal stoves offer a major breakthrough for dissemination of improved woodstoves since diffusion can take place through existing market channels. The manufacturing and selling of the stove can be a self-sustaining, employment-generating and

profitable activity that may require no Government intervention beyond the introductory phase. Acceptability of the stove by the consumers of commercial fuelwood should ultimately be ensured by the high cash savings that the stove offers. Preliminary introductory experiments have already been carried out with great success by the SFA. The initial emphasis should be placed on urban and semi-urban areas where fuelwood is a commercial good and where the purchasing power (1500 CFA.F) for buying the stove is believed to exist.

2.83 In order to foster rapid development of a self-sustaining market, the GOB's support is required to (a) train artisans, (b) establish an appropriate commercial marketing network, and (c) monitor stove quality and react to consumer feedback.

2.84 Metal stoves can be manufactured by metalworking artisans. IBE has established that a workshop with five artisans can manufacture 60 improved metal stoves per day. In order to spread their risk, they would not manufacture more than 10 to 20 stoves per day. For a city of 500,000 inhabitants (Ouagadougou) with one stove per five inhabitants and an average stove lifespan of two years, some 50,000 stoves would need to be manufactured every year. This is the output of ten to twenty-five workshops. Metalworkers could be trained within the well-established structure of the CNPAR (Artisans' Center) which organizes one-year long training programs for urban and rural artisans in Ouagadougou and Bobo-Dioulasso. It would also be possible to set up a special short-term course for artisans who do not participate in the year-long regular program.

2.85 Present sales of unimproved scrap-metal stoves ("foyers malgaches") give an indication of how the Ouaga metal improved woodstove could be marketed and at what price. The unimproved stove is sold as a normal retail market item at around 300 CFA.F. If the improved model is marketed in the same manner, consumers will be prepared to pay a premium for its wood savings, providing these have been adequately publicized. If the improved model is built out of new metal (as is assumed in the costings) rather than scrap, many consumers will be prepared to pay an additional premium for the stove's longer lifespan. New metal is recommended because of the widespread shortage of scrap metal in Burkina and to avoid rapid deterioration of combustion efficiency.

2.86 It is believed that initial market demand for the Ouaga metal stove will be relatively low if the selling price is set much above 800 CFA.F. Depending on stove size and retailing margins, the stove could cost from 1200 to 1500 CFA.F at the final point of sale. To avoid cutting up and reselling, the stoves could not be sold for much less than the value of the materials (around 850 to 1050 CFA.F depending on size). Under these circumstances the GOB may have to consider some form of temporary subsidy during an introductory phase. A subsidy of 400 CFA.F per stove is adopted below for illustrative purposes only. The method of applying the subsidy would have to be very carefully examined.

2.87 A suitable marketing network for the metal stoves exists (wood retailers, hardware retailers etc.). The SFA can help accelerate this process by launching a major promotion and demonstration program. Recent promotion efforts by the SFA proved to be enormously successful. Such a campaign could include radio shows, demonstrations in community organizations and support for private retailers. The cost of this publicity support might be of the order of 200 CFA.F per stove under favorable circumstances.

2.88 Quality control at the manufacturing level will be an essential component of the government's role in developing this market and will have to continue beyond the introductory phase. Feedback between the market and the IBE is necessary to ensure that the stoves are properly used and that timely and appropriate technical adjustments (design improvements, model diversification) are introduced. Sample quality control and re-training of artisans will be needed. A permanent sample survey monitoring of the actual use of stoves would be a useful device for this task.

2.89 Stoves for Artisans and Communities. Wood is consumed for craft work in proportions ranging from 10% in rural areas to 25% in some urban areas. Dolo beer brewing, metal work and various food processing activities are the main fuelwood consuming crafts. Institutions (schools, army barracks) often consume large amounts of fuelwood for cooking. Only one industry -- the brick plant -- is a heavy fuelwood user.

2.90 A different approach than for household stoves is needed to design and market improved stoves for artisans or communities. On the one hand, artisans are more atuned to cash savings than households and their technical concern for stove operations (installation, maintenance) is higher. On the other hand, it is necessary to identify artisans and their markets and to design stoves adapted to each specific craft/purpose. A craft-specific program is therefore needed. Dolo-brewers are the first target because they are the main wood users. Work has already been done in this area and will be intensified under IBE's technical monitoring during the next five-year Development Plan.

2.91 The total cost of the improved woodstoves project, including dissemination of portable, artisanal and improved three-stone stoves in both rural and urban zones, will be 2.336 billion CFA.F over the 1986-1990 period. This cost includes personnel, training and hardware expenses. A possible subsidy for improved stoves is not included in the present budget but could be considered if outside funds were available to this end.

Substitution

2.92 The basic substitution decision for household fuels in Burkina is between domestic and imported fuels. Agro-industrial residues are the only significant domestic resource which could be converted into household fuels without adding to the pressure of desertification. However,

in general these residues are located far from fuelwood-deficit regions. Electricity is essentially imported, since marginal generation is likely to remain oil-fired despite planned hydro developments. The remaining household fuel options are also imports: petroleum products (principally LPG and kerosene), coal and imported charcoal. Table 2.2 gives indicative economic costs for the lowest cost options for household cooking.

Table 2.2: ECONOMIC COSTS OF HOUSEHOLD COOKING
(CFA.F/Mcal of useful energy)
Ouagadougou, 1984

Fuel/Stove	Efficiency	Cost
Wood b/		
open fire	10%	76
improved mudstove	20%	38 a/
improved metal stove	30%	25 a/
Charcoal c/		
present stove	25%	72
Kerosene		
present stove	40%	43
hypothetical improved stove	60%	29 a/
LPG		
present stove	50%	69

a/ Principal policy options.
b/ Replacement cost component for wood is based on establishment of permanently-managed wood supply areas at 75,000 CFA.F/ha.
c/ Charcoal cost includes replacement cost of wood and is based on 20% conversion efficiency by weight.

Source: Mission estimates.

2.93 The scope for substitution between household fuels in Burkina is heavily constrained by three factors. First, the principal domestic fuels (wood, crop residues and dung) all have a value in the crop cycle which is not reflected in their consumer price (or collection time in rural areas). Second, most households in Burkina do not have the capacity to pay for fuels which are more expensive than the present "below-cost" price of fuelwood. Third, at a national level Burkina has a limited capacity to finance the foreign exchange cost of a large scale switch to imported household fuels. The commercial environment of the urban and semi-urban areas has options which differ from those of rural areas.

2.94 Urban Substitution. The overwhelming preference for fuelwood in urban areas is mainly explained by the price differentials per unit of useful energy. Comparing prices on the basis of calorific value and

average utilization efficiency, the price of charcoal per useful Mcal is 30 CFA.F, while the retail price of wood also per useful Mcal is 27 CFA.F. Electricity is by far the most expensive energy source for cooking, costing almost 150 CFA.F per useful Mcal, not including initial equipment costs. LPG and kerosene prices are in the intermediate range, between fuelwood and electricity, and cost respectively 61 and 50 CFA.F per useful Mcal.

2.95 Substitution from fuelwood to charcoal should not be encouraged since there are large wood-equivalent losses incurred in the carbonization process.

2.96 Since solar cooking is not technically and socially adapted to conditions in Burkina, the remaining substitution options are petroleum products. The most obvious consumer group to be considered for early conversion from fuelwood to petroleum is the middle class, which is located almost exclusively in the urban centers of Ouagadougou and Bobo-Dioulasso.

2.97 The GOB has attempted to encourage the expansion of the LPG market. Both for strategic and economic reasons, it would be preferable to shift the substitution effort from LPG to kerosene. The strategic reason is twofold. At present the Burkina LPG market depends completely on the SIR refinery at Abidjan in the Ivory Coast; the other regional refineries (in Ghana and Nigeria) are not reliable sources of supply. Second, port facilities for importing LPG do not exist at Lomé (in Togo) or Cotonou (in Benin).

2.98 Two economic reasons count in favor of kerosene rather than LPG. First, the delivered cost to Ouagadougou of butane can be expected to rise. SIR has been forced to import LPG at high freight costs in order to resell it, because its reduced production level alone does not meet demand. SIR will almost certainly transfer the cost increase to its customers in the near future. The economic cost of cooking on LPG already compares very unfavorably with the existing (1984) cost of kerosene.

2.99 The second economic reason is that the present rate of subsidy on LPG is not sustainable. A selling price of 6,000 CFA.F for 12.5 kg of LPG is needed to cover product cost and distribution. The GOB has fixed a maximum selling price of 4,175 CFA.F and the Stabilization Fund has refused to reimburse the difference, thus not providing any incentive to the companies to properly supply the market. Likewise, the bottles cost 15,000 CFA.F, while the companies are only allowed to charge a deposit of 3,000 CFA.F. The bottles tend to find their way across the border where they are sold for a price approaching their true value.

2.100 Kerosene does not require expensive, pressured packaging and can be sold in small, affordable quantitites. Yet two issues remain to be solved. First, the technical and social acceptability of kerosene stoves needs to be improved. The use of kerosene remains almost exclusively limited to lighting, although kerosene stoves are widely

available on the market at reasonable prices. It appears that existing stoves do not offer the required characteristics of safety, stability, ease of maintenance, longevity and odorlessness that would encourage their widespread use. And second, the increased foreign exchange burden associated with increased kerosene consumption needs to be weighed against the economic benefit of reduced desertification. The mission recommends that the GOB: (a) undertake a feasibility study of kerosene promotion in Ouagadougou and other cities; and (b) design a suitable demonstration project for funding by donors.

2.101 Rural Substitution. The only source of energy currently used as an alternative to fuelwood in rural Burkina is agricultural waste. Millet and sorghum stalks are burned in rural and semi-urban areas as a supplementary fuel for two to four months per year. Use of residues averages 10% of total energy use but increases to 30% in the northern wood-scarce part of the country. Little is known about the use of animal wastes as fuel.

2.102 Widespread residential use of crop residues and animal dung for cooking purposes should be discouraged since excessive removal of organic matter from the fields will cause a decline in agricultural productivity. Traditional mulching techniques on millet and sorghum fields, for example, maintain soil fertility without recourse to high-cost imported fertilizers. Moreover, surplus crop wastes, if any, have a high economic value as stock feed or as building material.

2.103 One possible exception to the rule of higher economic value of non-energy use of crop and animal residues is cotton, for two reasons. First, cotton stalks need to be burnt each year for phytosanitary reasons. Second, cotton is a cash crop, cultivated in well defined areas and within well developed harvesting and marketing structures (AVV, SOFITEX), which could organize efficient and low-cost collection of residues. Low technology, village-based briquetting units could be considered. Some 62,000 toe could be derived from cotton stalks in the two main cotton growing areas in the Hauts-Bassins and Volta Noire regions. However, most of the cotton is cultivated in the South where wood shortages are not as acute as in the Mossi plateau area. The economic attractiveness of cotton waste briquetting is therefore not particularly promising at the present time.

2.104 A biomass mix of 75% straw and 25% animal manure can be fermented in an anaerobic container to produce biogas which can be used directly for cooking or to drive a power generator. The IBE has tested and modified several types of biogas digestor. However, large scale introduction of biogas in rural areas is unlikely for several reasons:

(a) The current cost of a 5,000 liter digestor is around 150,000 CFA.F, which limits its application to communities and institutions.

(b) The operation of a digestor is warranted only when easily collectible manure from animals in stables is available. Since

there are few draft cattle in Burkina (60,000 out of over 1 million), the necessary conditions for economic installation of digestors in rural families rarely exist. Limited cases of concentrations of wastes are to be found in larger scale farms or in industrial operations such as slaughterhouses.

(c) Biodigestors require large quantities of water. The lack and irregularity of water supply often prevents their operation.

(d) Finally, numerous manual operations are necessary to run a digestor efficiently, and many villagers do not have the time, training or inclination to carry them out.

Investment Program

Minimum Program Required

2.105 Possible forestry and fuelwood consumption actions are constrained by the absorptive capacity of the forestry service and other government agencies. The mission judged that a global investment program of about 41 billion CFA.F would be feasible over the period 1985-1995. This amount is about three times the investment in fuelwood-related activities over the last ten years. This investment program would therefore have to include large components aimed at strengthening the management, planning and research capabilities of the forestry service in particular.

2.106 The investment program has two objectives: (a) to increase consumer welfare by slowing down the increasing cost of household energy; (b) to help slow down the process of desertification. These objectives have two important consequences. First, investment in more efficient woodstoves is worthwhile for the first reason even if its contribution to reduced desertification turns out to be marginal. Second, the program's anti-desertification objective means avoiding increased consumption not only of fuelwood but also of crop residues and dung. Substitution from fuelwood to crop residues and dung should be regarded as a step towards increased desertification.

2.107 Supply side actions are estimated to require a total investment of around 40 billion CFA.F between 1986 and 1995:

(a) Improved management of village forests on the Mossi Plateau would involve a cost ranging from 5,000 to 10,000 CFA.F/ha and would include:

— 375,000 ha in Zone I.1
— 100,000 ha in Zone I.2
— 250,000 ha in Zone II.1
— 250,000 ha in Zone II.2

thus totalling 975,000 ha or 25% of the total NFC area of the Provinces concerned. The total cost of this program would be about 6.6 billion CFA.F.

(b) The program for improved exploitation of bush fallows is expected to cost about 3,000 to 5,000 CFA.F/ha. Technical support for improved management would be provided for:

— 1,700,000 ha in Zone I.1
— 150,000 ha in Zone I.2
— 500,000 ha in Zone II.2.

A total of 2,350,000 ha would therefore be included in the program, or 50% of the bush fallow area in the provinces considered, for a total cost of 9.4 billion CFA.F.

(c) Permanent logging sites would be established on 300,000 ha of Zone III.2, at a cost estimated to range between 50,000 and 100,000 CFA.F/ha, and totalling about 22.5 billion CFA.F.

(d) The development of mini-nurseries should permit each family to plant on average 2 trees per year, only one of which is expected to survive. This planting rate is equivalent to establishing a 1,500 ha plantation per year, at a cost of 60,000 to 150,000 CFA.F/ha. By 1995, about 2,800 ha-equivalent or 1.4 million trees should be planted in each of the five following Zones: I.1, I.2, II.1, II.2, and III.1. Total costs are estimated to be 0.5 billion CFA.F.

2.108 These supply actions are expected to increase available production of fuelwood by 212,000 m^3 in 1995, or 3% of consumption. Of this total, 49,000 m^3 will be provided by improved management of rural forests, 60,000 m^3 by logging sites, 71,000 m^3 by improved exploitation of bush fallows and 32,000 m^3 by family tree planting actions.

2.109 It is estimated that, by 1995, efforts to promote improved woodstoves should be able to result in minimum penetration rates ranging from 30% among the rural population to 50% among the urban population. On the basis of: (a) an expected total population of 9 million in 1995, of which 7.3 million will be rural, 0.3 million will be semi-urban and 1.4 will be urban; (b) an average of 6-8 persons per household; (c) two stoves per household; and (d) a stove lifespan of two years, it is expected that 500,000 stoves will be in use in 1995. Half of these would be bought new that year. Using a constant exponential growth rate, it is estimated that some 800,000 improved woodstoves should be disseminated over the next ten years.

2.110 At an average cost per stove of 2,000 CFA.F, including GOB technical and extension support (metal stoves: 1,500 CFA.F retail cost plus 500 CFA.F support; mudstoves: 2,000 CFA.F including mainly support plus a small implicit cost component for labor and material), total investment in improved woodstoves over the next ten years should be 1.6

billion CFA.F. Of this total amount, the direct cost to the GOB (support and subsidies) could be 1/3 to 2/3 depending on the relative shares of metal stoves and mudstoves and on the decision on subsidies for metal stoves. The expected government investment required has been provisionally estimated of 0.7 billion CFA.F, of which 0.4 would be spent in Zone I.1, and 0.1 in each of the following three zones: II.1, II.2, and III.1. Assuming that improved mudstoves save 10-20% fuelwood, and that metal stoves save 25-30% fuelwood, in total amount of wood saved could amount to 264,000 m^3 per year by 1995.

2.111 Assuming that 15% of the urban population and 10% of the semi-urban population will switch from fuelwood to kerosene for cooking by 1995, some 150,000 m^3 of fuelwood could be saved annually. Some 72,000 stoves would be in use (two stoves per family unit of 6-8 persons), implying the yearly marketing of 24,000 stoves given a lifespan of three years. At a cost of 4,000 CFA.F per stove, total investment in the 140,000 or so stoves which would have to be distributed by 1995 would be 540 million CFA.F. It is estimated that government support could be up to 1,000 CFA.F per stove, or 140 million CFA.F over the next ten years. Additional kerosene imports in 1995 would amount to 12,000 toe, or 7% of total "base case" petroleum imports in that year. It has been calculated that introduction of kerosene stoves in 5% of the rural population could reduce fuelwood consumption by 300,000 m^3, but would also generate between 20,000 and 25,000 toe of additional kerosene imports.

2.112 This minimum action plan is summarized in table 2.3.

Table 2.3: FUELWOOD ACTION PLAN

Action	Scope	1995 Production Increase or Consumption Savings ('000 m^3/year)	1985-1995 Public Investment (billion CFA.F)
* Management of			
- Forest "terroirs"	975,000 ha	49	7.4
- Logging Sites	300,000 ha	60	22.5
- Bush Fallows	2,350,000 ha	71	9.4
* Rural Forestry	7 million trees planted, equiv. 13,900 ha	32	0.5
Subtotal supply actions		212	39.8
* Substitution	Kerosene a/	150	0.2 b/
* Improved Stoves	500,000 in use	264	0.7
Subtotal demand actions		414	0.9
Total		626	40.7
Trend deficit c/:		-1,503	
Net deficit:		-877	
Net/trend deficit:		58%	

a/ Exclusive of fuel import.
b/ Rounded figure.
c/ Base case (para. 2.35).

2.113 Three main conclusions can be drawn from the proposed minimum investment program. First, if all actions on forestry resources are implemented, they could, by 1995, fill only 10-15% of the trend deficit. Substitution and conservation actions could conceivably fill in 20% of the national deficit by 1995. Therefore, in strict terms of the fuelwood balance, actions on demand have a greater potential impact than actions to protect and develop the forest cover. However, the impact of these forestry initiatives goes well beyond fuelwood issues. Their environmental and ecological benefits make these actions indispensable for longer term survival.

2.114 Second, if all components of this minimum program are successfully implemented, a little less than half of the national trend deficit will be covered. The remainder will be supplied by: (a) overcutting of natural forest resources and deforestation; and (b) spontaneous substitution towards crop residues with serious erosion consequences because of excessive removal of organic matter from the fields. It is expected that between 10% and 20% of the rural population's fuelwood consumption (0.5 to 1 million m^3) will be replaced by crop residues and dung by 1995.

2.115 Finally, in spite of concentrated actions on the Mossi Plateau, the regional deficit in heavily populated zone I.1 will still amount to well over 50% of consumption in 1995. Projections out to 2005 show that the deficit situation in zone I.1 is irreversible and will be improved ultimately only by massive population migration flows towards surplus areas.

National Investment Program

2.116 Given that the results to be expected from the minimum investment program fall well short of eliminating the fuelwood deficit, the GOB has decided upon a larger national investment program that the strengthens the rural forestry and improved woodstove components of the minimum investment strategy: (a) The 1986-90 development plan envisages: (i) the creation of 160 tree nurseries at the department level, and (ii) the planting of 2 ha/village/year (of which 1 ha is a collective plantation and 1 ha is individual), i.e. 14,000 ha per year in the country as a whole or 70,000 ha over the next five years. The creation of village tree nurseries will be encouraged with a view to fostering improved management of forest resources by the villagers themselves. The same objectives should be targeted between 1991 and 1995. Rural forestry should therefore result in 140,000 ha of plantations over the next 10 years for a total cost of around 3 billion CFA.F. The resulting increase in fuelwood production is expected to amount to 320,000 m^3/year by 1995. (b) The national improved woodstoves program included in the five year Development Plan expects 1,035,000 improved stoves to be used by 517,500 households by 1990. By 1995, all Burkinabè familes, estimated to number 900,000, should own two improved stoves each, i.e. a total of 1,880,000 stoves. Assuming that each family consumes 5 m^3 of wood per year and that improved stoves allow 25% fuel saving, some 1.13 million m^3 of fuelwood could be saved annually by 1995. The total cost of

disseminating improved stoves over the next ten years is estimated at 4 billion CFAF.F.

2.117 The success of this program is crucial if the trend deficit (Table 2.3) is to be eliminated. The achievement of such an objective will depend on (a) a considerable strengthening of the number and quality of extension agents, both for rural forestry and improved woodstoves, and (b) massive and rapid mobilization of rural and urban populations. The mission recommends that donors continue and intensify their support to the Government's program.

III. PETROLEUM

Issues

3.1 This chapter focuses on decision-making in key areas of the petroleum subsector: (a) demand management; (b) procurement; (c) petroleum transport; (d) storage; (e) financial control. Burkina's petroleum requirements are likely to remain in the range 120,000 to 150,000 tonnes/year for the period to 1990. The GOB's main objective should be to create organizational arrangements which ensure that these products are purchased and delivered to Burkina at the lowest possible cost. 6/

Key Recommendations

3.2 Demand Management. (a) Petroleum taxation and price setting mechanisms should be reviewed and strengthened. (b) Petroleum conservation initiatives should focus on consumption in the transport sector and initially on the allocation of long-haul freight between road and rail. (c) The viability of producing ethanol as a gasoline extender in the SOPAL plant at Banfora should be verified and immediate steps taken to make firm contractual arrangements with SOSU-BF and the oil companies.

3.3 Procurement. (a) A single Government agency should be made responsible for monitoring petroleum market developments and devising a national procurement, transport and storage strategy for implementation by private operators. (b) Under present market conditions, it is probable that competitive procurement terms could be negotiated with SIR, and preparations for such negotiations should be initiated immediately. (c) Burkina should continue to import a small proportion of its requirements through other ports, and in particular through the proposed Togolese storage facility (STH) in Lomé. (d) Burkina should also request access to Ivory Coast's maritime petroleum receiving facilities; maximum use of jointly owned railway is possible even if oil products cannot competitively be purchased at SIR.

3.4 Petroleum Transport. As part of the proposed rehabilitation of the RAN railroad, there should be a major effort to upgrade the quality of service for petroleum freight in order to induce a progressive transfer of ex-Abidjan traffic from road back to rail.

3.5 Storage. (a) The GOB should consolidate the achievements of the last few years by managing the new storage systems with an efficient mix of public and private sector resources. (b) The GOB and the resident oil companies should agree on guidelines for management of strategic

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6/ Supporting data for this chapter are presented in Annex 5: petroleum product price structures; Annex 6: petroleum product imports 1972-1983; and Annex 7: ethanol as a gasoline extender.

stocks (to average around 45 days' consumption) under arrangements which give a reasonable rate of return on working capital.

3.6 Financial Control. (a) The GOB should acquire the expertise necessary to take over from the GPP (the association of resident oil companies) the accounting functions related to regular updating of petroleum price structures. (b) The forecasting and allocation of petroleum taxation revenues should be integrated with the preparation of the GOB's recurrent budget. (c) "Earmarking" of petroleum taxes to special-purpose funds should be confined to clearly justified cases such as road maintenance.

Donor Support

3.7 To implement these recommendations, the GOB could seek donor support for the following top priority activities. The subsitution of kerosene for woodfuels, also a priority, is covered in the chapter on fuelwood.

3.8 Procurement (1). Immediate expert assistance to (a) prepare for discussions with SIR on future supply arrangements; (b) train a nucleus of GOB personnel as policy advisors for future procurement arrangements; (c) study optimum petroleum freight arrangements on the RAN.

3.9 Procurement (2). Technical assistance for a GOB review of organizational options for the design and implementation of a petroleum procurement strategy.

3.10 Pricing/Financial Control. Technical assistance to support the GOB in (a) reviewing and improving arrangements for updating petroleum cost structures; (b) reviewing and simplifying price stabilization mechanisms involving petroleum products; (c) training GOB personnel to manage the new systems.

3.11 Ethanol. Immediate expert assistance to (a) review the options for energy conservation in the SOSU-BF sugar complex and for energy supply to the SOPAL ethanol plant; (b) determine the viability of commissioning and operating the ethanol production and marketing system; (c) establish firm contractual arrangements for molasses and energy inputs and for transport, storage and blending of ethanol.

Subsector Organization

3.12 Until recently, the procurement, storage and distribution of imported petroleum products has been shared among the five resident oil companies in Burkina — Mobil, Texaco, BP, Total and Shell. The first four are wholly owned by their respective parent companies. Shell BF is 51% owned by the GOB. The management of all five companies is in the hands of competent Burkina nationals. The companies are loosely

associated as the GPP (Groupement Professionnel des Pétroliers), an organization which serves as the interface between the industry and the Government. They are also associated in SEB (Société d'Entreposage à Bobo), a joint venture company created to manage the new storage depot in Bobo-Dioulasso. The parent companies of the resident oil distributors are minority shareholders in SIR (Société Ivoirienne de Raffinage), which has a large export refinery at Abidjan in the Ivory Coast.

3.13 The GOB has found it necessary to commit significant financial resources to ensure an adequate supply of petroleum products: it has taken a 10% interest in SIR (originally 7%, but raised as part of the financing of a major extension of the refinery); it provided private operators with a loan for constructing the depot in Bobo-Dioulasso (SEB); it embarked on the construction of the depot at Bingo outside Ouagadougou. The GOB has a controlling 70% shareholding interest in SEHBI (Société d'Entreposage d'Hydrocarbures de Bingo), a mixed capital company originally created to own and manage the new Ouagadougou storage depot at Bingo. Recently, the GOB has also taken an active interest in the procurement of petroleum products. SEHBI has acted as the Government's agent in these direct import arrangements.

3.14 Nominal administrative responsibility for the petroleum subsector lies with the Bureau of Mines and Geology, BUMIGEB (Bureau des Mines et de la Géologie du Burkina). BUMIGEB is structured as a non-trading company under the technical supervision of the Ministry of Commerce (Ministère du Commerce et de l'Approvisionnement du Peuple) and its budget is largely funded by a specific levy on sales of petroleum products. Over recent years BUMIGEB's priorities have shifted heavily towards exploration for minerals, mainly non-fuel minerals. At the same time, the creation of SEHBI has allowed BUMIGEB to entirely delegate its supervisory responsibility for petroleum procurement. BUMIGEB has a 40% shareholding in SEHBI and chairs the board of directors.

3.15 The setting of petroleum prices is the responsibility of the Pricing Directorate (Direction des Prix) of the Ministry of Commerce. The price structure for each petroleum product includes a balancing component which is part of a price stabilization system involving petroleum and ten other products, mainly food staples. This system is administered by the Equalization Fund (Caisse de Péréquation), a non-trading government company.

3.16 The organization of the petroleum subsector has evolved since the Assessment mission in September 1984. A Hydrocarbons Cell has been created in the Ministry of Commerce, consisting of SEHBI (now SEBHY, Société d'Entreposage Burkinabè d'Hydrocarbures), the Equalization Fund, the Pricing Directorate, the Distribution Directorate, BUMIGEB and the Burkina-Shell joint venture. The cell is chaired by SEBHY and is a consultative body charged with developing proposals for improving the national petroleum supply strategy. At the same time the GOB has created SONABHY -- la Société Nationale Burkinabè d' Hydrocarbures -- a State company which has been accorded a monopoly on petroleum importing and storage. As soon as it is staffed with qualified personnel, SONABHY will

turn its attention to diversifying the sources of supply and to supervising petroleum storage.

Demand Management

3.17 Energy planning in the petroleum subsector needs to focus on a few key elements which dominate petroleum demand and supply. On the demand side, these key elements are: (a) the relative prices of petroleum products; (b) the scope for supplementary measures to increase overall energy efficiency in the land transport sector; and (c) the balance of payments' implications of substituting kerosene for woodfuels in middle-income households.

Pricing

3.18 Pricing is the most important instrument for managing petroleum demand. Ideally, taxes, duties and levies imposed by the government should leave the ratio of one product price to another more or less the same as the ratio of their respective untaxed border prices. Higher individual tax rates may be warranted as a means of recovering government expenditure directly from the users, e.g. a road user charge specifically on road use of gasolines or diesel; however, in the case of diesel it may be more effective to tax vehicles. If there is a need to deviate from these guidelines to raise additional revenue, the additional taxes should be concentrated on products for which there are no close substitutes. This generally means gasolines.

3.19 Burkina's petroleum tax relativities comply reasonably well with these guidelines. For ex-Abidjan products, the January 1984 cost structures incorporated duties, taxes (including payments to the Equalization Fund) and levies amounting to the following percentages of the ex-depot cost (excluding taxes) in Ouagadougou: premium gasoline, 31%; regular gasoline, 29%; kerosene, 6.5%; gasoil, 15%; industrial diesel, 5%; fuel oil, 8%; and LPG, 14%. The main elements of the cost structure at that time are presented in Table 3.1.

Table 3.1: PETROLEUM PRODUCT COST STRUCTURE
Ouagadougou, from January 1984

CFA.F/HL a/	Regular Gasoline	Kerosene	Gasoil	Industrial Diesel	Fuel Oil
FOB Abidjan	15,652	10,208	14,815	10,002	7,510
Duties, taxes, levies	6,033	3,338	3,099	855	1,051
Transport, storage, etc.	4,705	4,355	5,326	5,868	5,434
Price ex-depot b/	26,390	16,790	23,240	16,724	13,994

a/ Priced in CFA.F; for approximate conversion to US$, use 450 CFA.F/US$: exchange rate at time of mission (September 1984).

b/ May not add due to rounding.

3.20 Future price changes could aim to move these tax rates in the following directions: (a) kerosene, industrial diesel and fuel oil -- to a common rate to be set according to the GOB's revenue requirements; (b) a narrowing of the gap between the rates on gasolines and gasoil. The latter recommendation is intended to reduce the risk of economically unwarranted conversions from gasoline to diesel vehicles at the light end of the weight range. These recommendations may be difficult to implement at present, since tax relativities do not appear to be the main criterion guiding petroleum price setting (para. 3.59).

3.21 In the context of measures to combat desertification, petroleum tax rates should be reviewed as soon as the roles of kerosene and LPG as fuelwood substitutes have been defined. However, there is a risk that a reduction in tax rates on these products could become a de facto subsidy to a small group of high income consumers; for this reason, it may be more efficient to subsidize the stoves rather than the fuels.

Conservation

3.22 Given that there are no net subsidies on petroleum products, the GOB's first priority should be to determine whether pricing needs to be supported by supplementary conservation initiatives in any of the petroleum consumption sectors. The objective would be to identify incentive schemes, training programs or minor investments where (a) total savings of imported petroleum would be large enough to justify including the activity in a strictly limited portfolio of energy planning activities, and (b) the foreign exchange savings would result in a 10-15% rate of return on total investment and recurrent costs.

3.23 A preliminary screening of the main petroleum consumption subsectors suggests that land transport should be the first priority for further investigation. Both electricity generation and the modern industrial sector (e.g. non-traditional brewing) appear to be sufficiently well managed to offer limited potential for increased energy efficiency. However, as a second priority, it would be worthwhile to investigate ways of indirectly reducing petroleum consumption by improving the management of the electric airconditioning load (para. 4.47-4.56).

3.24 Land transport (road and rail) consumes around 60% of total imported petroleum products. The estimated 1983 breakdown of petroleum consumption is as outlined in Table 3.2.

3.25 Although gasolines are the largest single consumption component (around 50%), there are limited opportunities for increasing the efficiency with which they are used. The GOB has recently imposed a ceiling of 5 fiscal horsepower on purchases of new government cars and this should result in a medium term improvement in the government fleet's average fuel efficiency. This should be supplemented by appropriate horsepower standards for other vehicle categories in the government fleet. On a wider scale, it would be useful to monitor gasoline specifications. The ex-SIR "regular" gasoline, for example, has a RON (octane rating) of 83

which is low enough to cause continuous pre-ignition in untuned vehicles; this could reduce engine life by 10%-15%. The RON could be raised to 87 at little extra cost.

Table 3.2: PETROLEUM CONSUMPTION, 1983
('000 tonnes oil-equivalent)

Transport		74		60%
— gasolines/light vehicles	(50)		(41%)	
— gasoil/heavier vehicles	(19)		(15%)	
— industrial diesel/rail	(5)		(4%)	
Electricity Generation		28		22%
Industry		9		7%
Households		12		10%
Total a/		124		100%

a/ May not add due to rounding.

3.26 The main scope for increasing the energy efficiency of land transport appears to lie in major modal transfers, such as shifting freight from road (gasoil) to rail (industrial diesel). While the energy consumption per tonne-km of rail transport can be as low as one third of road transport requirements, these fuel savings are only worth pursuing if they reduce overall transport costs without impairing the quality of service. These issues are discussed below in relation to petroleum transport (para. 3.44-3.52).

3.27 In early 1984 the GOB acquired a fleet of 60 buses for use in Ouagadougou, Bobo-Dioulasso and inter-city transport. This will probably result in a small transfer of passenger transport from mopeds and "taxis brousse" (i.e. gasoline) and possibly rail (industrial diesel) to buses (gasoil); with reasonable levels of capacity utilization there may also be a reduction in energy consumption per passenger-km. Again, this transfer will only be worthwhile if it reduces passenger transport costs without causing an unacceptable reduction in the quality of service.

3.28 There is also some potential for cutting costs by more efficient use of gasoil in truck fleet operations, particularly for international freight. The principal measures are: (a) improved truck maintenance, (b) driver training, and (c) improved truck fleet utilization through increased brokerage of information on loading and back-loading opportunities.

3.29 In late 1984 there were plans for a vehicle technical inspection center in Ouagadougou and two proposals under consideration for truck driver training programs. Both activities could be cost-effective in reducing truck maintenance and fuel costs. Under present contractual arrangements the railway handles the bulk of agricultural export freight through the Ivory Coast, but has a declining share of the much larger

volume of imports. As a result, trucks often travel empty to the Ivory Coast. Despite these constraints, it would probably be worth trying to improve the utilization of the long-haul truck fleet by extending the present information brokerage functions of COVOC (the association of Burkina's freight operators).

3.30 The lack of reliable information on the vehicle fleet is hampering the evaluation of options for increased energy efficiency in the land transport sector. Upgrading the present data base should be a high priority task for Burkina's energy and transport planners.

Substitution

3.31 In the medium term there are three main areas where inter-fuel substitution is likely to change the pattern of petroleum demand. The first is partial replacement of fuelwood by kerosene in middle-income households; this possibility is discussed in Chapter II on "fuelwood/household energy". The second is partial replacement of gasolines by locally produced ethanol; this is discussed below (para. 3.32). Finally, there is partial replacement of oil-fired power generation by other sources such as hydro, industrial cogeneration or electricity imports; these options are discussed in Chapter IV on "electricity".

3.32 Ethanol. The scope for producing and marketing ethanol as a gasoline extender in Burkina is outlined in Annex 7. The GOB has recently established at Banfora a distillery designed to produce three million liters/year of ethanol from the molasses output of the SOSU-BF sugar mill. The distillery was scheduled to start production in early 1985. However, at the time of the mission there appeared to be no firm contractual arrangements with SOSU-BF for supplying molasses or energy inputs (steam and electricity), nor with the oil companies for transporting, storaging, blending or distributing ethanol.

3.33 The SOSU-BF sugar mill consumes its entire output of bagasse in cogenerating steam and electricity and, under present operating conditions, a significant input of fuel oil is also required at the end of the milling season (Annex 13). This fuel oil requirement can and must be eliminated. It would therefore be useful to review the arrangements for energy supply from the sugar complex to the ethanol distillery in conjunction with an energy audit of SOSU-BF to specify the best combination of energy savings in the sugar manufacturing process (evaporators, juice heaters) and/or additional net energy input by recycling waste heat into bagasse drying.

3.34 Once the costs and transfer prices for the inputs and outputs of the ethanol plant are established, it will be possible to determine whether it would be viable to proceed with commissioning and operating the distillery and the associated ethanol transport, storage, blending and distribution system. These latter components might entail additional investments not budgeted for in the original project. It is therefore essential that the GOB seek immediate assistance to establish: (a) the costs and transfer prices for supplying molasses and energy from SOSU-BF,

(b) an ethanol transport, storage, blending and distribution plan and the respective responsibilities of SOPAL and the oil companies.

Procurement

3.35 Burkina's position as an importer of petroleum products evolved from being a captive market of the SIR refinery in Ivory Coast, with which it is linked by the RAN railroad, to a more leveraged position, with some discretionary power in the selection of suppliers and the route of access. This strengthened negotiating position is due to a more active role of government in oil procurement and to the strong competition of suppliers in the international product market.

3.36 Although Burkina's oil requirements are relatively small (they have remained at about 125,000 to 135,000 tonnes/year, or 2,500-3,000 b/d since 1980), they offer an important market outlet for oil companies attempting to optimize their operations in the West African region. The two main supply options for Burkina are: the refinery in Ivory Coast, and purchases in the open market routed through Togo. Since they are minority shareholders in SIR, the GOB and the private oil companies established in Burkina have the common incentive to use the Abidjan refinery as a preferred source of supply. This modern refinery (with a capacity of 80,000 b/d and significant conversion capacity) is making efforts to maintain economic viability. Success in recovering former clients is essential for increasing the refinery's throughput rate and to achieve long-term survival. Burkina can also import oil through Benin and Togo. An oil storage facility is being developed in Togo to ease such transit shipments. A refinery rehabilitation project is also underway in Ghana and this may open up another possible source of product imports for Burkina.

3.37 From a transport point of view, Abidjan is potentially the cheapest supply point if the railroad is efficiently used. While the road transport costs from Lomé are similar to road transport costs from Abidjan for volumes destined to Ouagadougou, Lomé is less competitive for supply to the second main consumption center at Bobo-Dioulasso. There is also a potential to reduce ex-Abidjan freight costs by improving the service on the RAN railroad to attract petroleum traffic back to rail. However, the railroad route cannot be used at present to import oil from sources different from SIR. 7/

7/ In September 1985 it was noted that GESTOCI had now commissioned storage facilities in Abidjan; in theory these facilities open up the possibility of using the port of Abidjan to import petroleum products from any source. SEBHY is investigating the operational significance of this option.

3.38 SIR's past pricing policy reflected its market position: industrial fuels (diesel oil and fuel oil) were priced at world market parity because the refinery had a surplus that had to be marketed off-shore; kerosene was slightly subsidized, and automotive fuels were charged a premium. This price structure remains in place, in spite of the fact that market conditions have become more competitive and the refinery has constructed a conversion capacity. Price levels were changed in 1981 and 1983, partly to offset operating losses that are largely due to SIR's massive investments in vacuum distillation and cracking equipment. Minor adjustments have taken place since then, in spite of the depreciation of the CFA.F. Table 3.3 illustrates the fact that the ratio of SIR ex-refinery prices to independently calculated landed prices (World Bank figures from Platt's Oilgram) has diminished over time.

3.39 Mission estimates indicate that the differential between import parity prices and ex-SIR prices could have cost Burkina in excess of US$10 million in 1982. Part of the potential savings were effectively realized. The resident oil companies responded to the SIR price increases by importing 36,000 tonnes of gasolines and gasoil through Lomé in Togo (80%) and Cotonou (20%) in 1982/83. For the volume passing through Lomé, the potential cost savings were diminished by transit through sister companies and by the high freight costs associated with the limited storge facilities at STE (Société Togolaise d'Entreposage). Despite these reductions, total savings are estimated at more than US$1 million compared with purchases from SIR.

3.40 In 1983, the GOB designated SEHBI, the GOB/oil company joint venture storage company, to act as its agent for importing products from SONATRACH in Algeria under a government-to-government contract. The marketing companies were to distribute the Algerian product and would continue to import and distribute the balance of national requirements. SEHBI's activities have now established a number of credible alternatives to procurement from SIR for products for which SIR prices are not competitive. In late 1984 these products were the gasolines and gasoil, the total volumes of which account for around 60% of national consumption. The costs of alternative supplies are verifiable and could reasonably serve as the basis of a purchase agreement with SIR for those products. In late 1984 SIR remained Burkina's most competitive source of supply for fuel oil, industrial diesel, kerosene and LPG.

3.41 In the event of satisfactory supply arrangements with SIR, the Togo supply route still needs to be kept in operation for strategic reasons. This will serve the dual purpose of demonstrating that a viable alternative exists and maintaining a functioning parallel supply line in case of disruption from the main source. A suitable target might be to import around 20% of Burkina's white product requirements through Lomé. This amounts to 15,000 to 20,000 tonnes/year at recent rates of consumption.

Table 3.3: PRICE COMPARISON FOR DIFFERENT SOURCES OF SUPPLY
(Abidjan)

		Gasoline	Kerosene	Gasoil	Exchange Rate (CFA.F/US$)
1980	Landed Price - a/ - CFA.F/HL	5,730	6,382	5,637	
	- US$/te	377.17	382.88	318.05	211
	Ex-refinery price	10,500	7,500	10,250	
	Ratio Ex-ref./landed	1.83	1.18	1.82	
1981	Landed Cost a/ - CFA.F/HL	7,402	7,646	7,153	
	- US$/te	379.37	357.12	314.24	271
	Ex-refinery	12,900	7,500	12,000	
	Ratio	1.74	0.98	1.68	
9/83	Landed Cost b/ - CFA.F/HL	8,941	10,614	9,628	
	- US$/te	312	320	288	398
	Ex-refinery	15,400	8,500	14,600	
	Ratio	1.72	0.80	1.52	
1984	Landed Cost c/ - CFA.F/HL	9,526	10,238	9,979	
	US$/te	294	288	264	
	Ex-refinery	15,400	10,000	14,600	
	Ratio	1.62	0.98	1.46	

a/ Second quarter averages - as calcuated by Word Bank.
b/ November 1983 (Platt's - quarterly averages).
c/ September 1984.

3.42 In principle, a common feature of Burkina's relations with both SIR and SONATRACH is that prices are set on a government-to-government basis. In the Algerian case, SEHBI also remained responsible for the product from shipping through to storage in Burkina.

3.43 The GOB needs a small nucleus of petroleum expertise to look after Burkina's strategic interests and to lead government-to-government discussions on product prices (e.g. in the Ivory Coast) and throughput charges (e.g. in Togo). Technical assistance is proposed above ("Procurement (1)", para 3.8) for the creation of this group, as well as for its initial on-the-job training. Technical assistance is also suggested for a GOB review of organizational options for integrating the proposed group into existing structures ("Procurement (2)", para 3.9).

Petroleum Transport

3.44 Burkina has access to the Atlantic coast via a railway and several road systems. A fully paved road runs north from Abidjan through Bobo-Dioulasso to Ouagadougou, a total of 1166 km. This is paralleled over 1145 km by the RAN railway (la Régie Abidjan-Niger), which is jointly owned and operated by the Governments of the Ivory Coast and Burkina.

Other all-weather access routes to the Atlantic include paved roads from Ouagadougou to Tema in Ghana (1030 km) and to Lomé in Togo (1000 km). There are also partly paved roads from Ouagadougou through Fada N'Gourma to Niamey in Niger and to Cotonou in Benin.

3.45 In comparison with road freight, the RAN has recently suffered a decline in both competitiveness and quality of service. Total rail freight from the Ivory Coast to Burkina declined by one-third over the period 1982-84; Burkina's merchandise imports are estimated to have declined by about 7% over the same period. The difference can be attributed to: (a) the diminishing relative importance of the Ivory Coast as a source or port of entry for Burkina's imports, and (b) the deteriorating share of rail in the remaining freight from Abidjan to Burkina.

3.46 In the case of petroleum freight, both of these factors are clearly evident in recent trends. As a result of the stagnation of Burkina's petroleum consumption and the opening of the Lomé route, total petroleum tonnages freighted out of Abidjan declined by more than 40% over the period 1981-84. During this time petroleum road freight tonnages remained constant, so that the decline was entirely borne by the RAN. However, the RAN's failure to compete effectively for petroleum freight was a problem even before the recent structural changes. Rail's share of ex-Abidjan petroleum tonnages had declined from a near monopoly in 1977 to around 70% in 1981, before falling to its estimated 1984 share of less than 50%. The structural changes in petroleum import arrangements since 1981 are not the root cause of the declining rail freight tonnages; they have simply exacerbated an existing problem of price and quality of service.

3.47 It is vital for both Burkina and the Ivory Coast that the railway's competitive advantage be restored and exploited, particularly for long-haul freight. As financial rehabilitation proposal is under consideration, it is useful to underline the importance of petroleum freight in any such scheme. Burkina's total petroleum imports are likely to remain in the range of 120,000 to 150,000 tonnes/year during the period to 1990. The RAN's possible share of this traffic can be illustrated by the following two scenarios:

(a) Relative prices remain unchanged; Burkina takes only fuel oil, industrial diesel and LPG from SIR; the RAN's share of ex-Abidjan tonnages declines further to around 25%.

(b) Burkina imports 20% of white product requirements through Lomé and all other requirements from SIR; the RAN's share of ex-Abidjan tonnages returns to the 1980/81 levels of around 75%.

These crude scenarios indicate that, in the absence of an integrated petroleum procurement and rail freight strategy, petroleum traffic could contribute as little as 10,000 tonnes/year in the period to 1990. However, the potential exists to raise this contribution to more than 90,000 tonnes/year and this is probably the only freight component where a GOB initiative could have such a significant impact.

3.48 In the absence of a firm development plan for the railway, it is difficult to evaluate the long-run marginal cost of freighting petroleum by rail. A crude inflation adjustment of a 1980 estimate suggests 20,000 CFA francs/tonne in late 1984 terms, or around US$45/tonne (at an exchange rate of 450 CFA.F/US$). A more recent analysis of the RAN indicates that, with some additional investment in infrastructure, the railway could service in 1985 a total volume 25 percent higher than 1981/82 levels. This target throughput includes approximately 90,000 tonnes of petroleum products from Abidjan to Burkina. The quality of service could also be improved by scheduling special-purpose trains just to handle petroleum freight.

3.49 In the longer term, the anticipated growth of freight volumes could be met by a combination of heavier trains and re-grading of a small section of the existing track sometime between 1987 and 1990. There is no immediate requirement for major investments such as a second track. The implication of this analysis is that the long-run marginal cost of routing additional petroleum freight via rail is relatively low and should not exceed earlier estimates, since these incorporated substantial additional investments.

3.50 The long-run marginal cost, including an allowance for road maintenance, of trucking petroleum products in 30 cu.m. tankers from Abidjan (or Lomé) to Ouagadougou appears to lie in the range of 30,000 to 50,000 CFA francs/tonne (1984 terms). The mid-point of this range is around US$90/tonne (assuming 450 CFA.F/US$). On this basis, the economic benefits of transporting petroleum by rail rather than road could be around 20,000 CFA francs (or US$ 45) per tonne. If an integrated petroleum procurement and rail freight strategy raises rail traffic from 10,000 to 90,000 tonnes/year, the total economic benefits could be about 1.6 billion CFA francs (or US$3.6 million) per year. This estimate needs to be reduced to allow for the shorter haul for the Bobo-Dioulasso share of the market.

3.51 The potential benefits of transporting petroleum by rail could easily be lost through a combination of: (a) higher product prices at Abidjan than at Lomé; (b) additional inventory costs to cope with less reliable service; (c) lost production and other economic costs of disruption in the event of petroleum shortages. Burkina's petroleum and transport planners need to work together to minimize the risk of incurring such losses.

3.52 A final element in the petroleum freight strategy is the use of incentives to ensure a progressive transfer from road back to rail. Within the limits imposed by the availability of petroleum rail-tankers, the road/rail split is influenced by the freight components allowed in the official petroleum product price structures. These are determined by the Direction des Prix.

3.53 In the official pricing structures of January 1, 1984, for example, the marketing companies were allowed to recover 2966 CFA.F/hectoliter (HL) for rail transport of regular gasoline from Abidjan to

Ouagadougou, and an additional 700 CFA.F/HL if the product was transported by road. The road total of around 3700 CFA.F/HL could be compared with a typical charge of 3100 CFA.F/HL for road freight of petroleum over a similar distance from Lomé to Ouagadougou. The comparison suggests that the marketing companies are adequately compensated for road transport costs and are offered no real incentive to transfer any part of this traffic to the railway. These incentives should be restructured regardless of progress on upgrading the quality of service on the railway.

Storage

3.54 Petroleum product storage and distribution in Burkina have traditionally been divided among local subsidiaries of five multinational marketing companies. By the early eighties it had become apparent that considerable cost savings could be achieved by operating shared storage, both in Ouagadougou and in Bobo-Dioulasso. The marketing companies were invited to finance the building of joint operational storage at Bobo-Dioulasso, but declined. This was presumably a consequence of the insecure investment climate prevailing at the time, since there appears to be no suggestion that the price-controlled rate of return on investment is inadequate. A decision was then taken to build the necessary joint storage at Bobo-Dioulasso with GOB finance. At the same time the marketing companies formed SEB (Société d'Entreposage à Bobo), a joint venture to manage the new depot. The finance provided by the GOB could be regarded as a loan to SEB.

3.55 At this stage the GOB decided to construct a new depot at Bingo, near Ouagadougou, both to rationalize operational storage and to create spare capacity for strategic reserves. For the financing and management of the new depot, the GOB formed SEHBI (Société d'Entreposage d'Hydrocarbures de Bingo), a 70/30 joint venture with the marketing companies. Construction was then financed by a mix of shareholder capital and bank loans. Commissioning of the depot is scheduled for the last quarter of 1985, with operational management in the hands of ex-GOB personnel. In a different investment climate it may have been possible for the GOB to exploit the financial and managerial resources of the resident oil companies to achieve these objectives.

3.56 As a land-locked importer of petroleum products, Burkina needs to protect itself against possible supply disruptions. Strategic stock levels could be based on the following assumptions: (a) 35 days' lead time for a single shipment through Lomé to Ouagadougou; (b) some access to products already in storage in Abidjan, Lomé or Cotonou; (c) 20 days' working inventories. It is recommended that the GOB adopt 45 days as a target minimum stock level, at least for gasolines, kerosene and

gasoil, 8/ The marketing companies could be compensated for the interest cost of holding the additional stocks by a suitably modified form of the existing "security stock" component of the official price structures.

3.57 As a result of the GOB's initiatives, Burkina is well endowed with storage capacity for most products, both for working inventories and for strategic reserves. Total depot capacity ranges from around 47 days' consumption (1983 levels) for industrial diesel to 141 days for premium gasoline. Only LPG storage is potentially a problem. While the Ouagadougou depot includes facilities for 100 tonnes (50 days), current consumption is artificially depressed by frequent shortages both of LPG and of bottles, in both cases due to anomalies in the price control system. As soon as these problems are resolved, consumption will rapidly increase to the point where storage will prove inadequate to avoid shortages. In the case of kerosene, present storage capacity (78 days) could cope with several years of significant consumption growth before becoming a constraint in any campaign to replace fuelwood.

3.58 The GOB's present objective should be to consolidate the achievements of the last few years by managing the new systems with an efficient mix of public and private sector resources. It is therefore recommended that the GOB investigate ways of using the resources of private companies to manage petroleum depots, while ensuring that national stocks of gasolines, kerosene and gas-oil are each maintained at a minimum of 45 days' consumption.

Financial Control

3.59 The retail prices of petroleum products are subject to price control. Prices are set separately for Ouagadougou and Bobo-Dioulasso and actual trucking costs are added for deliveries outside the two main centers. For each combination of product and destination (Ouagadougou or Bobo-Dioulasso), there is a separate official cost "structure" for each source of supply, normally Abidjan or Lomé. The structure defines the components which make up the difference between the FOB cost of product and the official retail price fixed by the GOB, i.e. (a) allowable transport costs by road or rail, (b) duties, taxes and levies, and (c) a balancing component to be paid either to or by the Equalization Fund (Caisse de Peréquation).

3.60 The Equalization Fund aims to stabilize prices on petroleum and ten other products, mainly food staples. Its interventions depend on the price trends of the different products and on the cash reserves of the Fund. At different times the Fund's operations result in: (a) subsidies

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8/ Present statutes envisage a minimum of 90 days for security stocks and a further 30 days for working inventories. SEBHY intends to construct additional depots.

on food, (b) subsidies on certain petroleum products, (c) stabilization of petroleum prices.

3.61 In principle, a new cost "structure" should be announced whenever there is a change in a basic cost item, i.e. for each new cargo through Lomé, a price change at SIR, or revision of the transport tariffs. In practice, the Direction des Prix changes the official structures as infrequently as possible, since each revision involves a complex recalculation of various "ad valorem" duty and tax components. In late 1984, for example, there was still no official cost structure for the Algerian product first imported in July 1984 through Lomé. While these delays do not affect final consumers, since retail prices remain unchanged, they introduce an undesirable element of uncertainty into (a) fiscal relations between the GOB and the marketing companies, and (b) forecasting of GOB petroleum taxation revenues.

3.62 The amounts involved are significant: the first Algerian cargo alone resulted in an additional cash inflow of 1.2 billion CFA francs (around US$2.7 million) to the Equalization Fund and ultimately to the Treasury. While waiting for an official revision of the cost structure, the marketing companies withhold payments to the Fund. 9/ It is therefore essential that the GOB acquire the expertise necessary to execute these accounting functions more efficiently. Timely updates of petroleum cost structures will provide basic information for (a) monitoring oil company activity, (b) energy planning in general, and (c) forward planning of the GOB's recurrent budget in particular.

3.63 The need for financial control extends to the allocation of revenues from the duties, taxes and levies imposed on petroleum products. In the regular gasoline cost structure of January 1, 1984, for Ouagadougou, for example, these components jointly accounted for 5324 CFA.F/HL, or 20% of the retail price of 27,200 CFA.F/HL. This total includes three components which are "earmarked" to specific uses: (a) a variable amount (184 CFA.F/HL at that time) for the Equalization Fund; (b) a fixed 250 CFA.F/HL for the "Petroleum Action Fund", i.e. BUMIGEB; and (c) a fixed 530 CFA.F/HL (330 CFA.F/HL in the Bobo-Dioulasso price structures) for "Security Stocks", currently allocated to SEHBI. For increased control over government expenditure, it would be preferable to finance these organizations directly from the GOB's recurrent budget, with no linkage to petroleum throughput.

3.64 A final consideration is road maintenance. In various loan covenants the GOB has undertaken to allocate 59% of petroleum taxation revenues to maintenance of the road network. It appears that expenditure on road maintenance may have been less than half this amount in recent

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9/ Since the Assessment mission in September 1984, a working group has been created of all the parties concerned, with the object of improving the process by which official price structures are updated.

years. In order to lessen the deterioration of the national transport infrastructure, it may be useful to (a) restructure the taxes on gasolines and gasoil to include a "road user charge" which is dedicated to road maintenance; and (b) take the steps necessary to ensure that maintenance expenditure reaches the desired levels.

3.65 Strong financial control in the petroleum subsector could make a significant contribution to the GOB's overall economic and financial management. This could be achieved by on-the-job training of one or two key personnel in the Hydrocarbons Cell. Technical assistance is proposed above ("Pricing/Financial Control", para. 3.10) for a GOB review of options to improve the present arrangements and for training of GOB personnel to manage the new system.

IV. ELECTRICITY

Issues

4.1 This chapter reviews electricity planning options in the two main areas of potential demand in Burkina: Ouagadougou/Koudougou and Bobo-Dioulasso/Banfora. The review focuses on (a) load forecasts and the near-term implications for the timing of new capacity; (b) longer-term alternatives to additional fuel oil capacity, including hydro, industrial generation and interconnection with neighboring countries.

4.2 The scope for increased energy efficiency in electricity generation, distribution and consumption is also briefly reviewed.

4.3 Investment capital for electricity and fuelwood supply represents the two main requirements for donor resources in the energy sector. The energy planning trade offs between these two requirements are discussed in Chapter V.

Key Recommendations

4.4 Rehabilitation. Upgrading of existing fuel oil plant to normal availability is an urgent priority for the Ouagadougou system.

4.5 Demand Management. (a) Tariff structures for medium voltage consumers should be more closely related to economic costs of electricity supply. (b) Electricity conservation initiatives should be directed initially at replacing the present airconditioning restrictions with longer term measures.

4.6 System Expansion. (a) Planning of system expansion should be based on load forecasts which take account of the recent stagnation of electricity consumption in the main centers. (b) New capacity is needed in 1986 for Bobo-Dioulasso; with full availability of existing fuel oil plant, and after commissioning of the Kompienga hydro-electric scheme, new capacity will be needed for Ouagadougou around 1994.

4.7 Interconnection. (a) Transmission from Ferkessédougou in the Ivory Coast to Bobo-Dioulasso is an option for electrical energy interchange with the Ivory Coast system from the mid-nineties and ultimately with the proposed West African interconnected system; evaluation of this option should be pursued. (b) Electricity imports from Ghana are an important supply option for Ouagadougou/Koudougou in the mid-nineties; Burkina should maintain permanent contact with Ghana to ensure coordinated development of hydro/transmission options on both sides of the border.

4.8 Thermal Capacity. The timing of additional thermal capacity at Ouagadougou should be reviewed to take account of possible commissioning

of: (a) the Bagré multi-purpose hydro project, and (b) interconnection with Ghana.

4.9 Industrial Generation. The GOB should: (a) define marginal cost-based tariffs at which SONABEL will buy privately generated electricity in Ouagadougou, Koudougou, Bobo-Dioulasso and Banfora 10/; and (b) encourage private sector sales of electricity in centers not currently served by SONABEL.

Donor Support

4.10 The main committed or probable electricity supply investments proposed for 1985-90 are: (a) the Kompienga hydro-electric scheme with transmission to Ouagadougou; (b) fuel oil-fired diesel capacity to reinforce present diesel capacity at Bobo-Dioulasso; (c) creation of four new small diesel centers; and (d) two short distribution extensions in small centers.

4.11 Rehabilitation. It is recommended that the GOB seek donor support for a rapid review of: (a) the costs of upgrading existing fuel oil plant at Ouagadougou to normal availability; and (b) the impact on timing of new capacity.

4.12 In parallel with current investment activity, there is a need for donor support to evaluate Burkina's medium to long term electricity supply options. It is recommended that the GOB give priority to the following pre-investment investigations.

4.13 System Expansion. Independent consulting assistance is needed to support SONABEL to: (a) review projected requirements for additional power and energy, including two scenarios for Ouagadougou -- with and without Bagré; (b) complete the evaluation of the longer term potential for major interconnectons (at 220 or 330 kV) with the larger systems in the region; (c) review the role of additional thermal capacity in the light of the results of these studies.

4.14 Tariffs. Expert assistance is required by SONABEL to undertake a tariff study in several stages. The immediate priorities are: (a) tariff restructuring -- simplification, and improvement of their incentive effects, particularly for medium voltage consumers; (b) definition of buy-back tariffs for purchase of privately generated electricity. The resulting tariffs would need to be reviewed as soon as the key elements of future system expansion are known.

4.15 Airconditioning. Technical assistance is suggested to enable the GOB's architectural and building services personnel to establish procedures for selecting energy-efficient airconditioning systems.

10/ This exercise could be part of an overall tariff study; SONABEL attaches high priority to completion of such a study.

4.16 Hydro Resource Inventory. Expert assistance is suggested (a) to extend the existing reconnaissance investigations in the Banfora area to cover a wider area and possible additional sites; and (b) to complete pre-feasibility evaluation of sites most likely to provide competitive supply to the present SONABEL system.

Management of the Present System

4.17 The development of the public electricity supply system in Burkina has remained limited. Electricity is an elite form of energy in relation to household incomes and the purchasing power of the traditional artisanal and trading sector in Burkina. At the same time, the modern industrial and commercial sector is small and major establishments are often independent of the public supply system. In 1983 total electricity sales in Burkina amounted to 109 GWh.

4.18 Eighty-seven percent of public consumption takes place in the country's two main cities: Ouagadougou (63%) and Bobo-Dioulasso (24%). Three other towns have skeleton public electricity distribution systems: Koudougou (10%), Banfora (1.4%); and Ouahigouya (1%). In 1983, seven new small distribution centers were commissioned, each with an installed capacity of less than 250 kW. While the population of these 12 load centers represents 8% of Burkina's total population, the number of households connected to electricity within these towns is generally less than 20-25%. Approximately 2% of Burkina's population therefore has access to electricity.

4.19 The electricity subsector is controlled by SONABEL (Société Nationale Burkinabè de l'Electricité), a commercial para-statal with a national monopoly on electricity generation and distribution. In principle, self-producers can only operate with an exemption from SONABEL. Total generation by SONABEL in 1983 [illegible] GWh, all of it from diesel plant using imported oil. No statistics are available for self-producers; however, it is estimated that their combined generation is of the order of 30 GWh/year, of which around two-thirds is produced from biomass residues. There are no transmission links between load centers.

Demand

4.20 Between 1972 and 1980, electricity generation and sales tripled, the latter from 37 to 113 GWh/year (Annex 8). During this period of rapid growth (15%/year on average), only one new load center was added to the public supply system: Banfora in 1973. The bulk of the growth therefore was due to the extension of distribution systems in the five load centers and to increased average sales per consumer. Throughout the period the capital city of Ouagadougou accounted for more than two-thirds of national consumption, with growth arising from a mix of new industry, government buildings and housing. The second city, Bobo-Dioulasso, also experienced significant growth in industrial and commercial activity over the period. The growth of Koudougou, the third

largest load center, is closely linked to the FASO-FANI textile factory (formerly VOLTEX), which takes more than three quarters of local generation.

4.21 Demand growth has slackened noticeably since 1980 and consumption has now been in a period of absolute decline since the second half of 1983. This decline is most noticeable in Ouagadougou (-7.3% for the first half of 1984), but is also clearly established in Bobo-Dioulasso and Banfora. The decline reflects the general slowdown of economic activity in Burkina and is also the result of austerity measures taken by the Government. This seems likely to continue for another two to three years, since the GOB intends to concentrate on a number of social objectives in preference to further industrial growth.

4.22 Contrary to this overall trend towards stagnation or decline in electricity consumption, demand growth has not faltered in the smaller centers, such as Ouahigouya and the seven new load centers commissioned in 1983. At present tariff levels there is considerable suppressed demand in these small centers and it is clear that their medium term demand growth will be largely determined by availability of supply. This in turn depends on the rate at which investment resources are made available to SONABEL for extending existing networks or creating new load centers.

4.23 The relatively higher growth rate of small center consumption will modify the structure of SONABEL's electricity sales. This structure was stable over the period 1972-82, with more than half of total sales going to major customers, generally medium voltage industrial consumers (Annex 9). A reduction of this share could have a negative impact on SONABEL's financial position, given the resource transfers which are implicit in the present tariff structure.

4.24 The daily and seasonal pattern of demand has different characteristics in each of the main centers:

(a) In Ouagadougou during the hot months (March to June, and October), the heavy office airconditioning load amounts to around 45% of annual peak demand (which occurs in April/May). As a result, there are two daily peak periods, one from 9:30 a.m. to midday and the other from 3:30 to 5 p.m. During the cooler months of December/January, the reduced airconditioning load leads to a peak demand of 50-60% of the annual peak. As a result, the daily peak is shifted into the evening, from 6.30 to 9 p.m.

(b) In Bobo-Dioulasso, the office airconditioning load is a lower proportion of total demand and is better matched with other loads. The pattern of demand is the same as for Ouagadougou except that, during the hot months, demand during the evening peak is as high as during the two daytime peak periods, i.e. for most of the year there are three daily peaks of about the

same size. Seasonal variations follow the lighting load and amount to around 15% of the annual peak.

(c) In Koudougou the demand pattern is determined by the FASO-FANI textile factory, which is in constant operation except for a one month shutdown in July/August. In the small centers (Banfora, Ouahigouya and the seven new centers), the office airconditioning load is very low. As a result the daily load curve has an evening peak and relatively little seasonal variation.

4.25 A simple indication of the pattern of electricity demand is the annual load factor, i.e. annual energy demand expressed as the number of hours of generation required at the equivalent of maximum demand. This parameter oscillates around 4,000 hours/year for Ouagadougou, and between 4,500 and 4,800 hours/year for Bobo-Dioulasso, Banfora and Ouahigouya. In Koudougou the load factor can be as high as 5,800 hours/year depending on the activity of the textile industry.

Generation

4.26 The total installed capacity of SONABEL plant is 60 MW, all of it diesels (Annex 10). Construction of the Kompienga hydro project is underway; this will add 15 MW installed (7 MW firm) to the Ouagadougou system by 1989/1990. Within the present thermal total, 32.5 MW is in fuel oil-fired units larger than 5 MW, with the remainder in units ranging in size from 50 to 1500 kW running on diesel ("DDO"). With the exception of Bobo-Dioulasso, the installed capacity in each of the main centers in 1984 was at least twice the expected peak demand (Table 4.1).

Table 4.1: SONABEL SECURITY MARGINS

Capacity Balance	Installed Capacity (MW)	Maximum Demand (MW)	Ratio
Ouagadougou	41.0	19.4	2.1
Bobo-Dioulasso	10.8	6.3	1.7
Koudougou	4.8	2.4	2.0
Banfora	0.9	0.4	2.3
Other centers	2.7	1.1	2.7
Total	60.2	29.6	

4.27 While these security margins are often necessary in small centers with small numbers of machines, this is not the case in Ouagadougou. Installed capacity in Ouagadougou is unusually high for two reasons: (a) the two most recent 8 MW units at Ouaga 2 were installed in anticipation of more rapid load growth than has actually occurred; (b) approximately 4 MW of plant which would normally have been retired

from Ouaga 1 has been kept available in reserve. At the same time, several serious breakdowns have reduced the capacity available at Ouaga 2, thereby reducing the effective security margin and justifying the retention of standby plant at Ouaga 1.

4.28 Restoration of all installed capacity at Ouaga 2 to a state of normal availability is now the most urgent task facing SONABEL, since permanent solutions still need to be found for some of the problems encountered in 1983. In order to eliminate this uncertainty, the mission recommends that independent expert assistance be employed to: (a) advise on the scope for additional measures, particularly relating to foundations, and (b) review the allocation of responsibility between the equipment supplier, other contractors and SONABEL. These measures are essential to minimize the risk of requiring a costly plant rehabilitation project in several years' time.

4.29 The operational management of SONABEL plant is good. The operating personnel are competent and pay considerable attention to the reduction of per-unit consumption of fuel and lubricants, as well as to the electricity consumption of auxiliary equipment:

(a) Specific fuel consumption is around 223 gm/kWh for the plant running on fuel oil and between 240 and 290 gm/kWh for the diesel-fired plant; lubricant consumption is between 1.2 and 4.3 gm/kWh.

(b) The consumption of electricity by auxiliaries is good (less than 3%) at Ouaga 2, Bobo-Dioulasso and Ouahigouya, but is high at Ouaga 1 (8%), Koudougou (8%) and Banfora (10%). The system average is nonetheless acceptable (3.6%) and will improve as a result of cooling system modifications which are under way at Koudougou and Banfora. The situation at Ouaga 1 will not be of concern while annual generation from this plant remains low.

Distribution

4.30 SONABEL's operational management of the distribution systems is also good. Metering seems to be complete and well maintained; billing and collection procedures are adequate; non-technical losses (i.e. non-payment, including theft) therefore appear to be low. Distribution losses are largely "technical"; their structure is as presented in Table 4.2.

Table 4.2: DISTRIBUTION LOSSES

Voltage Levels	Large Centers	Small Centers
HV & MV consumers	8%	5%
Low voltage consumers	10%	9%

Source: Mission estimates.

4.31 At present there are three standard voltages in use in SONABEL distribution systems: 5.5, 15 and 30 kV. In order to simplify the networks and increase their capacity, SONABEL has begun a program of progressive upgrading from 5.5 to 15 kV. The choice of 15 kV is perhaps unfortunate, since this type of equipment is becoming uncommon and relatively expensive. As a result, SONABEL management is now considering the possibility of moving to 20 kV. Another option would be to adopt 30 kV as the sole voltage, not only for distribution systems but also for small scale transmission links. The question of distribution voltages needs to be reviewed in detail in order to make a definite choice as soon as possible.

Supply Costs

4.32 In the absence of an agreed system expansion plan, the best basis for evaluating the economic costs of electricity supply is to assume continued thermal development, i.e., diesel plant running on either fuel oil or diesel fuel. These estimates will then represent an upper limit on future supply costs. The mission has estimated a range of indicative average incremental costs for commissioning and operating new diesel capacity and distribution extensions using 1983 data for Burkina conditions. Details and assumptions are presented in Annex 11.

4.33 The marginal capacity costs of installing and operating new generation and distribution have been estimated at: (a) 79,800 to 132,900 CFA.F/kW/year at the medium voltage level, for large and small centers, respectively; and (b) 114,700 to 181,800 CFA.F/kW/year at the low voltage level. Marginal energy costs have then been assessed on the basis of: (a) 1983 delivered costs of fuel and lubricants to SONABEL (less taxes, duties and levies); and (b) an allowance for losses. Finally, the average incremental cost (marginal capacity plus marginal energy costs) has been assembled on the basis of an assumed operating regime of 4000 hours/year (Table 4.3).

Table 4.3: SONABEL SUPPLY COSTS

CFA.F/kWh in 1983	Medium Voltage	Low Voltage
Marginal Energy Cost:		
large centers	33	37
small centers	50	54
Average Incremental Cost:		
large centers	53	65
small centers	83	100

4.34 These indicative economic costs suggest that, on a kilowatt-hour basis: (a) delivered costs vary by a factor of two, from 53 to 100 CFA.F in 1983 terms; (b) delivered costs are sensitive to the size of the

load center (a cost ratio of 1.5 to 1) and to the customer's delivery voltage (a cost ratio of 1.2 to 1); (c) off-peak costs are around 60% of average incremental costs for medium voltage consumers in both large and small centers. This pattern of electricity supply costs should be the basis of SONABEL's tariffs for the period until new sources of supply are commissioned, e.g. hydro, industrial cogeneration, or imports from neighboring countries in the longer term.

Tariffs/Revenue Collection

4.35 SONABEL's tariff structure consists of a single medium voltage tariff and a wide range of complex tariffs for low voltage consumers (Annex 12); they are the same in all load centers and do not include seasonal variations. These tariffs are to be compared with three general guidelines: (a) average incremental costs ("Supply Costs", para. 4.33); (b) daily and seasonal patterns of system peak demand ("Demand", para. 4.24); and (c) SONABEL's revenue requirements. The following comments focus first on ways to simplify tariff structures and improve their incentive effects, and second on likely trends in average tariff levels. More detailed proposals would need to be based on a full tariff study. SONABEL would like to commission such a study as soon as possible; the mission recommends that the study be made part of a broader technical assistance activity aimed at defining the principal elements of a system development plan.

4.36 The all-purpose Medium Voltage tariff has a low capacity charge per subscribed kilowatt, in combination with peak and off-peak energy charges. The peak period energy charge applies to consumption between 8 a.m. and 11 p.m. for all load centers throughout the year. The off-peak energy charge (61 CFA.F/kWh) is well above SONABEL's marginal energy cost (33-54 CFA.F/kWh in 1983) and should be reduced. It is also higher than the off-peak energy charge in the "force motrice B" tariff offered to low voltage consumers (55-59 CFA.F/kWh). This is an anomaly, since distribution losses are several percentage points higher at the low voltage level than at medium voltage.

4.37 A reduction in the off-peak energy charge for medium voltage consumers could be compensated by an increase either in the demand charge or in the peak period energy charge (presently 68-70 CFA/F/kWh). With these changes, the tariff structure would more accurately reflect the difference in SONABEL'S peak and off-peak supply costs and would provide a more substantial incentive to medium voltage consumers to alter their daily consumption patterns where possible.

4.38 SONABEL's average revenue for medium voltage electricity sales in 1983 was 70 CFA.F/kWh, i.e., midway between the estimated 1983 average incremental cost of medium voltage supply in large centers (53 CFA.F/kWh) and in small centers (63 CFA.F/kWh). Medium voltage consumers with favorable load characteristics were paying around 63 CFA.F/kWh. Given the present system of uniform national tariffs, the average level of medium voltage tariffs is reasonably well aligned with economic costs.

4.39 The main tariff for Low Voltage consumers is a kilowatt-hour charge in three declining blocks with negligible price differences between the blocks (92, 90 and 85 CFA.F/kWh). The size of the blocks is approximately proportional to the amperage of the load limiter chosen by the consumer (in the range 5-30 amps): as a result, consumers with similar load profiles will find their consumption distributed between the three blocks in similar proportions. This tariff structure does not give consumers a clear indication of the costs of increasing their demand for power or energy. It would be preferable to introduce a simple two-part tariff for low voltage consumers consisting of: (a) a demand charge in the range of 9,500-15,000 CFA.F/month (1983 costs) per kW of load limiter; (b) an energy charge in the range of 37-54 CFA.F/kWh.

4.40 There is also a special low voltage tariff intended for low income subscribers. This is offered in conjunction with a special 3 ampere connection which is itself subsidized. While this arrangement does succeed in making electricity available to low income users, it also causes a number of problems. By restricting household power demand to 0.7 kW, the 3 ampere connection severely limits the normal development of electricity consumption in the parts of the distribution system where these connections predominate. At the same time there is the additional cost of checks and procedures to avoid multiple connections to the same household.

4.41 The Government's social objectives would be better promoted by a connection, without load limiter, in association with a special case of the tariff proposed above (para. 4.39) for all low voltage consumers. Low income households could opt for a "social" tariff with a lower monthly fixed charge (possibly zero) and a higher kilowatt-hour charge than the standard low voltage tariff. This tariff could be structured so that it provided subsidized electricity for monthly consumption below a certain level. This level would cover basic needs such as lighting and should probably be set somewhere between 15 and 25 kWh/month. Consumers would then have an incentive to move to the normal tariff, with load limiter, as soon as their consumption exceeded the cross-over point in the tariff.

4.42 SONABEL's average revenue for low voltage electricity sales in 1983 was 83 CFA.F/kWh, with small household consumers generally paying around 100 CFA.F/kWh. Again, the average selling price lies in the middle of the range of estimated 1983 average incremental costs of low voltage supply in large (65 CFA.F/kWh) and small centers (100 CFA.F/kWh).

4.43 The main difficulty with not charging the full economic cost of supply in the smaller centers is the artificial stimulation of electricity demand in those centers. The resulting excess demand for diesel fuel and new generating plant will ultimately become an unacceptable burden on SONABEL's finances and in turn on consumers in the main centers. This problem will become progressively more acute as proposed rural electrification projects reduce Ouagadougou/Bobo-Dioulasso's share in total electricity sales below the present level of more than 85%.

4.44 SONABEL tariffs have been set at levels which approximately recover the accounting cost of sales. As a result, operating losses (1981 and forecast for 1984) or profits (1982, 1983) have been relatively small. Significant features of the financial cost structure are the impact of fuel costs (more than 50%) and the negligible proportion of financing charges (less than 2%). The role of fuel and finance costs will change dramatically as soon as SONABEL starts expenditure on capital-intensive electricity supply projects such as hydro or interconnection. However, regardless of the type of capacity chosen for system expansion, it is essential that these expenditures be deferred as late as possible. In the current period of stagnant load growth, additional fixed costs would have to be passed on in the form of tariff increases.

4.45 The present level of financing charges reflects both the low capital cost of diesel plant and the GOB's practice of allowing SONABEL to retain the full benefits of concessionary financing by donors, instead of on-lending at commercial terms. This policy should be reviewed, since it represents an implicit subsidy from the GOB's limited budgetary resources to a relatively less needy segment of the population, viz. electricity consumers. The effect on total supply costs of eliminating this subsidy could be significant if it coincides with a transition to capital-intensive developments, such as the Kompienga hydro project. In such circumstances SONABEL would have to be allowed to build these increased costs into its tariffs.

4.46 A final consideration is revenue collection. SONABEL has computerized its billing and follow-up system and the delay between consumption and payment is now around two months. However, during 1984 a problem arose as a result of the GOB's decision to give each administrative unit direct control over a fixed electricity budget. Unfortunately the new payment procedures were slower and soon led to accumulated unpaid arrears of 400 million CFA.F. The original measure needs to be complemented with some means of allowing the heads of administrative units to pay within the normal period. It would then be useful to extend to the government itself the normal penalties (reconnection charges, etc) applied to private subscribers.

Demand Management

4.47 The most important means of managing electricity demand is to align the structure and level of electricity tariffs with the economic costs of supply. Once this is done, there may be scope for complementary demand management measures in circumstances where institutional barriers or lack of information are preventing consumers from responding to the tariff incentives. These measures should only be undertaken where they will have a major impact on electricity consumption, peak or energy, and where the administrative or financial input will be very low in relation to the expected benefits.

4.48 In the Burkina public supply system, airconditioning is the only major load component which satisfies these criteria. First, airconditioning accounts for up to 45% of annual peak demand (in

Ouagadougou, para. 4.24) and up to a quarter of total electrical energy consumption, again in Ouagadougou. Second, it is not generally possible to meter airconditioning separately and apply a special tariff which reflects the unusually high costs of supply. Third, a shortage of airconditioning expertise in Burkina is delaying the introduction of equipment which is energy-efficient under tropical conditions. Finally, there do appear to be a number of simple measures which could be undertaken with the help of technical assistance.

4.49 The potential benefits of modifying the airconditioning load are high. It has been estimated that in Ouagadougou in April/May 1983 office airconditioning accounted for around 7 MW out of a total peak demand of 20.5 MW. Residential airconditioning accounted for a further 5-6 MW, but with a peak which did not coincide with system peak demand. Office airconditioning also has a much poorer load factor (around 1000 hours/year) than residential airconditioning (2500 to 3000 hours/year).

4.50 Mission estimates indicate that the 1983 cost of supplying low voltage loads with these characteristics was around 150 CFA.F/kWh for the office load and 72 CFA.F/kWh for residential (assuming 0.6 coincidence with system peak). A comparison with the average 1983 low voltage selling price (83 CFA.F/kWh) shows that the cost of supplying residential air-conditioning is fully recovered, but that office airconditioning is very seriously under-charged. Office airconditioning should therefore be the prime target for initial electricity demand management measures.

4.51 In response to economic difficulties, the GOB has already taken a number of steps to limit the use of office airconditioning. In 1983 it was decided to restrict the operating hours of government office air-conditioning to the months of April, May and June, and only after 10 a.m. This restriction, in conjunction with other budget control measures, is believed to have reduced government electricity consumption by around 20%. These measures need to be complemented and ultimately replaced by others which actually reduce airconditioning's contribution to system peak demand and reduce the electrical energy needed for a given cooling requirement. This means ensuring that airconditioning systems and buildings are more energy efficient in both design and operation.

4.52 The responsibility for government buildings and building services is shared between two divisions of the Ministere de l'Equipement. The "Direction Construction et Entretien des Bâtiments Administratifs" is responsible for operations and maintenance; the "Direction Architecture et Habitat" for design. With suitable external assistance, these divisions could have a significant impact on reducing the government office airconditioning load in the short and longer term, respectively.

4.53 While existing government airconditioning equipment is adequately maintained, the responsible division needs a specialist to advise on the size and type of replacement units. At present there is a tendency to install European or American units which are designed for ambient temperatures of 35 deg.C. In Burkina, where temperatures often

exceed 40 deg.C., the efficiency of these units is diminished by around 30%. The same specialist could devise a set of operating guidelines for government airconditioning systems and arrange procedures for their dissemination and enforcement.

4.54 Modern airconditioning systems with sophisticated control systems have been incorporated in several new buildings over recent years. These have achieved both higher comfort levels and significant electricity savings. Power demand is about 40% lower for both central systems and individual units; electrical energy consumption is about 30% lower than for a correctly maintained individual unit. For all future government airconditioning systems, the decision regarding additional investment required for more energy-efficient equipment should be based on the real cost of electricity supply (150 CFA.F/kWh in 1983 terms, para. 4.50) rather than the actual tariff.

4.55 Architectural design is another area where there is a demonstrated potential for reducing the electrical airconditioning load by means of correct orientation, barriers to solar radiation and use of insulating materials. Successful examples of this style of architecture in Ouagadougou include the CEAO headquarters (Communauté Economique de l'Afrique de l'Ouest) and the BCEAO building (Banque Centrale des Etats de l'Afrique Occidentale). Such examples are rare and the electrical airconditioning loads in many new buildings are very high. The GOB's architects are aware of these issues and are experimenting, for example, with the use of low-cost local materials for improved insulation.

4.56 The GOB's architectural and building services personnel needs to be strengthened by a short program of technical assistance. Burkina officials have also proposed that an international symposium be held in Ouagadougou on the problems of energy-efficient architecture in the Sahel.

Organization and Training

4.57 The operational performance of SONABEL has been widely considered to be among the best in West Africa over the decade to 1983. The main performance indicators improved steadily to reach 1983 levels of: (a) 41 subscribers per SONABEL employee (up 46%); (b) 0.15 GWh sales per employee (up 15%); (c) 12.3 employees per installed MW (58% improvement). Productivity growth slackened over the last two or three years, possibly as a result of integrating the seven smaller centers into the SONABEL system. Since 1983 there have been important changes in management and a declining input of expert assistance. The recent difficulties with the fuel oil plant at Ouaga 2 may be an early indication that operational management of SONABEL will need to be strengthened if the utility is to maintain its previous performance record.

4.58 The personnel structure, its skills and the use of external assistance are the other main factors determining performance. While the proportions of staff in each skill category appear reasonably balanced, SONABEL's training center is not well matched to the needs of staff at

all levels. The center is largely geared to long extensive training of the largest category of operational staff ("ouvriers qualifiés"); it would be useful to review (a) the duration and coverage of this training; (b) the promotion received after completion; and (c) the volume of staff accepted for this category of training.

4.59 The use of expatriate technical assistants is being phased out: there are currently two, down from six five years ago. This trend reinforces the need to reallocate some training resources from operational staff towards middle management. The mission advises against alternative proposals being considered for improving the utilization of the training center: (a) conversion to a regional training center, (b) general technical training for the national labor market.

4.60 The official organizational structure of SONABEL was drawn up in 1981 after a study by Electricité de France. Some of the positions have never been filled and there is now a proposal to simplify the structure to reflect this fact. The official structure is nonetheless simple and well conceived; it would be preferable to attempt to fully implement it without major modifications.

4.61 Key features of the official structure are: (a) the forecasting and planning group ("programmes et prévisions économiques générales") is attached to the Director-General's office; (b) in the generation branch there is already a hydro group, created in anticipation of the Kompienga project (which includes a suitable training component); (c) also attached to the Director-General is a group ("contrôle des branchements et comptages") created to combat electricity theft. The first two of these are areas where technical assistance could be useful.

4.62 The planning structure of SONABEL consists of a design and construction division ("Service études et travaux") and the forecasting and planning group. The latter currently comprises two local staff and an expatriate. Despite the group's strategic location in the organization, it has not yet had any significant impact on SONABEL's planning decisions. It is essential that this unit be strengthened. At the same time there is a major problem regarding the lack of coordination between SONABEL and other institutions involved in the planning, financing and implementation of multi-purpose hydro projects such as Kompienga (para. 4.65). This is the most serious constraint on orderly development of the electricity subsector in the medium term.

Development Options

4.63 In the short term, the scope for economically displacing diesel electricity generation in Burkina is limited by the need to serve small loads in widely scattered centers. Diesel plant is often the least cost means of supplying such loads, usually with fuel oil firing in the larger centers. This should remain the baseline for evaluation of other electricity supply options. The Kompienga hydro-electric scheme is now under

construction. In the longer term, there may be scope for developing other hydro potential, possibly in conjunction with interconnection with the larger systems of neighboring countries.

Hydro

4.64 Several potential hydro-electric power schemes have been investigated in recent years. The two main sites are at Kompienga and Bagré. Both are now designed as multi-purpose schemes and their physical characteristics are very similar in nearly all respects (Table 4.4). Even after allowing for the agricultural benefits of these projects, they both appear to be very marginal investments compared with continued development of thermal electricity generation. The Government has nonetheless decided to proceed with the construction of Kompienga. Preparations for presenting the Bagré scheme to donors are also well advanced.

Table 4.4: MAIN HYDRO PROJECTS

	Kompienga	Bagré
Installed capacity (MW)	15	16
Average energy output (GWh/yr)	39	44.3
Dry year firm capacity (MW)	7	11.5
Distance from Ouagadougou (km)	270	150
Reservoir volume (million cu.m.)	2,000	1,700
Reservoir area (sq.km)	210	250
Irrigated area (ha)	7,000	7,400
Cost, billion CFA.F (1983)		
- dam, plant, transmission	27.5 a/	24.7 b/
- irrigation	n/a	28.4

a/ In September 1985 the updated cost of the dam, plant and transmission was quoted as 37 billion CFA.F; a comparable cost for the agricultural component was not available.

b/ Bagré transmission cost covers only a short connection to the proposed line from Kompienga to Ouagadougou.

4.65 As early as 1979, the feasibility studies for Kompienga noted the possibility of significant cost savings from coordinated development of Kompienga and Bagré. In particular, it was recommended that the transmission line from Kompienga to Ouagadougou should pass through Bagré, rather than in a direct line through Tenkodogo. This recommendation has not been incorporated in the present contract documents for

Kompienga. 11/ Sequential development of the two projects with a separation of around three years is another cost-saving possibility which would be compatible even with low load growth scenarios. This option appears not to have been seriously investigated. The failure to coordinate the development of the two projects appears to be the result of rivalry between different government agencies. It is essential that the institutional arrangements for planning and implementing major multi-purpose projects be improved. The mission recommends that the GOB seek technical assistance to define the structure of a single government organization which would be responsible for implementing major projects, including the selection and supervision of contractors and the management of project investment funds.

4.66 The most significant of the other hydro sites which have been studied in Burkina is the Noumbiel scheme of around 80 MW. The site is on the border with Ghana and any decision to proceed with the scheme would require agreement between the two countries. While access to its 50% share of the potential electricity production is of interest to Burkina, it is clearly not in Ghana's interests to agree to implement the project. Evaporation losses at Noumbiel would significantly reduce the generation downstream in Ghana at Akossombo. The two countries are in the process of trying to find a consensus on this issue. An alternative possibility is for Burkina to be supplied from Bolgatanga in Ghana. This solution would require coordination between the two countries for generation and transmission planning.

4.67 Burkina's small-hydro potential (including micro and mini) is surprisingly ill-defined. A recent reconnaissance study, undertaken with support from West Germany, identified a number of sites in the range 200 to 1500 kW in the Banfora area. These sites could be of interest in cases where they are within economic connection distance of an existing or proposed SONABEL load center. Given the seasonality of river flows in the area and the run-of-river nature of the sites, their development would need to be accompanied by full thermal back-up. The size of any development is likely to be constrained by expected future peak demand at Banfora (400 kW in 1984), since the nearest major load center is 80 km north at Bobo-Dioulasso. This constraint would be lifted if the two centers were interconnected for some other reason.

4.68 The next step in promoting the development of Burkina's hydro potential is to complete a comprehensive hydro resource inventory at a reconnaissance level before proceeding to full investigation of the more promising site/load center combinations. The mission recommends that consultants be engaged to complete a general inventory of Burkina's hydro-electric potential, including: (a) a review of existing streamflow and other hydrological data; (b) map and aerial photo identification of

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11/ According to SONABEL this decision is now fully justified by the fact that Tenkodogo has been selected as supply point for electricity distribution in the eastern region of Burkina (Koupela).

promising areas; (c) definition of development possibilities on the basis of existing studies and investigations, complemented where necessary by additional site visits; (d) preliminary costing of selected site/load center combinations; (e) preliminary priority listing of development options.

Industrial Generation

4.69 With the exception of the FASO-FANI textile operation at Koudougou, the main agricultural processing industries in Burkina are largely independent of SONABEL for their supply of electricity (Annex 13). Their in-house supply is generally obtained from cogeneration of steam and electricity using either agro-industrial residues or fuel oil. Although SONABEL's statutes allow it to purchase privately generated electricity, some of the more efficient cogeneration options are not adopted because of the absence of an established market for sale of excess electricity production, e.g. to SONABEL for distribution in the public supply system. In some centers there would be scope for reducing both industrial energy costs and SONABEL supply costs if this market could be developed. For the small centers not yet served by SONABEL, there should also be a policy of encouraging future industries to generate a small surplus of electricity for public sale in the immediate area.

4.70 In order to promote the fullest possible development of Burkina's industrial cogeneration potential, the GOB should define tariffs at which SONABEL will purchase privately generated electricity in each of the main centers. The basic buy-back tariff would be set just below SONABEL's marginal energy cost (mainly fuel costs) in that center ("Supply Costs", para. 4.33). Where the autogenerated supply could be guaranteed to some extent, there would be an additional component in the buy-back tariff, set somewhere below SONABEL's marginal capacity costs in that center, i.e., as an allowance for the corresponding savings in SONABEL's investment program. Private industry needs to see firm, published buy-back tariffs before it will commit resources to evaluating new energy options. The setting of these tariffs should be regarded as a part of the GOB's energy policy.

Electricity Imports

4.71 Interconnection with the larger electricity systems in neighboring countries offers considerable promise for reducing Burkina's electricity supply costs in the longer term. At present there are limited transmission links from Ghana to Benin and Togo and from Ghana to the Ivory Coast. Consideration is being given to a West African interconnection, the first stage of which would connect all coastal countries from Nigeria through to the Ivory Coast. The northernmost point of the Ivory Coast 220 kV system is Ferkessédougou, which is 70 km south of the border with Burkina and 200 km south of Bobo-Dioulasso.

4.72 While the initial justification for interconnection might be to purchase future surplus energy from neighboring hydro systems, the

arrangement is likely to extend to pooling of capacity reserves and eventually to purchases of firm power. For each possible arrangement, a satisfactory basis for electricity transfer prices would have to be negotiated before promoting the project.

4.73 Preliminary calculations indicate that transmission from Ferkessédougou in the Ivory Coast through Banfora to Bobo-Dioulasso could be viable at some time during the nineties, depending on the development of other options (fuel oil, industrial cogeneration, small-hydro). If low-cost power should become available in northern Ghana, transmission to Ouagadougou could also be viable in the late nineties, particularly if transmission already exists from either Kompienga or Bagré to Ouagadougou.

4.74 The development of high voltage transmission links within Burkina depends largely on hydro development and interconnection with neighboring countries. The difference between fuel oil and diesel fuel operating costs is generally not sufficient to warrant interconnection of two centers. The two main proposals, Ouagadougou/Koudougou and Bobo-Dioulasso/Banfora, are discussed below.

Planning of System Expansion

4.75 The remainder of this chapter (a) reviews system load forecasts for SONABEL; (b) summarizes the main development options for Ouagadougou/Koudougou and Bobo-Dioulasso/Banfora and the timing implications of the revised load forecasts; and (c) presents order-of-magnitude estimates of the corresponding investment requirements.

Load Growth/System Expansion

4.76 Electricity load growth has been the subject of several forecasting studies in recent years. The most comprehensive study was the Electrification Master Plan prepared by BOAD (Banque Ouest Africaine de Développement), dated June 1980. SONABEL then updated these forecasts for presentation to the National Energy Colloquium in Ouagadougou in March 1982. More recently, in May 1983, the forecasts were again updated by consultants (SOGREAH), this time as part of the evaluation of the Bagré multi-purpose hydro project.

4.77 Two factors make it unlikely that electricity consumption will enter a period of sustained 8% annual growth from 1985 as assumed by SOGREAH. The first is the recent pause in economic growth. The second is the GOB's changing development priorities. A more probable scenario is that electricity consumption will remain stagnant for three to four years as the net result of two opposing trends, i.e. the reduction of certain economic activities will be offset by the connection of new subscribers as part of the continuing program of extending the distribution networks.

4.78 In the absence of a more detailed review of load forecasts, the mission proposes the following working hypotheses for annual growth rates in Ouagadougou: (a) 1.5 to 3% for 1985 to 1987; (b) 5 to 7% for 1987 to 1990; (c) 8 to 9% after 1990, assuming that the economy will have returned to a period of normal growth after the present restructuring. It is also assumed that growth rates will be similar in the other main centers (Bobo-Dioulasso, Koudougou and Banfora), but with minor differences as specified in Annex 14.

4.79 In the smaller centers there is a significant potential demand awaiting connection. This demand is to some extent artificially stimulated by the subsidy which is implicit in the uniform national tariff. Any extension of the seven newly electrified centers (16.7% load growth in 1983), or creation of new ones, could be expected to lead to rapid consumption growth in those centers. In view of the continuing support for this type of investment, from donor organizations such as DANIDA (Danish International Development Agency), the mission proposes the following working hypotheses for annual growth rates in the small centers: (a) 15 to 20% for 1985 to 1990; (b) 15% thereafter.

4.80 A synthesized load forecast for total electricity consumption in the public supply system is presented in Annex 14. In the short term the stagnation in the larger centers is cushioned by continued growth in the smaller centers. In the longer term the growth rate of total consumption stabilizes in the vicinity of 7 to 9%, since this is the trend assumed for the three largest centers (Ouagadougou, Bobo-Dioulasso and Koudougou). Table 4.5 then presents a comparison with earlier forecasts.

Table 4.5: COMPARISON OF RECENT ELECTRICITY DEMAND FORECASTS a/

	BOAD (1980)	SOGREAH (1983)	Mission's Estimate (1984)
Consumption 1985 (GWh)			
Ouagadougou	106.1-126.3	96.6	71-73
Koudougou	18.0-20.3	12.1	13
Bobo Dioulasso	42.1-51.3		30
Total Burkina	175.6-208.2		120-123
Consumption 1990 (GWh)			
Ouagadougou	188.4-265.4	159.7	85-95
Koudougou	30-36		17-18
Bobo Dioulasso	75.1-109.2		35-38
Total Burkina	308.7-429.6		149-164
Peak Demand 1990 (MW)			
Ouagadougou	47.1-66.1	40.3	24
Koudougou	7.3-8.7		3.7
Bobo Dioulasso	16.0-23.2		8.4
Growth Rate p.a. (%)			
1990 - 1995	11-13.1	7	8.2-9.1
1995 - 2000	10.2-10.8	6.5	8.4-9.2
After - 2000	8	6	8.8-9.0

a/ In October 1985 SONABEL indicated that internal load forecasts have now been reduced to about the same levels as those proposed by the mission, and even lower in some cases.

4.81 These lower expected growth rates need to be compared with current available capacities to determine the latest dates at which new capacity should be commissioned. The planning guideline adopted for this comparison is that the system should be able to meet the mission's "high" projection of maximum demand with a security margin of either 30% or the loss of the largest machine. This is a relatively conservative capacity planning criterion given that maintenance could be concentrated in the low-demand seasons. Earlier commissioning dates than those indicated by the capacity planning guideline would need to be justified by other economic benefits such as irrigation (in the case of multi-purpose hydro schemes) or lower fuel costs (such as replacement of diesel by fuel oil).

Ouagadougou/Koudougou

4.82 The first priority in the Ouagadougou system is to restore the existing fuel oil plant at Ouaga 2 to normal availability. No additional capacity will be needed until 1991 or 1992. On present timing, the Kompienga hydro scheme will be commissioned in 1989 or 1990. Additional capacity will then be required again in around 1994. At that time the main system expansion options for Ouagadougou are: (a) continued development of thermal generation, (b) construction of the Bagré multi-purpose hydro project and associated high voltage transmission lines, (c) electricity imports via interconnection with Ghana, e.g. by construction of transmission from Bolgatanga to Ouagadougou. Interconnection of Ouagadougou and Koudougou should also be evaluated as a possible alternative to separate development of the two centers.

4.83 Thermal. If no cheaper options are found, SONABEL could continue with the development of thermal generation in Ouagadougou. The simplest option at this point would be to add to Ouaga 2 another two or four 8 MW fuel oil-fired diesel units. Space limitations would then prevent any further development at this station. The construction of a new station, Ouaga 3, would create space for substantial growth of thermal capacity. 12/ This could be either fuel oil-fired diesels (8 or 12 MW and eventually 19 MW), or possibly coal-fired steam units in the very long term. The least cost thermal expansion plan should then serve as the base case with which other development options are compared.

4.84 Bagré. The decision to proceed with the Bagré hydro project depends on factors which are external to the electricity subsector, since electricity generation by itself does not ensure an adequate rate of return on the capital investments required. The agricultural impact will therefore be central to the process of evaluating and financing the project. Agricultural considerations may also dictate an earlier or later commissioning date than that which would best suit the electricity system. The Ouagadougou system is already able to absorb the entire

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12/ Feasibility study and design of a new thermal station, Ouaga 3, is now in process (October 1985) with a possible commissioning date of 1994 (without Bagré) or 1997 (with Bagré).

energy output of Kompienga and by 1990 it will also be able to absorb the entire output of Bagré. However, there is no need for additional generating capacity until 1994. The present draft (October 1985) of the five year plan envisages the commissioning of Bagré at the beginning of the nineties.

4.85 Imports from Ghana. Ghana's high voltage transmission system is not expected to reach the northern town of Bolgatanga before 1995. At present, the town is supplied by diesels. However, as soon as Bolgatanga is connected to Ghana's hydro-based national grid, exports to Burkina should be possible. Such exports could be part of an agreement to compensate Burkina for abandoning its right to share in the hydro potential of the Noumbiel scheme. A further possibility would be for Burkina to participate in the development of an alternative hydro project in northern Ghana. The mission therefore recommends that SONABEL seek technical assistance to evaluate the economic viability of importing electricity from Ghana, in comparison with additional fuel oil-fired diesels; in both cases the possibility of electricity supply from the Bagré scheme will need to be taken into account.

4.86 Koudougou. Various studies of system development in Burkina have made a case for a 90 km interconnection between Ouagadougou and Koudougou as a key element in the viability of large hydro projects and in the development of a national grid. Closer inspection shows that this is unlikely to be the case. The energy output of both Kompienga and Bagré is likely to be totally absorbed by Ouagadougou as soon as the schemes are commissioned. Thermal generation will remain the marginal source of energy at Ouagadougou throughout the period. The difference between the marginal cost at Ouagadougou (fuel oil) and Koudougou (diesel) could conceivably justify transmission between the two centers, but only for the period during which demand at Koudougou remains below the level at which fuel oil-fired diesels could be installed at Koudougou itself. This could be as early as 1989, when the installed capacity at Koudougou will become inadequate and the demand will approach 3.5 MW.

4.87 A final consideration is the possibility that interconnection could be justified in order to pool the spare capacity in the two centers and thereby defer the investment required in new capacity. In this case the line would need to be capable of carrying the output of one of Ouagadougou's larger machines (5 to 8 MW) without undue energy losses. A 30 kV line would be more suitable for this purpose than the 132 kV proposed in earlier studies, since the creation of a national grid now seems unlikely to be warranted in less than 15 to 20 years.

Bobo-Dioulasso/Banfora

4.88 The reference case for Bobo-Dioulasso is continued development of diesel generation (using fuel oil or diesel), either with or without 30 kV transmission to Banfora. The viability and timing of the transmission link would be affected by the development of: (a) industrial cogeneration of electricity for sale to SONABEL in either Bobo-Dioulasso or Banfora, (b) small-hydro development in the vicinity of Banfora. The

main alternative to thermal development is electricity imports from the Ivory Coast via an interconnection from Ferkessédougou through Banfora to Bobo-Dioulasso.

4.89 Thermal. The presently installed diesel capacity at Bobo-Dioulasso will be insufficient to cover demand beyond 1986, partly as a result of the need to retire aging plant. Additional capacity will be necessary. The current plan is to construct a new station, Bobo 2, the initial capacity of which would be two machines of 3.5 or 4 MW running on fuel oil. This capacity would meet increases in demand until 1992, when additional capacity would again be needed. In the absence of interconnection with the Ivory Coast, the new units would be in the same size range as the initial machines. With the interconnection already commissioned, the units could be much larger (8 to 12 MW) and possibly even gas turbines if the agreement with Ivory Coast is for large and relatively firm deliveries of energy.

4.90 Imports from Ivory Coast. The key prerequisite for the interconnection of Ferkessédougou and Bobo-Dioulasso is to determine the conditions under which power and energy are likely to be available from the Ivory Coast and to negotiate a satisfactory transfer price for each category of supply. If, for example, the Ivory Coast is only able to deliver excess hydro energy (seasonally or in wet years), the delivered price would be based on the cost of transmission only. Under some circumstances this might be as low as 0.4 USc/kWh (mission estimates). If the supply of energy is regular and "firm", the price could be based on the marginal cost of system development in the Ivory Coast. This is likely to be in the vicinity of the cost of possible new schemes such as the Soubré hydro project (estimated to be 3.4 USc/kWh).

4.91 In order for electricity imports to be worthwhile for Burkina, the delivered price at Ferkessédougou would need to undercut SONABEL's generation costs by a margin which is sufficient to ensure an adequate rate of return on the investment in the transmission line. Once the new fuel oil-fired diesels are commissioned at Bobo-Dioulasso these will become the marginal generation units for a large part of the year. Their marginal energy costs are around 6.6 USc/kWh.

4.92 These fuel oil-based marginal energy costs are: (a) approximately 6 cents above the probable cost of excess hydro energy delivered to Ferkessédougou, and (b) approximately 3 cents above the probable cost of firm supply from the Ivory Coast. The latter estimate could be raised by about one cent if Burkina were prepared to count on the interconnection as an alternative to maintaining its own capacity reserves in Bobo-Dioulasso and Banfora. For periods during which the marginal generation units are diesel-fired, these margins would be higher.

4.93 A 132 kV line from Ferkessédougou to Bobo-Dioulasso would cost around US$15 million. 13/ If valued at 3 to 4 US¢/kWh transferred, energy throughput would have to be around 50 GWh/year to make the investment worthwhile; total consumption at Bobo-Dioulasso and Banfora reaches this level in the mid nineties. The throughput required is reduced if some proportion of it is valued at more than 4 US¢/kWh, either because the supply is non-guaranteed or because it is displacing diesel-fired generation in Burkina. An earlier commissioning date would be warranted for the interconnection if, for example, the next increment of capacity at Bobo-Dioulasso were diesel-fired rather than fuel oil-fired as presently planned.

4.94 Banfora. Once fuel oil-fired capacity is established at Bobo-Dioulasso, a 30 kV interconnection over 80 km to Banfora would be one means of eliminating the present diesel-fired generation in that center. Others include (a) surplus electricity generation at the SOSU-BF sugar mill, (b) development of small-hydro and (c) supply from the proposed high voltage interconnection between Bobo-Dioulasso and the Ivory Coast.

4.95 The viability of the third option depends to a large extent on the cost of a sub-station to reduce the high voltage supply to medium and low voltage for use in Banfora. At the present time (October 1985), SONABEL is investigating another option, which is to construct a separate 30 kV line from Bobo-Dioulasso to Banfora. This is part of the study of interconnection with the Ivory Coast.

Investment Requirements

4.96 In both of the main areas of potential electricity demand in Burkina (Ouagadougou/Koudougou and Bobo-Dioulasso/Banfora) there are capital-intensive and fuel-intensive development options to be evaluated for commissioning in the early to mid-nineties. Total investment requirements could vary widely depending on the sequence of projects that would minimize SONABEL's total system capital and operating costs. In the absence of a comprehensive system development study, the mission has drawn up a number of simple scenarios to illustrate the range of possible outcomes.

4.97 The following investment scenarios use mission load forecasts and capacity planning guidelines (para. 4.81) to set the latest possible commissioning dates for new capacity. There is no attempt to select the most economic project for commissioning at those dates, nor to check whether other benefits (fuel savings, irrigation,...) would justify

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13/ SONABEL has indicated that this line would have to be at 225 kV, both for technical reasons and in order to be compatible with the other national systems in the region. Since the Assessment mission in September 1984, SONABEL has commissioned a preliminary study of a 225 kV line to link Bobo-Dioulasso with Ferkessédougou; early results are reasonably positive.

earlier commissioning. The base case for each region is "thermal" -- that is continued investment in diesel capacity running on either fuel oil or diesel. For Ouagadougou/Koudougou the alternative scenario is "hydro"; for Bobo-Dioulasso/Banfora it is "imports" of electricity. In all cases there is a low level of continuing investment in distribution extensions. Detailed assumptions regarding plant size, timing and costs are listed in Annex 15. For the period 1985 to 1994, the scenarios result in the range of possible investment requirements indicated in Table 4.6.

Table 4.6: INVESTMENT REQUIREMENTS, 1985 to 1994

billion CFA.F	"Thermal"	"Alternative"
Ouagadougou/Koudougou	40	63 (hydro)
Bobo-Dioulasso/Banfora	7	13 (imports)
Total :	47	76
Difference:	29	

4.98 The difference between these two extreme cases is 29 billion CFA.F, or around US$65 million, over a ten year period. This overstates the gap attributable to electricity investment alone, since the "hydro" scenario includes a project which would yield agricultural benefits over and above its electricity output. The low investment case is also associated with high annual fuel costs; the 1995 energy balance (Annex 16) gives 25,000 toe as an estimate of the additional fuel imports required in that year. In constant 1984 prices the additional fuel bill would amount to around 3.5 billion CFA.F (or US$8 million) in 1995.

4.99 Despite these drawbacks, the large difference between the investment requirements of the two scenarios does suggest that significant volumes of concessionary funding could be redirected towards other energy subsectors. The circumstances under which this might be desirable are discussed in Chapter V.

V. ENERGY SECTOR MANAGEMENT

Issues

5.1 This report has focused on key issues in the three energy subsectors: fuelwood/household energy (Chapter II), petroleum (Chapter III) and electricity (Chapter IV). This final chapter looks at the energy sector as a whole and proposes measures to improve management and investment planning in the sector.

5.2 The measures proposed cover: (a) sector organization; (b) manpower and technical training; (c) pricing; (d) financial management; and (e) investment planning/management of external assistance.

Key Recommendations

5.3 Sector Organization. (a) A small energy planning unit should be created within the Ministry of Planning. (b) Fuelwood supply-related activities should be coordinated through an interdepartmental working group which would include Environment & Tourism, Agriculture & Livestock and other departments working in social and rural development. (c) A multi-disciplinary planning and project monitoring group should be created within the General Secretariat of the Ministry of Environment and Tourism; it should be complemented by specialist groups (inventory, forestry economics, ...) in the DAFR. (d) There should be a single government agency responsible for ensuring that Burkina's petroleum imports are obtained at world market prices. (e) The resident oil companies should have a role in the management of the main petroleum storage facilities at Ouagadougou and Bobo-Dioulasso. (f) A single organization should be responsible for implementation of all major hydro projects.

5.4 Manpower and Technical Training. (a) Additional staff should be assigned to lower level positions in the forestry service. (b) A higher proportion of forestry staff should be assigned to fuelwood-deficit regions. (c) A higher proportion of forestry staff should be trained in extension methods and assigned to field positions. (d) Agricultural extension workers should be trained to work in natural forest management and rural forestry with the technical support of foresters. (e) IBE staff and work priorities should be re-oriented to support a large scale improved cookstove program. (f) A nucleus of staff should be trained as advisors for future petroleum procurement arrangements. (g) Petroleum price control staff should be trained to implement an improved system for updating petroleum cost structures. (h) The SONABEL training center should extend the range of staff categories covered by its programs. (i) The GOB's architectural and building services personnel should be trained in selecting and operating airconditioning systems.

5.5 Pricing. (a) The collection of woodfuel taxes should be reinforced and the tax rate increased. (b) The scope for reducing the

cost of kerosene cooking should be investigated. (c) Official price structures should allow full cost recovery for both LPG and LPG bottles. (d) Low voltage electricity tariffs should be simplified. (e) The gap between tax rates on gasolines and gasoil should be reduced. (f) Petroleum transporters should be encouraged to use rail from Abidjan to Burkina by an incentive in the official price structures. (g) The GOB should define marginal cost-related tariffs at which SONABEL will purchase privately generated electricity in each of the main centers. (h) Medium voltage electricity tariffs should be revised to more accurately reflect SONABEL's peak and off-peak costs of generation.

5.6 Financial Management. (a) The GOB should establish greater budgetary control over petroleum tax revenues. (b) Petroleum price control mechanisms should be strengthened. (c) Improved cookstove activities should be monitored through a single consolidated account. (d) Earmarking of petroleum tax revenues for purposes other than road maintenance should be reviewed. (e) Petroleum security stocks should be financed by oil company capital with suitable compensation through the official price structures. (f) Government lending or on-lending to para-statals should be on commercial terms.

5.7 Investment Planning. (a) The GOB should design an energy investment program within a pre-determined budget of investment resources. (b) Pre-investment evaluation of fuelwood-related investment options should be the highest priority energy planning activity for the coming decade.

Donor Support

5.8 For the bulk of these activities the requirements for donor support are outlined under that heading in chapters II, III and IV. One additional activity is listed below.

5.9 Sector Organization. Immediate technical assistance is recommended to establish a small energy planning unit in the Ministry of Planning. 14/

Sector Organization

5.10 Burkina needs energy planning mechanisms to serve two main functions. First, for the short term, energy activities need to be properly integrated with the GOB's recurrent budget, both on the revenue

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14/ This technical assistance could be integrated with the UNDP-financed project which has recently started its initial phase (October 1985); this project aims to strengthen the technical capability of the Ministry of Planning, both for overall planning and for the specialized sectors.

side (e.g. petroleum taxation revenue) and on the expenditure side. Second, for investment planning and implementation, there is a need to ensure continuous dialogue between government agencies at three levels: (a) between all sector agencies and the central economic and planning ministries (through the national development plan, for example); (b) between energy agencies and other closely related sectors (agriculture, forestry, water); (c) between agencies involved in the energy subsectors (woodfuels, agricultural biomass, petroleum, electricity).

The Plan

5.11 At the first and second levels many of the required mechanisms already exist but are not operating effectively. In principle, the GOB's development initiatives are coordinated through a series of 5-year national development plans. Sector inputs are prepared by working groups (Commissions) but these generally cease to function once the national plan has been drawn up. In their absence, there is no well defined forum for the various ministries to discuss implementation problems and the need to modify the plan to respond to changing conditions. Without this forum relations between government agencies tend to become competitive rather than cooperative.

5.12 The implementation of national development plans has generally fallen short of expectations. Targets have often been unrealistic and implementation has been curtailed by changes of government and re-allocation of ministerial responsibilities. As a result, the plan has not yet provided a satisfactory framework for the development of detailed investment plans in the energy sector and its subsectors. Energy planning arrangements need to be able to contribute to both the preparation and implementation of the national development plan. However, the arrangements also need to be able to survive and continue to function at times when the plan is not operating effectively.

5.13 The government which took office in August 1984 has: (a) suspended implementation of the previous 5-year plan; (b) launched a 1984/85 People's Development Plan to mobilize the country's human resources in a series of community projects; (c) re-activated the sector Commissions since the beginning of 1985 to prepare inputs for a 1986-1990 national development plan. The preparation and implementation of a new national plan could be one of the main means of implementing the recommendations of this Energy Assessment report.

Energy Planning

5.14 In principle, the second and third levels of energy planning (para. 5.10) are entrusted to l'Institut Burkinabè de l'Energie (IBE) which was created in 1982. IBE's functions include (a) collection and analysis of information on national energy resources, (b) advice on

national energy strategy, and (c) coordination of energy-related activities within the framework of the national development plan. In practice IBE has played a very dynamic role in the development and dissemination of new energy technologies, but has had only intermittent success in the wider area of energy planning.

5.15 In 1982 IBE organized a national Energy Colloquium to bring together energy-related planning information from all economic sectors in Burkina. Analytical working papers were prepared for all sectors and these remain the most comprehensive documentation on the energy sector to date. However, this exercise seems not to have resulted in implementation of an agreed energy strategy, possibly for two reasons: (i) there is no clear mechanism for coordinating multi-sectoral activities (energy with agriculture, forestry, water) other than the national development plan; (ii) IBE is under the jurisdiction of the Ministry of Higher Education and Scientific Research and tends to lack credibility with commercially oriented energy subsectors such as petroleum and electricity.

5.16 In the face of these structural difficulties IBE appears to have adopted a pragmatic approach to its role in energy planning. The IBE board of directors has never been convened and the energy planning positions in IBE's approved organization chart have only recently been filled. Nonetheless, IBE management continues to play a valuable role in energy planning by directly supplying the government with advice on current energy policy issues; this advice is independent of subsector interests. It would be useful to channel this advice into a forum which allowed a consensus to be reached at the Departmental level rather than sending conflicting advice to higher levels of government.

5.17 In cooperation with the IBE, the other main agency involved in energy planning is the Ministry of Planning (Ministere de la Planification et du Développement Populaire). This role arises both from preparing plans (national development plans and the People's Development Plan 1984/85) and from participating in negotiations with donors. In the previous national development plan the energy planning input mainly took the form of a shopping list of possible electric power projects for donors. As a result, the choice and timing of energy investments are presently being set by an "ad hoc" process of discussions between government agencies at the time of negotiations with donors.

5.18 The forthcoming national development plan would be a suitable time to strengthen the energy planning capability of the Ministry of Planning. The mission recommends that a small energy planning unit be created within the Ministry of Planning to ensure that: (a) the plan covers all energy subsectors; (b) energy projects are only included in the plan if they are economically viable and have a reasonable prospect of being financed; and (c) energy projects are systematically monitored, regardless of whether the plan is operational or not.

5.19 The focus of the energy planning unit should be on coordination between the planning units of energy subsector agencies, which should themselves be strengthened (para. 5.22). The skills of the unit's staff

should be concentrated in economic and financial evaluation of projects in order to complement the technical skills of the energy subsector agencies (forestry, petroleum, electricity) and of the IBE. The unit would need to have the capacity and authority to initiate and monitor studies in any of the energy subsectors. It would therefore be important to clearly define the relationships between the unit and the various subsector agencies.

5.20 The mission recommends that the unit be made up of two staff: an economist/financial analyst and a statistician. At present there are only three professional staff assigned to industry and energy in the Ministry of Planning. The creation of the unit therefore would require additional staff in this area, preferably by reallocation within the Public Service.

Subsector Planning

5.21 The energy planning capability of the main energy subsectors is discussed in chapters II, III and IV. The mission's main recommendations are summarized below.

5.22 The fuelwood demand management activities of government agencies are now coordinated by an Interministerial Commission for Improved Woodstoves. There is a need for a similar interdepartmental working group to coordinate fuelwood supply-related activities. This group would consist of the forestry service (of Environment and Tourism), the Ministry of Agriculture & Livestock, and a number of departments working in social and rural development. Within the forestry service itself, there is a need for a multi-disciplinary planning and project monitoring group to ensure a better regional allocation of manpower and investment.

5.23 The first requirement in the petroleum subsector is that there should be a single government agency responsible for ensuring that Burkina's petroleum imports are obtained at or close to world market prices. The GOB's joint venture with the resident oil companies (SEBHY) is not suitably structured for this task; at the same time, BUMIGEB has an economic planning unit which is currently not staffed. 15/ An organizational review is urgently required in this area. The second requirement is that the agencies responsible for petroleum price control (the Ministry of Commerce and the Equalization Fund) should have the independent capacity to provide timely updates of petroleum cost structures.

15/ Since the Assessment mission in September 1984, the GOB has created SONABHY — la Société Nationale Burkinabè d'Hydrocarbures — a State company which has been accorded a monopoly on importing and storage of petroleum products. The operating methods of this company have yet to be defined.

5.24 In the electricity subsector, SONABEL's forecasting and planning group has begun to play a role in the development of thermal generation and distribution. The group is correctly located in the organizational structure but would benefit from additional staff and training. However, in the area of hydro-electricity, there is a very serious lack of coordination between the numerous institutions involved in the planning, financing and implementation of multi-purpose hydro schemes. These schemes generally have an important irrigation component which is therefore the concern of the Ministry of Agriculture and Livestock, the Ministry of Water, and a number of other agencies.

5.25 The mission recommends that the GOB establish a single organization to be responsible for implementation of all major hydro projects, including the selection and supervision of contractors and management of project investment funds. For planning and financing of such projects, it is essential that the GOB find a means to reduce the present inter-project rivalry.

Private Sector

5.26 Given the importance of concessionary donor financing, the GOB is likely to remain the principal promoter and manager of major projects in the energy sector. This should not be allowed to obscure the present and potential role of Burkina's private sector in (a) managing existing energy supply systems and (b) promoting small and medium size projects. There is also a need to ensure that the GOB's financial and human resources do not become unnecessarily dispersed in a series of parastatal organizations and joint venture companies.

5.27 For supplying fuelwood to urban areas, the cutting, transportation and marketing are almost entirely in the hands of small private operators who are licensed by the Forest Service. The GOB should ensure that this market remains as competitive as possible within the constraints of a regulatory system designed to manage the location and extent of cutting. 16/

5.28 A similar situation exists for the fabrication and marketing of "Ouaga metal" improved woodstoves. At present, large numbers of craft metalworkers produce a scrap-metal stove of low combustion efficiency.

16/ Since the Assessment mission (September 1984), the GOB has introduced a system of licenses and price control on the whole urban fuelwood supply chain — cutting, transport and sales. The system has only recently been put into effect and the Government does not exclude the possibility that it could be improved. One of the options to be investigated would be: (a) to reduce the scope of the licensing system, (b) to further increase fuelwood taxes, and (c) to eliminate price control on retail fuelwood sales.

These are then sold as a normal retail item. The GOB should take advantage of this reservoir of skills and distribution networks to launch the new improved models of cookstove. 17/

5.29 The petroleum subsector is the main area where the GOB's role needs to be reviewed. While it may be necessary for the Government to play some part in the procurement process (for example, in government -to - government price negotiations), there is much less justification for involvement in the rest of the supply system: transport, storage and distribution. There are five oil companies operating in Burkina and all have competent local management. The mission recommends that, regardless of eventual procurement arrangements, the Government should investigate ways of using the resources of private companies to manage petroleum depots.

5.30 The GOB is also involved in two commercial ventures to produce ethanol as a gasoline extender. If future ethanol projects are proven to be economically viable and if government participation is deemed necessary, it should be restricted where possible to a token shareholding in a joint venture company. The main role of the Government in this area is to facilitate negotiation of sales agreements between the ethanol producer and the oil companies which distribute imported gasoline.

Manpower and Technical Training

5.31 Substantial efforts in education and training over the last decade have greatly increased the pool of skilled manpower available in Burkina. This has no doubt been a major factor in the good management record of the electricity subsector in particular. The mission believes that the total numbers of staff working in each subsector are generally adequate. The main exception is the forestry service, where there is an acute shortage of lower level staff. Within each subsector the allocation of staff among different functions (e.g. among the regions) could be improved. Re-training programs are then required to allow existing technical staff to adapt to their changing functions.

Fuelwood

5.32 A greatly increased effort will be required over the coming decade in natural forest management, rural forestry, and the promotion of improved cookstoves. This effort will need to mobilize: (a) a large proportion of the GOB's total pool of extension workers (in forestry, agriculture, and agencies involved in rural and social development);

17/ A hybrid model — for wood and charcoal — in scrap metal has just been put onto the market (October 1985).

(b) villagers -- both in fuelwood-deficit areas and in potential urban supply areas; and (c) craft metalworkers and stove retailers in conjunction with expanded technical support from the IBE.

5.33 On the fuelwood supply side, there is a need to allocate a higher proportion of forestry service staff to fuelwood-deficit regions; a higher proportion should also be trained in extension methods and assigned to field positions. At the same time agricultural extension workers should be trained to work in natural forest management and rural forestry with the technical support of foresters. Even with this level of support, the manpower available is unlikely to be sufficient to adequately manage a large-scale program of migration from the Mossi plateau to less populated areas in the south and west of Burkina.

5.34 For fuelwood demand management, the Interministerial Commission on Improved Woodstoves should serve as a forum to discuss (a) the allocation of extension work between mudstoves and metal stoves; and (b) the development of programs by the CNPAR (national artisans' training center) to train metalworkers to produce the "Ouaga metal" improved woodstove. The IBE will also need to reallocate the work priorities of existing technical staff to ensure that the design of improved cookstoves continues to evolve in line with feedback from consumers.

Petroleum

5.35 Training is needed in two key areas of the petroleum subsector: (a) to train a nucleus of GOB personnel as policy advisors for future procurement arrangements, and (b) to train price control staff to implement an improved system for updating petroleum cost structures. In a third area, it may also be cost-effective to train maintenance personnel and drivers of trucks used in international freight haulage; there are already technical assistance proposals to provide this kind of training.

Electricity

5.36 In the electricity subsector the principal requirement is to broaden the scope of the SONABEL training center from its present focus on one category of operational staff ("ouvriers qualifies") to a mix of activities which meet the needs of staff at all but the highest levels. This option is an alternative to the two proposals presently being considered for improved utilization of the training center: (a) conversion to a regional training center, and (b) general technical training for the national labor market. In the area of electricity demand management, it would be useful to employ technical assistance to provide training for the GOB's architectural and building services personnel in selecting and operating airconditioning systems.

Pricing

5.37 Burkina's energy sector is part of an economic system with a fully convertible currency (the CFA franc) and with few barriers to trade. Since there are relatively few major price distortions in other sectors, correct pricing in the energy sector will give consumers the right incentives for fuel switching and conservation.

5.38 The basic characteristics of energy prices in Burkina are as follows. The prices of fuelwood and charcoal have recently been put under price control, both for wholesale and retail sales. The official price structures include a wood tax which is well below the resource value of the wood (stumpage); it is also believed that the tax collection rate is low. 18/ Petroleum products are price-controlled in a system designed to impose full cost recovery plus a number of duties, taxes, levies and subsidies. While the system could result in net subsidies on various products, in general it does not. In January 1984, for example, net taxes were positive on all products, ranging from 5% to 31% of ex-depot cost (excluding taxes). Electricity tariffs are uniform nationwide and are controlled by the GOB on the basis of recovering SONABEL's accounting costs. These costs include subsidized capital which is on-lent from donors.

5.39 In general economic terms this means that commercial woodfuel consumption remains heavily subsidized (by "free" depletion of Burkina's forestry capital); petroleum products (including potential fuelwood substitutes such as kerosene) are taxed at varying rates; and electricity is slightly subsidized (from the GOB's investment budget). Electricity consumers in high-cost centers are also subsidized by consumers in low-cost centers; other cross-subsidies are implicit in the structure of SONABEL's medium and low-voltage tariffs.

Households/Crafts

5.40 Under these circumstances the GOB should take steps to bring household energy prices more closely in line with economic costs of supply. The first step is to attempt to reduce the subsidy on fuelwood consumption by: (a) reinforcing the present effort to increase the collection of existing fuelwood taxes; (b) then progressively increasing the tax to at least 50% of the estimated replacement cost, i.e., from the present 300 CFA.F/stere towards 2000 CFA.F/stere. At the same time the tax on charcoal should be raised to at least five times the tax rate on fuelwood (per kg) and maintained at that level to ensure that the effective tax on primary wood consumption is the same for both fuels.

18/ It is possible that tax collection has improved as a result of the recent measures to control the wood supply chain.

5.41 The second step is to ensure the availability of other household fuels at prices which reflect full economic costs. In ascending order of cost these are kerosene, LPG and electricity. With present costs and income levels kerosene is the only fuel with any significant potential to replace fuelwood. LPG and electricity are cooking fuels for a very limited urban elite. Kerosene and electricity also provide lighting for low and middle income households.

5.42 In the case of kerosene and LPG, there is little scope for reducing prices by reallocating taxes to other petroleum products. Present tax rates are not high (in January 1984 they were equivalent to 6.5% and 14% respectively on ex-depot cost) and not much above the lowest taxed products, i.e. industrial diesel (5%) and fuel oil (8%). A price reduction for kerosene would also be a poorly targeted incentive, since kerosene is predominantly used for lighting rather than cooking. For this reason it may be more effective to use GOB resources to directly reduce the cost of kerosene cooking, i.e. by increasing the combustion efficiency of kerosene cookstoves and by reducing their price. The scope for such action needs to be investigated.

5.43 For hotels, restaurants and the small part of the population that can afford to cook on LPG the main problem is reliability of supply. The GOB has imposed prices for both LPG and LPG bottles which do not allow full recovery of oil company costs. Under these conditions the companies have no incentive to adequately supply the market. Once this is rectified the present suppressed demand will come back onto the market and the availability of storage could then become a bottleneck on LPG supply. The simplest solution would be to de-regulate LPG altogether and allow the marketing companies to make their own decisions concerning pricing and investment in new storage.

5.44 Residential consumers of low voltage electricity face a complex set of tariffs with confusing incentives. The present declining block tariff should be replaced with a single kilowatt-hour rate; this rate should be higher in small high-cost centers than in the main centers. If a "social" tariff is considered politically desirable, it should be structured to provide subsidized electricity for no more than 15 to 25 kWh per month. If this tariff were available in all centers it would remove a large part of the pressure for a uniform national tariff.

Transport

5.45 Given that net taxes on all transport fuels are positive, the main requirement in this sector is to ensure that differences in individual product tax rates do not distort the consumer's choice between different transport modes. In January 1984 net taxes amounted to the following percentages of ex-depot cost (excluding taxes) in Ouagadougou: premium gasoline 31%, regular gasoline 29%, gasoil 15% and industrial diesel 5%. Future price changes should aim to narrow the gap between the rates on gasolines and gasoil in order to reduce the risk of economically unwarranted conversions from gasoline to diesel vehicles at the light end of the weight range.

5.46 International freight operations are also affected by other aspects of price control. The first is the transport component allowed in the official petroleum cost structure. At present there are two separate costs allowed for the transport of petroleum products from Abidjan to Burkina, depending on whether the products are transported by rail or by road. This system provides no incentive for the oil companies to use the least cost form of transport (rail) up to the limit of its capacity before resorting to higher cost road transport. A similar problem may arise if the GOB takes any further steps to regulate road freight tariffs on the major routes to the coast. Price control is likely to stifle the competitive pressure to reduce costs per tonne-km, including fuel costs.

Industry

5.47 The main energy pricing measure required in the industrial sector is to develop a market for the potential energy surplus in agro-industries such as sugar and oil processing. While production of solid fuels (briquettes) and liquid fuels (ethanol) is technically possible, the most promising market is the sale of cogenerated electricity to SONABEL for distribution in the public supply system. The GOB should define marginal cost-related tariffs at which SONABEL will purchase privately generated electricity in each of the main centers.

5.48 Some industries may have limited scope for altering their electricity consumption patterns in response to tariff incentives. SONABEL medium voltage tariffs need to be revised to more accurately reflect the utility's peak and off-peak costs of generation. As with low voltage tariffs, it would be preferable to allow tariffs to be higher in higher-cost centers. Tariff structures will become a major consideration if hydro-electricity becomes the marginal source of generation in any of the main centers.

Financial Management

5.49 Energy planning in Burkina should treat forestry, petroleum and electricity as components of one sector, the energy sector. This would assist political decision makers to focus on the allocation of resources both between broadly defined sectors (agriculture, energy, health, education) and within the energy sector itself. Energy planners should seek to make an integrated contribution (a) to the GOB's recurrent budget, both on the revenue and expenditure sides, and (b) to the management of the GOB's portfolio of loans and equity in energy-related para-statals and joint ventures.

Revenues

5.50 Taxes on petroleum make a significant contribution to government revenue. With increased collection and higher rates, taxes on woodfuels could also make a significant contribution. Finally, since

low-income consumers are protected by a "social" tariff, the GOB could broaden the tax base by introducing a sales tax on electricity. However, petroleum taxes are likely to remain the most important source of revenue.

5.51 Under present arrangements for petroleum (para 3.55), there is a complex structure of duties, taxes and levies, several of which are "earmarked" to specific government agencies. These taxes are then supplemented by an "equalization" tax (or subsidy) to balance total costs with pre-determined retail prices of petroleum. These prices are set by the Pricing Directorate (of the Ministry of Commerce) in line with the revenue requirements of the (price) Equalization Fund. As a result of these procedures a certain proportion of petroleum tax revenues bypasses the GOB's recurrent budget. It would be preferable for the GOB to have more direct budgetary control over these resources.

5.52 Up-to-date petroleum cost and tax data is essential information for both macro-economic and recurrent budget planning. The present price control systems need to be strengthened to give them the capacity to react more rapidly to market changes. This strengthening would also result in improved relations with the oil companies.

Expenditure

5.53 While the GOB's recurrent expenditure in the energy sector is largely concentrated in a small number of ministries, there are several related activities which need to be clearly accounted for. This applies to improved woodstoves activities in particular, since these involve not only Environment and Tourism but also the IBE (l'Institut Burkinabè de l'Energie) and seconded staff and part-time extension inputs from other ministries. The costs of these resources should be notionally charged to a single account as part of overall expenditure on fuelwood/forestry. This type of accounting could then serve as the basis for budget allocations between (a) supply and demand related activities, and (b) direct or indirect subsidies (e.g. extension work) for improved woodstoves.

5.54 In principle, the earmarking of specific government revenues to named ministries or activities should be avoided. Under the present circumstances there are two energy-related activities where earmarking may be warranted. The first activity is road maintenance. A proportion of the taxes levied on gasolines and gasoil could be considered a road user charge which should be earmarked to road maintenance. However, other existing earmarking of petroleum taxes should be reviewed. The second activity is forestry, where there is an acute shortage of lower level staff as well as a very low rate of investment. Allocation of woodfuel tax revenues to the forestry service for a fixed period would help to finance additional staff and training and would provide an incentive to enforce a higher rate of tax collection.

Capital

5.55 The GOB has a portfolio of energy investments which includes equity and/or loans in: (a) SONABEL, the electricity utility; (b) SEBHY and SEB, joint venture oil procurement and storage companies, and more recently SONABHY; (c) Shell B.F., a joint venture oil marketing company; (d) SIR, the oil refinery at Abidjan; (e) SOPAL, an ethanol production venture; and (f) a joint venture to investigate ethanol production from sweet sorghum.

5.56 While State ownership of the national electrical utility may be economically warranted, it is less clear that public funds should be committed in the petroleum subsector, where private venture capital is generally available. In this area the GOB should focus on maintaining a regulatory framework which promotes government objectives while allowing the companies a normal rate of return on investment. The mission is recommending, for example, that proposed petroleum security stocks be financed by oil company capital, with suitable compensation through the official price structures.

5.57 In instances where joint ventures are already established, there should be a periodic review of the objectives and benefits of the arrangements. It may be possible, for example, to make better use of the GOB's majority shareholding in Shell B.F. for: (a) petroleum industry training, (b) information on supply costs; and (c) applying competitive pressure on the other marketing companies to reduce transport and distribution costs. In future joint venture arrangements there should also be a greater effort to comply with normal legal and commercial criteria in matters such as establishment of statutes, regular audits and Board control over borrowing and expenditure.

5.58 A final consideration is the GOB's lending policy. At present the GOB on-lends concessionary funding to SONABEL on the terms provided by the donor rather than on commercial terms. This practice compromises SONABEL's status as a commercial enterprise and provides a hidden subsidy for the electricity consumer. Since low-income consumers are to some extent protected by a "social" tariff there is little justification for this additional subsidy. This is not a significant problem in the present diesel generation system, since capital costs are relatively minor compared with fuel and other operating costs. However, the subsidy will become significant as soon as the proposed hydro developments start to affect the tariffs. The mission recommends that commercial on-lending be adopted as soon as possible.

Investment Planning/Management of External Assistance

Availability

5.59 Gross fixed investment in Burkina was expected to be of the order of 60 billion CFA.F in 1984 (mission estimates). Public investment

will account for approximately 95% of the total and an estimated 93% of public investment will be financed by donors. These statistics underline the importance of good investment planning in the public sector and the need to make the best use of external resources.

5.60 Over the period 1977-1981, the energy sector accounted for approximately 4% of investment financed by external assistance (National Accounts). This consisted of 1.5% for forestry and 2.7% for energy (predominantly electricity). Since agriculture, integrated rural development projects and projects managed by the AVV together accounted for 18% of externally financed investment, an allowance should be made for fuelwood components in those projects. It therefore is assumed that total energy investment made up 4%-6% of the total investment financed by external assistance.

5.61 The mission projected total fixed public investment over the decade from 1985 at between 600 and 700 billion CFA.F in 1984 terms. This is equivalent to an annual growth rate of zero to 3.5%. If the energy sector retains 4%-6% of this total, investment resources for the sector available would be between 24 and 42 billion CFA.F.

Requirements

5.62 The mission has proposed a fuelwood program (forestry and improved cookstoves) of around 41 billion CFA.F over 10 years and has estimated that electricity investment requirements will be between 47 billion CFA.F (thermal development) and 76 billion CFA.F (predominantly hydro development). In the case of hydro development, the dam costs are incurred for both irrigation and electricity generation. Approximately 8 to 12 billion CFA.F therefore could be attributed to irrigation. The mission's assessment of requirements is outlined in Table 5.1.

Table 5.1: ENERGY SECTOR PUBLIC INVESTMENT REQUIREMENTS
1985-1994, in billion CFA.F

1.	fuelwood-related	41	41
2.	electricity		
	thermal scenario	47	..
	hydro scenario	..	66
	Total	88	107

5.63 The mission's assessment of requirements for the coming decade is substantially greater than the sector's traditional share of total public investment. The lower end of the range represents a necessary minimum, since it consists of (a) investments which are already

committed, principally Kompienga; (b) fuelwood-related investments which are an indispensable part of the anti-desertification campaign; and (c) the lowest capital-cost options for meeting electricity load growth in existing centers.

Planning Methods

5.64 In the context of the Government's public investment formulation and planning process which is expected to result in the beginning preparations of an overall program during 1985-1986, it will be important to explore the tradeoffs that might be required in other sectors to prepare and follow through on an energy sector program targetted at achieving at least the minimum level of investment identified in Table 5.1.

5.65 In recent years the investment planning process has consisted of periodic presentations of "shopping lists" for donors. Since the list is much larger than the typical availability of finance, the final pattern of investment is partly determined by the response of donors. The order-of-magnitude estimates outlined above are intended to illustrate an alternative method which would help to achieve a better match between actual investment and the GOB's priorities. The method should be adopted in the energy sector regardless of progress in improving planning methods in other sectors.

5.66 The first step is to estimate the total availability of investment finance over the planning period. This is likely to be determined by macro-economic considerations such as debt servicing and by the advance commitments of donors. The second step is to set the energy sector's share of total investment finance and to compare the corresponding volume of funds with the pool of available projects which have been appraised to at least the pre-feasibility level. This pool should exceed the availability of funds by a considerable margin. The final step is to choose a portfolio of projects with high economic rates of return in a mix which corresponds roughly with the GOB's subsector priorities, i.e. in particular, a balance between fuelwood-related projects and electric power projects.

Pre-investment

5.67 Burkina's principal problem in this area is a shortage of pre-appraised projects in the fuelwood subsector. This has led to a tendency to emphasize the role of electricity in the energy sector, mainly because of the scope for absorbing large amounts of concessionary finance in capital-intensive hydro projects. Under these circumstances the government regards the cost of capital as the direct financial cost of borrowing, rather than the cost of displacing another project (such as a fuelwood project) from the energy investment portfolio.

5.68 The main requirement for successful energy planning in Burkina therefore is for donors to support the GOB in a massive effort involving institutional strengthening, R&D and pre-investment appraisal of fuel-

wood-related projects. This is essential to ensure that increasing amounts of concessionary resources can be absorbed in fuelwood-related investments over the coming decade. Chapter II of this report suggests a few directions for this effort.

BURKINA ENERGY BALANCE, 1983 (TOE)

	Primary					Petroleum Products								
	Wood	Agricultural Residues	Bagasse	Charcoal	Electricity	LPG	Jet Fuel	Gasoline	Kerosene	Gas Oil	Diesel	Fuel	Total Petroleum Products	Line Total
Primary Energy														
Production	1,600,000 e/	57,000 e/	31,037											1,688,037
Import						740	5,894	50,236	12,017	24,024	18,059	18,847	129,817	129,817
TOTAL														1,817,854
Conversion														
Electricity Generation					10,727						(4,553)	(6,174)	(10,727)	0
Charcoal Production	(7,300)			7,300 e/										0
Conversion Losses	(8,200)				(371)						(7,164)	(9,835)	(16,999)	(25,570)
Distribution Losses					(804)									(804)
TOTAL	1,584,500	57,000	31,037	7,300	9,332	740	5,894	50,236	12,017	24,024	6,342	2,838	102,091	1,791,260
Re-export							(4,394)						4,394	(4,394)
Domestic Supply	1,584,500	57,000	31,037	7,300	9,332	740	1,500	50,236	12,017	24,024	6,342	2,838	97,697	1,786,866
Consumption														
Households (including artisans)	1,584,000	50,000		7,300	3,098	740			12,017				12,757	1,657,155
Transport							1,500 e/	44,176		18,310	4,750		68,736	68,736
Industry/Agriculture	500 e/	7,000 e/	31,037		5,786				5,042	1,592	2,838	9,472	53,795	
Government					448			6,060		672			6,732	7,180

e/ Estimates

Notes: Fuelwood — 620.5 kg cap/year
— 1 kg fuelwood = 4,000 kCal
— Population 1983 = 6.58 million
1,600,000 toe

Agricultural residues — Straw: 31 kg cap/year
1 kg straw = 2,500 kCal
50,000 toe
— 5,000 toe cotton seed waste
— 2,000 toe karite waste

Charcoal — 12 kg per urban and semi-urban population which numbers 700,000
— 1 kg charcoal = 7,800 kCal

Thermal power generation = specific consumption
— diesel = 250 gr/kWh
— fuel oil = 223 gr/kWh

Annex 2

BURKINA
BREAKDOWN OF VEGETATION COVER (1980)

Type of Cover	Hectare	Percent of Total Land Area
Woodlands	270,300	1.0
Savanna Woodlands	287,200	1.0
Tree savanna	4,290,800	15.6
Shrub savanna a/	10,184,200	37.2
"Fourres tigres"	386,900	1.4
Total NFC	15,419,400	56.2
Bush fallows and ASPA b/	8,770,300	32.0
Other (non-productive and urban areas)	3,230,300	11.8
Total	27,420,000	100.0

a/ includes 1,554,200 burnt areas identified by Landsat pictures.
b/ ASPA: Agro-sylvo-pastoral associations.

Source: National Forestry Inventory, PNUD/FAO Project UPV 178/004.

REGIONAL FUELWOOD BALANCES

1. Fuelwood balances have been calculated for the 30 new administrative provinces of Burkina and have been classified into 4 categories and 8 subzones according to their geographic location and to their fuelwood deficit situation:

Category I - The 12 deficit provinces on the Mossi plateau: 2 subzones

I.1 Ten provinces with a large deficit (high population density): KADIOGO (Ouagadougou), BOULKIEMDE, YATENGA, BAM, KOURITENGA, PASSORE SANMATENGA, OUBRITENGA, NAMANTENGA, BAZEGA.

I.2 Two provinces with a slight deficit (low population density): GANZOURGOU, ZOUNDWEOGO

Category II - The 6 provinces with average deficits bordering the Mossi plateau, subdivided into 2 zones.

II.1 The three provinces of the Sahel (low population density): OUDALAN, SOUM, SENO

II.2 The three provinces East and West of the the Mossi plateau (increasing population density): GNAGNA in the East, SOUROU and SANGUIE in the West.

Category III - The 7 surplus provinces neighboring the Mossi deficit zone. 2 subzones.

III.1 Four provinces with a moderate surplus located South and West (high population density): BOULGOU in the South, KOSSI, BOUGOURIBA and NMOUHOUN in the West.

III.2 The three provinces with a large surplus located in the South and East (low population density): NAHOURI and SISSILI in the South, GOURMA in the East.

Category IV The 5 surplus provinces located farthest from the deficit zone. 2 subzones.

IV.1 The TAPOA in the East (low population density).

IV.2 The four provinces in the South-West (high population density): COMOE, KENEDOU, GOU, PONI.

TREND EVOLUTION OF THE FOREST COVER 1983 - 1995

Zones		Average Rural Population Density (popn./km²)	NATURAL FOREST COVER Stumpage Volume (m³/ha)	NFC Area (x1000 ha)	Natural Productivity (m³/ha/yr)	Degraded Forest Area P.A. (x1000 ha)	BUSH FALLOWS AND ASPA (ASPA) Area (x1000 ha)	Natural Productivity (m³/ha/yr)	Accessibility Rate (%)	Utilization Rate As Fuelwood (%)
	1983	44,6	9,2	1583	0,198	11	3230	0,143	90	75
I.1	Evolution			-10%	-20%		+158	-20%		+10
	1995	56,5		1425	0,158	15	3388	0,114	100	85
	1983	36,9	16,2	405	0,380	3	262	0,229	75	60
I.2	Evolution			-10%	-20%		+40	-20%		+5
	1995	46,6		365	0,304	4	302	0,183	85	65
	1983	11,1	11,6	2581	0,076	21	511	p.m.	20	70
II.1	Evolution			-10%	-30%		+298			+5
	1995	14,0		2323	0,053	29	809	p.m.	25	75
	1983	23,0	12,8	1017	0,232	7	861	0,148	65	70
II.2	Evolution			-10%	-20%		+102	-20%		+10
	1995	29,2		915	0,186	10	963	0,118	70	80
	1983	24,3	17,6	2337	0,552	16	1,499	0,235	65	50
III.1	Evolution			-10%	-15%		+234	-15%		-
	1995	30,7		2103	0,469	22	1733	0,200	70	50
	1983	9,2	28,5	3184	0,667	22	1090	0,233	50	65
III.2	Evolution			-10%	-15%		+318	-15%		-
	1995	11,6		2866	0,567	37	1408	0,198	50	65
	1983	7,8	23,8	888	0,542	6	79	0,208	45	70
IV.1	Evolution			-10%	-20%		+89	-20%		-
	1995	9,3		799	0,433	9	168	0,162	50	70
	1983	12,6	38,6	3425	1,110	24	1238	0,332	50	40
IV.2	Evolution			-10%	-10%		+342	-10%		-
	1995	15,9		3083	0,999	33	1580	0,299	60	40

Source: National Forestry Inventory (UNDP/FAO/IDA), M. Keita (FAO, 1982), Mission Estimates.

FUELWOOD BALANCE EVOLUTION 1983-1995
(in '000 m^3/year)

Zones		Fuelwood Consumption (x1000 m^3/yr)	Fuelwood Production NFC + Total (x1000 m^3/yr)	Fuelwood Production ASPA Accessible Production (x1000 m^3/yr)	Clearing Wood Total (x1000 m^3/yr)	Clearing Wood Fuelwood (x1000 m^3/yr)	Wood Production Total (x1000 m^3/yr)	Wood Production Fuelwood (x1000 m^3/yr)	Gross Balance (x1000 m^3/yr)	Net Balance (x1000 m^3/yr)	Net Deficit Consumption (x1000 m^3/yr)
I.1	1983	2200	777	524	101	76	878	600	-1322	-1600	72,7
	1995	3161	611	519	138	117	749	636	-2412	-2525	79,9
I.2	1983	193	214	96	49	29	263	125	+70	-68	35,2
	1995	245	166	92	65	42	208	134	-14	-111	45,3
II.1	1983	317	196	27	244	171	440	192	+123	-125	39,4
	1995	404	123	23	336	252	459	275	+55	-129	31,9
II.2	1983	397	363	165	90	63	453	228	+56	-169	42,6
	1995	512	284	159	128	102	412	261	-100	-251	49,0
III.1	1983	787	1642	534	282	141	1924	675	+1137	-112	14,2
	1995	1009	1333	467	387	194	1720	661	+711	-348	34,5
III.2	1983	345	2378	773	627	408	3005	1181	+2660	+836	-
	1995	444	1904	619	884	574	2788	1193	+2344	+749	-
IV.1	1983	82	497	157	143	100	640	257	+558	+175	-
	1995	104	373	131	214	150	587	281	+483	+177	-
IV.2	1983	682	4212	842	926	371	5138	1213	+4456	+531	-
	1995	985	3552	852	1274	510	4826	1362	+3841	+377	-
Total	1983	5003	10279	3118	2462	1359	12741	4471	+7738	-532	10,6
	1995	6864	8346	2862	3426	1941	11771	4803	+4908	-2061	30,0
Evolution	1983 to 1995	+37,2%	-18,8%	-8,2%	+39,2%	+42,8%	-7,6%	+7,4%	-36,6%	+287,4%	-

Notes:
1. Average consumption per capita unchanged. 0,76 m^3/year.
2. Wood production is total forest production (NFC + ASPA) plus total clearing wood. Net fuelwood production takes into account accessibility usage.
3. The gross balance has been computed using the total wood production figures.
4. The net balance has been computed using the net fuelwood production figures.

Source: National Forest Inventory, mission estimates.

Annex 4

EVOLUTION OF FUELWOOD PRICE STRUCTURES
IN OUAGADOUGOU BETWEEN 1975 AND 1984

Cost Component	1975 a/		1980 b/		1984 c/		Average Growth rate p.a. %	
	CFA.F/kg	%	CFA.F/kg	%	CFA.F/kg	%	1975-80	1980-84
Producer's Selling Price	0.7	10.0	3.8	25.3	4.4	31.0	40.2	3.7
Truck Transport Cost	1.5	21.4	3.8	25.3	5.2	36.6	20.4	8.1
Tax	NA	NA	NA	NA	0.8	5.6	-	-
Transporter's Net Margins	2.8	40.0	2.5	15.6	2.6	18.3	-2.2	1.0
Wholesale Price Ouaga	5.0	71.4	10.0	66.7	13.0	91.5	14.9	6.8
Wholesale Margin d/	2.0	29.6	5.0	33.3	1.2 e/	8.5	20.1	-30
Final Retail Price Ouaga	7.0	100.0	15.0	100.0	14.2	100.0	16.5	-1.4

a/ A. BERTRAND, 1975, AVV-CTFT.
b/ EC de 1980-81, M. DE BACKER, PNUD-FAO, Project UPV 78/004.
c/ Mission estimates September 1984.
d/ Including chopping costs.
e/ This is low value. In certain cases, the wholesale price of wood (by truckload can be as low as 9.4. CFA.F/kg, and in this case the retailer's gross margin would be 4.8 FCFA/kg, that is 33.8%of the final retail price.

EVOLUTION OF CHARCOAL PRICES
IN OUAGADOUGOU SINCE 1975

	Francs CFA/kg			Average Growth Rates p.a.
	1975 a/	1980 b/	1984 c/	1975-1984
Wholesale, Bagful	24.5	40-60	46.5	7.4%
Retail, Heap	44.0	58.0	58.8	3.3%

a/ See A. BERTRAND, 1975, AVV-CTFT.
b/ See M.T. THIOMBIANO, 1981.
c/ I.V.E. figures and mission findings (September 1984).

PETROLEUM PRODUCT PRICE STRUCTURE JANUARY 1984
(CFA.F)

Item	Premium	Regular	Kero	Gasoil	Industrial Diesel	Fuel Oil
	(HL)	(HL)	(HL)	(HL)	(te)	(te)
Bobo-Dioulasso						
F.O.B. (SIR)	16,023.90	15,651.59	10,207.63	14,814.90	114,961.09	81,892.04
Customs and Taxes	4,377.74	4,359.08	,975.85	1,853.96	6,629.35	3,674.26
Other Assessments	2,424.51	1,968.41	1,368.21	1,726.35	5,246.83	10,038.78
Transport	2,277.06	2,228.84	2,391.58	2,452.90	29,722.78	27,860.22
Company Handling, Profit, etc.	1,993.79	1,739.38	1,403.73	1,849.75	28,110.55	22,219.52
Price Ex-depot	27,097.00	25,847.00	16,347.00	22,697.00	185,882.40	144,565.22
Retail Pump Price/L	279	266	171	234	-	145,684.22
Ouagadougou						
F.O.B. (SIR)	16,023.90	15,651.69	10,207.63	14,814.90	114,961.09	81,892.04
Customs and Taxes	4,347.74	4,359.08	,975.85	1,853.90	6,629.35	3,674.26
Other Assessments	2,228.35	1,674.14	1,251.64	1,244.73	3,201.61	7,782.18
Transport	2,994.24	2,943.76	3,146.46	3,355.59	39,167.03	36,724.17
Company Handling, Profit, etc.	2,015.77	1,761.33	1,208.42	!,970.82	28,276.22	22,536.05
Price ex-depot	27,640.00	26,390.00	16,790.00	23,240.00	192,235.30	152,608.70
Retail pump price/L	285	272	176	240	-	-

Included in OTHER ASSESSMENTS are:

1. The price Stabilization Fund.
2. A surcharge for the Fonds d'Action Petroliere which is the source of funds for BUMIGEB.
3. A surcharge for security stocks which funds SEHBI's activities.
4. A surcharge representing the road transport differential compared to the rail charge.
   For products received by rail the purchasing oil company must refund this amount to the Stabilization Fund.

Source: Price structure as of January 23, 1984, modified for kerosene.

PETROLEUM PRODUCT IMPORTS 1972-1983

Product	Unit	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
						(Volume)							
Gasoline Premium	M^3	1,702	2,108	2,433	3,123	4,175	5,600	7,281	8,433	9,335	8,914	8,921	8,379
Gasoline Regular	M^3	26,851	30,121	30,416	36,883	41,609	47,100	52,190	58,250	61,863	64,829	65,142	57,933
Total Gasolines	M^3	28,553	32,229	32,851	40,006	45,784	52,700	59,471	66,683	71,198	73,743	74,063	66,312
Kerosene	M^3	8,676	9,314	10,959	11,765	12,263	11,870	12,454	12,984	13,652	15,000	16,671	14,901
Gasoil	M^3	12,228	13,347	14,545	14,333	17,253	21,300	24,455	24,958	27,756	30,265	30,897	28,588
Diesel	M^3	13,821	15,686	15,782	15,879	19,616	25,317	25,998	23,124	30,202	30,259	25,400	20,046
Fuel Oil	te	2,739	2,224	2,900	3,781	6,941	4,500	6,266	14,615	17,623	16,182	22,130	19,224
LPG	te											637	
Memo-Jet Fuel	M^3	5,554	5,846	6,153	6,476	8,203	8,123	12,463	13,163	6,466	4,055	4,286	7,308

Product Conversion	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
					(tonnes oil-equivalent)							
Total Gasolines	1.32	21,631	24,416	24,887	30,308	34,685	39,924	45,053	50,517	53,938	55,866	56,108	50,236
Kerosene	1.24	6,997	7,511	8,838	9,488	9,890	9,573	10,044	10,471	11,010	12,097	13,444	12,017
Gasoil	1.19	10,276	11,216	12,223	12,045	14,498	17,899	20,550	20,973	23,324	25,433	25,964	24,024
Diesel	1.11	12,451	14,132	14,218	14,305	17,672	22,808	23,432	20,832	27,209	27,350	22,883	18,059
Fuel Oil	1.02	2,685	2,180	2,843	3,707	6,805	4,412	6,143	14,328	17,277	15,865	21,696	18,847
LPG	1.06											674	

Source: GPP.

ETHANOL AS A GASOLINE EXTENDER

Background

1. The main scope for producing a local substitute for imported petroleum products lies in ethanol as a gasoline extender. In this area the GOB is supporting two projects, one based on agro-industrial residues and the other on dedicated cropping. It is essential that these developments be tailored to the size of the potential market and be genuinely viable without State support.

2. There are two types of gasoline replacement possible with currently proven technologies using ethanol. The first is as an extender in blends of up to 15% or 20%. The ethanol replaces gasoline approximately liter-for-liter and needs to be of anhydrous quality (ethanol content greater than 99.6%), i.e. with production costs higher than hydrous fuel-grade ethanol. The second technique is to use fuel-grade ethanol by itself in specially adapted engines. Under these conditions a liter of ethanol replaces significantly less than a liter of gasoline. International oil prices would have to increase dramatically before this option would become cheaper than continuing to import gasolines into Burkina.

3. The presence of excess water in gasoline/ethanol blends can cause phase separation, which makes the fuel unusable. The cost of maintaining storage systems and vehicle tanks moisture-free is an additional cost of using the blend. Since water-tolerance is higher in 15%-20% blends than in lower blends, it may be desirable to distribute high blends in specific regions rather than attempt to distribute a low blend nationwide. On the other hand, blend ratios of 15-20% ethanol could cause corrosion in the fuel loop (tank, fuel pump, filter and carburettor) as well as damage to rubber and other non-metallic parts.

4. The two main distribution centers for gasolines are Ouagadougou and Bobo-Dioulasso. The most likely strategy for blending is to transport ethanol into the depots in these two centers for storage and in-line blending with gasoline in the outgoing tanker trucks. The additional costs of ethanol transport to the depots (particularly if it involves secondary roads from outlying areas), and of storage and blending facilities are again costs which need to be taken into account in the evaluation of ethanol projects. If the ethanol production is seasonal, it may be necessary to invest in considerable inter-seasonal storage in order to maintain a sufficiently constant blend over the year. The availability of excess storage capacity in relation to requirements needs to be investigated.

5. On the benefit side, addition of ethanol to gasoline will generally increase the product's octane rating. Once blend distribution is established over a sufficiently large area, it may be possible to import a lower-cost grade of gasoline as a blending stock. The benefits of the octane boost value of ethanol are not likely to be significant.

6. A comparison of the per-liter costs (excluding indirect taxes) of getting ethanol and gasoline into the blend at the depot gate will indicate whether ethanol production is economically viable. The agricultural inputs should be costed at the best ex-factory price which could have been obtained in an alternative use, such as food or fertilizer. Even before economic viability is established, the GOB will need to establish a suitable taxation and pricing regime for the project promoters to use in assessing the financial viability of the venture.

7. There are several ways to structure taxes and prices for ethanol. In setting these arrangements, it is essential for the GOB to ensure that: (a) ethanol contributes to the taxation revenues needed for road maintenance to the same extent as gasoline; (b) the final arrangements do not conceal an implicit subsidy from either the GOB or the user to the ethanol producer. In the event that the GOB takes an equity share in the venture, there must be a clear separation between the regulatory and shareholding roles of the State.

Ethanol from Molasses

8. Burkina has one sugar operation, SOSU-BF, which is established in the south of the country at Banfora. In 1983/84 the mill produced 13,342 tonnes of molasses, about half of which was used as fertilisers (approx. replacement value 72 million CFA.F/year) after dilution with irrigation water. The remainder was exported to the Ivory Coast or used locally as supplemental feed for cattle. On present projections of the long-run price of molasses (US$71.50 per ton, New Orleans), exports through Abidjan to the international market seem unlikely to be viable.

9. The GOB has recently established, next to the sugar mill, a distillery designed to produce ethanol from molasses. The 1.6 billion CFA.F plant was built with commercial Austrian financing and is to be operated by SOPAL (Societe pour la Production d'Alcool), an industrial entity which is separate from SOSU-BF. The plant was scheduled to start production in early 1985 with an initial output of 2.1 million liters/year, rising to 3 million liters/year from the fifth year onwards. As the production capacity is quoted at 10,000 liters/day, this would imply an operating regime of 300 days/year. Since this is well in excess of the operating season of the sugar mill, the distillery would depend on oil for its energy requirements in the off-season. The viability of producing ethanol during the off-season needs to be investigated; as an alternative it may be worthwhile to increase the capacity of the distillery.

10. The plant's output is presumed to be of anhydrous quality, i.e. suitable for blending with gasolines. Molasses and energy inputs (steam and electricity) are to be purchased from SOSU-BF during the sugar milling season; in the off-season the ethanol plant will use oil to meet its energy requirements. Since it is not clear what part of the present molasses market is being diverted to ethanol production, it is difficult to establish the economic cost of the main input. Partial estimates indicate that the economic cost of ethanol ex-depot in Bobo-Dioulasso may

be competitive with gasoline. This should have been verified before a commitment was made to the project.

11. The financial viability of SOPAL will depend on bilaterally negotiated prices for inputs from SOSU-BF. These were not established at the time of the mission, despite the advanced state of the distillery's construction. The scope for physical integration of the two plants also appeared to have been neglected, probably as a result of the arms-length relationship between the two entities. Financial returns will also depend on the Government's position on taxation and price control and on the pricing and other contractual arrangements with the petroleum product marketing companies. At the time of the mission there was little evidence that these key matters had been adequately addressed.

12. Burkina imports around 70 million liters of gasolines annually, of which 30 million liters/year are consumed in the Bobo-Dioulasso distribution area. The blending of SOPAL's output over this area would therefore result in a 7% blend, rising to 10% at full production.

Ethanol from Sweet Sorghum

13. The GOB has also taken a 30% shareholding in a venture to investigate and promote ethanol production from sweet sorghum in the Sourou valley. In this case the ethanol would be produced directly from the crop, rather than from the residues of an agro-industrial process such as sugar production. The economic cost of the feedstock is likely to be higher as a result. The next phase of the project, from 1985 to 1988, is a $US3 million investigation of sweet sorghum production costs on a 10 hectare plot.

14. If the project proceeds, the proposed output is 17.5 million liters/year, equivalent to 12% of total national consumption of gasolines at the time of commissioning (around 1990). The Sourou valley is in the north-west of Burkina, approximately equi-distant from Bobo-Dioulasso and Ouagadougou; transport costs will be a major consideration for both the economic evaluation and the marketing arrangements. Approximately half of the market potential in the Bobo-Dioulasso area will have already been absorbed by the SOPAL project.

15. At this stage, the GOB's main concern should be to establish a sound taxation and regulatory framework to ensure that the Sourou project will only proceed if it is economically worthwhile. This will then allow the project's private sector promoters to continue their investigation and evaluation within a secure and predictable set of rules. In the event that the project proves to be viable, the GOB should not need to take a shareholding in the subsequent phases (construction, commissioning and operation), with the possible exception of a token investment to indicate the Government's continued goodwill.

Recommendations

16. With present costs and technologies, the scope for ethanol production is limited to 15%-20% of the national gasoline market (itself around 34% of total petroleum imports in TOE terms). While this is a significant item in the total cost of petroleum, it should not be allowed to distract energy planners from the more important task of ensuring least-cost procurement of all petroleum imports.

17. In developing ethanol as a gasoline extender, the GOB's energy planning input should be confined to: (a) developing a sound and stable taxation and regulatory framework for private sector development; (b) facilitating dialogue with potential suppliers of suitable feed-stocks, particularly agro-industrial residues; (c) facilitating dialogue with the petroleum product marketing companies concerning costs and practical arrangements for transport, storage, blending and distribution.

Annex 8

SONABEL: ENERGY GENERATION 1972-1983
(GWh)

Year	Ouaga-dougou	Bobo Dioulasso	Koudougou	Banfora	Ouahi-gouya	Total
1972	21.6	9.6	5.4	-	0.32	36.9
1973	24.7	11.3	5.2	0.04	0.35	41.6
1974	27.8	13.2	5.2	0.74	0.37	47.3
1975	31.6	14.3	5.6	0.96	0.44	52.9
1976	35.2	16.4	6.2	1.14	0.58	59.5
1977	42.5	18.8	6.6	1.49	0.65	70.0
1978	49.4	21.0	7.4	1.70	0.83	80.3
1979	59.4	25.1	11.4	1.85	0.99	98.8
1980	68.5	28.4	12.9	1.86	1.12	112.8
1981	71.5	28.7	11.3	1.95	1.22	114.6
1982	78.5	29.8	11.4	1.84	1.33	122.8
1983	79.0	30.3	12.0	1.92	1.46	124.7

Average Growth Rate p.a. (%)

1972-83	12.5	11.0	7.5	9.0(a)	15.1	11.7
1972-80	15.5	14.5	18.5	14.1(b)	16.7	15.0
1980-83	4.9	2.2	-2.4	1.1	10.9	3.4

(a) 1975-1983.
(b) 1975-1980.

Annex 9

SONABEL: ANNUAL PEAK DEMAND, 1978-1984 (MW)

	Ouagadougou	Bobo Dioulasso	Koudougou	Banfora	Ouahigouya
	A. Annual Peak Demand (MW)				
1978	11.52	4.44	1.96	0.324	0.176
1979	14.54	5.48	2.21	0.360	0.212
1980	16.74	6.20	2.20	0.366	0.231
1981	17.34	6.33	2.10	0.396	0.264
1982	19.37	6.83	2.24	0.444	0.290
1983	20.50	6.15	2.43	0.432	0.305
1984	19.37	6.33	2.35	0.396	0.330
	B. Annual Load Factor (hours/year)				
1978	4291	4731	3770	5244	4731
1979	4067	4589	5168	5146	4658
1980	4090	4588	5862	5069	4858
1981	4124	4528	5369	4919	4634
1982	4052	4363	5068	4136	4601
1983	3857	4932	4921	4441	4788
1984	...	...	...	...	...

ELECTRICITY CONSUMPTION PATTERNS: TRENDS

	1972		1980		1982		Average Growth Rate 1972-82	1980-82
	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)	(percent p.a.)	
Low Voltage Consumption	13.81	43.3	38.53	42.1	44.08	41.7	12.3	7.0
- Households	9.90	31.0	30.62	33.4	34.38	32.5	13.3	6.7
- Government	1.56	4.9	3.44	3.8	4.10	3.9	10.1	9.2
- Small Industries	1.94	6.1	3.45	3.8	4.15	3.9	7.9	9.7
- Public Lighting	0.41	1.3	1.02	.1	1.45	1.4	13.5	19.2
High Voltage Consumption	18.07	56.7	53.04	57.9	61.61	58.3	13.0	7.8
- Industry	15.78	49.5	48.17	52.6	55.48	52.5	13.4	7.3
- Pumping	2.29	7.2	4.87	5.3	6.13	5.8	10.3	12.2
Total Energy Sold	31.88	100	91.57	100	105.69	100	12.7	7.4

Annex 10

INSTALLED CAPACITY IN SONABEL'S GENERATION FACILITIES (1984)

Station Machines	Commissioning Date	Installed Capacity MW	Type	Fuel
OUAGA 1		5.5		
G4, G2	1958, 59	2 x 0.5	MGO	Diesel
G6, G8, G5	1964, 64, 72	3 x 1.5	AGO	Diesel
OUAGA 2		35.5		
G1	1975	(2 x 1.5) TWIN	AGO	Diesel
G2, G3, G4	1978, 79, 80	3 x 5.5	PC2-12	Fuel Oil
G5, G6	1982, 82	2 x 8.0	PC2-18	Fuel Oil
BOBO				
DIOULASSO		10.8		
G0, G1, G6	1970, 72, 74	3 X 1.1	AGO	Diesel
G4, G3, G2	1958, 59, 64	3 x 0.5	MGO	Diesel
G16, G8, G7, G9	1972, 76, 77, 77	4 x 1.5	AGO	Diesel
KOUDOUGOU		4.8		
G1, G2, G3	1969, 69, 69	3 X 0.6	MWM	Diesel
G4, G5	1978, 79	2 x 1.5	MWM	Diesel
Banfora		0.9		
G1	1958	0.5	MGO	Diesel
G2	1960	0.4	MGO	Diesel
OUAHIGOUYA		0.57		
G4, G5	1969, 69	2 x 0.06	Berliet	Diesel
G2, G3	1976, 76	2 x 0.1	Poyaud	Diesel
G1	1983	0.25	Poyaud	Diesel
DEDOUGOU		1.1		
G1, G2	1960, 68	2 X 0.5	MGO	Diesel
G3	1983	0.1	Daimler	Diesel
			Benz	Diesel
DORI		0.1		
G1, G2	1983	2 x 0.05	Daimler	Diesel
			Benz	Diesel
GAOUA		0.2		
G1, G2	1983	2 x 0.1	Daimler	Diesel
			Benz	Diesel
FADA		0.2		
G1, G2	1983	2 x 0.1	Daimler	Diesel
			Benz	Diesel
KAYA		0.2		
G1, G2	1983	2 x 0.1	Daimler	Diesel
			Benz	Diesel
TENKODOGO		0.2		
G1, G2	1983	2 x 0.1	Daimler	Diesel
			Benz	Diesel
TOUGAN		0.1		
G1, G2	1983	2 x 0.05	Damiler	Diesel
			Benz	Diesel

Annex 11

SONABEL MARGINAL COST ESTIMATES

Cost Component	Unit	Large Centers	Smaller Centers
Production equipment: diesel machine size	MW	12	0.25
Fuel		Fuel Oil	Diesel
Specific consumption	g/kWh	220	250
Fuel price	F/tonne	128,600	170,000
Fuel price	F/kWh Produced	28.29	42.50
Lubricants price (4% of fuel price)		1.13	1.70
Auxiliary consumption (% fuel consumption)	%	3	6
Distribution losses on HV + MV networks	%	8	5
Distribution losses on LV network	%	10	9
Variable cost MV	F/kWh	32.97	49.50
Variable cost LV	F/kWh	36.63	54.39
Capacity Investments	MF/MW inst.	290	340
Lifespan	Years	15	10
Annuity (rate 10%)	F/kW inst/Y	38,135	55,318
Fixed Operating Costs	F/kW inst/Y	9,100	15,500
Security margin	MW inst/MW demand	1.3	1.5
Fixed Capital costs	F/kW/y	63,305	113,007
MV and HV distribution network investment	MF/MW	95	125
Lifespan	Years	30	30
Annuity. MV network	F/kW/y	10,080	13,263
LV distribution network investments	MF/MW	125	175
Annuity LV network	F/kW/y	13,263	18,568
Unit Fixed Costs LV	F/kW/y	10,165	13,965
Fixed cost. MV	F/kW/y	79,766	132,916
Fixed cost. LV	F/kW/y	114,660	181,812

Note: A more detailed estimation should take into account projected changes in fuel prices relative to other prices.

Annex 12

SONABEL ELECTRICITY TARIFFS EFFECTIVE SEPTEMBER 1984

	Load Limit amps	Blocks kWh/month 1	2	Tariffs CFA.F/kWh 1	2	3
LOW VOLTAGE						
(1) Residential - A	3	flat rate:		61 CFA.F/kWh		
	5	30	30	92	90	85
	10	60	60	92	90	85
	15	100	100	92	90	85
(2) Residential - B	10	200	200	92	90	85
	15	300	300	92	90	85
	20	390	390	92	90	85
	25	490	490	92	90	85
	30	590	590	92	90	85
(3) Business - A (Force Motrice)	up to 30	flat rate:		85 CFA.F/kWh		
(4) Public Lighting	—	flat rate:		95 CFA.F/kWh		

	Tariff CFA.F/yr. /subscribed kW	Tariff CFA.F/kWh Peak 8 am-11 pm	Off-Peak 11 pm-8 am
(5) Business - B (Force Motrice)			
up to 10 kW subscribed	3891	90	59
12.5 kW subscribed + above	3891	90	55
MEDIUM VOLTAGE			
(6) Industry, commerce and government			
up to 49 kW subscribed	11,672	70	61
50 kW subscribed + above	11,672	68	61

INDUSTRIAL COGENERATION

The largest agro-industrial operation in Burkina is the SOSU-BF sugar mill at Banfora. The factory is designed to produce 35,000 tonnes/ year of sugar and during the milling season it consumes its entire output of bagasse (typically 100,000 tonnes) for cogeneration of steam and electricity. An input of fuel oil is also required at the end of the season and, under present operating conditions (i.e., below capacity), this accounts for a significant proportion of energy supply. This fuel oil requirement can and must be eliminated. For this reason alone there should be an energy audit to specify the best combination of: (a) energy savings in the sugar manufacturing process (evaporators, juice heaters), and/or (b) additional net energy input by recycling waste heat into bagasse drying. In both cases the investment requirements are small, particularly in relation to the potential cost savings.

SOSU-BF management has estimated that the presently installed plant has a surplus generating capacity of around 400 kW, after completion of minor modifications to the turbo-generator cooling system. It is likely that this spare capacity will be used largely to power pumps for canefield irrigation and to supply electricity to the adjacent ethanol factory. This appears to eliminate the low-cost option of using this capacity to supply Banfora (400 kW maximum demand in 1984) during the milling season. Other options would involve new generating plant and are likely to be viable only in association with transmission from Banfora to Bobo-Dioulasso.

Development of the full cogeneration potential of the sugar mill is a possibility in the longer term, although 30,000 tonnes/year is generally regarded as the lower limit for viable development of an energy surplus. This would involve investment in modifications such as maximum bagasse drying and several megawatts of additional turbo-generator capacity. It may also be possible to extend the electricity generation period to a full 12 months by means of pelletizing the excess bagasse from the milling season. These are possibilities which need to be carefully considered in conjunction with all other electricity supply options for the Banfora/Bobo-Dioulasso area (fuel oil, interconnection, small-hydro).

The other major consumer of agro-industrial residues is the oil processing industry. The CITEC plant at Bobo-Dioulasso burns cotton seed, karite wastes and fuel oil and generates about three-quarters of its own electricity requirements. Despite this shortfall, a preliminary energy balance indicates a theoretical potential (i.e. with a different plant configuration) for surplus electricity generation of 26 GWh over the six month operating season. SONABEL's generation requirement at Bobo-Dioulasso over the same period is currently around 15 GWh. While animal feed may be a better use for some of the residues, such as karite cakes, the potential for selling surplus electricity to SONABEL is clearly worth investigating.

Potential for industrial cogeneration of surplus electricity also exists in industries which use only fuel oil. In Ouagadougou, for example, the SOVOBRA brewery has a theoretical surplus potential of 2.8 GWh/year, compared with SONABEL's annual generation requirement of around 80 GWh/ year. The mission estimates that the total potential for industrial supply to SONABEL in Bobo-Dioulasso and Ouagadougou could be around 10 MW.

Annex 14

ELECTRICITY DEMAND PROJECTIONS
(GWh and average annual growth rates)

Year	Ouagadougou GWh	%	Bobo Dioulasso GWh	%	Koudougou GWh	%	Banfora GWh	%	Other Centers GWh	%	Totals GWh	%
(a) Low growth scenario												
1982	78.5		29.8		11.4		1.84		1.33		122.8	
		+0.6		+1.7		+5.3		+4.3		+9.8		+1.5
1983	79.0		30.3		12.0		1.92		1.46		124.7	
		-7.6		-1.0		+5.0		-6.2		+167		-2.7
1984	73.0		30.0		12.6		1.8		3.9		121.3	
		-2.5		-1.5		+5		0		+20		-0.7
1985	71.2		29.6		13.2		1.8		4.7		120.5	
		+1.5		+1		+5		+2		+15		+2.4
1987	73.4		30.2		14.6		1.9		6.2		126.3	
		+5		+5		+6		+5		+15		5.7
1990	84.9		35.0		17.4		2.2		9.5		149.0	
		+8		+7		+7		+10		+15		+8.2
1995	124.8		49.1		24.4		3.5		19.0		220.8	
		+8		+7		+7		+10		+15		+8.4
2000	193.3		68.9		34.2		5.6		38.2		330.2	
		+8		+7		+7		+10		+15		+8.3
2010	395.7		135.5		67.3		14.5		154.5		767.5	
(b) High growth scenario												
1984	73.0		30.0		12.6		1.8		3.9		121.3	
		0		0		+5		0		+20		+1.1
1985	73.0		30.0		13.2		1.8		4.7		122.7	
		+3		+2		+6		+6		+20		+3.8
1987	77.4		31.2		14.8		2.0		6.7		132.1	
		+7		+7		+7		+7		+15		+7.5
1990	94.9		38.2		18.2		2.5		10.2		164.0	
		+9		+8		+8		+10		+15		+9.1
1995	146.0		56.1		26.7		4.0		20.5		253.3	
		+9		+8		+8		+10		+15		+9.2
2000	224.7		82.5		39.2		6.4		41.2		394.0	
		+8		+8		+8		+10		+15		+9
2010	485.1		178.0		84.7		16.7		166.8		931.3	

LOAD FORECASTS
(MW, including losses)

	Ouagadougou	Bobo Dioulasso	Koudougou a/	Banfora a/	Other Centers b/
1984	19.37	6.33	2.35	0.396	1.2
1985	19.5	6.6	2.7	0.41	1.5
1987	19.6	6.9	3.0	0.45	2.1
1990	24.0	8.4	3.7	0.57	2.9
1995	36.0	12.5	5.5	0.91	5.1
2000	56.0	18.5	8.0	1.45	9.8
2010	120.0	40.0	17.0	3.80	37.0

a/ High uncertainty, due to the presence of major industrial consumers.
b/ Total with no allowance for diversity; includes the new centers.

NB. The table above gives "most likely" estimates. The following percentages give an indication (plus or minus) of the uncertainty in the central estimates:

1985	1987	1990	1995	2000	2010
5%	8%	12%	17%	25%	35%

INVESTMENT REQUIREMENTS OUAGADOUGOU/KOUDOUGOU 1985-1999
(in m. CFA.F)

	Investment m. CFA.F	Commission-ing date	Approximate Timing 1985-89	1990-94	1995-99
"THERMAL" SCENARIO					
Kompienga: 15 MW	18,400	1989	18,400		
Ouaga 2: 8 MW fuel oil	2,560	1994		2,560	
Ouaga 2: 8 MW fuel oil	2,560	1996			2,560
Ouaga 3: 12 MW fuel oil	3,600	1998			3,600
Ouaga 3: 12 MW fuel oil	3,600	2000			3,600
Koudou: 5.5 MW fuel oil	1,760	1992		1,760	
Koudou: 5.5 MW fuel oil	1,760	1999			1,760
(SUB-TOTAL)	37,840				
Kompienga-Ouaga 132 kV line	9,100	1989	9,100		
Ouaga-Koudou 30 kV line	840	1989	840		
Distribution networks	12,000		3,800	4,000	4,200
(TOTAL)	56,180		32,140	8,320	15,720
"HYDRO" SCENARIO					
Kompienga: 15 MW	18,400	1989	18,400		
Bagré: 2 x 8 MW	23,650	1994		23,650	
Ouaga 3: 12 MW fuel oil	3,600	1997			3,600
Ouaga 3: 12 MW fuel oil	3,600	1998			3,600
Ouaga 3: 12 MW fuel oil	3,600	2000			3,600
Koudou: 5.5 MW fuel oil	1,760	1992		1,760	
Koudou: 5.5 MW fuel oil	1,760	1999			1,760
(SUB-TOTAL)	56,370				
Ouaga-Koudou 30 kV line	840	1989	840		
Kompienga-Ouaga 132 kV line	9,100	1989	9,100		
Bagré-Tenkodogo 132 kV line	1,250	1994		1,250	
Distrbution networks	12,000		3,800	4,000	4,200
(TOTAL)	79,560		32,140	30,660	16,760

1. The cost of restoring fuel oil plant at Ouaga 2 to normal availability is not included in either scenario.
2. Transmission from Kompienga to Ouagadougou is assumed to be routed via Tenkodogo rather than via Bagré.

INVESTMENT REQUIREMENTS BOBO-DIOULASSO/BANFORA 1985-1999
(in m. CFA.F)

	Investment m. CFA.F	Commissioning date	Approximate Timing 1985-89	1990-94	1995-99
"THERMAL" SCENARIO					
Bobo 2: 4 MW fuel oil	1,320	1986	1,320		
Bobo 2: 4 MW fuel oil	1,320	1988	1,320		
Bobo 2: 4 MW fuel oil	1,320	1992		1,320	
Bobo 2: 4 MW fuel oil	1,320	1995			1,320
Bobo 2: 8 MW fuel oil	2,560	1997			2,560
Bobo 2: 8 MW fuel oil	2,560	1999			2,560
(SUB-TOTAL)	10,400				
Bobo-Banfora 30 kV line	670	1988	670		
Distribution networks	4,000		1,200	1,300	1,500
(TOTAL)	15,070		4,510	2,620	7,940
"ELEC. IMPORTS" SCENARIO					
Bobo 2: 4 MW fuel oil	1,320	1986	1,320		
Bobo 2: 4 MW fuel oil	1,320	1988	1,320		
Bobo 2: 4 MW fuel oil	1,320	1992		1,320	
Bobo 2: 10 MW gas turbine	1,800	1996			1,800
Bobo 2: 10 MW gas turbine	1,800	2000			1,800
(SUB-TOTAL)	7,560				
Bobo-Banfora 132 kV line	2,400	1993		2,400	
Ferke-Banfora 132 kV line	4,100	1994		4,100	
Distribution networks	4,000		1,200	1,300	1,500
(TOTAL)	18,060		3,840	9,120	5,100

BURKINA PROJECTED ENERGY BALANCE - 1995

	Fuelwood	Residues	Charcoal	Hydro	Electricity	LPG	Gasoline	Kerosene	Gasoi	Diesel	Fuel oil	Petroleum Total	Total
SUPPLY													
Production	1,650,000	150,000		9,850									1,809,850
Imports						1,050	71,500	29,100	34,200	13,530	45,250	194,630	194,630
TOTAL	1,650,000												2,004,480
CONVERSION													
Charcoal	(9,500)		9,500										0
Power				(3,825)	21,340					(1,690)	(15,825)	(17,515)	0
Conversion Losses	(10,500)			(6,025)	(520)					(2,810)	(25,275)	(28,085)	(45,130)
Transmission Losses					(2,020)								(2,020)
Net Supply	1,630,000	150,000	9,500		18,800	1,050	71,500	29,100	34,200	9,030	4,150	(149,030)	1,957,330
CONSUMPTION													
Households	1,630,000	110,000	9,500		8,400	1,050		29,100	--	--		30,150	1,788,050
Transport							71,500		27,000	6,760		105,260	105,260
Industry		40,000			10,400				7,200	2,270	4,150	13,620	64,020

Source: Mission estimates.

NOTES TO PROJECTED ENERGY BALANCE, 1995

Conversion factors are as in the 1983 energy balance. Hydro-electricity is converted to a thermal replacement value at 84.3 toe/GWh.

GDP growth in real terms is assumed to be zero until 1986 and 2% per year thereafter.

Population growth is assumed to be 2% per year.

BASE CASE ASSUMPTIONS

Fuelwood consumption remains at the equivalent of 0.76 m^3/person/year; however, penetration of improved woodstoves reaches 50%/40%/30% in urban/semi-urban/rural areas, respectively; in conjunction with rising fuelwood prices, this reduces fuelwood consumption in 1995 from 1.8 million toe to 1.7 million toe/year.

Residues: (a) Consumption of bagasse and other agro-industrial residues remains at approximately the same level as in 1983. (b) Straw and dung consumption almost doubles as a result of fuelwood shortages.

Charcoal consumption increases by 2% per year; conversion efficiencies increase (from 20% by weight in 1983) to 25% in 1995.

Electricity consumption is as in the "high growth" scenario (Annex 14); it is assumed that this corresponds with a growth rate of 6% per year for industrial consumption and 10% per year for household and commercial consumption (after an initial period of stagnation until 1986).

Installed capacity is as in the "thermal" scenarios for both Ouagadougou/Koudougou and Bobo-Dioulasso/Banfora (Annex 15); hydro generation at Kompienga is 45 GWh; generation at Ouagadougou (101 GWh in 1995), Bobo-Dioulasso (56 KWh), Koudougou (27 GWh) and Banfora (4 GWh) is supplied by fuel oil (at 223 g/kWh), with the remainder (20 GWh) diesel-fired (at 250 g/kWh); auxiliary consumption averages 3% and distribution losses are around 10%.

Petroleum consumption, other than for electricity generation, stagnates until 1986 and then increases by 4% per year; kerosene consumption rises by a further 12,000 toe in 1995 as a result of limited penetration of the cooking market in urban and semi-urban areas (15% and 10% respectively, para. 2.110).

ALTERNATIVE SCENARIOS

Fuelwood/kerosene substitution in rural areas: if kerosene cooking achieves 5% penetration in rural areas by 1995, consumption of fuelwood and/or agricultural residues will decline by 95,000 toe and kerosene consumption will increase by a further 22,000 toe.

Non-thermal electricity generation, i.e., the Bagré "hydro" scenario for Ouagadougou/Koudougou and the "electricity imports" scenario for Bobo-Dioulasso/Banfora (Annex 15): fuel oil requirements are reduced by 55 GWh per year (12,000 toe of fuel oil) of hydro generation for Ouagadougou/Koudougou and by up to 60 GWh/year (13,000 toe of fuel oil) of electricity imports for Bobo-Dioulasso/Banfora.

Industrial cogeneration of excess electricity for sale to the SONABEL public supply system in Bobo-Dioulasso and/or Banfora could replace up to 60 GWh (13,000 toe of fuel oil) of fuel oil-fired electricity with no additional consumption of agro-industrial residues.

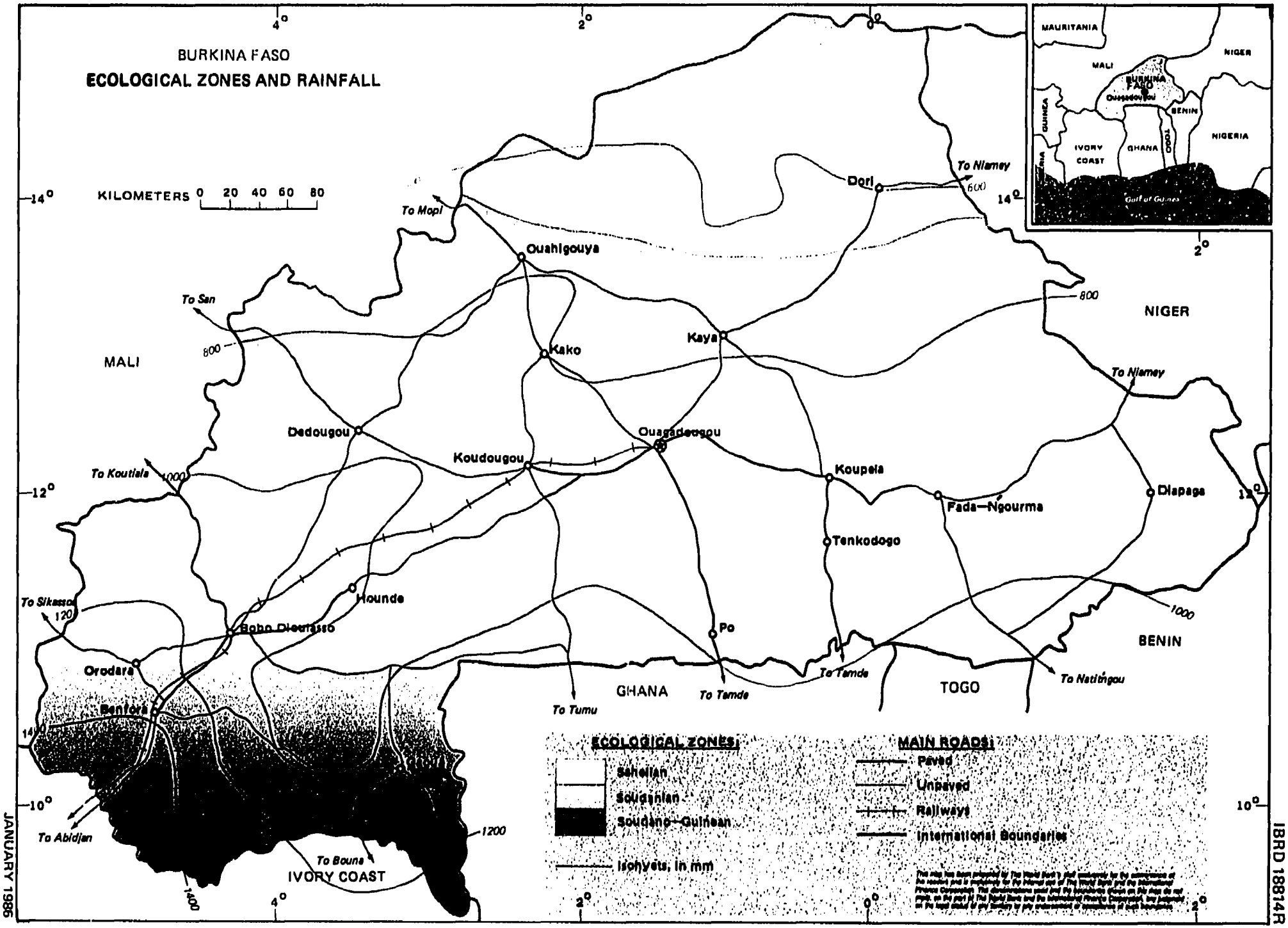
COMPARISON 1983/1995

Biomass consumption (fuelwood plus residues) will rise from around 1,690,000 toe in 1983 to around 1,800,000 toe in 1995 (base case), or remain at the 1983 level if kerosene succeeds in penetrating 5% of the rural cooking market.

Petroleum consumption will rise from around 130,000 toe in 1983 to around 195,000 toe in 1995 (base case), plus or minus:

(a) minus 25,000 toe of fuel oil if maximum hydro and electricity import (or industrial cogeneration) options are implemented.

(b) plus 22,000 toe of kerosene if this fuel succeeds in penetrating 5% of the rural cooking market.



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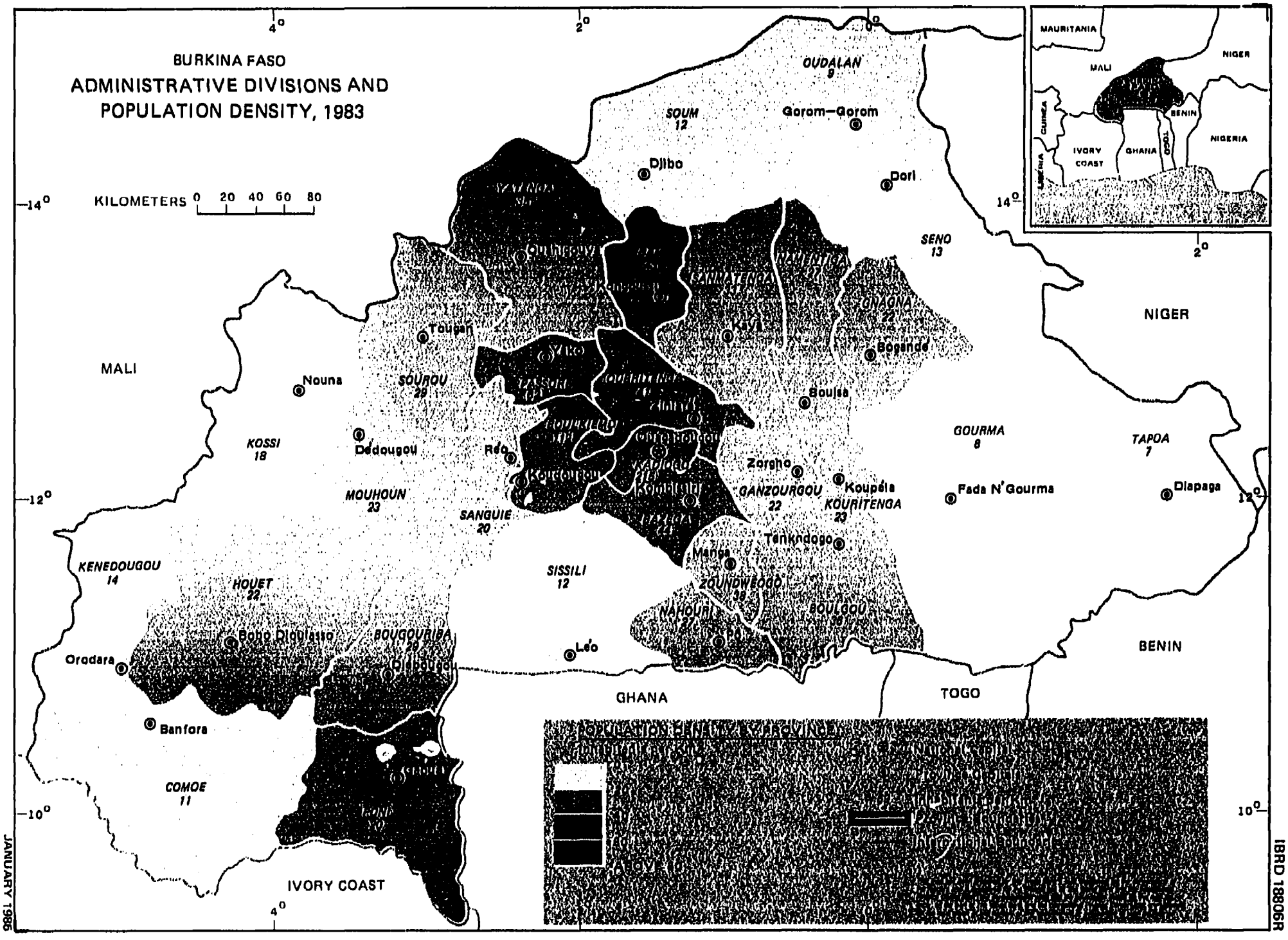
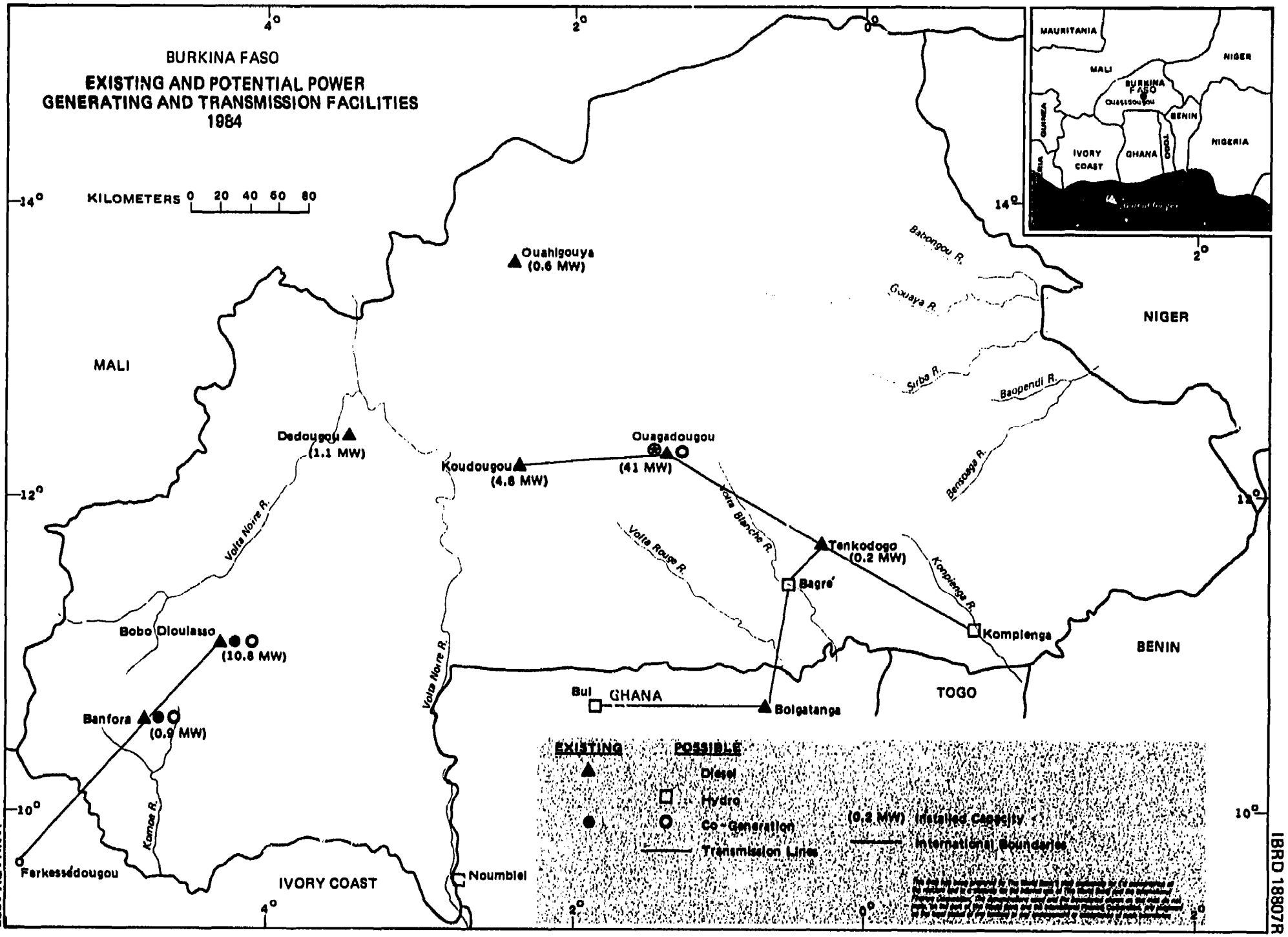
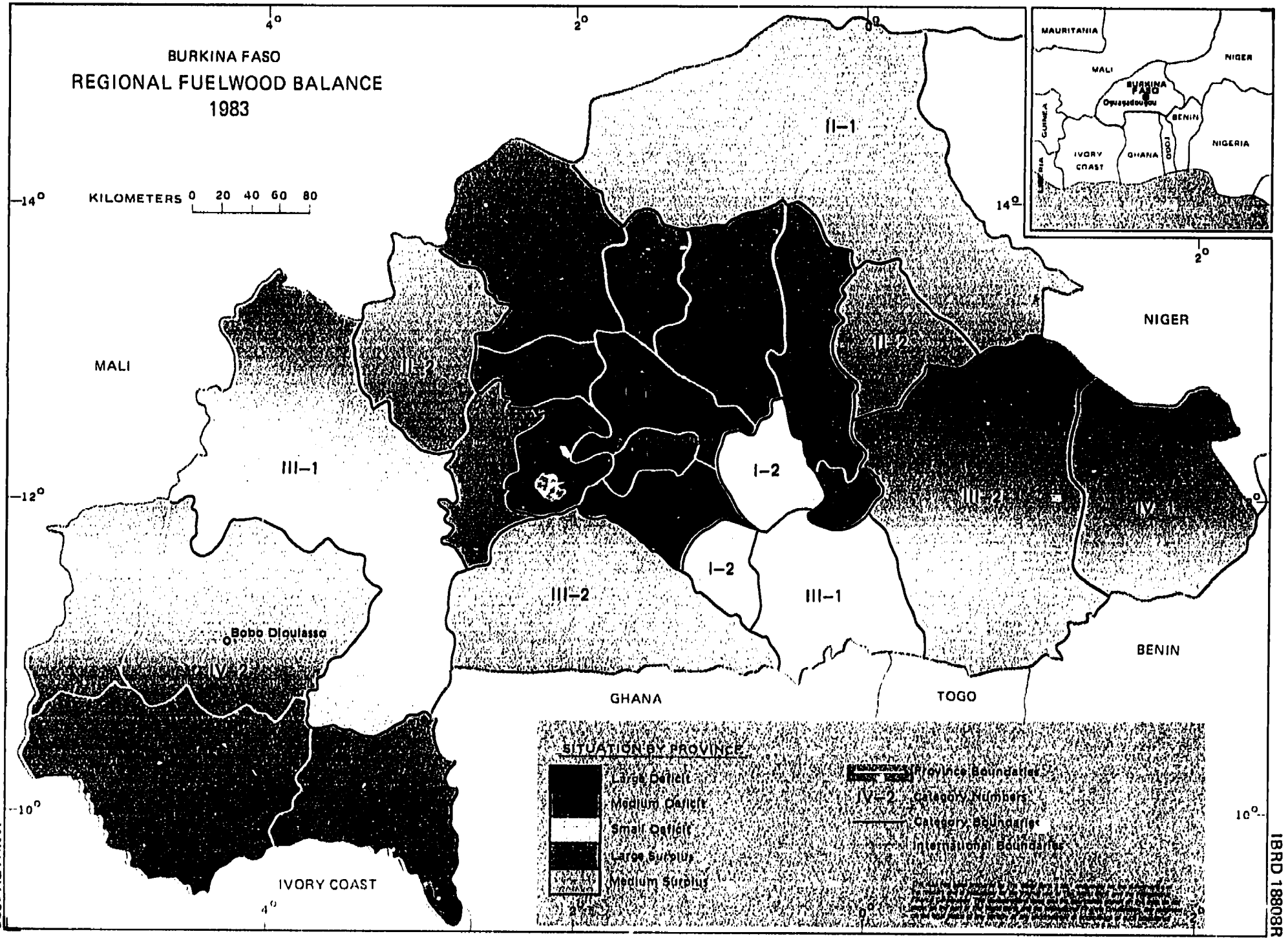

BURKINA FASO
ADMINISTRATIVE DIVISIONS AND
POPULATION DENSITY, 1983
KILOMETERS 0 20 40 60 80
MAURITANIA
MALI
NIGER
GUINEA
LIBERIA
IVORY COAST
GHANA
TOGO
BENIN
NIGERIA
OUDALAN 9
SOUM 12
SENO 13
GOURMA 8
TAPOA 7
KOSSI 18
SOUROU 29
MOUHOUN 23
SANGUIE 20
SISSILI 12
KENEDOUGOU 14
HOUET 22
COMOE 11
BOUGOURIBA
ZOUNDWEOGO
NAHOURI
BOULGOU
GANZOURGOU 22
KOURITENGA 23
Gorom-Gorom
Djibo
Dori
Tougan
Nouna
Dédougou
Réo
Kaya
Boulsa
Bogandé
Zorgho
Koupéla
Fada N'Gourma
Diapaga
Tenkodogo
Manga
Léo
Boho Dioulasso
Orodara
Banfora
IVORY COAST
GHANA
TOGO
BENIN
NIGER
MALI
POPULATION DENSITY BY PROVINCE
ABOVE
JANUARY 1986
IBRD 18806R


BURKINA FASO
EXISTING AND POTENTIAL POWER
GENERATING AND TRANSMISSION FACILITIES
1984
KILOMETERS 0 20 40 60 80
MALI
NIGER
BENIN
TOGO
GHANA
IVORY COAST
Ouahigouya
(0.6 MW)
Dedougou
(1.1 MW)
Koudougou
(4.8 MW)
Ouagadougou
(41 MW)
Tenkodogo
(0.2 MW)
Bagré
Kompienga
Bobo Dioulasso
(10.8 MW)
Banfora
(0.9 MW)
Ferkessédougou
Bui
Bolgatanga
Noumbiel
Volta Noire R.
Volta Rouge R.
Volta Blanche R.
Kamoe R.
Kompienga R.
Bensoaga R.
Baopendi R.
Sirba R.
Gouaya R.
Babongou R.
EXISTING
POSSIBLE
Diesel
Hydro
Co-Generation
Transmission Lines
(0.2 MW) Installed Capacity
International Boundaries
MAURITANIA
MALI
NIGER
BURKINA FASO
OUAGADOUGOU
GUINEA
BENIN
IVORY COAST
GHANA
TOGO
NIGERIA
JANUARY 1985
IBRD 18807R



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