ESMAP

Energy Sector Management Assistance Programme

Mali

Issues and Options in the Energy Sector

Report No. 8423-MLI

JOINT UNDP / WORLD BANK
ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

PURPOSE

The Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP) was launched in 1983 to complement the Energy Assessment Programme, established three years earlier. ESMAP's original purpose was to implement key recommendations of the Energy Assessment reports and ensure that proposed investments in the energy sector represented the most efficient use of scarce domestic and external resources. In 1990, an international Commission addressed ESMAP's role for the 1990s and, noting the vital role of adequate and affordable energy in economic growth, concluded that the Programme should intensify its efforts to assist developing countries to manage their energy sectors more effectively. The Commission also recommended that ESMAP concentrate on making long-term efforts in a smaller number of countries. The Commission's report was endorsed at ESMAP's November 1990 Annual Meeting and prompted an extensive reorganization and reorientation of the Programme. Today, ESMAP is conducting Energy Assessments, performing preinvestment and prefeasibility work, and providing institutional and policy advice in selected developing countries. Through these efforts, ESMAP aims to assist governments, donors, and potential investors in identifying, funding, and implementing economically and environmentally sound energy strategies.

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FUNDING

ESMAP is a cooperative effort supported by the World Bank, UNDP and other United Nations agencies, the European Community, Organization of American States (OAS), Latin American Energy Organization (OLADE), and countries including Australia, Belgium, Canada, Denmark, Germany, Finland, France, Iceland, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Sweden, Switzerland, the United Kingdom, and the United States.

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FOR OFFICIAL USE

Report No. 8423-MLI

MALI

ISSUES AND OPTIONS IN THE ENERGY SECTOR

November 1991

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ABSTRACT

This study is based on the information available in late 1998 and early 1989. It carries out a diagnosis of the Malian energy sector, assesses options that could contribute to improving its operation, and proposes a series of recommendations to the Government. A technical assistance program has also been designed and is proposed to the donor community. These recommendations relate to the woodfuel and charcoal subsector, the electricity subsector, the hydrocarbons subsector, new and renewable energies, and to the development of energy conservation strategies and globally to improving the overall management of the energy sector, particularly through the development of Malian expertise. The diagnosis and the associated recommendations deal with (i) the supply and marketing of woodfuel, charcoal, and other new and renewable energies; (ii) demand, pricing, and substitution strategies; and (iii) management and institutional setup in each subsector.

About 90% of the energy consumed in Mali is provided by wood, a resource whose exploitation is largely uncontrolled. In a situation rendered even more difficult by recent droughts, this exploitation poses a significant threat to the environment. Hence, with respect to household energy, a strategy is proposed taking into account the management of forest resources, rational use of existing deadwood, improvement in the efficiency of cookstoves, an adjustment in prices to producers, and energy substitution. With respect to petroleum products and electricity consumption, costs and prices are very high; Mali should therefore give the highest priority to reducing the economic and financial costs, reviewing the pricing mechanisms, and improving subsector planning and management.

The Energy Assessment particularly focuses on institutional reforms, on energy pricing, and on improving and reorganizing existing national expertise in the areas of energy planning, project evaluation and supervision, and energy management. The study also recommends the promotion of the role of the private sector, still largely not involved in the Malian energy sector, with particular emphasis on investing in and managing specific energy projects. The study also recommends increased competition between private enterprises.

ABBREVIATIONS

bbl	barrel
b/d	barrels/day
b/y	barrels/year
CIF	cost, insurance and freight
GWh	gigawatt-hour
GDP	Gross Domestic Product
GNP	Gross National Product
ha	hectare
hl	hectoliter
HV	high voltage
kcal	kilocalorie
kg	kilogram
km	kilometer
km^2	square kilometer
koe	kilograms of oil equivalent
kv	kilovolt
kVA	kilovolt-ampere
kW	kilowatt
kWh	kilowatt-hour
l	liter
LPG	liquefied petroleum gas
LV	low voltage
m^3	cubic meter
MJ	megajoule
MV	medium voltage
MVA	megavolt-ampere
MW	megawatt
p.a.	per annum
pW	peak watt
t	ton
toe	tons of oil equivalent

ACRONYMS

AFME	Agence Française pour la Maîtrise de l'Energie
CEES	Cellule d'Entretien des Equipements Solaires (Solar Equipment Maintenance Unit)
CILSS	Comité Permanent Inter-Etats de Lutte contre la Sécheresse au Sahel (Permanent Inter-State Committee for Drought Control in the Sahel)
CMDT	Compagnie Malienne de Développement des Textiles
CNH	Commission Nationale de Hydrocarbures
CRES	Centre Régional de L'Energie Solaire
DNAE	Direction Nationale des Affaires Economiques
DNGM	Direction Nationale de la Géologie et des Mines
DNEF	Direction Nationale des Eaux et Forêts
DNHE	Direction Nationale de l'Hydraulique et de l'Energie
DNSI	Direction Nationale de la Statistique et de l'Information
EDF	European Development Fund
EDM	Energie du Mali
EEC	European Economic Community
ESMAP	Energy Sector Management Assistance Program
FAC	Fonds d'Aide et de Coopération (France)
FFN	Fonds Forestier National
GPP	Groupement Professionnel de l'Industrie du Pétrole du Mali
GTZ	Gesellschaft für Technische Zusammenarbeit (Federal Republic of Germany)
IDA	International Development Association
IDRC	International Development Research Centre (Canada)
LESO	Laboratoire de l'Energie Solaire
MIHE	Ministry of Industry, Hydraulics and Energy
NGO	Nongovernmental organization
OERHN	Office pour l'Exploitation des Ressources Hydrauliques du Haut Niger
OMVS	Organisation pour la Mise en Valeur du Fleuve Sénégal
ONT	Office National des Transports
OSRP	Office de Stabilisation et de Régulation des Prix
PASEP	Programme d'Adjustement Sectoriel des Entreprises Publiques
PIRL	Programme d'Inventaire des Ressources Ligneuses (Fuelwood Resources Inventory Program)
PNLD	Programme National de Lutte Contre la Désertification (National Desertification Control Program)
RCFM	Régie des Chemins de Fer du Mali (Mali Railways)
RCFS	Régie des Chemins de Fer du Sénégal (Senegal Railways)
SAR	Société Africaine de Raffinage (Dakar)
SEP	Special Energy Program
SIR	Société Ivoirienne de Raffinage (Abidjan)
WHO	World Health Organization

CURRENCY EQUIVALENTS

Currency Unit - CFA franc (CFAF)

US$1 - 280 a/

ENERGY CONVERSION FACTORS

Fuel	Calorific Value (million kcal/ton)	toe/t
Crude oil	10.2	1
LPG (butane)	10.8	1.059
Gasoline	10.5	1.029
Jet fuel	10.4	1.020
Kerosene	10.3	1.007
Gas oil	10.2	1
Fuel oil	9.7	0.951
Fuelwood	4.1	0.405
Charcoal	7.0	0.690

Electricity

4000 kWh = 1 toe, thermal equivalent of hydroelectricity (with a thermal efficiency of 34.4%)

1 GWh = 86 toe (equivalence in terms of calorific power supplied)

Wood

1 stère = 0.6 m^3 = 0.42 kg wood

a/ Exchange rate at time of mission. This is the rate used in the report, unless otherwise stated.

This report is based on findings of an Energy Sector appraisal mission that visited Mali in November/December 1988, and on information available at mid-1990. The mission comprised Messrs. Joseph Gilling (Mission Leader, Principal Energy Economist), Philippe Durand (Household Energy Specialist), Marc Heitner (Consultant, Hydrocarbons Sector Institutional Questions), Willem Kupper (Consultant, Electrical Energy), Gérard Madon (Consultant, Fuelwood Resources), William Matthews (Consultant, Hydrocarbons Supply and Distribution), and Peka Soininen (Consultant, Energy Rationalization). The report was drafted by Michel Layec.

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PREFACE

Since the discussions of the draft final report on Issues and Options in the Malian Energy Sector, various events have occurred at the political and macroeconomic levels as well as in the energy sector itself. This preface will give a very brief overview of the most striking changes, focusing in particular on the principal measures taken by the Government in the energy sector since publication of the draft final report.

Political and macroeconomic environment

At the political level, the internal social pressures for introduction of a multiparty political system culminated in 1991 in a coup d'état, the establishment of a Transitional Government, the organization of a National Conference, and the preparation of general elections, scheduled for early 1992.

The Transitional Government confirmed Mali's adherence to the adjustment and reform program undertaken in collaboration with the principal donors, in particular the World Bank and the International Monetary Fund (IMF), and in May 1991, Mali, the World Bank, and the IMF came to an agreement on a new macroeconomic framework and an Action Plan designed to continue the adjustment measures. World Bank and IMF strategy is still geared to increasing national income, by means of: (a) institutional and general policy reforms, (b) improved efficiency in the use of public funds, and lastly (c) improved management of human resources, natural resources and infrastructure development and management.

Fuelwood and domestic energy supply

In this area, the Government has continued its work of preparing a strategy echoing the principal themes of this report, designed to: (a) promote household access to domestic energy sources, in particular modern energy sources (principally LPG and kerosene and light photovoltaic equipment), also introducing more efficient energy infrastructure equipment, and (b) reduce the forest cover degradation resulting from the production of fuelwood to meet urban energy requirements. An integrated strategy has been prepared to achieve these objectives. Three of the components of this strategy relate to household energy demand, namely the search for and introduction of energy products for low-income groups, promotion and marketing support for those products, and the design of producer and consumer credit mechanisms. Five other components relate to measures in the area of fuelwood supply, specifically the preparation of master supply plans, assistance to suppliers, modernization of the charcoal sector, recovery of deadwood reserves, and classified forest management. As a first stage, the Government has decided to set up a Steering Unit for the Household Energy Strategy, which will coordinate the activities of a Household Energy Unit, part of the National Water and Energy Directorate (DNHE) of the Ministry of Water Supply and Energy, and a Fuelwood Unit, part of the National Directorate of Water and Forestry (DNEF) of the Ministry of Agriculture, Livestock and the Environment.

Electricity subsector

In 1990 and 1991, given the limited availability of installed hydroelectric capacity, the sustained growth of production (around 8%) and demand (around 9%) entailed a substantial increase in thermal production. Overall, despite the efforts made, the situation of the electricity subsector remains very disturbing in terms of infrastructure development, management, financial results and the institutional context. For the situation to improve, the appropriate decisions must be taken and acted upon without delay.

Development of production and transmission facilities. The rehabilitation of the existing thermal sets at Dar Salam and the expansion of the power plant (addition of a 6-MW set) has been completed, as has rehabilitation of the sets at the Sotuba hydroelectric facility and the raising of the dam. Financing has been requested to cover installation of an additional thermal set, so that the peak power demand of the interconnected system should be covered through 1993. Lastly, work on the 150-kV Bamako-Segou line has been completed (with EIB/CIDA financing), and this should enter into operation by the end of 1991. One of the main issues in the electricity subsector is the future development of the means of production, in particular the installation of the electrical and mechanical equipment at the existing dam at the site of the Manantali hydro-electric plant and the interconnections to the load centers. This site should be developed by OMVS, as a source of supply for Mali, Mauritania and Senegal. The economic viability of installing generating capacity at this site and the possibility of building a regional transmission network among the three countries were confirmed by a World Bank study carried out in 1991, which also showed that the development of this site would be extremely profitable for Mali. The World Bank study estimated that the project would not be able to enter into service before 1996.

To take into account further delays in bringing Manantali on stream, the Government is preparing to solicit bids in 1992 for a feasibility study of the Petit Kénié hydroelectric project (48 MW). The Government also envisages carrying out a study to determine the optimum uses of the hydropower generated, which will also make it possible to validate the guaranteed energy level at Sélingué.

A pricing study was also undertaken in early 1991, and the results should be available toward the end of the year. Beyond this study, however, little progress seems to have been made toward management of demand for electricity.

Lastly, at the institutional level, although the reform of the subsector and implementation of the performance contract between the Government and Energie du Mali (EdM) reflect an understanding on the general principles of institutional reform and have brought about a substantial improvement in operation of the subsector, the transfer to EdM of subsector planning and feasibility study preparation is not yet fully completed. Moreover, EdM's financial situation has deteriorated, owing, on the one hand, to an increase in fuel costs, and, on the other, to the size of the technical and nontechnical losses and of the existing arrears, for which no significant or sustained recovery campaign has yet been implemented.

Hydrocarbons subsector

Following a study carried out in 1991 on a revision of the pricing system for oil products, several of the principal recommendations appearing in this report on the Malian energy sector have been approved, some of them having already been implemented by the Malian Government. In this subsector, the Government should modify its activities considerably, assuming a role where it regulates private sector activities and develops competitiveness basically through pricing, as a means of improving the subsector's operating efficiency.

Pricing and taxation. With respect to pricing and taxation policy, a decision in principle has been taken by the Government regarding total liberalization of pump prices, and the adoption of a simplified system of tax collection at the Customs, incorporating into a single tax heading all of the many different taxation components originally payable to the Office de Stabilisation et de Régularisation des Prix (OSRP). The mechanisms for establishing the tax on each product must, however, reflect the tax revenue projections of the national budget. A number of safe-guards and controls will also have to be set up to ensure healthy competition among distributors, supply the country's remote locations at affordable prices, and minimize smuggling and non payment of taxes.

Subsector management. In parallel with pricing and taxation reform in the hydrocarbons subsector, the Government has adopted reorganization of the subsector management as one of its basic courses of action, combining all oil product supply and distribution activities in an Office National des Produits Pétroliers (ONPP), which could be an "établissement public à caractère administratif" (EPA), with management autonomy. This new establishment would replace both the OSRP and Pétrostock, an 100% government owned company, whose function was to construct and manage storage facilities for the Government and to participate in oil product supply and distribution.

The measures affecting the hydrocarbons subsector should be implemented in early 1992.

MAIN FINDINGS AND RECOMMENDATIONS

Scope of Study

1. This report assessing energy issues and options summarizes the conclusions of a mission that visited Mali in November/December 1988 and information obtained in mid-1990. The aims of the report are: (a) to assess the situation of the energy sector in terms of supply, demand, and energy and human resource constraints, and (b) to submit recommendations on the possible options in the fuelwood, hydrocarbons, electricity, renewable energy, and energy rationalization subsectors. Recommendations regarding the organization and management of the energy sector as a whole are also presented, together with a technical assistance program.

Constraints, Main Problems and Recommendations

Overview of Energy Sector and of the Economy

2. With a per capita GNP of the order of US$230 in 1988, the structure of energy consumption in Mali is characteristic of the Sahelian countries. Nearly 90% of the country's energy requirements is met by fuelwood (total final energy consumption of 1.7 million toe in the form of wood, charcoal and other biomass) while the modern energy sector is largely undeveloped. Thus, of a population of nearly 8 million in 1987, only 5% was using electricity and the peak power demand on the interconnected system was around 34 MW. Hydrocarbons consumption in 1987 was of the order of 171,000 tons, the cost of which represented 27% of exports and 14% of imports.

3. The future growth rate of fuelwood consumption is estimated at about 2.0% p.a., while for commercial energy sources (petroleum products and electricity) growth of 4.5-5% p.a. between now and the year 2007 is expected, coupled with population growth of 3% p.a.

Constraints and Main Problems

4. Mali's energy sector is subject to constraints over which the country has virtually no control, the chief ones being:

(a) total dependence on and high cost of oil product imports, due primarily to the country's landlocked location and lack of economically producible oil deposits;

(b) a high present and future demand for fuelwood resources in a difficult climate context and hence significant risks of permanent soil degradation; and

(c) despite the existence of a considerable technical potential in Mali, the cost of developing national hydroelectric resources and new and renewable energy sources is high.

5. Other difficulties are connected with factors specific to Mali and can therefore easily be reduced, the main ones being:

(a) dispersion of national responsibilities and jurisdictions among a number of ministries and institutions, which contributes to the weaknesses of public management, such as lack of adequate coordination, planning and control, exacerbated by a lack of resources, advisory services and reliable data;

(b) inadequate wood and charcoal prices, which do not reflect the economic cost of the wood, provide no incentive for adoption of energy-saving measures and do not permit self-financing of the fuelwood subsector; and

(c) limited size of the domestic energy markets and lack of development of private service enterprise in the energy sector.

Action Strategy for Fuelwood and Household Energies

6. For the fuelwood sector, which currently represents over 80% of energy consumption and will still account for 80% in 2010, actions are proposed in the form of a Household Energy strategy focusing on:

(a) management of existing fuelwood resources;

(b) retail prices, through amendment of taxation and existing control arrangements;

(c) acceleration of programs to promote and popularize improved wood stoves; and

(d) reduction of demand by means of substitution in cases where replacement of one form of energy for another is clearly economically advantageous.

The availability of firewood and charcoal at relatively low and stable prices, consumption of which represents about 3-5% of urban households' budgets at current prices, suggests that there would not by any overall shortage of firewood in the short term. In the medium and long term, improvement of resource management, increased use of improved stoves and substitution by kerosene and LPG would reduce the demand for wood and make it possible to bring the supply of and demand for fuelwood permanently into balance in the long term.

Resources and Supply System

7. The Fuelwood Resources Inventory Program (Programme d'Inventaire des Ressources Ligneuses - PIRL) using satellite images is under way in the Kayes, Koulikoro, Ségou and Sikasso

regions. The data provided by the PIRL are essential for resource management and future planning. It is vital that this inventory work be completed by covering as soon as possible the ecologically fragile regions of Mopti, Tombouctou and Gao. Using the data from this inventory, it is therefore recommended that master fuelwood supply plans be drawn up for Mali's chief towns, in order to bring about a certain geographic reorientation of felling by determining: (a) the areas where felling can be done profitably compared with the present extraction areas, and (b) the areas where the present rate of extraction is already or will become a threat to the environment.

8. As regards wood extraction, which is presently largely uncontrolled and too heavily dependent on costly reforestation projects, it is recommended that efforts be reoriented toward management of existing resources and of deadwood reserves and that the strategy adopted reflect the fact that the State cannot by itself alone perform the management of the natural forests. The Government must therefore shift its emphasis to technical assistance to local communities who could participate in managing these resources. This would make the wood trade more financially attractive for rural dwellers, operators and traders. These changes will have to be instituted gradually, giving priority to curbing the overexploitation of the forest areas around the six main urban centers and along the main highways. In addition, as regards the transportation of and trade in wood and charcoal, it is recommended that steps be taken to control the geographic distribution of extraction by strengthening the mechanisms for controlling fuelwood supplies brought into the towns: setting up of checkpoints at the entrance to the five main towns of the interior and improvement of the operation of the existing checkpoints for Bamako.

Consumption, Substitution and Equipment Efficiency

9. Fuelwood represents nearly 85% of the primary energy in Mali's energy balance and charcoal consumption is rising very rapidly. With regard to consumption of these fuels, the following strategy targeting primarily the urban centers is proposed, starting with Bamako:

(a) progressive raising of taxes, with the deliberate intent of increasing wood and charcoal prices;

(b) continuation of programs to popularize improved metal wood- and charcoal-burning stoves in the urban areas by artisans and organized groups such as women's committees;

(c) promotion of kerosene and LPG in the urban areas vis-à-vis groups with a certain level of purchasing power; and

(d) in the northern cities, promotion of kerosene, the most economical energy source after wood for cooking and, in certain circumstances, LPG.

For the kerosene strategy to bear fruit, Malian consumers will, however, need efficient and cheaper stoves. Mali ought to seek to benefit from other Sahelian countries' experience in this respect.

Taxation and Price Structures

10. The present taxation and retail prices of wood and charcoal are inadequate: they do not reflect the economic cost of using the resource and permit neither satisfactory self-financing of the subsector nor producer prices sufficient to encourage rational management of the resource. It is accordingly recommended: (a) that a new tax system be instituted that would include a development incentive component to remunerate the people's work in developing and managing the resource, and (b) that the collection of the second component, paid by the transporters to the State at the checkpoints on entering the towns, be strengthened. The details of this system will be spelled out when the plan of action for the household energy strategy is drawn up. This modified system should be managed by the proposed DNEF Fuelwood Unit.

Administrative Management

11. Governmental supervision of the forest subsector is performed by DNEF, which has 15 sections directly or indirectly concerned with firewood. As a general rule these sections operate independently and the lack of any consistent overall strategy results in inadequate planning characterized by excessive controls. To remedy this situation, it is recommended that the national responsibilities in this sphere be grouped into a Fuelwood Unit in DNEF that would centralize and analyze data regarding supply and, in general, all activities connected with the administrative management of fuelwood, including the checkpoints at the entrances to the towns. The operating policy of DNEF and of the regional forestry services in particular should be reoriented toward advice on resource development for the rural population and monitoring of proper resource management.

12. It is also recommended that all actions concerning fuelwood be coordinated and supervised in the context of an overall strategy for the sector covering both supply and demand and including, therefore, the completion of the ESMAP Household Energy project as soon as possible. Since the ecological risks are significant, a degree of interventionism in this subsector -- at least in the short term -- appears called for.

Strategy and Actions for the Electricity Subsector

13. The electricity energy subsector is one of the most capital-intensive and currently absorbs about 7% of the rolling three-year investment program. With a peak demand of 37 MW in 1988 in the interconnected system, a firm installed capacity of 40 MW during the dry season, and a demand trend growth rate of about 9% p.a., generation facilities will have to be increased in annual steps of about 5 MW to meet demand prior to the entry into service of the Manantali regional hydroelectric plant, planned for 1996.

14. The Organisation pour la Mise en Valeur du Fleuve Sénégal (OMVS), a tripartite organization set up by Mali, Mauritania and Senegal, will handle execution of the Manantali regional

project comprising installation of: (a) 200 MW installed capacity (about 50% of which will be allocated to Mali) from the multipurpose dam already built on the Bafing in Mali, and (b) transmission lines to Bamako, Nouakchott and Dakar. Further studies are being undertaken and financing is being sought; meanwhile, OMVS is proceeding with preparation of the project.

15. In this context, the action priorities for the Malian electricity subsector relate to:

(a) the strategy to be adopted in view of the delayed entry into service of Manantali, originally planned for 1993, but currently put back to 1995 or even 1996;

(b) the adjustments in EDM's tariff structure to prompt more rational use of electricity; and

(c) improvement of management of the subsector through implementation of the institutional strengthening program agreed on as part of the Second Power Project.

Development of Generation and Distribution and Management of Demand

16. In view of the successive delays in bringing Manantali into service, EDM and the Government will have to decide very quickly on a transition strategy and it is recommended that this strategy combine both steps to increase supply, such as the addition of diesel units, and also measures to enhance energy efficiency, which are justified in all cases. These energy-saving measures would include:

(a) acceleration of the program to reduce distribution losses in Bamako and the secondary centers, as envisaged in the Second Power Project; and

(b) instituting of an energy rationalization program supported by modification of the structure of the tariff matrix.

Slowing of the growth of the distribution networks would be advisable if it becomes evident that generation capacity would fall short of demand prior to the entry into service of Manantali, in order to prevent appreciable economic losses due to possible deterioration of service as a result of excessive demand.

Electricity Pricing

17. EDM's tariffs were raised by 35% in 1985. This made it possible to align tariffs on marginal costs and restore EDM's financial position. However, the planned adjustments to the tariff structure, in particular elimination of the distortions between the low and medium-voltage (LV and MV) tariffs, increasing of the power premium for MV users and introduction of a fixed premium for users have not been implemented. It is therefore recommended that the tariff study included in the Second

Power Project be carried out as soon as possible in order to be able to update the earlier proposals and also propose concrete measures regarding:

(a) seasonal pricing;

(b) demand-based pricing, particularly for air conditioning or subscribed power; and

(c) power factor penalties.

Management of the Electricity Subsector

18. The general management policy for the subsector was formulated during the preparation of the Second Power Project and is presently in place. Its principal components are:

(a) entrusting of general subsector policies and regulation, and responsibility for controls, to the Ministry of Industry, Hydraulics and Energy (MIHE);

(b) assignment as a general rule of all technical responsibility for the planning, construction and operation of power infrastructure in Mali to EDM, with the exception of regional (e.g., Manantali, which is under OMVS) or multipurpose projects. The State could, however, authorize activities by other producers and distributors of electricity; and

(c) strengthening of EDM's technical and management capacities and implementation of performance contracts.

19. This redistribution of responsibilities is a very important step toward improvement of the subsector's functioning, but its effects on EDM's and the subsector's performance will probably only became apparent very slowly. It is therefore recommended:

(a) that a core technical planning team be formed in EDM and that DNHE's capabilities in the financial and economic appraisal of projects be strengthened; and

(b) that a reliable statistical system be designed and put in place to form the basis of the management information system.

Strategy and Actions for the Hydrocarbons Subsector

20. Very significant progress in the efforts to reduce hydrocarbons import costs for Mali was achieved in 1989 with the two agreements on the formulas for price setting ex-depot SIR Abidjan and SAR Dakar, under which the ex-depot prices will henceforward be set on the basis of the Platts Mediterranean FOB prices. Compared with the 1988 situation, the State will save nearly CFAF 5

billion/year (US$17.9 million). However, further savings can still be made and Mali ought therefore to resume the talks. For the hydrocarbons subsector, priority must be given to the options for direct supply through the international markets, distribution, strategic stocks, public management of the subsector and prices.

Organization of Supply

21. The main supply problem concerning petroleum products is that as a result of the storage constraints in the coastal refineries and depots, Mali cannot purchase petroleum products in the international markets. It is therefore recommended that the discussions with Côte d'Ivoire and Senegal be resumed to enable Mali to assert transit rights and rights to access to the Abidjan and Dakar storage facilities.

22. In addition, a strategic stocks program involving a fivefold increase in storage capacity to 73 days' consumption has been proposed by the national oil company, Pétrostock. It is recommended that this program be very quickly reviewed with a view to its reduction by examining the need to stock 73 days' consumption, the capital and operating costs entailed and product losses.

23. Finally, there needs to be better supervision of operating safety among the small independent distributors in order to curb dangerous practices and verify product quality. It is accordingly recommended that as a minimum the existing regulations be applied and that a permanent product quality control program be instituted by the proposed new institution to manage the Hydrocarbons subsector and by the existing DNGM laboratory.

Subsector Management

24. Management responsibilities are presently spread among numerous public services with poorly defined areas of jurisdiction, with the result that they are dispersed among units that are too small to have a significant impact on a key sector for the country's tax revenues and operation. It is therefore recommended that all activities pertaining to public management of hydrocarbons and all national authorities be consolidated into one single structure (a Hydrocarbons Directorate or an Office of Petroleum Products). This new agency could be part of OSRP, MIHE or ONT. As regards Pétrostock, it is also recommended that its role be reassessed in the context of the study under way of the 22 public enterprises not covered by the Public Enterprise Structural Adjustment Program (PASEP) and that at the same time the allocation of responsibilities between the State and the private sector be reviewed. Some proposals have already been formulated to this end and the liquidation of Pétrostock and, if justified, the transfer of its personnel to the new agency appear indicated.

Prices and Taxation

25. In Mali, as in a number of French-speaking African countries, the prices of petroleum products and the various components of the cost structure are fixed and controlled by the State. An equalization factor is then added to keep prices uniform throughout the country, together with a

stabilization fund to ensure the temporary stability of prices. Tax accounts for a large proportion of prices at the pump (at least 40%) and keeps prices well above import parity. Moreover, current petroleum taxation is complex and involves numerous beneficiaries who at times have no more than a very indirect connection with the subsector, which complicates verification of tax revenues. At the same time, the present mechanisms for setting prices at the pump, in particular the fixing of distribution margins as a percentage of costs, do not give distributors any incentive to hold supply and distribution costs to a minimum. Finally, LPG costs are high and could be brought down nearly 20% by action on various cost items.

26. In order to improve the present hydrocarbons pricing, it is accordingly recommended that:

(a) taxation be simplified by applying one single tax per product, to be collected directly by the Customs upon entry into Mali and paid into the Treasury;

(b) the price-setting mechanisms be modified by fixing ceiling prices that are sufficient to ensure distribution of petroleum products to the rural centers together with proper functioning of the market in the well-served urban centers, by eliminating the fixed and approved prices; and

(c) the structure of LPG prices be analyzed and negotiations undertaken with Côte d'Ivoire and possibly Senegal as soon as possible in order to reduce its ex-depot cost.

Strategy and Actions for the New and Renewable Energies (NRE) Subsector

27. Although after nearly 25 years of research Mali can point to more concrete achievements in this sphere than any other Sahelian country, NREs only play a very minor role and their medium-term prospects are limited. There are a number of factors holding back development of these technologies: Mali's economic and financial constraints, insufficient technical maturity and the fact that these technologies are currently at an economic and financial disadvantage due to the prevailing low conventional energy prices plus the initial capital costs entailed. In addition, the work currently under way is spread over a number of technologies and is being conducted by many different parties.

28. In light of the present situation and medium-term prospects for NREs, it is therefore recommended that:

(a) public resources and agencies be focused on a limited number of applications such as photovoltaic pumping for rural water supply and solar-powered lighting and battery-recharging systems, and possibly semi-industrial solar-powered dryers;

(b) the pourghère oil projects be thoroughly reassessed, since the fuel production costs appear to be distinctly higher than for imported products; and

(c) a rapid technical and economic appraisal be made of other applications such as biogas, solar dryers, wind pumps, etc., in order to determine whether investment in them should continue.

29. With regard to management of this subsector, it is recommended that:

(a) DNHE, particularly the Energy Division, clearly set priorities in this area;

(b) LESO be restructured into research and development sections focusing on specific operational goals (e.g., testing of improved stoves) and support for existing NRE projects; and

(c) the private sector be encouraged to market and provide after-sales service for equipment.

Strategy and Actions for Improving Energy Rationalization

Proposed Energy Rationalization Strategy

30. Mali currently does not have any formal energy rationalization program and no Malian institution is responsible for this question. However, programs are under way to develop improved stoves and reduce power distribution losses. Theoretical potential energy savings are between 20% and 30% for fuelwood and 12% and 25% for commercial energies and the economic return obtainable from actions in this field is generally high.

31. World experience indicates that there is a general need to adopt an energy rationalization strategy based on the following principles:

(a) establishment of an autonomous agency responsible for formulating and implementing energy rationalization programs;

(b) provision of information to consumers regarding potential energy savings and applicable technologies;

(c) energy price setting based on economic cost of supply;

(d) consumer access to the necessary technologies and financing; and

(e) the fact that in the majority of cases the measures adopted should allow recovery of the initial investment within two years, to make them attractive to consumers.

Institutional Organization

32. For reasons connected with the limited size of the market, especially the industrial and tertiary markets, costs, and the lack of national capabilities in this field, establishment of an autonomous agency specializing in energy rationalization does not appear warranted in the Malian case. It is recommended instead that the DNHE Energy Division establish policy in this field, but that the technical resources of the individual subsectors be used for the promotion and follow-up of specific measures. This action would be supported initially by technical and financial assistance which would then be able to perform audits and finance the implementation of energy-saving measures.

Proposed Energy Rationalization Action Program

33. The energy rationalization programs have already been referred to in the case of the fuelwood and electricity subsectors, with regard to price setting and rational energy use, including improved stoves, reduction of distribution system losses, installation of condensers, etc. In addition to the general policy guidelines already discussed, the following concrete measures are recommended:

(a) For industry and modern buildings, a series of specialized audits made by a mobile technical squad, with immediate implementation of their findings. Establishment of an Energy Rationalization Fund for this purpose should be proposed to the donors; and

(b) In the transport sector, which consumes almost two thirds of the country's petroleum product imports, information and training workshops should be offered to the managers of the main truck fleets while the vehicle tax scales should be revised to penalize fuel-gulping vehicles and reduce the relative cost of the main parts affecting fuel consumption.

Strategy and Actions for Global Management of the Energy Sector

34. Although the recent decisions in the electricity subsector will help to improve its management, the fundamental problems in the energy sector still remain. They derive in part from Mali's present constraints, but also and particularly from the lack of a clear strategy. Any proposal for improving the management of the sector must, however, take into consideration the reform of the Malian public sector that is currently under way, especially the staffing freeze and the policy of having the State withdraw from commerce.

Organization and Definition of Responsibilities in the Energy Sector

35. The general coordination of the energy sector's various activities ought logically to be performed by DNHE, while basic decisions should be evaluated and their execution monitored by an interministerial committee. In order to enhance DNHE's capacity to play its role and cope with material and human resource constraints, it is recommended that:

(a) policy coordination and planning responsibilities be redefined prior to being assigned to DNHE and an interministerial energy committee;

(b) technical planning and implementation be placed under a single subsector agency, such as: (i) the DNHE Household Energy Unit for the Household Energy Strategy (to be set up); (ii) the DNEF Fuelwood Unit for fuelwood (to be set up); (iii) EDM for technical planning for Electricity; (iv) the National Hydrocarbons Directorate (to be set up) for petroleum products; (v) DNHE for NREs, and (vi) various institutions for energy rationalization questions;

(c) the nature of LESO's research and development mandate be redefined;

(d) Pétrostock be liquidated and the transfer of its personnel, where appropriate, to the new institution proposed for the subsector be considered; and

(e) promotion of the private sector be pursued, especially in the hydrocarbons subsector and for solar-powered equipment.

These institutional adjustments have to be effected without any increase in staff, by reassigning personnel in post.

Investment Program in the Subsector

36. The additional investment requirements of the energy sector for the period 1989-95 are of the order of CFAF 84 billion (US$300 million). A part of this financing has already been secured. Apart from technical assistance, the chief actions still to be financed are the following:

(a) Fuelwood subsector, excluding the improved stoves programs: about CFAF 3.6 billion (US$13 million) for the implementation of master supply plans for the main towns, forest inventories in the Mopti, Tombouctou and Gao regions, development of forests and village plantations to supply Bamako, Ségou, Mopti and Koutiala, recovery of deadwood reserves, improvement and increasing of checkpoints at entrances to towns, modernization of the charcoal subsector and promotion of substitute equipment, especially kerosene cooking stoves;

(b) Electricity subsector: EDM's 1989-95 investment program is estimated at CFAF 800 billion (US$285 million). Additional investments in diesel units are probably also to be expected on account of the delays in bringing Manantali into service;

(c) Hydrocarbons subsector: all investments should be financed by the private sector, including strategic storage facilities; and

(d) Energy rationalization: Implementation of an Energy Rationalization Project including establishment of a fund for financing energy-saving measures is proposed; this project would cost about CFAF 840 million (US$3 million).

Technical Assistance

37. Well-coordinated technical assistance is essential for the efficient resolving of Mali's main energy sector problems. In addition to the technical assistance programs already financed in the electricity subsector in particular, donors should therefore give high priority to the following needs:

(a) Fuelwood subsector: to set up and support the Household Energy Unit (HEU) proposed in DNHE for coordination of implementation of the different components of the Household Energy Strategy, involving (i) technical assistance, as and when needed, from several national and international specialists over the period 1991-96; (ii) the financing and equipping and part of the operating costs of the HEU and the Fuelwood Unit (in DNEF), and the checkpoints of entrances to towns. In all, the cost of this assistance, including contingencies, is estimated at CFAF 323 million (US$1.155 million);

(b) Hydrocarbons subsector: In order to set up a new institution entirely responsible for managing this subsector, periodic technical assistance over two years appears necessary, at an estimated cost of CFAF 185 million (US$660,000); and

(c) Energy rationalization: this assistance would also be used for improving DNHE's energy project and program appraisal capacity. The cost of this assistance and of the related training programs is estimated at CFAF 182 million (US$650,000), to which must be added CFAF 70 million (US$250,000) for the cost of an Energy Bus (used in the context of a Regional Program), CFAF 84 million (US$300,000) for procurement of equipment and basic materials, and an Energy Rationalization Fund estimated at CFAF 560 million (US$2 million).

Table 1: SUMMARY OF RECOMMENDATIONS AND PRIORITY ACTIONS

Recommendations	Actions	Proposed Assistance	Amount (US$ thousands)	Text Reference
A. Fuel and Household Energy		Household Energy Program		Table 2.3
1. Improve subsector management	- Establish Unit to guide the Household Energy Strategy (DNHE/DNEF)	Technical assistance and equipement	1,050	2.33
2. Formulate a household energy strategy				
a. Manage existing fuelwood resources	- Complete resource inventories in Mopti, Tombouctou and Gao regions	Continuation of PIRL	2,500	2.5
	- Define supply master plans for the 6 main towns villes	Studies, equipement, and technical assistance	1,750	2.20
	- Forest development with participation by rural population and recovery of dead wood	Studies, equipement, and technical assistance	2,950	2.21
b. Increase sector self financing capacity and institute firewood pricing that reflects the economic cost of fuelwood resources	- Set up checkpoints at entrance to main towns and increase tax-collection capacity	Equipement and technical assistance	700	2.28
	- Modernize the charcoal subsector	Equipement and technical assistance	500	
	- Increase taxes on firewood with development premium component			2.29
c. Reduce demand for firewood	- Pursue present imporved stove programs	Continuation of current projects		2.42
d. Substitute other fuels where economically justified; promotion of energy-efficient equipement	- Promote kerosene and LPG, especially in the northern towns and other energy products	Continuation of current projects and establishments of a revolving fund	2,200	2.46
3. Contingencies	- Item: Household Energy Strategy		1,165	
		Total Fuelwood Resources and Household Energy	12,815	

Table 1: SUMMARY OF RECOMMENDATIONS AND PRIORITY ACTIONS

Recommendations	Actions	Proposed Assistance	Amount (US$ thousands)	Text reference
B. Electricity Subsector				
1. Adopt a strategy for covering the delays in entry into service of Manantali	- Reduce growth rate of demand and generation requirements by: - reducing distribution losses - an energy rationalization project - acceleration of condenser installation program	Second Power Project Regional Energy Rationalization Project		3.4 3.20
	- Install diesel units	CCCE financing planned		3.13
2. Restructure OEHRN and EDM tariffs to prompt more rational electricity use	- Make pricing study included in the Second Power Project and analyze what is obtainable from Selingué	Second Power Project		3.18
3. Improve subsector management by means of institutional strengthening measures	- Implement the measures planned in the Second Project	Second Power Project		3.27
C. Hydrocarbons Sector				
1. Improve subsector management	- Regroup national jurisdictions into one National Hydrocarbons Division	Technical assistance and equipement	350	4.21
2. Resume discussions with Côte d'Ivoire and Senegal with a view to reducing the cost of hydrocarbons imports	- Obtain access to storage facilities in Abidjan and Dakar to permit direct importation of hydrocarbons	Specialized consultancy services	50	4.6
3. Re-examine policy on strategic stocks and the role of Petrostock	- Entrust maintenance of stocks to the private sector	Specialized consultancy services	60	4.11
	- Liquidate Petrostock			4.24
4. Simplify hydrocarbons pricing	- Make pricing and regulation study planned in the context of the proposed IDA Structural Adjustment Credit	Study and technical assistance	200	4.31
		Total Hydrocarbons Subsector	660	

Table 1: SUMMARY OF RECOMMENDATIONS AND PRIORITY ACTIONS

Recommendations	Actions	Proposed Assistance	Amount (US$ thousands) SEU)	Text Reference
D. New and Renewable Energies Subsector				
1. Refocus efforts and capabilities on a limited number of applications	- Reappraise projects whose return appears marginal in light of present petroleum prices, such as the pourghere oil project	In the framework of the assistance proposed in Section E.		5.6
	- Assess and establish the strategy regarding the presently non-viable alternatives such as biogas, solar dryers and wind mills			5.9
2. Restructure LESO into research and development sections and support for existing projects	- Set priorities in conjunction with DNHE			5.12
3. Market NREs that are presently viable	- Encourage the private sector to do the marketing and provide after-sales services			5.8
E. Energy Rationalization				
1. Establish an energy rationalization program	- Formulate a policy in DNHE and define a program of energy-saving measures	Technical assistance with personnel, documentation and workshops	650	6.21
	- Charge subsector technical agencies with execution of the program	Already noted for each subsector		
2. Implement the energy rationalization program in industry, buildings and transport	- Perform a series of energy audits and see that boilers, air conditioners and vehicle fleets, etc., are tuned to maximum efficiency	Vehicle, equipement, materials and operating costs	550	6.22
3. Give consumers financial incentives	- Establish an Energy Rationalization Fund		2,000	6.23
	- Make equipment economically justified for energy rationalization tax exempt			
		Total Energy Rationalization	3,200	6.24

Table 1: SUMMARY OF RECOMMENDATIONS AND PRIORITY ACTIONS

Recommendations	Actions	Proposed Assistance	Amount (US$ thousands) SEU)	Text Reference
F. Energy Sector Management				
1. Improve coordination of sector activities	- Form interministerial energy Committee			7.6
2. Redefine responsibilities in the energie sector	- Assign energy policy coordination and planning to DNHE	Included in the assistance proposed for the Household Energy Program		7.8
3. Define and specify responsibilities and and reduce dispersal of national jurisdictions	- Assign technical planning and implementation of energy programs to one single agency			7.10
	- Redefine LESO's research and development mandate			7.10
4. Divestiture by withdrawal of State and promotion of private sector activities	- Liquidate Petrostock			7.10
				7.10
	- Promote role of private sector in hydrocarbons, energy rationalization and NRE subsectors			

I. ENERGY IN THE MALIAN ECONOMY

Socioeconomic Context

Introduction

1.1 Located in the heart of Sub-Saharan Africa, Mali has an area of about 1.2 million square kilometers of which only one quarter is cultivable. Three quarters of its population of 8 million live in the south of the country; 1/ only the capital, Bamako, has more than 500,000 inhabitants while a further six towns have between 50,000 and 100,000 (map IBRD 1916R). On the basis of a demographic growth of 3% p.a., World Bank forecasts put Mali's population at over 11 million by the year 2000 and about 14 million by 2007. Although some degree of urbanization will take place, around 70% of the population will still be living in the rural areas in that year.

1.2 Mali is a very poor country with a per capita GNP of the order of US$230 (1988) and the majority of its socioeconomic indicators are in the lower range for low-income countries. Although for 20 years now Mali's real economic growth has been of the order of 4% p.a., it was only 2.7% p.a. in the 1980s. As a result, the real increase in per capita income was limited to 1% a year during the same period. The country has received massive external assistance, representing 20% of GNP in 1987.

Economic Reforms and Prospects

1.3 Because of its growing fiscal and external deficits, ever since 1982 Mali has been implementing a series of stabilization programs and economic reforms designed to reduce its budget deficits, the losses incurred by public enterprises and the public sector's arrears, and to liberalize its markets, bring about divestiture by the State and promote the role of the private sector. These actions have been supported by the International Monetary Fund, the World Bank and other donors.

1.4 As regards the energy sector, these macroeconomic actions are designed to support:

(a) the process of State disengagement and rationalization of the management of sector agencies and enterprises;

(b) reviews and adjustments in the area of pricing policies (levels and structure), particularly for petroleum products and electricity; and

(c) the introduction of strategies and pursuit of specific measures to reduce energy production, transportation and distribution costs.

1/ The entire northern part of the country, i.e. about 60% of its area, is desert.

1.5 Although its basic resources are relatively limited, Mali's economic potential nevertheless seems better than that of most Sahelian countries. A real increase in per capita income of 1-2% p.a. appears possible, provided the economic programs and reforms are carried out and that demographic growth is limited. Economic growth of the order of 4% p.a. appears attainable in the 1990s. Agriculture, 2/ which presently accounts for 50% of GDP and two thirds of export earnings, should remain the principal economic activity and industry's share in economic activity should rise from 13% in 1987 to around 15% in 1997. Mineral resources are limited; however, gold production offers some attractive possibilities. Finally, since the domestic market will offer little in the way of opportunities for creation of new industries, for example for import substitution, the anticipated industrial growth will probably be based on agricultural and livestock products. In light of these potentials and the present state of the economy, Mali's domestic economic policy should focus on improvement of the public management of the country's resources in order to progressively provide the people with essential public goods and services and lessen the constraints related to human and natural resources in order to support development of the private sector.

Overview of the Malian Energy Sector

Energy Resources and Constraints

1.6 Like a number of low-income countries, Mali is confronted with a threefold energy crisis: total dependence on imported petroleum products, uncontrolled exploitation of fuelwood resources in a physically fragile environment and high development costs for hydrocarbons and new and renewable energies (NREs).

1.7 Assessment of the results of an oil exploration project financed by IDA in 1981 to gather and compile geological and geophysical data has led to the conclusion that Mali does not have any economically producible deposits at present crude prices. At the same time, these prices make resumption of exploration unlikely. Mali's landlocked situation also entails very high transport costs. 3/ The absence of producible oil deposits and of economic substitution potential, and the burden of oil import costs, which represent 14% of total imports and 27% of merchandise export earnings in 1987, therefore make hydrocarbons management one of the energy sector's priorities. Moreover, consumption of petroleum products is expected to more than double in volume over the coming 20 years.

1.8 Fuelwood resources represent more than 90% of primary energy consumption. The climatic environment is conducive to erosion and rapid reduction of soil fertility, while the forest cover

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2/ *Chiefly cotton, rice, maize and stockraising.*

3/ *Bamako is about 1,300 km from Abidjan and 2,000 km from Lomé by road, and 1,200 km from Dakar by rail.*

is under severe pressures from largely uncontrolled exploitation due to the demand for firewood but also the needs of agriculture and stockraising. It should further be noted that this exploitation is proceeding without any precise knowledge of the existing resources and potentials of each of the ecological zones. However, on the basis of the findings of recent forest inventories (which only cover the most ecologically fragile zones of the country), fuelwood resources available for energy appear sizable in overall terms compared with the needs. There is a stock of dead wood which in the short and medium term will continue to satisfy the demand for fuelwood. The localized overexploitation of the periurban areas and current management deficiencies nevertheless pose a significant risk to future supplies and to the environment, a risk that should therefore first be contained and then eliminated.

1.9 Mali also has a hydroelectric potential that is quite considerable compared with its needs. Utilization of all the sites would provide nearly 5,700 GWh/year and a guaranteed power of 800 MW. This figure should be compared with the present peak demand of the order of 50 MW.4/ However, this is a technical potential; the cost of developing the facilities and their size in relation to present and expected demand 5/ reduce the economically usable hydro potential. Moreover, certain of the sites, particularly Manantali, are regional in nature and can only be developed in collaboration with other countries.

1.10 The potential in terms of new and renewable energies is also considerable, especially as regards solar energy, which is available country-wide and for the greater part of the year. Wind regimes, on the other hand, are very variable from region to region and depending on the season. Finally, although the volumes of agricultural, agroindustrial and livestock residues are large, with a few exceptions 6/ they are already used for energy generation or nonenergy purposes, or are very scattered, which lessens their economic value. As for the hydroelectric potential, mobilization of these resources with existing technologies will be very costly and their contribution to Mali's energy balances is bound to remain very limited even in the medium term.

Energy Balance and Final Energy Consumption (1987)

1.11 Energy consumption data are sparse and of poor quality, especially for the traditional energies. 7/ However, total primary energy consumption in 1987 is estimated at 1,800,000 toe (Table 1.1 and Annex 1.1). Nearly 90% of the final energy is obtained from wood and biomass; the modern component of the sector in terms of final energy is therefore no more than 10%. The residential sector consumes nearly 89% of this while about 70% of petroleum products are used in transport. A

4/ *Including the interconnected system, the isolated centers and private generation.*

5/ *By 2007, peak power demand is expected to be of the order of 200 MW.*

6/ *Sukala sugar mill residues for ethanol production.*

7/ *Defined in this study as wood, charcoal and agricultural and agroindustrial residues. Commercial energy is defined as comprising electricity and hydrocarbons.*

comparison of commercial energy consumption (1986) in some West African countries is presented in Table 1.2.

Table 1.1: SUMMARY OF MALIAN ENERGY BALANCE IN 1987
(thousands of toe)

	Firewood	Crop residues	Charcoal	Electricity products	Petroleum	TOTAL
Production	1,786	111	---	40	---	1,937
Imports					174	174
Final consumption	1,601	111	38	13	166	1,929
In % of final consumption	83	6	2	1	9	100

Source: Annex 1.1.

Table 1.2: WESTERN AFRICA: COMMERCIAL ENERGY CONSUMPTION

	Per capita GNP in 1986	Per capita energy consumption		Energy imports as % of merchandise exports		Growth of energy consumption (%)	
	(1986 US$)	1965 (koe)	1986	1965	1986	1965/80	1980/86
Mali	180	14	23	16	27	7.0	2.3
Burkina Faso	150	7	18	11	7	10.5	0.2
Côte d'Ivoire	730	101	175	5	5	8.6	2.7
Ghana	390	76	131	6	15	7.8	-4.9
Guinea	-	56	59	-	-	2.3	0.6
Liberia	460	182	166	6	10	7.9	-12.4
Niger	260	8	42	9	9	12.5	3.3
Nigeria	640	34	134	7	2	12.9	6.5
Senegal	420	79	116	8	25	7.4	-2.3

Source: World Bank: 1988 World Development Report.

1.12 Electricity represents less than 1% of final energy demand and 7% of commercial energy consumption, but absorbs nearly 10% of public sector investment. Less than 5% of Mali's population has access to electricity; in Bamako, the capital, this proportion is of the order of 30%. For 1987, electricity consumption is estimated at 147.5 GWh. The interconnected system represents 90% of this

demand 8/ and low-voltage sales make up 48% of consumption (Annex 1.2). In 1987, petroleum products represented 9% of the final demand for energy but 93% of commercial energy consumption. The transport sector accounts for more than 70% of the consumption of petroleum products, among which gasoline (37%), gas oil (28%) and diesel fuel (12%) predominate.

Past Trends in Commercial Energy Consumption

1.13 For the period 1983-87, demand elasticity for commercial energy with respect to GNP was 1.1; however, this conceals the substantial differences between demand elasticity for petroleum products, put at 1.0, and that for electricity, estimated at 2.0. It is essential to bear in mind that as far as electricity is concerned, the growth of consumption has reflected the rate of development of the distribution networks, the capacity of new power stations and the relative amount of load-shedding rather than the country's rate of economic development. Between 1980 and 1987, commercial energy consumption rose on average by 1.1% p.a. and by 5.0% p.a. after 1983, though this average conceals significant differences between petroleum products and electricity (Table 1.3). In the electricity subsector, following the entry into service of the Sélingué hydroelectric plant in 1980, which considerably increased generating capacity, demand for electricity has risen very rapidly by an average of 13% p.a. notwithstanding tariff adjustments to reflect economic costs more fully. As regards petroleum products, however, consumption has only increased on average by 0.3% p.a. since 1980; this is due essentially to the significant price increases in 1980 and 1981. Since 1983, with a drop in prices in real terms and a resumption of economic activity, consumption of petroleum products has risen by an average of 4.6% p.a.

Table 1.3: COMMERCIAL ENERGY CONSUMPTION TRENDS IN MALI

Type of energy	1987 Value (toe '000s)	Growth rate (% year) 1980/87	1983/87	Elasticity with respect to GNP
Electricity	13	10.7	9.5	2.0
Petroleum products	166	0.3	4.6	1.0
Commercial energy	179	1.1	5.0	1.1
GNP growth			4.7	

Source: ESMAP estimates - Annexes 1.2 and 1.3.

Probable Evolution in Demand for Energy (1987-2010)

1.14 The development of energy demand in Mali will depend on the usual socioeconomic factors (demography, urbanization, global economic growth and structural changes in the economy, etc.) and on energy policy (especially energy prices and taxation, substitutions and energy rationalization measures), but probably also on the availability of funds for investment and imports through which supply can be increased, of electricity in particular. Altogether, if past trends and linkages are maintained and no

8/ *For a maximum power demand of 34 MW in 1987.*

sustained energy rationalization policy is applied, total energy demand can be expected to grow by about 2% p.a., representing 1.8% p.a. for traditional and 4.0-4.5% p.a. for commercial energies respectively, with a rapid rise in electricity consumption (Table 1.4).

Table 1.4: COMPARATIVE SUMMARY OF FINAL ENERGY CONSUMPTION BALANCES (1987/2000)

	BASE (1987)		Trend-Based Scenario			Energy Rationalization Scenario		
	'000 toe	Structure %	87/2000 %/year	'000 toe	Structure %	87/2000 %/year	'000 toe	Structure %
Fuelwood and biomass	1,751	90.70	2.27	2,343	87.99	1.83	2,215	88.49
Electricity	13	0.67	8.10	36	1.34	6.00	28	1.11
Petroleum products	166	8.62	4.20	284	10.67	3.50	260	10.40
Final energy	1,930	100.00	2.51	2,663	100.00	2.02	2,503	100.00
Commercial energy	179	9.30	4.55	320	12.01	3.71	288	11.51

Source: ESMAP estimates and Annex 1.4.

1.15 These general prospects are based on the following assumptions:

(a) Long-term economic growth of the order of 4% p.a. is achievable (para. 1.5), corresponding to a real increase in per capita income of the order of 1-2% p.a. This growth would be based essentially on development of agriculture and processing of agricultural products and on the mining sector (gold); and

(b) Up to the present, few resources have been devoted to enhanced energy rationalization in Mali, apart from the improved stove popularization projects and the projects to introduce LPG for household uses. Although precise data for Mali are not available, the experience gained in other countries indicates that the theoretic potential for energy savings in Mali is of the order of 10-15% of present consumption. Conversion of this theoretic potential into real savings is relatively difficult, but the return obtainable on efforts in this field is generally excellent; a rationalization policy of this type should therefore be implemented by the Government in order to cut energy costs, improve enterprise competitiveness, cut the trade balance deficit and also ease the pressures on the environment, in particular the overexploitation of fuelwood resources.

Organization and Management of the Energy Sector

1.16 The constraints connected with the availability and mobilization cost of the different energy resources (para. 1.6) are aggravated by the absence of an energy strategy and the involvement of numerous institutions whose efficiency is limited by the dispersion of responsibilities and lack of coordination, inadequate capabilities and the paucity of technical and financial resources. In addition, the almost complete lack of reliable data is a fundamental obstacle to development of more effective management.

1.17 The main institutions involved with energy are:

(a) At sector level, the Ministry of Industry, Water Resources and Energy (MIHE) is the supervisory authority for the sector, acting chiefly through its National Directorate of Water Resources and Energy (DNHE);

(b) At macroeconomic level, the Office de Stabilisation et de Régulation des Prix (OSRP), handling the taxes on petroleum product sales, the National Directorate of Economic Affairs of the Ministry of Finance and Trade for prices, the Interministerial Prices and Incomes Commission for the setting of petroleum product and electricity prices, and the Ministry of Planning for investment programming; and

(c) At subsector level, the main institutions are in the fields of:

(i) Fuelwood: the National Directorate of Water Resources and Forests, which coordinates various projects, the Directorate of Social Affairs, the Union des Femmes du Mali and the small-scale manufacturers who produce and market improved stoves;

(ii) Electricity: Energie du Mali (EDM), which since the institutional reform of 1988/89 has had sole responsibility for planning, constructing and operating public facilities, and the Office pour l'Exploitation des Ressources Hydrauliques du Haut Niger (OERHN), which owns the Sélingué hydroelectric plant. 9/ However, EDM does not have a monopoly of production. The regulation and control function for the subsector is performed by DNHE. At regional level, the Organisation pour la Mise en Valeur du Fleuve Sénégal (OMVS) is currently developing the Manantali project;

(iii) Hydrocarbons: the National Directorate of Geology and Mines (DNGM) of MIHE for petroleum exploration, the Office National des Transports (ONT) of

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9/ *Following the recent reform of the electricity subsector, operation of the Sélingué plant has been transferred from OERHN to EDM.*

the Ministry of Transport and Public Works for transport permits, OSRP for the management of price structures, equalization and stabilization funds, Pétrostock for storage installations, the Groupement Professionnel de l'Industrie du Pétrole du Mali (GPP) 10/ and the independent distributors, and the DNGM laboratory for quality and the certification of installations;

(iv) New and Renewable Energies: the Solar Energy Laboratory (LESO) essentially for research and development and support for various projects supervised by DNHE: the Special Energy Program, the Solar Equipment Maintenance Unit (CEES) and the Mechanized Agriculture Center; finally, at regional level, the Regional Solar Energy Center (CRES) is concerned with promotion of and training in solar energy.

The Main Thrusts of Malian Energy Policy

1.18 Taking into account the present energy situation and the 20-year prospects presented in the preceding sections, Malian energy policy should be based on the following principles:

(a) Protection of existing fuelwood resources, which are presently being devastated, probably irreversibly, and more generally of Mali's ecology, by better management of existing resources and modernization of firewood supply activities, since for the coming 20 years firewood will continue to furnish over 80% of the country's energy requirements;

(b) Improvement of public management of the various subsectors by simplifying the present procedures, reducing the dispersion of jurisdictions and utilizing private sector capabilities to the best advantage;

(c) Acceleration of the rationalization of traditional and commercial energies through a cost-pricing policy, expansion of the improved stoves programs and introduction of an energy-saving program in industry and trade; and

(d) Enhancing Mali's energy independence by optimizing and guaranteeing supplies of petroleum products and exploiting national energy resources.

10/ Mobil, Total, Texaco, BP and Shell but excluding the independent distributors.

II. FUELWOOD RESOURCES AND MEETING HOUSEHOLD ENERGY NEEDS

Principal Issues, Options and Recommendations for the Subsector

2.1 In 1985, the Government, recognizing that desertification was the outcome not only of droughts but also of poor natural resource management, poor coordination of remedial actions, and a scarcity of financial and human resources, adopted a plan for a nationwide campaign against desert encroachment. By 1987, eight priority measures had been decided on and were grouped together as the Programme National de Lutte Contre la Désertification (PNLD), for which support was obtained from several donors. One of these measures concerns fuelwood resources and focuses on three objectives:

(a) Reducing the consumption of fuelwood through distribution of improved, fuel-efficient cooking stoves (energy component of PNLD);

(b) Rationalizing forest exploitation by organizing and training loggers, demarcating felling sites, and specifying the conditions under which production operations may be conducted (forestry component of PNLD); and

(c) Promoting other energy sources as substitutes for fuelwood (energy component of PNLD).

2.2 The recommendations of this study on issues and options in the household energy subsector dovetail with the objectives of PNLD. Meanwhile, on the basis of the findings of the 1989-90 ESMAP household energy strategy study, the plan finally adopted should incorporate PNLD's (1) forestry and (2) energy components. In other words, the PNLD forestry component should be emphasized in the Kayes, Koulikoro, Ségou and Sikasso regions, the energy component in the Tombouctou and Gao regions, and both components in the Mopti region.

2.3 In overall terms, the action strategy recommended in this study is designed to:

(a) Ensure better use of fuelwood resources through the rationalization of forest exploitation and marketing operations, so that adequate supplies can be made available without harm to the environment;

(b) Meet the needs of the rural population as fully as possible by developing forestry operations, stockfarming, and environmental protection measures;

(c) Promote and support sound management of fuelwood resources -- by rural communities themselves wherever possible;

(d) Rationalize fuelwood consumption through coherent policies on improved stoves and energy substitutes; and

(e) Make the subsector self-financing eventually, by instituting a new fiscal policy, improving the collection of forest tax revenues, and, when necessary, bringing fuelwood prices up to the level of their economic cost.

Resources and Supply Channels

Forest and Biomass Resources: Projects in Progress

2.4 To pave the way for this strategy, an action program, partly in the institutional sphere and partly in the investment and technical assistance spheres, is recommended. The components of this program, detailed in the following sections of this study, would focus on fuelwood resource management, improving sector administration, and curbing growth in demand, particularly for fuelwood. The total cost of the investment and technical assistance subprojects in the Household Energy Program is estimated in Table 2.3 at approximately CFAF 3.6 billion (US$12.8 million). Of this amount, US$1 million is currently allocated under the Second Power Project (para. 3.6).

2.5 Although the Fuelwood Resources Inventory Project (PIRL-FAC) has yielded precise SPOT satellite data on such resources in the Kayes, Koulikoro, Ségou and Sikasso regions, inventorying activity must be continued until Mali's entire territory has been covered, since it is precisely the noninventoried regions where shortfalls might be most serious. Unfortunately, financing is still not available for an inventory of the Tombouctou, Gao and Mopti regions (Table 2.3). Annex 2.1 provides full details as currently available on Mali's fuelwood resources, which are now summarized in the following paragraphs.

2.6 Koulikoro and Sikasso regions: In the light of data on other Sahel countries, the volume of wood available in Koulikoro and Sikasso can be estimated at over 4 million tons/year plus approximately 5 million tons of dead wood. Since present consumption in these regions and Bamako is estimated at under 2 million t/a, there would be a sizeable surplus. This remains true even if Bamako is assumed to have a radius of supply of 150 km, as it could be supplied for a period of 3-5 years from the Banamba *cercle*. These, however, are overall estimates; meanwhile, a significant degradation around the cities is apparent.

2.7 Kayes and Ségou regions: Although there would appear to be no immediate problems in these two regions, which contain 70% of the Malian population, long-term deterioration is to be feared unless a better forest cover management system is put in place.

2.8 Mopti, Tombouctou and Gao regions: In these three regions, there is greater cause for concern, although precise data are not available. There are frequent shortages, particularly in the towns

in the Niger delta, which result in intensive use of crop residues and cow dung and the spontaneous setting up of supply channels from other rural areas in Mali.

2.9 Other biomass resources: The limited volumes of agroindustrial residues available 11/ are already used as energy sources or in the manufacture of animal feed. Crop residues 12/ are fairly significant in volume, accounting for 1,150 toe/a (Annex 2.2). They are generally left in the fields, and burned on the spot or used as litter (cotton stems). Attempts have been made to produce charcoal from cotton-plant stems, although with not very encouraging results. 13/

2.10 Pourghère oil: The Special Energy Program (SEP) is also studying the possibility of developing pourghère plantations in the form of hedges by fostering demand for the seeds, from which an oil can be produced that is usable as fuel for small stationary engines employed for production purposes or even as a fuel for vehicles (para. 5.6).

2.11 Forestry projects in progress: Assessment and lessons: Since 1972/73, Mali has spent roughly CFAF 15 billion (US$50 million) on forestry projects, all of them financed by international agencies (Annex 2.3). Reforestation activities include two rainfed plantation projects being executed by force account that absorb 75% of the funds allocated to forestry programs, 14/ but the results make it clear that this type of project is too costly and should not be repeated in Mali. Some irrigated plantations have also been created: 15/ although the yields from them are twice as high as those obtained from the rainfed plantations, this approach does not appear to be economically justifiable either, because of the opportunity cost of the land areas taken up. Finally, a number of village-scale reforestation projects have been started; however, owing to a lack of local technical expertise, high costs, and little interest on the part of the local communities, this type of project has gradually been replaced by privately owned plantations, where the chief concerns are soil protection and forage production, with fuelwood production no more than a secondary objective. Although private plantations may be able to meet the fuelwood requirements of scattered rural communities, they will be incapable of meeting demand from urban areas over the long term. Where fuelwood supplies are concerned, therefore, the conclusion would appear to be that future efforts should preferably concentrate on the development and rational management of existing forestry resources.

11/ *Bagasse, groundnut cake, cotton seed from the Compagnie Malienne de Développement des Textiles, and rice chaff from Office du Niger.*

12/ *Millet, sorghum, maize stalks and cotton stems, rice straw, groundnut shells. Although the potential of this area is little known, a closer study does not seem necessary at this time.*

13/ *Special Energy Program (SEP-GTZ). The raw materials are too light and burn too quickly, and the charcoal produced was not comparable with wood charcoal.*

14/ *Opération Aménagement et Production Forestière, a part of the Second Forestry Project, for the supply of Bamako, and Opération Aménagement et Reboisement de Sikasso, a part of the Mali Forestry Operation Support Program.*

15/ *By IDRC (International Development Research Centre, Canada), in the Ségou region.*

Fuelwood and Charcoal Supply Systems

2.12 The rural population appears to have no serious problems in obtaining firewood, except in the Mopti, Tombouctou and Gao regions. Reliable data on collection zones, distances, time spent, types of wood, etc., are not available. 16/ Only a few surveys, focused on consumption, have been conducted in rural areas. 17/ In urban areas, on the other hand, situations vary considerably. Several studies have demonstrated how supply systems vary from town to town and even in the same town, 18/ but have generally concluded that they are effective, given the ready availability of wood to consumers at comparatively low prices (Annex 2.4).

2.13 As far as charcoal is concerned, trading is still conducted on a small scale and is limited to urban centers, although consumption is growing very rapidly. 19/ It is produced in medium-size or very small earth kilns (the largest being able to produce no more than 60 bags, of 75 kg each, per operation) in the Banamba region and around Koutiala. Kiln efficiency varies from 10% and 15% of original weight.

Control of Exploitation of Fuelwood Resources

2.14 Forests in Mali are the property of the State and their exploitation is governed by the Forestry Code. 20/ Before beginning logging operations, an entrepreneur must obtain a felling license, 21/ pay the related tax charges and, before transportation begins, obtain the necessary

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16/ *Supply systems are generally of the nonformal type. As a rule, each family collects its own firewood, work that is done mainly by women and children along the borders of paths and tracks, in fields or in woodland areas. For the most part, it is dead wood that is collected.*

17/ *Bamako and Mopti (1978), by Institut Polytechnique Rural de Katibougou (FAO); Sikasso, Koutiala and Bougouni (1985), by Opération Aménagement et Reboisement de Sikasso; and Kayes (by UNSO project now in progress).*

18/ *There are three main types of supply system: nonmotorized, motorized, and transportation by train or pirogue. The scale of each system or network depends on a number of factors: demand volume, distances, traffic volume, relative prices of alternative fuels, etc. Annex 2.4 provides a breakdown of the transportation methods used to supply five towns.*

19/ *In Bamako, 3% of households were using charcoal as their main fuel in 1978 (TRANSENERG report), 8% in 1987 (SEP surveys) and 11% in 1989 (ESMAP household surveys).*

20/ *The Forestry Code (Law of March 1986) specifies that the collection of wood for personal use is a traditional right exercisable by every individual except in the case of reserve forests and certain species. Only loggers registered with DNEF's regional branches are authorized to engage in extraction activities on a commercial scale.*

21/ *Indicating type of product, quantity, felling site and period of validity of the permit.*

permit 22/ on presentation of his felling license. Infringements of these regulations may result in fines. However, only a very small percentage of the data available from the issue of licenses and permits and from other records kept by the forestry authorities is centralized and analyzed by DNEF. Consequently, systematic monitoring of forest exploitation, specifically of felling sites and quantities of timber extracted, is impossible, and there is also little to motivate rangers. In addition, administrative control in the interests of tailoring forest exploitation to firewood and charcoal demand is inadequate. In 1987, the DNEF recorded production of 122,400 t of fuelwood and 5,240 t of charcoal -- in other words, between 10% and 20% of estimated total urban consumption throughout the country (para. 2.39). 23/ Despite the new checkpoints that came into operation at the beginning of 1988 at entrances into Bamako, volumes recorded are still well below estimated actual consumption. 24/

Recommendations

2.15 Development of a better data base and its utilization in daily management are first necessary in order to obtain a true picture of fuelwood production potential and exploitation methods. Subsequently, efforts should be directed at rationalizing management of this resource. If these advances are to be achieved, the DNEF unit which is to specialize in the fuelwood subsector (para. 2.33) must be provided with the staff and physical resources it will need to create and administer such a data base, complete the national inventory of fuelwood resources by covering the Mopti, Tombouctou and Gao regions (PIRL program), and begin implementing the strategies 25/ to be proposed on completion of the ongoing studies.

2.16 Any actions taken in the spheres of forest exploitation and fuelwood marketing arrangements should adhere to two principles:

(a) The Government alone cannot attend to management of the country's natural forests. It should therefore concentrate its resources and capabilities on technical assistance and delegate the management and monitoring of exploitation activities to the inhabitants of the rural areas in question, logging operators and wood merchants. However, it should conduct periodic inspections to ensure the type of management recommended is being applied; and

(b) The changes proposed should be made gradually. Reducing over-exploitation in areas adjacent to urban centers and major traffic arteries should be the first concern (through

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22/ *Specifying products, quantities, type of vehicle, destination, and period of validity of the permits.*

23/ *Annual report of the Directorate of Forests for 1987.*

24/ *This is largely explained by the fact that the authorities concerned display little interest in the findings, as well as by the failure to make use of data that are actually collected.*

25/ *In its forest products market study completed in March 1990 and its household energy strategy planning study begun in the second half of 1990.*

measures to move fuelwood collection out toward less fragile zones). Subsequently, a mode of forest exploitation should be instituted which is based on systematic rural community participation, so that eventually all management responsibilities can be transferred to the communities and private operators.

2.17 Forest resource management and tree-planting programs should therefore be reoriented: village communities themselves should be encouraged to protect extraction sites and develop their own nurseries; and management responsibility should gradually be handed over to villages or, even better, to families. This will necessarily involve providing incentives, principally financial, either in the form of rights of usufruct or ownership regarding forest resources, access to a stable market, and, over and above reimbursement in respect of felling activities, a payment to remunerate villagers for the work involved in managing fuelwood resources. This payment, which might be called a "development premium," would be conditioned on satisfactory exercise of the management function.

2.18 As to actual management of the supply of fuelwood, although various types of organization might be considered, the following key elements should be present in all cases:

(a) The new management practices should be based on supply master plans drawn up for each geographic zone (para. 2.20);

(b) Wherever possible, producers should organize themselves into local producer associations centered around local rural fuelwood markets so that collective responsibility for management of this resource may have the opportunity to develop;

(c) Regulatory and taxation requirements should be modified to make producers accountable and enable them to receive a development premium; and, right away,

(d) Checkpoints at the entrances to urban communities should be selectively reinforced to serve both as tax collection offices and the key element in the new management system.

2.19 Detailed proposals on the best means of paying a development premium and/or allocating to producers a proportion of the tax revenues received on fuelwood cannot be formulated with currently available information. Even if the principles and benefits of making rural communities accountable for the management of fuelwood resources are clearly apparent, the organization and operating rules of such a system will have to be formulated carefully if the goals in view are to be attained.

2.20 Supply master plans: The current system of wood collection to cover requirements in rural areas does not appear likely to cause further deforestation. However, supplying urban zones is another matter (para. 2.12). Fuelwood supply master plans for major urban areas should therefore be drawn up to provide a basis for designation of extraction and conservation zones, control of their exploitation, negotiations with local resource management groups, writing of regulations to govern the assignment of land and resource ownership, rationalization of transportation arrangements, and identification of the intermediaries involved. Where classified forests are concerned, another formula

could be envisaged, possibly involving the sale of management and extraction concessions to logging entrepreneurs.

2.21 Amendment of present regulations: This new management approach will require changes in the current regulations: fixing and acceptance by producers of collection quotas for each zone; introduction of a system of surveillance and penalties at the production level; 26/ obligations for transporters to prove the origin of the wood they are carrying, the payment of development premiums to producers, and their own membership in a professional association; prohibition of buying/selling along roads lying outside authorized felling areas. As a transitional measure, the present system of felling licenses should be replaced by one of vouchers issued to loggers at the beginning of the year for their zone and certifying payment of fees due for the period. As mentioned above, it remains to determine how a system of paying communities a development premium in respect of their resource management work can be set up. Lastly, additional checkpoints should be established at entrances to major urban areas so that possession of the vouchers mentioned and payment of taxes can be verified and required data collected. The necessary studies, the ensuing proposals for action, and their eventual implementation should be the responsibility of CCL (Cellule de Combustibles Ligneux) proposed as part of DNEF (para. 2.33).

2.22 Reorientation of the role of regional forestry services: In view of these changes, the work of the regional forestry authorities should be geared more toward providing private producers and logging operators with advice and training, particularly in fire prevention/fighting measures, felling methods, grazing, etc. 27/

2.23 Priority activities: The following priority activities are designed to pave the way for necessary improvements in resource management and rationalization of the networks through which urban centers are supplied:

(a) Drafting of supply master plans for Bamako, Ségou, Mopti and Gao which define production organization, fuelwood collection, surveillance systems, taxation policy, and financial administration. This set of activities should be initiated quickly by CCL as part of the proposed Household Energy Program (para. 2.4);

(b) Development of production/collection zones, (starting with inventories) and then the creation of such infrastructure as firebreaks, access roads, etc.; and

(c) Applied research into forest productivity by ecological zone and into forest exploitation and management techniques through which the master plans can be implemented.

26/ *Initial steps to organize logging entrepreneurs in Mali have been under way for more than a year.*

27/ *This approach has already been taken as part of certain projects (the World Bank project in southern Mali and the village-level forest development and reforestation scheme in the Koulikoro region) and by a number of Malian organizations (e.g. CMDT).*

Taxation Policy and Price Structures

Current Taxation Policy, Price Structures and Subsector Self-Financing

2.24 Present taxation policy and firewood and charcoal retail prices are as a general rule inadequate, since they neither reflect the economic costs of fuelwood resources nor allow either satisfactory subsector self-financing or reasonable remuneration for producers. 28/ Unfortunately, fuelwood cost structures and price movements are poorly understood, never having been studied in any rigorous fashion. 29/ Retail prices depend on such factors as: (a) the season (prices are 15-20% higher in the rainy season); (b) the geographical location and size of the population center supplied; (c) the type of wood; 30/ and (d) the supply system. Throughout Mali, 1988 prices varied between CFAF 12 and 20. 31/ Over the last 15 years, annual increases in fuelwood prices have roughly matched the rises in the general price index, apparently reflecting the existence of a stable production/supply system. However, it should not be concluded that a crisis is not in the making: in some cases, for example, forest reserves may already be exhausted although no immediate and significant change occurs in the cost structure of fuelwood production, transportation and distribution. Taking the data available on transportation by truck (more frequent in Mali than other modes), the following conclusions can be drawn (Annex 2.5):

(a) Retail prices vary very widely from one town to another, mainly reflecting resource availability and transportation distances;

(b) Transportation costs account for 20-30% of retail price and 33-60% of cost (except if a truck returns empty to Bamako); and

(c) Gross profit margins, which represent 25-40% of retail prices and 50% if a truck travels empty to Bamako, appear comparable to margins on other products when wholesalers, retailers and chopping of the wood are taken into account.

2.25 The felling licenses logging operators are required to pay for currently cost CFAF 2,000/stere for wood (CFAF 0.7/kg) and CFAF 250/100 kg for charcoal (CFAF 2.5/kg). These charges

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28/ *The 1988 economic cost of wood delivered to consumers is estimated at CFAF 20-30/kg, whereas retail prices were in the range CFAF 12-20/kg.*

29/ *Although the National Directorate of Statistics conducts monthly surveys, it does not allow for wood quality grades and takes no weight readings.*

30/ *In this study, firewood is defined as: air-dried wood with density of 0.7, moisture content of 15%, and minimum calorific value of 15 MJ/kg.*

31/ *The price of wood in Bamako and Mopti is twice as high as in Sikasso.*

are set arbitrarily and do not represent the economic value of fuelwood. 32/ To reflect actual economic costs they ought to be raised again, although this was done in 1986 (para. 2.27). ESMAP estimates put the economic cost of fuelwood production in Mali between CFAF 3/kg (natural forest managed so as to give long-term sustained production) and CFAF 12/kg (cost of replacing natural forests with industrial-type plantations); in other words, it is at least four times the present charges for felling licenses. Where charcoal is concerned, since it takes 7-10 kg of wood to produce a kilo of charcoal, the tax on this material should be roughly CFAF 500/100 kg. The fact that the present charge amounts to only CFAF 250/100 kg is likely to encourage an activity dependent on very high wood consumption. Moreover, the charges payable by transport operators 33/ are monthly flat-rate payments calculated on estimates of monthly volumes and number of journeys, which tends to reduce the revenue collected still further.

2.26 Under these circumstances, present subsector self-financing is inadequate. Tax revenue amounts to less than CFAF 100 million p.a. (US$360,000) on annual firewood sales estimated at CFAF 6.5 to 7 billion (US$23-25 million). 34/ In other words, the revenue obtained is equivalent to 2% on sales volume, which clearly falls far short of subsector investment requirements. Present financing for the subsector comes from: (a) the general government budget; (b) the National Forestry Fund (FFN); and (c) loans and subsidies from the international community. The total annual budget required to cover execution of projects and operation of forestry services is close to CFAF 2 billion (US$7 million). In 1987, the funding put up by Mali itself totaled some CFAF 600 million (roughly US$2 million), sufficient only to cover forestry service operating costs; approximately 60% of this sum was allocated from the general government budget and mainly covered payroll costs.

2.27 The National Forestry Fund therefore finances current capital spending and other expenditures, while external aid amounts to roughly CFAF 1.4 billion/year (US$5 million), or 70% of subsector financing requirements. Since 1987, FFN has been funded with the proceeds of taxes and penalties collected; 35/ the felling license fees paid by logging operators probably account for less than 25% of this amount. Since 1984, FFN has contributed only about 10% (CFAF 200-220 million/year) to the domestic financing appropriated to the subsector. However, these funds, which are administered by the Ministry of Finance, are not necessarily available for subsector activities.

32/ *Which in any event is difficult to estimate accurately.*

33/ *It is estimated that such charges are currently paid on only 10-20% of wood consumed and 5% of charcoal.*

34/ *That is, 433,500 tons at an average price of CFAF 15/kg.*

35/ *Set up in 1967, the Fund was allocated 50% of these receipts until 1982, and has received 100% since that date.*

Recommendations

2.28 A new tax policy and improved management arrangements should be put in place gradually as part of a clear substitution strategy (paras. 2.45 and 2.46) so that:

(a) Retail prices may reflect the economic costs of firewood and charcoal better; this would involve providing consumers with accurate information on the prices of these necessities, thereby promoting economically warranted substitutions. However, differential tax rates must be used because costs and prices vary greatly from one town to another;

(b) The subsector itself may (progressively) finance more of its own activities; this would mean that payment of the fees and charges due to the State would have to be monitored more effectively by the forestry authorities;

(c) The business of resource management may be handed over to local communities; as the communities would need to be motivated for this change, it would have to be accompanied by adequate financial incentives and the introduction of a resource management monitoring system, ideally one for which the communities themselves would be responsible (para. 2.17-2.19); and

(d) Zone-to-zone differentials in felling license fees and development premiums may be introduced as a means of encouraging the exploitation of production areas at greater distances from urban centers, all within the framework of the supply master plans adopted.

2.29 The present taxation system should be reworked and reinforced so that the following two components may be included:

(a) A new development premium (para. 2.17) to remunerate communities for their development and management of their local forest resources; and

(b) Reinforcement of the arrangements for collection of the "second payment" to the State (earmarked as general budget revenue) by transport operators at checkpoints located at the entrances to major urban centers. This would involve strengthening existing checkpoints and adding new ones.

This new fiscal system should be administered by CCL and the charges payable increased gradually so as to bring retail prices up to the level of the economic costs of production, transport and distribution of firewood and charcoal. Details of the system should be worked out at the same time that the plan to implement the Household Energy Strategy is being drawn up.

Current Organization

2.30 Administrative supervision of the forestry subsector is the responsibility of DNEF (Direction Nationale des Eaux et Forêts). 36/ This is the agency which sees to the formulation and implementation of Mali's forestry and environmental policies, the organization and monitoring of forest exploitation activities, the marketing of forest products, the management of classified forests, and the protection of flora and fauna. It also supervises hunting, fishing and fish-farming matters. DNEF consists of 20 divisions, 15 of which are concerned to varying degrees with fuelwood matters. These divisions are grouped as follows: (a) at the national level, the Direction du Service, which consists of seven divisions responsible for the formulation, implementation and evaluation of policies, for associated regulatory matters, and for financial, personnel and technical management; (b) at the regional level, eight divisions execute projects and enforce regulations, each in its particular region; (c) four "operating" divisions, which manage specific projects and a training center. 37/

2.31 Generally speaking, these divisions operate independently, and the lack of any coherent overall strategy has led to poor organization and monitoring of the subsector. For instance, forest exploitation activities and the associated marketing system is the responsibility of the Industry and Exploitation Section of the Development and Reforestation Division, although the Section is without either the financial or staff resources for such a task and has no administrative jurisdiction over the regional services, which actually issue felling licenses and monitor operators' activities.

2.32 Several donors are providing technical and financial assistance for the improvement of subsector management. For instance, through its Second Forestry Project, the World Bank is involved in institution building, while the PAFOMA-FAC (France) Project is focused on upgrading the functioning of DNEF and its divisions and their capacity to formulate a coherent national policy and to deal with the design, appraisal and execution of forestry projects.

Recommendations

2.33 (Cellule de Combustibles Ligneux): Where Mali's fuelwood resources are concerned, institutional reorganization is needed to (a) expand DNEF's operational capacity by upgrading its infrastructure and logistics, and (b) build up coordination both within DNEF and between the forestry service agencies and other entities working in the rural development and energy fields. Establishment within DNEF of a unit to specialize in fuelwood resources (CCL) should be considered by the Government. It would be responsible for centralizing and analyzing data on supply and demand, and in general for all activities arising out of the administration and management of fuelwood resources, particularly for making a reality of supply master plans (para. 2.20). CCL would also be responsible for the checkpoints located at the approaches to urban centers. As far as possible, it should be staffed with

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36/ *Part of MEE (Ministère de l'Environnement et de l'Elevage) (Annex 2.6).*

37/ *Practical Forestry Training Center, Tabacoro.*

personnel already in the civil service ranks who form the right kind of multi-disciplinary team. 38/ Annex 2.7 suggests a sharing of responsibilities among CCL, the other units of DNEF, and other competent entities.

Subsector Administration

Availability and Quality of Data

2.34 The data essential to sound administration of both biomass consumption (fuelwood, in particular) and the resources present in each geographic zone are either not available or unreliable. Efforts are under way to improve this situation as regards both biomass consumption by households and consumption of other energy resources. A household energy study was begun by ESMAP in 1989 to obtain data on household consumption in Bamako, Ségou, Mopti, Koutiala and Gao and on the supply networks serving these population centers.

Recommendations

2.35 Data management: A modern system for the management of subsector data should be brought into operation by CCL. It should be a system which allows the collection and processing of all available data on consumption and supply of fuelwood resources, including tax data, data recorded at checkpoints, and data gathered through DNEF's regional branches. It will be vital to successful implementation of supply master plans, and could also be used for the analysis and maintenance of data obtained through the forest product market study of major urban areas to be carried out as part of the Second Forestry Project. In addition, a full stocktaking of the country's fuelwood resources and potential production levels must be completed at the earliest possible date, which will mean conducting an inventory of the Mopti, Tombouctou and Gao regions -- at an estimated cost of CFAF 700 million (US$2.5 million).

2.36 Technical assistance: As part of the preparations for launching CCL, technical assistance should be obtained in the form of short-term missions over a two-year period by experts on the economic and technical aspects of fuelwood reserves. In addition to these arrangements, to benefit CCL managers, the experts should take part in training other CCL personnel and in setting up a system for the monitoring and analysis of fuelwood flows. The cost of this assistance, and necessary logistical support for the effective functioning of CCL, is estimated at CFAF 230 million (US$850,000).

38/ *At the minimum, a forestry engineer, an economist, a sociologist, and a statistician, provided with computers and means of transport.*

Consumption, Energy Substitutions and Equipment Efficiency

Present and Potential Consumption

2.37 As in most Sahelian countries, fuelwood provides almost 90% of the energy consumed by households in Mali (Annex 1.1). 39/ Most firewood is used for cooking purposes, but the traditional stoves (three-stone type) generally used are inefficient, pose health risks, and are difficult and even dangerous to use. On the other hand, the acceptance rate for improved stoves, which partially eliminate these inconveniences, is excellent.

2.38 In rural households, in addition to its widespread use for cooking and numerous traditional activities, 40/ wood is also used for lighting when either supply difficulties or high prices mean that kerosene purchases are cut back. For a great many other activities, it is human energy that is used. In urban households, the main fuel is also firewood; charcoal is utilized by only 11% of households in Bamako but its use is expanding very rapidly (para. 2.13). LPG, a relatively costly fuel, is used by only 1% of households in Bamako as their main fuel and by 15% of them as a secondary fuel. As to electric power, fewer than 30% of households are connected to a supply network; they use electricity mainly for lighting. 41/

2.39 Estimated present consumption and projected future consumption figures, based on the current trend and on a strategy of diversification, are shown in Table 2.1 and Annex 2.8, which gives a detailed analysis. However, the changing pattern of household consumption could be very different if energy substitution programs were accelerated, if energy prices, particularly for fuelwood, were modified significantly, or if there were an improvement/deterioration in supply networks. For instance, given the current prices for LPG and the household equipment it requires, adjustment of the taxes on kerosene could make kerosene a more frequent substitute for firewood (para. 2.45). Detailed evaluation of the options available and drafting of a strategy were undertaken in 1989 as part of the ESMAP Household Energy Study.

39/ *Survey findings (the LESO survey in 1984-85 of 20 villages in the Gao, San, Bougouni and Nioro districts; the LESO survey in 1986 in Bamako; and the SEP survey in 1987 in Bamako and Ségou) indicate a wood consumption figure varying between 0.9 and 1.3 kg/inhabitant/day in urban households and between 1.3 and 2 kg/inhabitant/day in rural areas.*

40/ *Brewing of millet beer, making of shea butter and soap, drying of agricultural products, smoking of fish, firing of pottery, dyeing, etc.*

41/ *Monthly electric power consumption rarely exceeds 100 kWh/compound/month.*

Table 2.1: SUMMARY OF HOUSEHOLD ENERGY CONSUMPTION
Using (a) Trend-Based Scenario and (b) Diversification Strategy

	Trend-based scenario			Diversification Strategy	
	'000 Tons per Year		% Growth Rate	'000 Tonnes/year	% Growth Rate
	1987	2000	1987/2000	2000	1987-2000
Firewood					
Urban	614	1,093	4.5	909	3.1
Rural	3,331	4,141	1.7	4,099	1.6
Total	3,945	5,234	2.2	5,008	1.8
Charcoal					
Urban	53	130	7.1	78	3.0
Rural	--	--	--	--	--
Total	53	130	7.1	78	3.0
Other biomass					
Urban	--	--	--	--	--
Rural	247	329	2.2	329	2.2
Total	247	329	2.2	329	2.2
LPG					
Urban	0.5	6.2	21.4	22	33.8
Rural	--	--	--	--	--
Total	0.5	6.2	21.4	22	33.8
Kerosene					
Urban	5.2	7.2	2.5	15.2	8.6
Rural	7.3	8.8	1.5	12.8	4.4
Total	12.5	16.0	1.9	28.0	6.4

Source: ESMAP estimates.
See Annex 2.8.

Energy as an Item in Household Budgets and Cooking Costs

2.40 Expenditure on energy is not a large item in the average household budget. According to 1987 surveys by DNSI (Direction Nationale de la Statistique et de l'Informatique), energy and water absorb between 3.3% of the household budget in Sikasso and 6% in Kayes, whereas food costs may account for between 50% and 73% of expenditure (Annex 2.8, Table 7). Although reliable data are not available, it is clear all the same that energy costs have a much greater impact on the budgets of urban low-income households, since this expenditure is difficult to cut back. Distribution of household spending by type of energy demonstrates that in urban areas purchases of fuelwood absorb between 60% and 90% of the household energy budget, averaging roughly CFAF 2,500/month (US$8.5).

2.41 It is for their cooking requirements that households use most of the energy they consume. In terms of both present retail prices and real economic costs, wood is by far the cheapest fuel. In Bamako, where substitutions are possible, kerosene is competitive in terms of economic costs, while LPG and charcoal are significantly dearer than firewood. Since urban consumers' costs of cooking with wood (assuming an improved stove is used for cooking and allowing for its depreciation) are at present 1.3-2.3 times less than with other types of energy, current price levels and structure mean that no rapid and significant degree of substitution can be expected. 42/ Furthermore, as regards increased substitution of kerosene for wood, consumers must first of all have access to stoves which suit their cooking practices and are available at affordable prices; they must also overcome their preconceptions as to the possibly disagreeable taste of food cooked by kerosene. Unfortunately, little is known of the preferences, motivations and expectations of the various groups of consumers in Mali. In addition to questions of income level and relative cost of the different types of energy, other factors may also enter the picture: ease of use, modernity, a guaranteed supply, time saved, etc. If a successful substitution policy is to be introduced, and if it is to be clear what degree of energy substitution can be expected and exactly which substitutions should be fostered, more thorough knowledge of consumer preferences will have to be obtained. A body of key data has already been put together as a result of surveys undertaken for the ESMAP Household Energy Study.

Improved Stoves Program and Energy Substitutions

2.42 Two types of more fuel-efficient stove have been promoted since the 1970s: an improved three-stone stove (the Louga) built of a material known as banco and an improved movable metal stove. Each of them is designed for a single cooking pot of a particular size and gives fuel savings of 30% if used correctly. In March 1986, the Government introduced legislation requiring households to use improved stoves if they cooked with wood. Whereas only 15,000 stoves had been distributed prior to this legislation, between 1986 and 1988 some 300,000 new stoves were distributed and are generally being used as prescribed. This provides an illustration of the impact of such legislation and (especially) the associated extension programs. 43/

2.43 The Improved Stoves Program is carried out by DNAS (Direction Nationale des Affaires Sociales), under the supervision of CNCFA (National Advisory Committee on Improved Stoves) and with technical and financial assistance from SEP. The Program provides for the small-scale industrial manufacture of well-priced movable metal stoves, the setting up of sales outlets, and arrangements for information and awareness training for housewives. The early results are encouraging: for instance, 6,000 stoves were sold in Bamako in the second half of 1988. UNFM (Union Nationale des Femmes du Mali) and to a lesser extent LESO (Solar Energy Laboratory) have contributed actively to the wider use of improved stoves.

42/ *The theoretical economic cost of petroleum products is determined by the international prices paid for them, while their actual economic cost is a matter of sources and current cost of supplies obtained from refineries in Senegal or Côte d'Ivoire.*

43/ *It is estimated that between 25% and 30% of Malian households have the improved stoves, which often replace rather than merely complement the traditional stoves.*

2.44 As far as substitution programs are concerned, in 1986 the taxes and duties on LPG were reduced and distributors of petroleum products encouraged to promote it as a cooking fuel by means of incentives incorporated into the Investment Code. Shell and Total/Texaco have introduced two new types of portable stove (the Déméba and the Guatéli) which operate on 3- and 6-kg bottles of gas and are suited to Malian cooking customs. These two companies have built gas-bottling plants in Bamako and construction of another unit is planned in Mopti. In addition, plans are being made to import Algerian LPG for distribution in Gao and Tombouctou. However, at the present time, only 1% of households in Bamako use LPG as their main fuel. A new project, supervised by DNHE and CILSS, and financed by the European Community, is also planned and includes activities for the promotion and partial financing of the cooking equipment itself (stove and gas bottle to be partially financed by the Gas Fund).

Recommendations

2.45 Regarding programs focused on improved wood or charcoal stoves, the following recommendations are made:

(a) Current programs should be continued in Bamako and extended to other major towns. Measures for quality control of stoves made by blacksmiths should also be continued, but LESO could perform the tests if the promotion project managers so request;

(b) Since there is cause for concern over the very rapidly growing use of charcoal in Bamako, immediate steps are recommended to raise the retail price of charcoal by increasing taxes on it, as proposed (para. 2.28). In addition, an efficient model of charcoal stove should be offered for sale through the Improved Stoves Program, which could subcontract the necessary R&D to LESO. As far as improvements in charcoal-making techniques and technology are concerned, an action strategy should first be developed (as part of the ESMAP study), although it will doubtless have only a limited impact since Mali's numerous charcoal burners are widely scattered and follow their occupation on a seasonal basis; and

(c) Within the context of a strategy to promote the use of improved stoves, firewood and charcoal prices should be raised on a differential basis, according to region, so that they are brought gradually into line with their economic costs.

2.46 Regarding programs for the replacement of firewood and charcoal as cooking fuels, the following recommendations are made. It should be noted that pricing policies must take account of the prices of substitute energies in the subregion in order to minimize any undesirable effects.

(a) Promotion of kerosene use: More widespread use of kerosene for cooking is warranted from the economic viewpoint (para. 2.39), and experience in Niger, for example, demonstrates that it can be successfully substituted for firewood for cooking purposes. However, greater acceptance of it in Mali is hindered first of all by its retail price (including a combined tax rate of 34%) and to the lack of a satisfactory type of stove.

A comprehensive promotion strategy must therefore be devised, combining actions by the State and the oil companies. As an initial step, LESO, taking advantage of the experience of Burkina Faso's Energy Institute, should develop a cooker for the Malian market. Subsequently, an extension effort to promote kerosene as a cooking fuel should be undertaken by the oil companies, while the taxes on it should be either eliminated or at least reduced. In addition, its use should be heavily promoted as a priority in such urban centers as Mopti, Tombouctou and Gao;

(b) With respect to LPG as a substitute for firewood and charcoal: its economic cost is currently estimated at CFAF 275/kg (Table 2.2) and even if its price were reduced by 20-30% (paras. 4.30 and 4.31), its economic cost as a cooking fuel would be considerably higher than any alternative. This is a very general statement, however, since the relative economic costs of the different forms of energy in Mali vary significantly from one geographic zone to another. Promotion of the use of LPG and such substitution projects as the EC/CILSS program should therefore be very selective and adhere to rules which will assure:

(i) that LPG promotion be coordinated with efforts to promote kerosene use in zones where the economic costs of firewood are or will become higher than or comparable to those of LPG -- i.e. most probably in the Mopti, Tombouctou and Gao areas and in Bamako and Ségou, where there is a trend toward modern amenities, but perhaps not in the southern region of the country; and

(ii) that consumers have access to a cheaper and more efficient stove. 44/

44/ *Taking the current prices of stoves in Senegal as a basis for comparison, their prices in Bamako could be reduced by 20-30%.*

Table 2.2: ENERGY COSTS AND ANNUAL EXPENDITURES ON COOKING IN BAMAKO

	FIREWOOD	CHARCOAL	KEROSENE	LPG
A. FUEL PRICES (CFAF/kg)				
Current price	18	66	250	320
Price excluding taxes	17	63	112	300
Theoretical economic cost	17 (a)	63 (a)	94	275 (b)
B. COST OF UTILIZABLE ENERGY				
At current prices (CFAF/MJ)	5.3	9.1	12.8	14.0
Relative cost compared to wood	1.0	1.7	2.4	2.6
Relative cost compared to charcoal	0.6	1.0	1.4	1.5
At prices excl. taxes (CFAF/MJ)	5.0	8.7	5.7	13.1
Relative cost compared to wood	1.0	1.7	1.2	2.6
Relative cost compared to charcoal	0.6	1.0	0.7	1.5
At theoretical economic cost (CFAF/MJ)	5.0	8.7	4.8	12.0
Relative cost compared to wood	1.0	1.7	1.0	2.4
C. ANNUAL COST OF COOKING (from Household Surveys)				
Cost of fuel (CFAF/year)	37,300	51,100	73,000	86,000
Price of a stove (CFAF)	1,250	1,500	7,000	16,000
Life of a stove (years)	2	2	4	5
Annual payments on stove (CFAF/year)	650	800	3,000	2,600
Total cost (CFAF/year)	38,450	51,900	76,000	88,600
Cost as compared to wood	1.0	1.3	2.0	2.3
Cost as compared to charcoal	0.7	1.0	1.5	1.7

Notes: (a) Minimum cost (for zone with sustainable extraction).
(b) Without taking account of a possible major increase in the tonnage consumed.
Family of 8 persons
Meals: rice with sauce, midday meal
Wood consumption: 0.9 Kg/person/day, of which 0.72 for cooking, of which 40% for lunch.
Charcoal consumption: 330 g/person/day, of which 265 g for cooking, of which 40% for lunch.
Kerosene consumption: 0.15 L/person/day, of which 0.125 for cooking, of which 40% for lunch.
LPG consumption: 115 g/person/day, of which 92 for cooking, of which 40% for lunch.

Source: ESMAP estimates.

Household Energy Project: Short-Term Investment and Technical Assistance

2.47 Implementation of the proposed Household Energy Project will cost an estimated CFAF 3.6 billion (US$12.8 million) in public funds over the period 1990-1995, in addition to the funding required for projects now in progress. The latter consist of the butane gas promotion program (CFAF 300 million, or US$1.1 million) and the improved stoves program forming part of PSE/GTZ Phase II for the period 1990-1993. As part of the Second Power Project, a component of US$1 million has been allocated as partial financing for the Household Energy Project, but the balance will have to be obtained elsewhere. Details of the components of the Program are given in Table 2.3, which does not include expenditure by the private sector and oil companies in Mali.

Table 2.3: HOUSEHOLD ENERGY PROGRAM:
ADDITIONAL INVESTMENT AND TECHNICAL ASSISTANCE (1990-1995)

	CFAF (millions)	US$ (thousands)
A. Investments		
Forestry Resources:		
- Inventories of fuelwood resources in the Mopti, Tombouctou and Gao regions	700	2,500
- Drafting of master plans for supply of the the following urban centers: Bamako, Ségou, Mopti, Koutiala, Tombouctou and Kayes	490	1,750
- Development of forest stands for supply purposes within the context of the master plans; strategy to collect dead wood.	826	2,950
- Upgrading and increasing the number of checkpoints; support to wood suppliers	196	700
- Modernization of charcoal production (studies, equipment, technical assistance)	140	500
B. Demand-Side Measures		
- Promotion of energy-efficient stoves (market studies and setting up of a working capital fund)	616	2,200
C. Technical Assistance		
- Steering unit for the Household Energy Strategy, to include the Cellule Energie Domestique (DNHE) and the Cellule de Combustibles Ligneux (DNEF), equipment (logistical and data-processing) and operations support.	294	1,050
D. Contingencies (10%)	326	1,165
TOTAL	3,588	12,815

Source: Estimations ESMAP.

III. THE ELECTRICITY SUBSECTOR

Principal Issues, Options and Recommendations

3.1 This part of the study examines the main problems of the electricity subsector in Mali and makes some recommendations for their resolution. The actions to be undertaken in the subsector should focus on:

(a) adoption of a transitional strategy to cover the delays in entry into service of the Manantali hydroelectric plant;

(b) modification of Energie du Mali's tariff structure to reflect costs, influence demand (especially during the dry season) and prompt more rational use of electricity;

(c) managing demand and reducing losses in order to make better use of existing infrastructures and defer new investments in the subsector; and

(d) strengthening EDM's capabilities in accordance with the technical assistance program for the Second Power Project and those of the Direction Nationale de l'Hydraulique et de l'Energie (DNHE).

Production and System Development

Description of Subsector

3.2 In 1987, the interconnected network in Mali produced 173 GWh and peak demand was 33.8 MW; 45/ in addition, 17.3 GWh was generated in 10 isolated centers (IBRD map 22070 - Map of Mali's Electrical System and Table 3.1). Approximately 4.7% of the population used electricity, the number of interconnected network customers being about 27,000 46/ plus a further 10,200 users in the isolated centers. In 1987, the Sélingué hydroelectric power station generated nearly 73% of the interconnected network power; installed capacity was 67.5 MW and base load capacity 39.5 MW.

45/ 188.9 GWh and 38.5 MW, respectively, in 1988.

46/ Of which 25,000 in Bamako, the capital, i.e., an electrification rate of the order of 30-35%.

Table 3.1: BASIC SUBSECTOR ELECTRICITY DATA (1987)

	INTERCONNECTED NETWORK	ISOLATED CENTERS	SELF PRODUCTION
Power stations			
Installed capacity (MW)	67.5 a/	11.1	19.0-23.0 b/
Base load capacity (MW)	39.5		
of which: hydroelectric	29.5 d/	0.5 c/	
thermal	10.0 d/ e/	10.6	19.0-23.0
Transmission and distribution system			
Transmission (km) 150 kV	130		
30 kV	75		
15 kV	152	107	
Distribution (km)	273	206	
Gross production (GWh)	173 f/	17.3	
Consumption			
Peak demand (MW)	33.8		
Sales (GWh)	135	12.6	
Customers	26,866	10,163	
Miscellaneous			
Load factor (%)	58		
Losses (%)	22		

a/ 49.2 MW of which is hydroelectric (Sélingué - 4 x 11 MW, Sotuba - 2 x 2.1 MW) and 18.3 MW thermal (Dar Salam). In 1990, 6 MW were added at Dar Salam.
b/ As a rule these are decrepit generating sets, only a few of which could offset EDM insufficiencies.
c/ Félou hydroelectric plant.
d/ During the dry season.
e/ The biggest standby set.
f/ Purchase by EDM from the OEHRN responsible for the Sélingué plant.

Source: EDM and ESMAP estimates.
See Annexes 3.1 and 3.2.

Demand

3.3 Between 1976 and 1987, power consumption increased on the average by 8.3% per year, while peak demand rose by 9.1% per year 47/ (Annex 3.2). In the isolated urban centers, sales increased by roughly 4% per year. It should be noted, however, that sales statistics do not correctly represent demand potential, since the growth rate is dictated by power station capacity and the pace of system development. On the basis of past trends and in the absence of an energy management program in this subsector, interconnected power system consumption growth of between 8% and 9% p.a. for the next 20 years would seem likely (Table 3.2). This forecast reflects the economic constraints and the probable rate of system expansion; it takes into consideration:

47/ *However, 1978-1983 consumption was affected by the Dar Salam power station's mechanical problems.*

(a) The impact of the Second Power Project, 48/ which is to finance extension of the interconnected system to Ségou and development of the distribution systems in the Bamako area and eight secondary centers, in particular;

(b) Extension of the transmission system to Kalana (under way) and Bougouni, Koutiala and Sikasso, and execution of the Manantali regional project;

(c) Reduction of technical and nontechnical losses from about 20% of output in 1988 to 15% in 1992 and stabilizing thereafter; and

(d) Maintenance of the annual load factor at roughly 58-59% and the distribution of consumption between the dry and rainy seasons. 49/

3.4 Without an energy rationalization program or capital expenditure constraints, interconnected system power generation should therefore rise from 182 GWh in 1988 to 479 GWh in 2000 and 756 GWh in 2007, with peak demand increasing from 35.7 MW in 1988 to 93 MW in 2000 and 148 MW in 2007. This would be an average annual increase of interconnected system peak demand of approximately 4% up to 1993 and 6% between 1993 and 2000. Consumption in the isolated urban centers is expected to increase slightly faster than in the interconnected system. In the event of investment constraints being imposed on production or the networks, demand growth would be limited to the increase in supply.

Table 3.2: INTERCONNECTED SYSTEM CONSUMPTION AND OUTPUT FORECASTS (1989 - 2007) a/

	Sales (GWh)	Losses (% of output)	Output (GWh)	% p.a.	Peak demand (MW)	% p.a.
1985	116	21.2	148		28.1	
				7.1		8.3
1988	146	20.0	182		35.7	
				7.9		7.8
1990	174	18.0	212		41.5	
				8.7		8.6
1993	232	15.0	272		53.2	
				8.4		8.3
2000	407	15.0	479		93.1	
				6.7		6.8
2007	642	15.0	756		147.9	

a/ Current interconnected system, including Second Power Project extensions to Ségou and those proposed to Bougouni, Koutiala and Sikasso within the framework of the Manantali project.

Source: ESMAP estimates; Annex 3.3.

48/ *IDA Credit 1988-MLI.*

49/ *Demand is divided almost evenly between the first and second half of the year, even though Sélingué and Sotuba usable hydroelectric capacity is 45% during the dry first half and 55% during the rainy second half; long-term marginal generation costs vary considerably according to the season.*

3.5 In 1987, technical and administrative losses in the interconnected system amounted to 21-22% of gross output and are estimated at roughly 20% for 1988. In 1987, Energie du Mali (EDM) launched a meter-checking campaign covering all its MV customers and main LV customers. A specialized unit handles both metering and supply problems, customer records and payments. If technical losses of 12-14% are accepted for a distribution system such as EDM's, nontechnical losses are therefore put at about 5-6% and might be eliminated or at least reduced to around 2-3%. In view of the distribution system rehabilitation work included in both the First and Second Power Projects, the objective of progressively reducing interconnected system losses to 15% of gross output (not including power station consumption) seems realistic. This reduction would be in the form of a reduction in both technical and administrative losses of the order of 2-3% of gross production.

Investment Program

Introduction

3.6 Based on entry into service of the Manantali hydropower plant in 1995 (Tables 3.3 and 3.4), the cost of the 1989-94 investment program was estimated at the end of 1988 at roughly CFAF 80 billion (US$285 million), not including interest during construction estimated at nearly CFAF 5 billion (US$18 million). A breakdown of the cost of this program by components is given in Table 3.3. Excluding the financing provided by the Organisation pour la Mise en Valeur du Fleuve Sénégal (OMVS) for Mali's share in the Manantali power plant and certain minor investments financed by the State, the investments to be funded by EDM are of the order of CFAF 67 billion (US$239 million). 50/ This program is therefore very ambitious as regards both size and costs and may, moreover, have been underestimated to the extent that, as a result of possible delays in bringing Manantali into service, new diesel power stations will have to be added (para. 3.13).

Table 3.3: ELECTRICITY SUBSECTOR INVESTMENT PROGRAM, 1989-1994
(In 1988 Prices)

	CFAF millions	US$ millions	Percentages a/
Operation 51/	21,840	78	27
Transmission 52/	38,360	137	48
Distribution	12,040	43	15
Tech. assistance	2,560	9	3
Training	1,205	4	1
Miscellaneous	3,860	14	4
TOTAL	79,865	285	100

a/ Rounded off.
Source: Second Power Project Appraisal Report, January 1989.
Details: Annex 3.4.

50/ *Second Power Project Appraisal Report, January 1989.*

51/ *Of which CFAF 15 billion (US$54 million) for Manantali.*

52/ *Of which CFAF 17 billion (US$61 million) for Manantali.*

3.7 The main components of this investment program are:

Table 3.4: MAIN INVESTMENT PROGRAM COMPONENTS

Investment	Date of entry into service
Generation	
Sélingué, Félou, Sotuba rehabilitation, Dar Salam extensions	1989/92
Rehabilitation/addition of isolated power stations at Kayes, Sikasso, Mopti/Sevare, Tombouctou, Fana, Bougouni, Koutiala, Ségou/Markala	1990/94
Entry into service of Manantali	1995/96
Transmission	
Line construction:	
- Sélingué/Kalana	Under way
- Bamako/Ségou	1990
- Ségou/Koutiala and Ségou/Niono	1989/94
- Manantali/Bamako	1995
Distribution	
Rehabilitation, loss reductions and system extensions:	
- Bamako	1989/95
- Kayes, Sikasso, Mopti/Sevare, Tombouctou, Kita, Fana/Diola, Bougouni, Koutiala, Ségou/Markala and Gao	1990/94
Other investments	
Kénié hydroelectric project feasibility study, technical assistance	1990/94
Buildings, logistics, parts, etc.	1990/94
Partial implementation of the Household Energy Project	1990/94

Source: World Bank: Second Power Project Appraisal Report. See Annex 3.4.

Transmission and Distribution Systems

3.8 Transmission system development includes the following components:

(a) The 150 kV, 240 km Bamako (Sirakoro)-Ségou single three-phase line, fed by the Manantali power station and running from the Sirakoro substation (IBRD map 21018) to Ségou, and the 30 kV, 40 km line from Fana to Diola, which initially carried 15 kV. Entry into service is currently envisaged in 1992/1993, before Manantali is commissioned. This construction is nevertheless justified since savings from relatively more efficient thermal units in Bamako will exceed the cost of building and operating a new diesel power station in Ségou to replace the present units;

(b) The 150 kV south loop connecting Ségou-Koutiala-Bougouni-Sélingué, the feasibility of which has been examined by DNHE. Preliminary results indicate that the Ségou-Koutiala (152 km) and the Koutiala-Sikasso sections are economically viable, whereas the Sikasso-Bougouni (202 km) and Bougouni-Sélingué (85 km) sections are not. Subsequent future extensions of the interconnected system extensions should be to the northeast toward Niono (60 and 30 kV lines) and toward San and Djenne from Koutiala;

(c) The 75 km 60 kV line (between Sélingué and Yanfofila) and the 52 km, 30 kV line (from Yanfofila to Kalana) serving the Kalana gold mine is under construction under DNHE supervision. The equipment was supplied in 1982 but work did not start until late 1987; this project was financed by a credit in kind from the USSR for the line, by the Mali Government for construction, and by the EDF for the transformer station. Since the gold mine load is expected to be some 1 MW and 5 GWh/year, construction of a line would seem a marginal solution for meeting such demand. 53/ However, as the equipment is on site and construction has been begun, the project should be completed.

3.9 As regards rehabilitation and extension of the distribution systems, an initial program has been completed within the framework of the IDA First Power Project. A second stage calls for the rehabilitation and extension of distribution in the nonelectrified areas of Bamako54/ and in eight isolated urban centers. 55/

3.10 Distribution system investment cost per kW supplied and by customer is high because of several factors:

(a) low customer density per km of line;

(b) low consumption per connection; and

(c) high construction cost and planning standards not adapted to conditions in Mali.

To ensure the cost-effectiveness of future extensions to the distribution system, more rigorous criteria as to minimum load density of connections and consumption must be adopted. Ways to reduce construction costs should also be found.

53/ *The economic cost of long-term diesel-generated power supply to the mine is estimated at CFAF 70-75/kWh (1988 prices), and that of supply from the 60-kV line is estimated at nearly CFAF 70/kWh with the relatively cheap Manantali energy. Renegotiation of the price of fuel (DDO) with SIR and SAR (para. 4.6) might bring the cost of diesel generation at Kalana down.*

54/ *Approximately 200 km of lines and switching stations.*

55/ *Kayes, Mopti, Sikasso, Fana, Bougouni, Koutiala, Ségou and Markala.*

Manantali Project

3.11 Within the framework of the OMVS regional project, a multipurpose dam has been built at Manantali on the Bafing, a Senegal River tributary (IBRD map 21018), creating a 450 km2 lake with a volume of 11 km3. A 4 x 50 MW power station with an average annual capacity of around 800 GWh is planned. On the basis of the present agreement between OMVS partners, output is to be distributed as follows: 52% to Mali, 33% to Senegal and 15% to Mauritania. Mali should therefore obtain 100 MW and 402 GWh from the project. Generation equipment requirements to meet demand growth in Mali's inter-connected system were analyzed in the master plan study for generation and transmission in 1987/88 56/ (Table 3.5), according to which the Manantali hydroelectric project is seen as forming part of the least-cost supply solution for the country. A 295 km, 220 kV single three-phase high-voltage line would be needed to connect Manantali with Bamako. Since Mali's share would initially exceed its requirements (para. 3.4), part of this energy would be sold to Senegal, whose power requirements are five times greater than Mali's.

3.12 Since the master plan which envisaged Manantali entering service in 1993, considerable delays have occurred. The in-service date will not now be before 1995 at the earliest, and more likely not before 1996/97, taking into account the current political problems between Senegal and Mauritania plus the fact that certain questions, such as the financing of the project, the terms of resale of power to Senegal, and line ownership and maintenance, have not yet been settled.

Table 3.5: PROPOSED ADDITIONAL INTERCONNECTED SYSTEM GENERATING FACILITIES

Year of entry into service	Additional Type Facilities	Types
1990-1991	2 X 6 MW	Diesel Dar Salam a/
1993	2 x 40 MW	Manantali (hydro) b/
2000	6 MW	Diesel
2002/3	+ 40 MW	Manantali (hydro)

a/ A GMW set was brought into service during the first part of 1990.
b/ See para. 3.12.

Source: Master Plan Study (Tractionnel - Electrobel, 1988).

Options to be Considered in Light of Delays with Manantali

3.13 The main problem facing the electricity subsector today derives from the delays that have already occurred and those that are likely to occur in the future regarding the entry into service of the Manantali hydroelectric plant (para. 3.11). The delays also negatively impact the return on the Bamako-Ségou transmission line. Each additional year's delay in bringing Manantali into service will entail the addition of 5-6 MW of capacity and development of a transition strategy.

56/ *Power Sector Master Plan, Tractionnel, Electrobel Engineering, January 1988.*

3.14 Given these delays, Mali's short and medium-term options for dealing with the growth in demand for electricity appear very limited, and new diesel sets will probably have to be added. The hydroelectric sites will either be very expensive to develop (particularly Markala and Sotuba II), or their potential output will vary considerably from one season or year to another, or they cannot be brought into service for six to seven years, as in the case of Kénié, which is at the feasibility study stage. (Annex 3.5 sets out the capital and production costs of various generation alternatives in Mali.) Additional production capacity needs were recently analyzed; 57/ it is proposed to add diesel sets of 5-6 MW, the first in 1991 and further units in light of changes in demand and in the estimates for power not supplied. 58/

3.15 Opting for larger generating sets (e.g. 20 MW, to permit production savings of 8-10% at best in comparison with 6 MW sets) does not seem warranted, given (a) a current demand of 34 MW (para. 3.2), (b) technical and economic considerations, 59/ and (c) the capital that would be tied up unproductively in light of the fact that the growth of demand should be around 5-6 MW a year.

Transition Strategy - Recommendations

3.16 Given the probable delays in entry into service of the Manantali power plant, development and implementation of a transition strategy is recommended. Such a strategy would combine the following measures:

(a) Speeding up if possible of the negotiations with the OMVS partner countries and donors with a view to bringing Manantali into service;

(b) Acceleration of implementation of the technical and nontechnical loss reduction program (para. 3.5);

(c) Tariff restructuring, power demand management and an energy savings program. Such a program would make it possible to reduce consumption by the equivalent of around two years of demand growth, and hence to defer investments;

(d) A selective slowing down of distribution network expansion and new connections for a limited time in order to reduce the rate of growth of consumption and hence avoid any investment in diesel generators around 1994;

(e) An analysis of the energy and power that private generators might be able to supply; and

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57/ *Thermal Transition Study - Provisional Report, Electricité de France, June 1989, and Diesel Sets Equipment Program, EDM, September 1989.*

58/ *If the aim is to fully meet demand during the benchmark dry year, the capacity of the new plant should be 5-6 MW/year. When a breakdown cost is added (EDF study), the "optimal" additions, if Manantali is brought into service in 1996, would be a 6 MW set in 1991 and another similar set in 1994.*

59/ *As a general rule, the largest set should not provide more than 15 to 20% of peak demand.*

(f) On the basis of the requirements still to be met, making detailed studies for the addition of thermal capacity in Bamako.

(g) detailed analysis of other hydroelectric options, particularly Kénié (para. 3.17).

Other Recommended Actions

3.17 Other recommendations concerning the development of generation, transmission and distribution facilities are as follows:

(a) The principle of annually updating the EDM investment program was accepted during the negotiations on the Second Power Project. It is therefore recommended that EDM recruit, as soon as possible, three persons who would constitute the core of its planning department. This team would participate in the preparation of the next investment program, the Second Project and the distribution projects, and should also periodically evaluate scenarios concerning interconnected system generating capacity development, in light of the latest information regarding the in-service date for Manantali;

(b) Make feasibility studies for the Kénié project, the financing of which is included in the second IDA project, and encourage OMVS to study power plants at Gouina and Félou and possibly other sites. 60/ These studies should be started as soon as possible, since Manantali's output is expected to be absorbed by the year 2000;

(c) Review Sélingué capacity availability. Since its entry into service in 1980, flows at Sélingué have fallen short of the initial estimates. This capacity should therefore be re-evaluated in the context of the interconnected system energy and power update. This might be done within the framework of the recommended EDM study on pricing (para. 3.22); and

(d) Reduce distribution line construction cost through the adoption of standards in line with conditions in Mali (para. 3.10).

Pricing

Introduction

3.18 Following a tariff study made in 1985, 61/ tariffs were increased by 35% and the selling price of the Sélingué hydroelectric energy by 26%. This made it possible to align the average

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60/ The Gouina and Félou studies can be financed within the framework of the Manantali project.

61/ Electric energy pricing study - EDF (January 1987) and Sélingué activities pricing study - EDF (April 1987). These studies were made in 1985 using 1983 data.

tariff on long-term marginal costs 62/ and to restore the financial situation of EDM and of the Office pour l'Exploitation des Ressources Hydrauliques du Haut Niger (OERHN), which operated the plant (para. 3.28). However, in spite of the recommendations, the tariff structure has not been modified. Even though the latest financial projections 63/ do not indicate the need for a rate increase (Annex 3.7), the need to modify the tariff structure (Table 3.6), i.e., to introduce a progressive structure to replace the current degressive one, still remains, since this would encourage energy savings.

Table 3.6: SIMPLIFIED PRESENT TARIFF STRUCTURE

	CFAF		US$	
	Annual fixed charge /kW subscribed	/kWh	Annual fixed charge /kW subscribed	/kWh
Social tariff (max. 1 kVA)		58		.21
LV domestic tariff				
less than 50 h/units of power		76		.27
2nd block of 50 h		68		.24
Over 100 h		49		.18
LV Motive power	10,944		36	
1st block		68		.24
2nd block		57	.20	
3rd block		46	.16	
MV 15/30 kV	10,944		36	
period: peak		63		.23
off-peak		46		.16
night		34		.12
		64		.23
Billing periods: peak : 18:00-24:00				
off-peak: 6:30-18:00				
night : 24:00- 6:30				

Source: EDM and ESMAP estimates.

3.19 Apart from two minor changes, EDM's tariff structure has not been modified since 1961. Although several studies have recommended changes, these recommendations have not been implemented with the exception of general adjustments which have, however, been applied across the board.

3.20 The uniform tariff increase, which amounted on average to 35%, in 1985 has actually aggravated the distortions between LV and MV that it was supposed to lessen. The MV tariff structure was improved in 1985 with the introduction of hourly tranches, but a number of distortions still remain.

62/ *The study estimated interconnected system marginal generation cost based on the addition of thermal units at CFAF 45.5/kWh (US$.162/kWh)) (Annex 3.5). As regards LV, power supply cost was estimated at CFAF 83/kWh (US$.296/kWh), or slightly in excess of current rates (Annex 3.6). The EDF rate study (1985 data, proposed assuming a marginal production cost of CFAF 40/kWh (US$.143/kWh) and of CFAF 67/kWh for LV (US$.239/kWh).*

63/ *Second Power Project Appraisal Report.*

Recommendations - EDM Tariffs

3.21 A new tariff study is planned within the framework of the Second Power Project; it is essential that it be made rapidly and its recommendations implemented as soon as possible. To ensure that the recommendations are taken into account, it is also recommended that the preparation of the Third Power Project be tied to application of the tariff changes proposed. Aspects that should be analyzed in detail in this new study are:

(a) Long-run marginal cost estimates (and not short-run ones as in the last tariff study) and assessment of the impact on pricing of further delays in bringing Manantali into service;

(b) Changing of the degressive power tariff for domestic service customers, and adoption of a progressive tariff;

(c) Introduction, for all LV customers, of a fixed premium, and for the larger ones, especially those using air conditioning, of a seasonal or hourly rate; and for MV customers, re-evaluation of the demand premium; 64/

(d) Analysis of any cross-subsidization between MV and LV; 65/

(e) Analysis of the current power factor penalty;

(f) Evaluation of the impact of introduction of an automatic fuel cost recovery clause protecting EDM against oil price increases and variations in water flows; and

(g) Verification that all the assets used in the subsector have been taken into account in the tariff base and that an adequate return is obtained on them.

Recommendations - Pricing of Sélingué Production

3.22 The current OEHRN tariff dates back to the years when Sélingué had not yet reached full capacity. As a result, the per kWh cost was calculated on a lower output basis than at present. Since the possible maximum annual output depends on the reservoir's operating rules, the kWh base can also vary. In addition, historical data on hydroelectrics is now larger, so that the Sélingué available output could be re-estimated using the reservoir management model available at EDM. It is therefore recommended that both aspects, Sélingué pricing and available output, be analyzed within the framework of a single study included in the technical assistance financed under the Second Power Project.

64/ *Thus, the demand premium for an MV consumer amounts to less than 10% of his annual bill, which does not encourage better management of his demand.*

65/ *It is important to note than two thirds of the LV customers benefit from the social tariff and that 5% of LV consumers account for 50% of electricity consumption.*

Demand Management

Potential Energy Savings

3.23 No analysis of potential energy savings from a more efficient use of power in the household sector (lighting, refrigeration, air conditioning and domestic hot water), in public and private buildings (air conditioning and hot water) and in industry (even though some consumers have already installed condensers) has been made, so the potential is not known. On the other hand, part of the demand responsible for daily peaks currently occurring between 7 p.m. and 10 p.m. (hot water in particular) might possibly be economically shifted to off-peak hours. 66/ As already noted, energy savings could make it possible to defer investment in thermal generating units and, possibly, in networks.

Recommendations

3.24 What is proposed is a rapid analysis of the options, costs and benefits of an energy savings and demand management program based on the experience gained in other countries and oriented toward concrete measures, such as, in particular, analysis of the air-conditioning load based on a survey of major consumers, comprising checking of equipment and evaluation of the benefits of a seasonal tariff, the potential, the return obtainable and the ways of managing this particular load (see Chapter VI on Energy Rationalization). In addition, as part of a program to reduce network losses, EDM should make a systematic analysis of main MV and LV customer consumption to evaluate the potential for and return obtainable from installing new condensers. 67/ It is recommended that EDM then advise customers of the conclusions. It will be up to them to decide whether or not to make the required investments.

3.25 For these measures to bear fr t, EDM's tariff structure will also have to be modified, in particular as regards fixed charges and the power factor penalty (para. 3.21).

Subsector Management

Present Management Policy and Organization

3.26 The subsector's management policy, formulated before the start of the Second Power Project, is based on the following objectives:

(a) As a general rule, the State entrusts technical responsibility for planning, construction and operation of Mali's power facilities, with the exception of regional or multipurpose

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66/ *To cite an example, the Bamako Grand Hôtel has taken advantage of EDM's hourly rates to install thermostat-clocks on water heaters.*

67/ *EDM has made a preliminary analysis and a certain number of condensers have been installed in industrial plants.*

facilities, to EDM. However, the State can authorize other parties to produce, transmit and distribute electricity; 68/

(b) Entrusting the establishment of subsector policies, general planning, regulation and control to MIHE; and

(c) Strengthening EDM's planning and financial management capacities and introducing electricity and water performance contracts, which, among other things, would enable monitoring of the training and technical assistance program financed under the Second Power Project.

3.27 Various studies to remedy the subsector's poor coordination and definition of responsibilities were financed under the First Power Project. Institutional and organizational aspect analyses have been completed and have led to institutional reforms. A human resources study was made in 1989, evaluating subsector personnel, developing a training program and specifying future technical assistance requirements. Following the institutional reform approved in the second half of 1988, subsector management responsibilities are now essentially split between:

(a) The Direction Nationale de l'Hydraulique et de l'Energie (DNHE) of the Ministry of Industry, Hydraulics and Energy is responsible for overall policy, general planning, regulation and control; and

(b) Energie du Mali (EDM), which has sole responsibility for technical planning, construction, operation and maintenance of public power and drinking water facilities in Mali, which it is authorized by the State to manage. 69/ EDM operates according to the concession system, i.e. it operates State-owned facilities in addition to its own. 70/ It employs roughly 1,000 persons and receives significant technical assistance.

3.28 The other subsector institutions are:

(a) The Office pour l'Exploitation des Ressources Hydraulique du Haut Niger (OERHN), a governmental institution, initially created to operate the Sélingué hydroelectric power station and to develop irrigation and fisheries. As of January 1, 1990, EDM has taken over management of OEHRN's electromechanical plant; 71/ and

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68/ *Law 90/10-AN-RM of February 19, 1990.*

69/ *For the short and medium term, and in view of the limited capabilities presently available in Mali, EDM will control both power and water, but will keep two separate sets of accounts. When circumstances, especially the financial context, permit, an autonomous water authority may be created.*

70/ *Under certain conditions, as regards tariffs in particular.*

71/ *With OERHN retaining ownership of the assets.*

(b) The Organisation pour le Mise en Valeur du Fleuve Sénégal (OMVS), responsible for the development of the Senegal basin. This tripartite organization (Mali, Mauritania and Senegal) 72/ is to construct the Manantali hydroelectric power station and 1,850 km of lines in the three countries at a total cost of US$433 million (1989 prices).

3.29 The principal subsector management problems and the measures under way to solve them are as follows:

(a) At EDM, personnel are poorly motivated. There is a lack of qualified personnel, responsibilities are not clearly defined, there is no accounting or administrative system and the institution has financial constraints. To handle the majority of important issues, EDM has had to resort to external resources, which has frequently involved placing expatriates in management positions. To date, EDM has neither a satisfactory cost accounting system nor a satisfactory statistical system, and, therefore, no data management system (para. 3.32). A plan of action for institutional strengthening of EDM was included in the First Water/Power Project, but its objectives were only partially achieved. During the preparation of the Second Power Project, agreement was reached on a revised action plan, implementation of which has begun. Over the past year, EDM has been working on changing its organizational structure, while considerable progress has been made in client account management, accounting and administration, particularly as regards preparation of separate operating budgets for the power and water sections. An inventory control system is also being set up. The new distribution department structure is operational and the meter calibration and connection verification unit has posted excellent results (para. 3.5); and

(b) DNHE is understaffed. Currently, there is just the department head with four engineers, whose training and experience appear insufficient to handle both planning, regulation/control and administrative management of the power subsector and the energy sector.

Recommendations

3.30 The principal recommendations as regards management of the subsector are:

(a) For DNHE, for it to be able to handle its responsibilities in both the Power subsector and the Energy sector as a whole, the capabilities of its staff in the field of economic and financial appraisal of projects and policies should be strengthened first of all. Limited technical assistance is accordingly proposed here. The objectives of this technical assistance are detailed in Chapter VII on Management of the Energy Sector; and

(b) As regards EDM, the recommendations of the manpower study and the organizational capacity strengthening program, including technical assistance and training, were

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72/ *Guinea has recently joined the organization but is not a partner in the Manantali project.*

submitted to IDA in the context of the Second Power Project. The technical assistance program is expected to be finalized in 1990, which will allow the recommendations of this report to be taken into account.

Management Information System

3.31 Although EDM has an abundance of data, there is no organized data system, while the Statistics Unit consists of only two persons who are not well qualified in this field. Moreover, the data are not, as a rule, very reliable.

Recommendations

3.32 It is therefore recommended that EDM introduce an information system that will determine:

(a) The periodic reports indispensable for good management;

(b) The kind of data required for the preparation of such reports (on generation, networks, customers, accounting, finances, etc.);

(c) The data-processing system and the data-base management system thus created, together with the forms for gathering and recording the data.

To operate such a system, the Statistics Unit personnel should be trained under the technical assistance with the Second Power Project.

3.33 In addition, it would appear necessary to design and implement a system of measurement and management of network data. Though transformer load and voltages are recorded, there is no system for storing and managing these data. Since many network tasks will be performed under the Second Power Project, it is recommended that the contracts to be signed include provision of a complete system capable of measuring network data before and after rehabilitation and managing these data on a permanent basis (computerized, if possible), as well as ensuring the training of EDM personnel and the transfer to EDM of all data accumulated during the works.

Short-Term Investment and Technical Assistance Program for the Subsector

3.34 An investment and technical assistance program of CFAF 79,865 million (US$285 million) is being financed under the Second Power Project (para. 3.6). It is recommended that the preceding recommendations be included in the terms of reference of the experts to be provided under that Project rather than being made the subject of additional technical assistance. Part of the funds could be allocated to the studies listed in Table 3.7. However, additional technical assistance to DNHE in the electrical energy field is proposed (para. 7.12).

Table 3.7: SUBSECTOR INVESTMENTS AND TECHNICAL ASSISTANCE

	CFAF Millions	US$ Millions
(a) Electricity Subsector Investment Program (Second Power Project) 1989-1994 (1988 prices)		
Investment program	79,865	285
of which Tech. Assistance	2,560	9
Training	1,205	4
(b) Studies proposed for Financing under the Second Power Project		
Pricing and re-estimating of Sélingué available output	42	0.15
Power factor analysis	42	0.15
Analysis of measures to reduce distribution costs	42	0.15
TOTAL	126	0.45
(c) Long-Term Studies (financed by OMVS)		
Gouina and Félou hydroelectric plant feasibility studies	560	2.00

IV. THE HYDROCARBONS SUBSECTOR

Principal Issues, Options and Recommendations

4.1 This chapter analyzes the main problems of the hydrocarbons subsector and puts forward a certain number of recommendations. Overall, actions to be undertaken in this subsector should focus primarily on:

(a) Optimizing sources of supply, quality, distribution safety and the review of storage programs;

(b) Reducing the cost of oil products and diversifying purchasing options by obtaining rights of access to port and storage facilities at Dakar and Abidjan;

(c) Changing domestic pricing methods and simplifying taxation; and

(d) Reorganizing the administrative management of the subsector by consolidating the various authorities concerned with the subsector into a single entity to ensure better coordination of activities, better control and creation of a reliable data base.

Organization of Supply

Current Consumption and Outlook

4.2 Mali's total petroleum product consumption for 1987 73/ is put at 171,000 tons. This figure is only an estimate, because data for the two main products (gasoline and gas oil, which make up 68% of total consumption) are not reliable. Inconsistencies between data sources are probably due to the presence of a considerable number of independent distributors. 74/ Per-product estimates as of 1980 are shown in Table 4.1 and market shares per supplier for gasoline and gas oil are shown in Table 4.2. Average consumption in 1987 was 22 kg/capita, which is comparable with that of countries with a similar per capita GNP. The transport sector uses nearly 70% of the products and the industrial sector 15%.

73/ *Last year for which data are available.*

74/ *Up till 1988, the country was supplied almost exclusively by BP, Shell, Mobil and Total-Texaco, which together form the Groupement des Professionnels de l'Industrie du Pétrole du Mali (GPP). The group obtains its supplies from the Dakar and Abidjan refineries. In the course of 1988, independent distributors (the Independents) assumed an important role in providing supplies, essentially from Lomé (Togo). The supply systems are analyzed in detail in the next sections and in Annex 4.3.*

The capital, Bamako, accounts for over 60% of total oil product consumption. Annex 4.1 presents a detailed analysis of past consumption figures and the current outlook.

Table 4.1: OIL PRODUCT CONSUMPTION (1980-1987)

	Tons				Growth rate	
	1980	1981	1982	1987	1980-87	1982-87
LPG	199	238	231	536	15.2	18.3
Gasoline	63,697	57,503	53,950	61,976	-0.4	2.8
Aviation gasoline	530	454	495	332	-6.5	-7.7
Kerosene	12,586	12,285	12,013	13,150	0.6	1.8
Jet fuel	13,684	12,216	10,480	12,538	-1.2	3.7
Gas oil	48,943	43,137	40,511	54,427	1.5	6.1
Diesel fuel	22,217	16,264	15,964	22,764	0.3	7.4
Fuel oil	5,856	4,442	2,975	5,377	-1.2	12.6
Total	167,712	146,539	136,619	171,100	0.3	4.6
	Real relative selling prices, 1979 = 100					
Gasoline	161	203	217	85		
Kerosene	137	163	177	70		
Gas oil	155	193	207	81		

Source: ONT and ESMAP estimates.
Details in Annex 1.3.

Table 4.2: PRODUCT ORIGINS (1987)

	Tons		
	Total	GPP	Independents (+ Pétrostock)
Abidjan	45,893	45,893	0
Dakar	75,572	75,572	0
Lomé	42,160	8,338	33,822
Other	7,475	500	6,975
Total	171,100	130,303	40,797

Source: ONT and ESMAP estimates.

4.3 Two subperiods can be distinguished in past consumption history: 1980-82, during which prices rose in real terms but consumption fell for all products, LPG excepted, and 1983-87, during which consumption rose while real prices fell (Table 4.1). According to the trend-based scenario, Mali's total oil product consumption will increase by a factor of 1.7, from 171,000 tons in 1987 to 290,000 tons in 2000, i.e., an average growth of 4.2%. This growth will nevertheless vary substantially from product to product, with consumption of the two main ones, gasoline and gas oil, growing by 5% and 4% p.a. respectively, while that of LPG rises more rapidly.

Petroleum Resources and Supply Sources

4.4 Mali has no petroleum resources; 75/ moreover, its landlocked situation and the length of its supply lines make the country fully dependent on the port facilities and road networks of neighboring countries for its oil supplies. 76/ Consequently, supply security, the determination and management of strategic stocks and supply source diversification to avoid disastrous shortages are essential concerns. The cost of imported oil products is another concern to the Government; because of its geographic location, in particular, its neighboring supplier countries consider Mali a captive market and charge it prices well above world levels (para. 4.30-4.31).

4.5 The two main sources of supply currently used by the Groupement Professionnel de l'Industrie du Pétrole du Mali (GPP) are the SAR refinery at Dakar and the SIR refinery at Abidjan. 77/ 78/ The Independents, who have a considerable share of the gasoline and gas oil market these days, 79/ supply themselves essentially from Lomé, and since March 1989 from Abidjan, though to a lesser extent. In addition, a small quantity is imported from Parakou (Benin) for the area east of Gao. The national oil company, Pétrostock (paras. 4.10 and 4.21) has also, though only very infrequently, imported small amounts from Guinea and Nigeria. The breakdown of supplies by source is shown in Table 4.2.

Recommendations

4.6 The main supply problem facing Mali today is that its supplies cannot pass through the ports of Dakar and Abidjan, since it is denied access to depot storage facilities in those ports. Consequently, Mali should reopen discussions on direct purchasing in the international market and on the use of the unloading and transfer facilities at Dakar and Abidjan. 80/ It is therefore recommended that Government-level talks be reopened to obtain access to depot storage facilities at Abidjan and Dakar, thereby enabling Mali to acquire products directly on the international markets and convey them to Mali. These negotiations and the associated studies would benefit from the experience of international oil marketing, shipping and trade consultants.

75/ *Annex 4.2 gives a summary of exploration results.*

76/ *Essentially Dakar, Abidjan and Lomé.*

77/ *By rail (Régie des Chemins de Fer du Sénégal (RCFS) for the Senegal part and Régie des Chemins de Fer du Mali (RCFM) in Mali), via the Diboli border crossing, and further by way of Kayes to Bamako.*

78/ *By road, crossing the border at Zégou, for the Sikasso, Koutiala, San, Mopti, Ségou and Bamako regions.*

79/ *In 1987, 42% of the gasoline market and 26% of the gas oil market. Recent ex-refinery price reductions at Dakar and Abidjan should nevertheless reduce or eliminate profits on imports from Lomé, the Independents' main source of supply.*

80/ *Even though the 1988 and 1989 talks enable Mali to considerably reduce ex-Abidjan and ex-Dakar prices (para. 4.30), negotiations broke down on the question of the use of the existing unloading and storage facilities.*

4.7 Moreover, the new institution to manage the subsector, creation of which is proposed, should review the breakdown of imports by source of supply (para. 4.23), so that the country can benefit from the lower ex-Dakar transport prices. Annex 4.4 shows supply cost and economic supply zones for the different centers of consumption under the old cost structure. Currently, supply by rail from Dakar is the most economical (para. 4.27) and should be preferred while maintaining a variety of routes and sources of supply. The present Dakar-Bamako railway capacity is approximately 131,000 m^3/year (105,000 tons/year). Rolling stock condition and management have been considerably improved during the past two or three years; with continued improvement of personnel training, and provided the RCFM continues to receive technical assistance, rolling stock turn-arounds could attain two to three times per month, which would increase the railway's capacity to approximately 197,000 m^3/year (158,000 tons). However, even under these conditions, only 70% of Mali's future requirements could be covered by rail. To hold supply costs as low as possible, it is therefore recommended that the new institution managing the subsector make a detailed analysis of capacities, possible bottlenecks and actions to be taken.

Storage and Intermediate Depots

4.8 Oil product storage capacity in Mali is currently 21,400 m^3, mainly concentrated at the Mobil depot in Bamako and the airport. There are also two small depots at Kayes (380 m^3) and Tombouctou (780 m^3). The main depot in Bamako is located in a densely populated area; the access road to it is in bad condition and congested and there are unauthorized buildings inside the depot's security perimeter. Its capacity could be increased by about 50% by adding three or four storage tanks.

4.9 GPP policy is to stock the equivalent of 30 days' consumption for Bamako and environs in the city. For 1987, this meant approximately 7,900 m^3 or less than half the current Bamako storage capacity. Bearing in mind that the working stock represents 15 days' consumption, the present GPP stock therefore includes a strategic stock of about 15 days' consumption.

4.10 However, current regulations require strategic reserves to be equivalent to 73 days' consumption. 81/ Pétrostock, the national company responsible for oil products, had accordingly planned to progressively construct storage facilities with a capacity for a 75-day supply, i.e., a total of 100,000 m^3, and has started construction of a first tank farm of 7,200 m^3 at Kayes, the cost of which is estimated at CFAF 2.3 billion (US$8.3 million). Before the implementation of this strategy is pursued, the following factors should be considered:

(a) The rationale behind maintaining strategic reserves of this size, in light of the costs entailed;

(b) The opportunity cost of keeping stocks worth about CFAF 610 million would be of the order of CFAF 100 million/year 82/ while the annual storage plant cost (operating and financial costs, but not including amortization of principal) would be some CFAF 300 million/year (US$1.1 million/year). Finally, losses are estimated at 3% over and above the deterioration that could occur when products are held over a long period;

81/ *Decree dated May 1933.*

82/ *On the basis of an average annual stock of 6,100 m^3 or 85% of storage depot capacity.*

(c) With annual consumption in the Kayes area being approximately 9,000 m^3, this stock would represent about eight months' consumption for that region and would be poorly located to supply the main market, which is Bamako. This would also lead to annual losses of roughly 3% by volume.

(d) Finally, the cost of the Kayes depot (US$1,150/$m^3$ or CFAF 322,000/m^3) seems much higher than it might have been had international bidding been applied.

Recommendations

4.11 The Mali Government has recently acknowledged that the strategic reserve and depot construction program was too ambitious and poorly adapted to requirements. The review of the program should therefore focus on:

(a) Capital and operating costs, in particular losses, the country's financial capacity, benefits, and actual strategic reserve requirements in light of existing sources of supply (para. 4.10);

(b) Practice in the countries of the region; 83/

(c) Incorporation of the new facilities and stocks into the current and future oil product distribution network; and

(d) Construction savings obtainable by having such storage facilities built on the basis of international bidding.

This detailed review should be one of the priorities of the new institution that will manage the subsector. An initial analysis of the main options was made in the Skaarup study, 84/ and by Pétrostock. The study concluded that it should be possible to surmount any interruptions in supply by less costly measures than substantial investments in storage depots.

Distribution

4.12 Mali currently has 135 authorized service stations. 85/ In addition, there are about 200 authorized "mixers," selling two-stroke fuel (for mopeds, etc.) A substantial number of "unauthorized" distributors also sell oil products; 86/ evaporation, losses and soil contamination are

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83/ *Actual strategic reserves in the countries of the region are not generally in accordance with the relevant legislation and amount to roughly one months' consumption. However, there are no generally accepted standards in the region.*

84/ *Skaarup Oil Corporation Report, June 1989. Study to improve oil product supply and distribution procedures in Mali.*

85/ *One hundred twenty of which are owned or controlled by GPP, 12 by independent distributors and three by Pétrostock. There are 50 service stations in Bamako (Annex 4.4).*

86/ *Roughly 65% of oil product consumption is distributed by the formal distribution network.*

considerable in such establishments. This activity is moreover dangerous and should be eliminated or controlled.

4.13 As regards quality of oil products, and even though the National Directorate of Geology and Mines (DNGM) has the authority, equipment and trained personnel for the purpose, there is currently no program for periodically sampling and testing products.

Recommendations

4.14 To eliminate unsafe practices by Independents during product transfer as well as during storage and "informal" distribution, current regulations should be enforced by the new institution proposed for the subsector (para. 4.23), with special attention to informal distributors.

4.15 The institutions managing and controlling the subsector and DNGM should examine product quality problems and introduce a quality control program; funding should be made available for developing this program and, above all, conducting continuous checks of retailers. The DNGM laboratory and its currently underemployed personnel could be used for this purpose.

Subsector Management

Current Organization of Subsector Management

4.16 Management of Mali's petroleum sector is complicated by: (a) the small size of the market, (b) the size of the country, 87/ and the length of its borders, (c) the various supply channels serving such a sprawling market. In addition, all hydrocarbons are imported and extremely costly, but are also a major source of Government revenue. This has led to an environment subject to strict control by a cumbersome administrative apparatus, in a context that is now changing.

4.17 At the present time, administrative responsibilities for the subsector are scattered among many public services and the private sector, where the number of parties involved has also become considerable (Annex 4.5). The main public sector authorities are:

(a) The Office National des Transports (ONT - supervision, transport, policy on stocks);

(b) The National Directorate of Geology and Mines (DNGM - specifications and product quality control, certification of plant and facilities);

(c) The National Directorate of Hydraulics and Energy (DNHE - energy planning);

(d) The Office de Stabilisation et de Régulation des Prix (OSRP - price structure, equalization);

(e) The Directorate of Economic Affairs (DNAE-licenses, weights and measures);

87/ *1.2 million km².*

(f) The Customs Directorate (fiscal revenue);

(g) Pétrostock (construction and management of storage facilities); and finally

(h) The Commission Nationale des Hydrocarbures 88/ (CNH - policy definition, price structures, preparation of recommendations).

Supply is controlled by the local subsidiaries of four multinationals organized in the GPP (para. 4.2), who also have minority interests in the Dakar and Abidjan source refineries, as well as by Independents (Annex 4.5).

4.18 This rigid framework has broken down recently with the entry on the scene of independent importers controlling a large part of the Bamako gasoline and gas oil market, together with the collapse as of mid-1988 of the transport voucher system and the rise in the number of unauthorized distributors. In principle, the advent of the Independents should have created competition, which in turn ought to have led to lower prices at the pumps. However, since retail prices are controlled by the Government, consumers have not benefited from any price reductions at all. Meanwhile the lack of adequate controls and the proliferation of small stocks of products constitutes a threat to public safety.

4.19 This institutional complexity has created or aggravated the following problems:

(a) Absence of a consistent subsector policy. The current organization of oil product distribution has not resulted from planned liberalization in which all participants are subject to the same rules. Access to storage facilities, for example, is limited to GPP and Pétrostock; GPP members pay the Stabilization Fund (para. 4.29) after delivery, whereas Independents pay when the import license is granted; in theory, Independents are not allowed to obtain supplies from Dakar or Abidjan. A decree designed to ensure the same treatment for all concerned was prepared in 1987, but was not promulgated;

(b) Dispersion of national capabilities, few enough to begin with, among many departments and services that are individually too small (having one or two staff) to have any real impact on the subsector's activities. Even though the subsector is of critical importance to the country, the majority of issues (supply, quality, price, taxation, etc.) are handled by small units scattered among various institutions and acting without coordination apart from CNH which, however, only meets twice a year.

(c) Ambiguous definition and distribution of responsibilities between various public services on the one hand and the private sector on the other. This applies more particularly to Pétrostock, whose role vis-à-vis that of the private sector and its objectives have been poorly defined, while it also lacks adequate financial resources.

(d) Lack of reliable statistics (para. 4.25).

88/ *A consultative body. ONT provides CNH's permanent secretariat.*

Pétrostock

4.20 Pétrostock is a national oil products company formed in 1981 to build and operate storage facilities. It can also import products for the national strategic reserve (para. 4.10) or for its own account for the three service stations it owns in Bamako and to supply the parts of the country that are difficult to access and commercially unattractive to private companies. From the beginning, Pétrostock has encountered problems connected with the nature of its task and its financial constraints. Pétrostock's operations are financed from taxes on DDO, fuel oil and kerosene, the margins on its commercial operations and external loans. The tax revenues are small compared with requirements, and donors hesitate about financing storage facilities and strategic reserves, while the company's operating statements show that public enterprises have run up bad debts. Pétrostock's main achievement has been the Kayes storage plant built at a very high cost for such a project (para. 4.10).

Recommendations

4.21 A new policy for managing the subsector therefore needs to be formulated. The subsector is currently moving from a situation where the GPP had a monopoly and the Government regulated all activities to a different, more liberal system in which import licenses are granted to all who meet certain minimum conditions. In the present circumstances, this liberalization seems appropriate and the Government should assess the different options to determine: the State's priorities (including keeping the oil bill to a minimum), the respective roles of the public and private sectors, and the rules applying to all participants.

4.22 For this to be done, the present administrative structures dealing with the subsector should be consolidated into a single institution, for example, a National Hydrocarbons Directorate. This should eliminate a certain number of the bodies currently involved. This new institution, which would combine powers that are presently dispersed, might be attached to any of several ministries: MIHE, in light of its mandate to manage the energy sector, might be chosen in line with the arrangements in several countries; or OSRP, which is in the Finance Ministry, and already handles certain activities; or again ONT, which is attached to the Ministry of Transport, Public Works and Telecommunications, and currently provides CNH's permanent secretariat. The new institution would be responsible for formulating price, supply and storage policies, data collection and management and the preparation and implementation of regulations, 89/ etc. Some preliminary considerations regarding the role of this new institution are put forward in Annex 4.5. Whatever the Government's final choice, periodic technical assistance for a period of two years is proposed to allow for establishment of the new institution and preparation of priority analyses (para. 4.32).

4.23 Finally, in light of the present policy for withdrawing the State from commercial activities and the private sector's ability to handle Pétrostock's functions, it is recommended that Pétrostock's role be reviewed, for example in the context of the study of the 22 public companies not covered by PASEP and that the distribution of responsibilities between the State and the private sector also be reviewed at the same time. A certain number of proposals have already been formulated, and the liquidation of

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89/ *Proposals were also made in the Skaarup report (ibid). For practical reasons, the DNGM laboratory should remain within the MIHE structure and provide the subsector's managers with the services they need, particularly as regards safety inspections of facilities and product quality control.*

Pétrostock and transfer of the personnel needed for subsector operations should be pursued. 90/ The establishment of effective Government control through the creation of a single, efficient hydrocarbons management institution would enable the State to maintain the necessary strategic reserves, under private sector management.

Availability and Quality of Data

4.24 The availability and the quality of data concerning consumption, stocks, imports and revenues generated leave much to be desired. Information on quantities imported broken down by origin and importer, as well as data on consumption by sector of activity and geographic area, are vital for planning supply, preparation of emergency programs and assessment of the impact subsector plans and programs may have on the economy. The present situation also causes a loss of revenue to the Treasury, since the State is not able to ensure that tax receipts, a very important source of revenue, are consistent with the quantities brought in, especially where the Independents are concerned.

Recommendations

4.25 Development of an information system (data gathering, storage, analysis and dissemination) especially geared to handle independent distribution accordingly appears necessary. Such a system, which would improve control of oil products tax payments, would in addition certainly produce a considerable return for the State. The system would entail surveying both the GPP and the Independents, as well as setting up a system of simple statistics, quality control and management of these data. The proposed new institution could do this, with some initial technical assistance (para. 4.23).

Pricing and Taxation of Oil Products

Price Levels, Official Price Structures and Pricing Mechanisms

4.26 As in a number of French-speaking African countries, the prices at the pump for oil products and the various cost components, including operator margins (jet fuel and LPG excluded), are State controlled. Moreover, taxation represents nearly 60% of the price at the pump and ex-Dakar transport costs are approximately US$7/bbl lower than ex-Abidjan costs (Table 4.3).

4.27 Under current regulations, prices at the pump should be the same throughout Mali; however, operators are allowed to offer rebates to big customers. There are two official price structures, each corresponding to one principal source of supply 91/ (Table 4.3). For other sources of supply, used mainly by the Independents, the ex-Abidjan pricing structure is applied. The detailed price structure and the administrative pricing mechanisms are shown in Annexes 4.3 and 4.6 respectively. These structures and mechanisms complicate administration and should therefore be simplified (para. 4.31).

90/ *E.g.: Note on the reformulation of Pétrostock's objectives (December 1987). A new mixed company, Société Malienne d'Entreposage (SME), has been formed.*

91/ *One for products ex SAR-Dakar and another for products ex SIR-Abidjan.*

Table 4.3: PRICE LEVELS AND SIMPLIFIED PRICE STRUCTURES OF THE MAIN OIL PRODUCTS (BEFORE THE 1989 REDUCTIONS)

	CFAF/hl		US$ bbl a/	
	Dakar	Abidjan	Dakar	Abidjan
Gasoline				
Ex-coastal depot	7,217	6,654	40.98	37.78
Transport	2,252	3,392	12.79	19.26
Taxes	17,185	16,631	97.59	94.44
Services	3,346	3,323	19.00	18.87
Total	30,000	30,000	170.36	170.36
% of taxes	57	55		
Kerosene				
Ex-coastal depot	7,863	7,359	44.65	41.79
Transport	2,359	3,392	13.40	19.26
Taxes	7,249	6,741	41.16	38.28
Services	2,529	2,509	14.36	14.24
Total	20,000	20,000	113.57	113.57
% of taxes	36	34		
Gas oil				
Ex-coastal depot	7,628	7,070	43.32	40.15
Transport	2,329	3,392	13.23	19.26
Taxes	8,041	7,558	45.66	42.92
Services	3,002	2,980	17.05	16.92
Total	21,000	21,000	119.25	119.25
% of taxes	38	36		

a/ Exchange rate: US$1 = CFAF 280

Source: ESMAP estimates.
Details: See Annex 4.3.

4.28 The Stabilization Fund is an essential component of the pricing mechanism; it is in theory designed to (a) keep prices at the same level throughout the country, (b) eliminate price discrepancies of imported products and (c) to promote a certain price stability over time. Until recently, the Abidjan and Dakar refineries set prices themselves without any automatic adjustment based on international market prices. Recent agreements have changed this practice and refinery prices are aligned monthly on the Platts Italy quotations.

4.29 As regards current costs of importing products and pricing mechanisms, the chief comments to be made are:

(a) The ex-depot prices charged by both SAR and SIR up till mid-1988 varied between US$315-340/t for gasoline and US$298-318/t for gas oil, i.e., well above import parity. The Government of Mali, helped by consultants, has entered into negotiations with the Côte d'Ivoire and Senegal Governments, SIR and SAR to obtain transit facilities for direct imports and a reduction of ex-refinery prices. 92/ As a result of these talks,

92/ *The ESMAP mission responsible for the Energy Sector evaluation study helped to draft the terms of reference for the consultants and provided guidance during the early stages of their work at the end of 1988.*

a new tariff structure was agreed on early in 1989 and prices are currently between US$180-200/t for gasoline and US$165-185 for gas oil, reflecting Platts Italy quotations plus a fixed premium per ton for storage and handling on land; 93/ prices will be reviewed monthly (Table 4.4). Based on quantities imported in 1988, these reviews should lead to savings for Mali of the order of CFAF 5 billion/year (US$17.9 million/year). Although this is a significant improvement, prices are still above import parity; the ultimate goal for Mali therefore remains direct purchasing in the international market. 94/ To this end, Mali must obtain access to the Abidjan and Dakar port facilities (para. 4.6);

Table 4.4: NEW EX DEPOT PRICES - 1989

PRICE/SOURCE	SAR - Dakar		SIR - Abidjan	
	Gasoline	Gas oil	Gasoline	Gas oil
US$/t				
Price FOB Mediterranean	160	145	160	145
Premium	20	20	40	40
Ex-depot price (mid-1989)	180	165	200	185
CFAF/hl				
Ex-depot price	3,679	3,880	4,088	4,351
Price as of Dec. 1988	7,217	7,628	6,654	7,070
(CFAF/hl)	3,538	3,748	2,566	2,719
(%)	49	49	39	38

Source: Skaarup Oil Corp. Study to improve oil product supply and distribution procedures in Mali, June 1989.

(b) Present policies for setting prices at the pump do not give operators any incentive to achieve greater economic efficiency and will be very difficult to apply on account of the new pricing agreements under which ex-depot prices may change every month. Distributor margins are presently based on the real cost of the services rendered (Annex 4.3); current procedures, therefore, do not reward either risk-taking or better service, seeking out less costly sources of supply 95/ or other cost reductions;

93/ *For SAR this fixed premium, following the negotiations of October 1989, will vary between US$20/t and US$27/t depending on the quantities involved. For SIR, the premium will be US$40/t up to 50,000 t/year, US$37 from 50,001 to 80,000 t/year and US$35 for larger tonnages.*

94/ *This strategy is preferable from an economic viewpoint to buying refined products from Abidjan or Dakar.*

95/ *This policy has precluded obtaining larger quantities from Dakar, although transport costs from Dakar are lower.*

(c) Current taxation is difficult to manage, since numerous institutions are financed by petroleum taxes. 96/ This penalizes both the Treasury, since it is very hard to keep control of these revenues, and operators owing to the cumbersome procedures; and

(d) LPG prices are high because of the SIR ex-depot price, 97/ general overhead and the margins allowed within the price structure, plus the level of losses. Retail LPG prices are currently about US$1,300/t (Table 4.5).

Table 4.5: LPG PRICES AS OF END 1988

		US$/t	CFAF/t
Ex SIR depot-Abidjan		531	148,680
Transport to Bamako plus distributor margins		765	214,200
Total		1,296	362,880
	Shell	Total/Texaco	Shell
Retail price	3 kg	6 kg	12.5 kg
CFAF/kg	351	363	448
US$/t	1,250	1,296	1,600

Source: GPP and ESMAP.
Annex 4.3.

Recommendations

4.30 There is still scope for further oil product cost reductions on the Malian market. Specificactions concerning prices and taxation are set out below and should be implemented by the new institution managing the Hydrocarbons subsector (para. 4.23) immediately after a survey of oil product taxation and pricing mechanisms to be undertaken within the framework of a proposed World Bank (IDA) structural adjustment credit:

(a) Negotiation with the Côte d'Ivoire and Senegal Governments to obtain access to the Abidjan and Dakar facilities; in-depth analysis of other supply options;

(b) Review of the mechanisms for setting prices at the pump, introducing a ceiling price and eliminating the floor price to promote competition in the large towns. Ceiling prices per product would reflect c.i.f prices, estimated transport and distribution costs, taxes and

96/ *Some of which are only very indirectly connected with the subsector (Annexes 4.4 and 4.6).*

97/ *Ex-depot, currently US$530/t. In light of current volumes, including purchase on the international market and transport to Abidjan, LPG cost should be roughly US$350/t.*

margins. These new mechanisms should motivate operators to buy, transport and distribute at least cost;

(c) Simplification of oil product taxation, by imposing a single tax per product, which would be collected by Customs and passed directly to the Treasury. Institutions financed by oil product taxation would, under the new system, obtain their budget appropriations from the General Budget. 98/ This will simplify administrative procedures, improve the control and collection of funds, and clarify the sources and uses of public funds; 99/

(d) Reduction of LPG and kerosene prices by acting on the various price components, including a renegotiation of SIR and SAR prices. The present LPG prices, for instance, could be reduced about US$250/t, or nearly 20%. This would accelerate LPG penetration as a substitute for charcoal; and

(e) A progressive reduction of the tax on kerosene, which currently represents 34% of the retail price, within the framework of the fuelwood substitution programs, but taking into consideration the risk of kerosene being used for motor fuel.

Short-Term Investment and Technical Assistance Program

4.31 Investments in storage and distribution facilities should essentially be financed by the private sector on the basis of a call order contract with the public authorities. The public short-term investment program in this subsector should therefore concentrate on improving management. The bulk of the efforts should be coordinated by the proposed new institution to manage the hydrocarbons subsector, strengthened initially by technical assistance in the form of ad hoc missions over a two-year period to enable the recommended measures to be implemented. The cost of this assistance is estimated at CFAF 185 million (US$660,000) and its principal objectives are set out in Annex 4.5.

98/ *In accordance with a principle already adopted for the Road Fund and the Mining fund.*

99/ *Agreement on a study of these issues was recently reached between the Ministry of Finance and Trade and the World Bank. It should get under way toward the end of 1990.*

V. NEW AND RENEWABLE ENERGIES SUBSECTOR

Principal Issues, Options and Recommendations

5.1 The efforts proposed for the short term (1990-1995) in the new and renewable energies (NRE) subsector reflect the financial and human constraints in Mali and the fact that, for technological and economic reasons, NREs will only make, at least in the short and medium term, a limited contribution to Mali's energy balance. Priorities for action must therefore be established. Future actions in this area should accordingly concentrate on:

(a) refocusing efforts to give priority to a limited number of applications that are technologically proven and economically justified; and

(b) improving the coordination of activities in this area, avoiding duplication of efforts and promoting private sector participation.

The analyses supporting these recommendations are contained in the paragraphs that follow.

Development of the Subsector

Current Resources and Constraints

5.2 Solar energy resources are substantial (Annex 5.1), reliable and relatively well-distributed; 100/ wind energy potential on the other hand is small, irregular and varies by region. Resources in agricultural byproducts 101/ are considerable but are already being used for nonenergy purposes; agroindustrial residues 102/ are mostly used as an energy source or as animal feed. Finally, animal biomass potential is very scattered and collection costs are prohibitive.

5.3 Given Mali's meager conventional energy resources, it is logical that efforts should be made to realize the country's significant potential in NREs, particularly solar energy. The government took an early interest in this field and the Solar Energy Laboratory (LESO) was established in 1965. Almost 25 years later, although Mali's achievements in this subsector surpass those of any other Sahelian

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100/ Average monthly radiation ranges from 4 to 7 kWh/m2/day.

101/ Straw, and millet, sorghum and corn stalks.

102/ Cotton bolls, groundnut shells and rice husks, bagasse and molasses, groundnut cake, etc.

country, NREs are playing only a very limited role and the prospects for the short and medium term are modest. Annex 5.1 contains a summary of Mali's experience with NREs.

5.4 A number of factors are holding back the development of NREs in Mali. Some are exogenous, such as the current prices of replacement energies, particularly petroleum products, and the basic cost of technologies, the availability of financing, the limited size of the market in Mali and the special interests of a number of parties. Other obstacles, however, are local in origin and it is on these that efforts must be focused; among the most important are:

(a) the lack of any clear analysis of markets and of commercial factors in general;

(b) the neglect in Mali of technology evaluation methodologies;

(c) the choice of insufficiently established technologies and the pursuit of overambitious and unrelated objectives; and

(d) the cost of equipment that is heavily taxed, and the lack of financial incentives for users. This has led to numerous failures, both technical and financial, in such areas as thermodynamic solar power stations and the first generation of photovoltaic pumps (Annex 5.1).

The Ethanol and Pourghère Oil Projects

5.5 The project to produce ethanol from molasses, currently operating on a small scale, is an example of an NRE project on which the economic return has been sharply cut by the fall in petroleum prices. It is financed by the World Bank and, in full production, was to have produced 2 million liters of anhydrous ethanol from ordinary molasses. 103/ The project was designed at a time when the international price of oil was about US$35/barrel, making the project clearly profitable for Mali. The drop in international oil prices to around US$20/barrel has markedly reduced the return on the project; indeed, if the capital costs of ethanol production and storage are included, the project is nonviable. However, since the investment has already been made, only the operating costs enter into the calculation; on this basis, a recent supervision mission determined that the project is viable. While this is the case when ethanol is used as a fuel, it is nonetheless possible that the return could be higher if the ethanol were sold as a pharmaceutical or cosmetic product at higher prices. Therefore research into possible alternative outlets for ethanol other than its use as fuel is recommended.

5.6 The SEP Pourghère pilot project was intended to evaluate the technical, economic and financial feasibility of producing engine fuel from pourghère seeds. However, the cost of the fuel produced in this way is significantly higher than for current alternatives. Thus according to the SEP, the production cost, excluding taxes, of a perfect substitute for diesel fuel will be about CFAF 230/L (US$0.80) or almost twice that of imported fuel. The cost of processing, excluding collection of the

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103/ Credit 1403-MLI.

seeds, by itself exceeds the cost of imported fuel. At the beginning of 1990 the SEP stopped work in this area in Mali.

Recommendations

5.7 Despite these drawbacks and while recognizing that in the short and medium term NREs will make only a very small contribution to Mali's energy resources, it is important to preserve certain achievements. Local specialists have been trained and their skills must be utilized; existing research and development infrastructures, particularly the LESO, may be jeopardized in the absence of a specific, well-focused program. Furthermore, the lessons learned from the projects and programs already carried out 104/ have made it possible to identify a limited number of technologies that are both technically reliable and economically and financially viable, 105/ while experience has been gained in the introduction and use of NRE technologies.

5.8 The development of renewable energies in rural areas should focus on applications that represent least-cost solutions for a given demand, or, in the best case, financially profitable applications that can be developed by the private sector. Where the least-cost applications are concerned, the investments required must be measured against other socially beneficial investments (e.g. in health care, production infrastructures, etc.) in the wider context of the development of Mali's rural areas.

5.9 It is therefore recommended that the resources available for this subsector be concentrated on the following applications, on the understanding that marketing and after-sales service should be the responsibility of the private sector:

(a) photovoltaic pumps for village water supply within their range of viability as compared to hand or animal-powered or mechanical pumps, between approximately 200 m^4/day and 1500 m^4/day; 106/

(b) photovoltaic systems for lighting (low-voltage lamp) and recharging accumulators (radio, torch, etc.) and batteries (television sets), for average semiurban areas and certain rural areas. The ESMAP surveys (1989) have, however, confirmed that development of this market partially depends on the availability of credit;

(c) heating of water by solar collectors for the tertiary and industrial sector, provided that costs are reduced, either by importing less expensive equipment or by optimizing that

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104/ *Such as the LESO/USAID Renewable Energy Project from 1979 to 1985, CEES, the SEP, etc.*

105/ *Such as photovoltaic pumps and photovoltaic systems in general.*

106/ *m^4 = pumping height in m multiplied by volume in m^3.*

manufactured by LESO, that this equipment is not taxed, and that there is an adequate after-sales service; 107/

(d) testing of improved wood, charcoal or kerosene stoves, but by subcontracting the projects selected by DNHE; and

(e) semi-industrial solar-powered dryers for fruit and vegetables. According to SEP findings on the equipment installed over the last two years, there is a genuine and viable demand for this kind of apparatus.

5.10 It is therefore recommended, at least for the short and medium term, during which time the cost of conventional energies is expected to rise only moderately, that the commercial development of the technologies E.N.R. should be very modest. Hence it is suggested that, in view of the resources invested in these technologies, a comprehensive evaluation be undertaken of their achievements in order to determine the adequacy of the equipment involved. The results must be available as a prerequisite for any promotion efforts.

(a) wind-driven pumps, which have to compete with photovoltaic pumps and are handicapped throughout most of Mali by light winds and maintenance problems; 108/

(b) village hydroelectric micro powerplants, since these require favorable flow and load factor conditions and therefore, very probably, the use of auxiliary diesel generators;

(c) photovoltaic refrigerators for isolated health posts, the initial investment being four to five times greater than for the alternatives (kerosene or LPG refrigerators); and

(d) production of biogas in individual or community digesters and solar-powered dryers and cookstoves.

107/ *The cost of the flat-plate collector produced by LESO is currently making this technology noneconomic for industry and the tertiary sector, particularly hotels and the health sector. Ways must therefore be sought to reduce these costs and then to improve the after-sales service. The same comments apply to the residential sector. Since 1975 LESO has manufactured and installed about 200 solar-powered water heaters; the market has never expanded because of their initial high cost and the poor after-sales service. Meanwhile the economic and financial evaluations must take into account the fact that better-off residential customers want a mixed solar-electric system providing hot water throughout the year, whereas lower-income customers will basically only use a water heater three or four months a year, during the "cold" season. For the residential sector, under current conditions, this technology is not justified from a financial standpoint.*

108/ *Fifty windmills (of the Père Plasteig and Sahores types) installed in the Ségou region have suffered from maintenance problems. LESO has now stopped research and development of this type of windmill.*

Management of the Subsector

Current Organization

5.11 Like the energy sector as a whole, the NRE subsector features a proliferation of agencies. In addition to NGOs, which are very active in this subsector, the principal entities are:

(a) DNHE, which supervises and coordinates activities; DNHE is a directorate in MIHE, the supervisory ministry for LESO, and supervises the SEP and CEES projects and acts as the liaison body with CRES (see following paragraphs);

(b) LESO, set up in 1965, comes under DNHE 109/ and is principally responsible for research and development activities, but is also involved in the marketing of solar water heaters;

(c) the Special Energy Program (SEP, under DNHE supervision) receives technical and financial support from GTZ and concentrates on appropriate technologies for rural areas; 110/

(d) the Solar Equipment Maintenance Unit (CEES), also under DNHE supervision, receives financial and technical support from FAC and is responsible for promoting, installing and maintaining photovoltaic pumps, lighting and battery-recharging systems;

(e) the Regional Solar Energy Center (CRES), a regional organization headquartered in Bamako, is engaged in NRE-related training, promotion, research and development for the Sahelian countries; it was financed initially by the Federal Republic of Germany and France and is currently supported by the West African Economic Community;

(f) the Agricultural Machinery Division, organizing or participating in demonstration projects on the use of biomass in rural area; and

(g) in addition, a new CILSS/EEC regional photovoltaic pumps program will also be starting up shortly under DNHE supervision.

Recommendations

5.12 This proliferation of activities in the field of NREs suffers from a lack of priorities and coordination, in the absence of a clear policy regarding priority technologies (para. 5.4) and the

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109/ Its total operating costs are some CFAF 100 million (US$350,000), entirely financed from public funds. It has a staff of 86, of whom some 50 are professionals and technical specialists.

110/ Use of pourghère oil as fuel, biogas, solar-powered dryers, photovoltaic pumps and lighting, etc.

respective roles of the public and private sector. Setting priorities and coordinating activities should be the task of the DNHE, through the appointment within the Energy Division of an NRE specialist (para. 7.10). The choice of NRE applications to be promoted and supervised can only be made if an appraisal capacity exists. This capacity should be established within DNHE and be based on field data from the numerous ongoing projects and programs in Mali. Product promotion and market development should, however, be undertaken by the private sector, with the State playing a complementary role (regulatory framework, incentives, etc.).

5.13 It is also proposed that LESO be restructured in sections targeting very specific short-term operational objectives that focus almost exclusively on direct research and development support for NRE projects; these sections would be:

(a) a photovoltaic support unit for CEES in DNHE; private sector interest in this area should be stimulated by removing the taxes on this equipment and by promotion activities carried out by the State; 111/ an evaluation of all photovoltaic equipment, such as the ongoing assessment in conjunction with WHO, of the performance of photovoltaic refrigerators, should be undertaken as soon as possible (para. 5.10);

(b) a thermal solar section concentrating on improving the flat-plate collector already developed, focusing on cutting production costs by subcontracting industrial and commercial applications (para. 5.9), in order to make optimum use of existing equipment and LESO's expertise; and

(c) a center for testing production equipment for household use, such as improved wood, gas and kerosene stoves, charcoal kilns and presses for briquettes made from residues.

Short-Term Investment and Technical Assistance Program

5.14 It is therefore recommended that, for the short term (1990-95), national resources, technical assistance and investments in the NRE subsector be concentrated on the satisfactory execution and rigorous evaluation of existing CILSS/EEC programs for photovoltaic pumps, 112/ EEC/FAC programs for other photovoltaic applications, and SEP/GTZ programs for renewable energies in a rural environment. After a careful assessment of the results of these ongoing projects and a re-examination of the situation when they are completed, DNHE will then be able to prepare an investment and technical assistance program for those applications whose technical and economic viability has been demonstrated.

111/ *By way of example, CEES should transfer responsibility for the installation and maintenance of photovoltaic equipment to the private sector, while providing the technical, promotional and financial support required to develop the market, with taxation on this equipment being abolished; the same observation applies to solar water heaters.*

112/ *Some 250 photovoltaic pumps are to be installed over five years in the Mopti region to equip tubewells for water supply (pumping height < 50 m and Q > 3 m³/h).*

VI. ENERGY RATIONALIZATION

Principal Issues, Options and Recommendations

6.1 This chapter proposes a number of economically and financially justified pragmatic measures for improving energy rationalization, especially as regards the demand for energy in Mali. 113/ The priority recommendations should focus on:

(a) for the main industries and modern buildings, intervention at the design stage for boilers, insulation, air-conditioning and hot-water systems, lighting and the power factor;

(b) for transportation, enhancing the energy efficiency of vehicles by improving maintenance, reducing taxes on parts affecting fuel consumption and introducing penal taxation on fuel-guzzling vehicles; and

(c) training of personnel, particularly in the DNHE.

6.2 These recommendations are incremental to those already made in Chapters II and III regarding household and electric energy, namely:

(a) as regards household energy, improving the efficiency of wood and charcoal-burning stoves and promoting substitution of these fuels by kerosene and, in certain circumstances, LPG; and

(b) for the electricity subsector, improving the power factor and reducing distribution losses.

6.3 For these measures to be fruitful, certain prerequisites must be met as regards energy prices, taxation and data availability, along with a consensus on the general philosophy underlying actions in this area and on institutional organization. The analyses supporting the principal recommendations are contained in the paragraphs that follow.

113/ *Energy rationalization covers all actions leading to a reduction in the cost of the energy used to meet a final need, and therefore includes substitutions toward less expensive forms of energy. The aim therefore is to make the final energy required for the various socioeconomic activities available at the lowest possible cost.*

Introduction of Energy Rationalization: Potentials and Activities

Current Organization and Past Achievements in Energy Rationalization

6.4 There is currently no energy rationalization program in Mali and no institution is responsible for this issue. Certain isolated initiatives have nonetheless been taken as regards fuelwood (improved stoves program, LPG substitution program), in the electricity subsector (losses reduction program, installation of condensers) and in relation to producing hot water by solar energy (LESO solar water heater program).

Potential and Ongoing Activities

6.5 There is very little information on the potential for enhancing energy efficiency in Mali. The following estimates are put forward on the basis of experience obtained in other countries in the region, the partial surveys carried out in Mali as part of the preparation of this study, 114/ and certain earlier studies. 115/ It must, however, be noted that these are theoretical resources; actual realization of this potential is hampered by numerous difficulties linked to the lack of information, financing and technical capabilities.

6.6 In the fuelwood subsector, which accounts for more than 85% of primary energy, it is estimated that the introduction of improved stoves in urban areas would increase efficiency by about 10-15%, 116/ thus reducing consumption by about 135,000-195,000 toe/year. Two main activities are currently proceeding in this field, viz. a program to expand the use of improved woodstoves and an LPG substitution program undertaken with the support of petroleum product distributors; nonetheless, this second program, to be stepped up with the introduction of the CILSS/EEC butane project, raises certain questions (para. 2.46). Meanwhile a study of supply channels is being carried out with ESMAP assistance and is intended to lead to a strategy for the household energy subsector.

6.7 In the industrial and tertiary sectors, consumption and estimates of potential are as follows:

(a) Industrial Sector: In 1987 industry consumed about 56,000 toe, or about 3% of Mali's total energy consumption 117/ and 15% of its commercial energy use. Industry

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114/ *A survey of leading industrialists and building managers was carried out in December 1988 as part of the preparation of this study.*

115/ *In particular the AFME/Transenerg Study (1985) on energy planning.*

116/ *Although gains of the order of 30% are sometimes mentioned, the evaluations made by ESMAP in Mali show that the actual savings will be nearer 10% to 15%; housewives are already cooking relatively efficiently on three-stone stoves on the one hand, and do not follow all the rules for using the improved stoves on the other.*

117/ *About 50% of this energy is obtained from biomass (bagasse, straw, husks, bolls and shells, wood and charcoal, etc.).*

consumed 50% of electricity and 13% of petroleum products, the main applications being the production of steam, cold, hot water and lighting. However, the industrial sector in Mali is small, containing only some 15 to 20 sizable industries. 118/ In the absence of precise data and on the basis of the visits to industries in Mali made at the end of 1988 and experience obtained in other countries, the potential for energy savings in Malian industry is put at between 13% and 17% of industry's consumption, or between 7,000 and 10,000 toe (Table 6.2); and

(b) Modern commercial sector: in this sector there is again very limited information on energy consumption. To remedy this situation a comprehensive analysis of electric power consumption by EDM's main customers should be made, using the company's billing records. 119/ It is estimated that about 15% of the peak demand for power -- or 3 to 4 MW -- is due to air-conditioning (para. 3.23). The potential for savings is estimated at between 20% and 25% of current consumption, to be achieved largely through better utilization and maintenance of air-conditioning, hot water and lighting equipment (Table 6.2).

6.8 The transportation sector accounts for almost two thirds of commercial energy consumption or, in 1987, some 122,000 toe (Table 1.1), and transportation by road accounts for 83% (Table 6.1). There is, however, very little reliable information on the makeup of the vehicle fleet, which in 1988 was estimated at around 40-45,000 vehicles, 120/ or on the breakdown of consumption by type of vehicle and their age (estimated at between 7 and 12 years). On the basis of the results of the 1985 study by the Agence Française pour le Maîtrise de l'Energie (AFME)/Transenerg and the experience acquired in a number of other countries, the technical potential for energy savings in the Mali transportation sector is estimated at around 15% to 20%. Improving energy rationalization in this sector will, however, be particularly difficult.

Table 6.1: CONSUMPTION OF PETROLEUM PRODUCTS IN MALI BY MODE OF TRANSPORTATION

Mode	% of consumption
Road	83
River	2
Air	11
Railway	4
Total	100

Source: Energy and Transportation Study in Mali, AFME/Transenerg, June 1985 (1982 data).

118/ *For the principal industries see Annex 6.1. An industrial survey was carried out in 1989 by the Directorate of Industry and included questions on energy consumption and equipment.*

119/ *This analysis is designed to complement the work performed by EDM which led to the installation of a number of condensers; it could be carried out as part of the proposed technical assistance (para. 6.7).*

120/ *Of the 29,000 privately owned vehicles, some 11,000 are light trucks, 1,350 trucks of less than 20 tons and 680 trucks of more than 20 tons. This, however, is a very approximate estimate.*

6.9 In the electricity subsector there have already been improvements in the reduction of distribution losses. The Second Power Project aims to reduce these losses, currently some 20% at Bamako, to 15%.

6.10 Potential energy savings in Mali in the short and medium term are the following (Table 6.2).

Table 6.2: SUMMARY OF POTENTIAL ENERGY SAVINGS IN THE SHORT AND MEDIUM TERM (in % of current consumption)

	Commercial energy	Traditional energy
Household energy		10-15 in urban areas
Industry	13-17	
Buildings	20-25	
Transportation	15-20	
Electricity	12-15	

Source: ESMAP estimates.

Proposed Energy Rationalization Action Program

Prerequisites for Improving Energy Rationalization and Principal Obstacles

6.11 The experience gathered both in industrialized and developing countries shows that certain conditions must be satisfied if energy rationalization is to be improved. Data must be available, energy tariffs must be appropriate and the structure of taxation must encourage energy savings, access to financing and the appearance of dynamic private energy services companies. In addition, there must be coordinated action by the public authorities and consumers.

Data

6.12 As already noted, basic data on consumption and equipment are generally lacking. To remedy this situation, the industrial census recently undertaken should be carefully analyzed by the Directorate of Industry and DNHE along with EDM and GPP customer records, in order to identify priorities as regards end users of energy.

Recommendations for an Energy Rationalization Policy

6.13 Information in Mali on available technologies, potential energy savings and the return thereon, and the principles of rational energy management, is generally very limited. Information and training to complement the introduction of energy-saving measures must therefore be provided to managers and consumers.

6.14 As regards prices, the following recommendations (set out in the chapters pertaining to the different forms of energy) should be implemented:

(a) Fuelwood: The current prices of wood and charcoal are three or four times less than the economic costs of these resources; this does not encourage optimum utilization or necessary substitutions, and prevents adequate self-financing of the subsector (para. 2.23). It is therefore recommended that the structure of taxation be altered, that effective controls be introduced around the main urban centers to measure quantities transported and verify supply sources, that development premiums be paid and taxes adjusted so as to gradually bring retail prices into line with economic costs. Specific measures should be prepared as part of the Household Energy project and execution should be the responsibility of the DNEF Fuelwood Unit and DNHE (para. 2.28);

(b) Electricity. Although the present average tariff appears adequate, EDM's tariff structure should be updated as soon as possible through the tariff study included in the Second Power Project (para. 3.21), so that:

(i) the medium- and low-voltage tariffs reflect the structure of marginal costs;

(ii) the power premium is increased for medium-voltage customers and introduced for the main low-voltage customers;

(iii) the penalty for the power factor is increased; and

(iv) the gains deriving from a seasonal and/or hourly tariff for the principal low-voltage customers, particularly those using air-conditioning, are evaluated.

(c) Petroleum products: the pump prices of petroleum products (excluding LPG) are higher than their economic costs because of taxation and the Stabilization Fund (para. 4.28). This policy generates significant revenue for the State and promotes rational energy use. Nonetheless, it would seem possible to reduce distribution costs; it is therefore recommended that changes be made in the arrangements for fixing pump prices and operating margins, and that to this end the new institution responsible for the hydrocarbons 121/ subsector should analyze:

(i) the introduction of a ceiling price system, without any fixed floor price, to encourage distributors to reduce their supply and distribution costs; and

(ii) a simplification of the current tax system 122/ so as to replace it with a single tax collected by the Customs and paid directly to the Treasury.

121/ *Which it is proposed be established (para. 4.21).*

122/ *Which currently includes a number of taxes and beneficiaries (para. 4.29).*

6.15 Where import duties and other charges are concerned, the current structure of taxation does not encourage the introduction of energy-efficient equipment, energy-saving materials or energy substitutions (Table 6.3).

Table 6.3 DUTIES AND TAXES ON CERTAIN ENERGY-SAVING EQUIPMENT
(in % of CIF price)

Heat exchanger	43
Flat-plate collectors	87
Condensers	67
Insulators	67

Source: ESMAP estimates based on customs tariffs.
Note: Taxes applicable to the purchase price (including customs duties, import duty and value-added tax).

Recommendations for Energy Rationalization

Household Energy Subsector

6.16 The principal recommendations applicable to this subsector relate to (see Chapter II):

(a) Developing a Household Energy strategy. Better fuelwood management requires the introduction of a strategy for both demand and supply. Formulating and implementing this strategy is the principal goal of the ESMAP-Household Energy Project which should start during 1990 as a follow-on to the study of marketing channels;

(b) Improving the efficiency of stoves by wider distribution of improved wood and charcoal-burning stoves, particularly in the urban centers; 123/ and

(c) Slowing the consumption of wood and charcoal. This should be brought about by steadily increasing the retail prices of wood and charcoal following the introduction of a development premium, raising taxes and improving the verification of their payment at the entrances to the main urban centers, and promoting substitutes (kerosene and in certain situations LPG).

Modern Industry and Buildings

6.17 In light of the findings of visits to Mali, subject to confirmation following analysis of the industrial survey recently undertaken (para. 6.7), and on the basis of experience obtained in Senegal and Côte d'Ivoire, it is recommended that programs be implemented that focus on the industry (about 15 firms) and tertiary (about 10 buildings) sectors, with support from a technical assistance project. The program objectives would include:

123/ *The results of the distribution of improved stoves are encouraging and this effort should be stepped up. These stoves are being produced and marketed by artisans.*

(a) the overhaul and repair of boilers and hot-water, air-conditioning and refrigeration equipment, including improved insulation;

(b) installation of condensers in connection with electricity use in industries and buildings;

(c) installation of efficient light bulbs, especially in large buildings; and

(d) energy-management training for maintenance personnel in industry and buildings. 124/

Transport Sector

6.18 In the transportation sector, the introduction of specific economy measures yielding durable and economically justified results will be difficult. Experience in this area shows that fuel prices, enhanced engine effectiveness and vehicle maintenance have the greatest impact on fuel consumption. In Mali, however, petroleum product prices are already very high; the recommendations therefore focus on: 125/

(a) Giving priority to informing/training for vehicle fleet managers and drivers through a series of workshops on ways of reducing fuel consumption. This could be carried out as part of the proposed Energy Rationalization project (para. 6.22);

(b) Revising customs duties on the basis of cylinder capacity, i.e., penalizing the higher capacities; and

(c) Reducing duties and taxes on certain parts critical to fuel consumption: spark-plugs, carburetor parts, diesel injectors and pumps, testing and training equipment, etc.

Electricity Subsector

6.19 In the electricity subsector, the specific actions recommended for more efficient energy utilization are the following (see Chapter III):

(a) restructuring of EDM's tariff matrix (para. 3.18);

(b) reduction of technical and nontechnical losses during distribution and in thermal power stations to a maximum of 15% of net generation (3.16);

124/ *In maintenance of boilers and air conditioners, insulation, instrumentation, tariff utilization, etc.*

125/ *From an economic point of view a diesel conversion program for light vehicles does not seem justified; from the standpoint of the final consumers, however, given the high prices of fuels, the extra cost of diesel vehicles appears justified. The payback period for the additional investment is estimated at around 2.5 years.*

(c) improvement of major customers' power factors through installation of condensers, following a careful analysis of EDM's customer records; and

(d) evaluation of the options and benefits of an electricity demand management program, especially as regards air conditioning and hot water. Management of this demand could enable investments in production and distribution networks to be phased over time.

Institutional Organization

6.20 Mali's energy rationalization policy should therefore incorporate two main lines of action: (a) implementation of specific measures 126/ that are economically justified, and (b) coordinated action by public authorities and consumers. The public authorities should act to review tariffs, provide information to consumers, promote actions that are justified from an economic standpoint, and facilitate financing. Within such a framework, decisions to go ahead with these measures should be left to consumers.

6.21 Establishment of a public agency for the specific purpose of energy rationalization 127/ does not currently seem justified in Mali, given the philosophy underlying the actions proposed (para. 6.20), and the small size of the energy sector, the costs of such an agency and the lack of national expertise in this area. Instead it is proposed that the technical resources of each subsector 128/ should be devoted to promoting and monitoring the measures to be introduced, supported initially by external technical assistance and under the national coordination of DNHE in MIHE, the supervisory ministry for the energy sector (para. 7.8).

Technical Assistance for Energy Rationalization

6.22 Energy Rationalization Project in Mali. It is therefore recommended that a series of actions to improve energy rationalization be undertaken in Mali. Their satisfactory execution will, however, depend on access to external expertise in the various aspects of energy rationalization and to financing. Some components, specifically the improved stoves and household energy substitutions, tariff changes and the reduction of losses in the electricity subsector, have already been included in some existing financing arrangements; for the other measures new financing must be obtained. To implement

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126/ *This implies reduction of studies of a general nature to a strict minimum, in order to concentrate technical, human and financial resources on concrete steps yielding high returns and quick results.*

127/ *Known in other countries as the Office of Energy Savings, Energy Rationalization Agency, etc.*

128/ *The Fuelwood Unit of DNEF, the institution responsible for petroleum products, the National Directorate of Industry, National Directorate of Transportation, EDM, etc.*

these measures effectively, and to finance them, it is proposed to bring them together in an Energy Rationalization Project in Mali, coordinated by DNHE and described below (Table 6.4):

Table 6.4: MAIN COMPONENTS OF MALI ENERGY RATIONALIZATION PROJECT

Components	Target
Program	
Boilers	Industry (15 industries)
Insulation	Industry (15 industries)
Cold (air conditioning/ refrigeration)	Industry/buildings
Hot water	Industry/buildings
Lighting	Industry/buildings
Energy management training in industry	Manager/maintenance personnel
Energy management training in buildings	Building manager/maintenance personnel
Power factor	Industry/buildings
Training/information	Industry/buildings/transport
Taxation	Tax on energy-saving equipment/materials Tax on transportation vehicles
Standards	Construction and equipment standards
Tariffs	Tariffs on kerosene and LPG 129/
Financing	Energy management fund 130/
Personnel training	Personnel in the agency responsible for coordinating energy rationalization activities (former Energy Division of the DNHE)

6.23 A project of this kind contains a very wide range of components; it is therefore proposed that its execution be planned as follows (for details see Annex 6.2):

(a) technical assistance provided by two specialists, if possible in the form of ad hoc missions as part of a Sahel regional program over a period of two years, to identify appropriate measures to be taken in industry and buildings, as well as their technical, economic and financial appraisal; the specialists will have the use of a vehicle equipped with measuring

129/ *Electricity tariffs should be reviewed as part of the Second Power Project and fuelwood prices as part of the ESMAP Household Energy project.*

130/ *The regulations for the management of this fund remain to be defined. Rationalization measures could be financed in the form of traditional loans, rebated or repayable in light of the economies made, etc.*

instruments and can immediately make a certain number of low-cost measurements, etc. 131/ Expertise will also be needed on an ad hoc basis;

(b) Energy Rationalization Fund for financing measures requiring capital investment;

(c) DNHE will coordinate the project in Mali and manage the Energy Rationalization Fund, through an ad hoc national energy management committee; and

(d) active participation of technical personnel in the subsectors concerned.

6.24 Project costs. The cost of the project is estimated at US$3.2 million (CFAF 896 million) allocated as follows:

		US$ thousands
(a)	Technical assistance (personnel)	500
(b)	Training/information (workshops, documentation)	150
(c)	Vehicle, measuring equipment, maintenance equipment and operating expenses	250
(d)	Small tools and basic materials	300
(e)	Energy Rationalization Fund	2,000
	TOTAL	3,200

6.25 Given the significant cost of the technical assistance compared to the relatively limited potential for energy savings in Mali, it is proposed to incorporate the Energy Rationalization project into a regional energy rationalization program. In this way the investment costs, in particular those of the vehicles and equipment (Energy Bus), can be shared among similar projects in a number of Sahelian countries.

131/ *The two specialists would be an expert in energy savings in industry and buildings and a specialist in the economic and financial appraisal of investments. The latter would also assist the Energy Division in DNHE. (See Chapter VII.)*

VII. MANAGEMENT OF THE ENERGY SECTOR

Main Issues, Options and Recommendations

7.1 This chapter considers measures that will enable improvement of the management of Mali's energy sector. Although recent decisions in the electricity subsector should help to improve the management of the sector as a whole, some fundamental problems remain. These are due in part to Mali's present financial constraints but also and maybe particularly to the lack of coordination in the management of the sector and the fragmentation and poor definition of responsibilities. Any proposal aimed at improving the management of the sector must, however, take into consideration the reform of the Malian public sector now under way coupled with the personnel freeze, the policy of divestiture by the State and the constraints bearing on the Malian public finances. The solutions proposed will therefore have to respect to the extent possible these constraints affecting the Malian public and parapublic sectors.

7.2 The actions to be given priority should concentrate on:

(a) Improving the coordination of the sector management activities;

(b) Defining and specifying responsibilities and reducing the dispersion of national powers;

(c) Bringing about divestiture by the State and promoting the activities of the private sector, and

(d) Improving personnel training.

The analyses on which these recommendations are based are presented in the following paragraphs.

Administrative Organization of the Energy Sector

Present Organization

7.3 Coordination of the various activities of the Energy sector ought logically to be the responsibility of MIHE and in particular DNHE and basic decisions should be evaluated and their execution monitored by an inter-ministerial group. However, DNHE cannot at this time assume responsibilities of this sort and no interministerial agency has been formed. This situation is explained in particular by the fact that:

(a) The distribution of responsibilities between the supervisory authority and the various agencies has not been clearly defined and the management of the energy subsectors needs to be reorganized (see Chapters III to VI);

(b) The main thrusts of Malian energy policy have not to date been clearly established; and

(c) DNHE, and especially its Dams and Energy Division, has concentrated so far on the electricity subsector 132/ and does not have the human resources in particular 133/ nor the data to perform such a coordination task.

7.4 Moreover, since energy has ramifications in all economic activities the implementation of a policy will have repercussions for the activities of numerous ministries and parastatal corporations. Decisions and especially their application accordingly call for negotiations at the highest level of the State apparatus. Mali does not presently have an institution of the type needed for this purpose. 134/

Recommendations

7.5 It is therefore recommended that responsibility for coordination of the Energy sector's activities be assigned to DNHE. A coordination function is specifically intended here, with DNHE concentrating its resources on preparation of the national energy policy, evaluation and monitoring of the implementation of the subsector development plans prepared and executed by the subsector institutions, analysis of multi-energy questions, pricing, regulation and the management of domestic energy data. The technical aspects would therefore essentially be the responsibility of the subsector institutions themselves, restructured when necessary to regroup and simplify procedures (para. 7.10).

7.6 Furthermore, it is proposed that an interministerial task force be formed to make the multisectoral analyses involved and the necessary trade-offs. This "policy" decision group could be called the Energy Council 135/ or the National Energy Commission, and would be made up of the ministers most closely concerned with energy and chaired by the Minister of Industry, Hydraulics and Energy, the supervisory authority for the sector. It could decide on the specific analyses to be undertaken and form ad hoc working groups grouping available expertise on particular topics. 136/ Its permanent secretariat would be furnished by DNHE.

132/ *By making feasibility studies, supervising construction, etc. The recent institutional reform of the subsector has clarified the allocation of responsibilities between DNHE and EDM.*

133/ *The Dams and Energy Division, which has responsibility for energy in the Ministry of Industry, Hydraulics and Energy, currently consists of only five persons, including the director.*

134/ *Known in some countries as the National Energy Commission or Committee, Energy Council, etc., this institution formalizes the trade-off involved and lays down specific operating rules.*

135/ *According to DNHE's proposals to this effect.*

136/ *Such as energy pricing, substitution policies, energy rationalization policy and program, role of the State and of the private sector, etc.*

Definition of Responsibilities

Present Situation

7.7 The energy sector in Mali is still embryonic and relatively few people possess sufficient experience to cope with the difficult problems of the future. Unfortunately, responsibilities and powers are dispersed among various institutions that are individually too weak and lack adequate material resources, data, etc., while their responsibilities are poorly defined. Moreover, the State intervenes in activities that the private sector is capable of handling efficiently, specific examples of this being Pétrostock in the hydrocarbons subsector and LESO and CEES in the new and renewable energies subsector.

Recommendations

7.8 It is accordingly recommended that DNHE's responsibilities be clearly established on the basis of, for instance, certain of MIHE's 1985 proposals, defining DNHE's mandate according to the following main lines of action:

(a) Centralization of data on energy resources, ensuring promotion of their development by means of information or promotional activities or else legislative or regulatory measures;

(b) Coordination of the studies and research needed to be able to utilize energy resources;

(c) Adoption of measures that will permit more rational energy use;

(d) Processing of requests for authorization to proceed with construction of energy infrastructure projects, and

(e) Appraisal of energy development policies and projects.

7.9 To do this while taking into consideration the financial and other constraints it is proposed that DNHE's present staff be strengthened and that they be organized into an Energy Unit in the Dams and Energy Division, to be subdivided into two sections: (a) Commercial Energies and (b) Traditional Energies (Annex 7.1). 137/ To implement this, DNHE should hire one or two persons experienced in energy project and policy appraisal. This unit would benefit from the limited technical assistance proposed in the Energy Rationalization project (para. 6.22) and better equipment (computers, office equipment).

137/ *DNHE and the Tractebel Diagnostic Study of the Electricity and Urban Water Supply Sectors (September 1988) have submitted proposals that are distinctly more ambitious. However, while these proposals constitute a long-term objective they appear excessive in the present context.*

7.10 For each of these subsectors a clear definition of responsibilities and a regrouping of jurisdictions are also necessities. Subsector recommendations along these lines have been proposed in Chapter II on fuelwood, Chapter III on electricity, Chapter IV on hydrocarbons and Chapter V on new and renewable energies. A simplified representation of the functioning of the sector is proposed in Annex 7.2. These institutional reforms should not entail any additional personnel but just transfers or redundancies resulting from the proposed changes. The specific recommendations for each subsector are summarized below, it being understood that DNHE will be responsible for overall planning, regulation and control.

(a) Electricity Subsector. Following the institutional reorganization under way, EDM will assume sole responsibility for technical planning, construction and operation of public sector facilities; 138/ DNHE will concentrate on policy preparation, general planning and regulation of the subsector;

(b) Fuelwood Subsector. All activities concerning planning and administrative management of fuelwood demand should be covered by the DNHE Energy Unit while supply management should be taken care of by the DNEF Household Energy Unit. Reform of the management of this subsector, including taxation and substitution, is one of the components of the ESMAP Household Energy project scheduled to be started in 1990 (para. 2.47);

(c) Hydrocarbons Subsector. Establishment of a National Hydrocarbons Directorate or at the least a single institution to manage the subsector is recommended (para. 4.23). This new directorate would centralize the management of all the presently dispersed activities and national authorities regarding petroleum product supply and distribution. 139/ It could also be located in MIHE according to the formula used in a number of countries or in other institutions such as OSRP or ONT. In addition, it is recommended that in view of its contribution and the fact that its operating expenditures are financed out of public funds, Pétrostock be liquidated and that storage including strategic stocks be entrusted to the private sector (para. 4.24). Regulation, particularly as regards the levels of strategic stocks and rules to be followed in the event of crises, should be assigned to the new institution managing the subsector;

(d) New and Renewable Energies. No major institutional reform is proposed for this subsector except for a refocusing of LESO's activities and priorities on the research and development needed for projects, and leaving marketing and after-sales service to the private sector. From the overall angle, it is proposed that DNHE should very closely

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138/ *Other public or private institutions will nonetheless be able to manage electricity production or transmission installations, although EDM has been given a monopoly of distribution. For regional (e.g. Manantali) or multipurpose facilities special arrangements have been (as in the case of Sélingué with OERHN) or will have to be made.*

139/ *In ONT, OSRP, the Directorate of Economic Affairs, DNGM, etc.*

coordinate what is done 140/ in order to reduce duplication of effort, set priorities and if necessary decide on trade-offs. In parallel, LESO's activities ought to be focused solely on the research and development necessary for projects while the marketing of economically and financially justified technologies should be left to the private sector (para. 5.8). Along the same lines, DNHE should assess the conditions necessary for transfer to the private sector of the photovoltaic equipment installation and maintenance activities currently performed by CEES; and

(e) Energy Rationalization. Responsibility for execution of projects and specific interventions would lie with the subsectors, the ministers concerned 141/ and the private sector. DNHE would be responsible for setting priorities and coordination and, where necessary, for project formulation (para. 6.22).

Human Resource Training

7.11 As a general rule, the staff assigned to the sector have received sufficient theoretic training. However, since Mali's energy sector is still relatively undeveloped, few persons have built up enough practical experience. It is therefore proposed that the resources available for training be channeled to this type of practical training. Since several projects are presently in the planning or execution stage in the sector, it is therefore recommended that the possibilities for on-the-job training offered by them be systematically utilized.

Technical Assistance Program for Sector Management

7.12 Some light technical assistance appears necessary for the DNHE Energy Unit. This would be in two parts:

(a) assistance to the Household Energy Unit for coordinating the formulation and implementation of the different components of the Household Energy Strategy; for the period 1991-96 about 53 man-months of national and international consultant services at an estimated total cost of US$0.7 million plus US$0.35 million for equipment and logistical resources; and

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140/ *LESO, PSE, CEES, CRES, Household Energy-ESMAP, CILSS/EEC for butanization.*

141/ *For example, MIHE for an efficiency program concerning industry, and the Ministry of Public Works for a program targeting public buildings, etc.*

(b) assistance for the Energy Rationalization project (para. 6.22) which could comprise:

(i) assignment to the DNHE Energy Unit of one expert in economic and financial appraisal of energy projects and policies for one year; and

(ii) provision of computers and software.

7.13 Besides this assistance to DNHE, other subsector management technical assistance is also proposed for the fuelwood subsector (para. 2.47), the electricity subsector (para. 3.34) and the hydrocarbons subsector (para. 4.32).

ENERGY BALANCE FOR 1987 (TOE)

	PRIMARY ENERGY					PETROLEUM PRODUCTS											
	Fire-wood	Bio-mass	Hydro-elec.	Char-coal	Elec-tricity	LPG	Gaso-line	Kero-sene	Jet fuel	Avgas	Diesel	Gas oil	Fuel oil	TOTAL Pet.Prod.	GRAND TOTAL		
GROSS SUPPLY																	
Production	1786000	111500	39500												1937000		
Imports						568	63773	13242	12789	342	22764	54971	5221	173670	173670		
TOTAL DOMESTIC SUPPLY	1786000	111500	39500			568	63773	13242	12789	342	22764	54971	5221	173670	2110670		
PROCESSING																	
Charcoal production	-185000			38000											-147000		
Thermal generation					2936						-6431	-824		-7255	-4319		
Hydroelectricity generation			-39500		13430										-26070		
Transport and distribution losses					-3672										-3672		
NET SUPPLY	1601000	111500		38000	12694	568	63773	13242	12789	342	16333	54147	5221	166415	1929609		
																%TOT. ENER.	%COMM. ENER.
FINAL CONSUMPTION																	
Industry & agriculture	1500	25000			5966						10292	13165	5221	28678	61144	3.2	16.0
Commerce/administration	2500			1000	1904	114		2648			1144			3906	9310	0.5	3.1
Transport							63773		12789	342	4898	40982		122784	122784	6.4	56.6
Household	1597000	86500		37000	4824	454		10594						11048	1736372	90.0	24.4
TOTAL FINAL CONSUMPTION	1601000	111500		38000	12694	568	63773	13242	12789	342	16333	54147	5221	166415	1929609	100.0	100.0
% Consumption/sector/energy	83.0%	5.8%	0.0%	2.0%	0.7%	0.0%	3.3%	0.7%	0.7%	0.0%	0.8%	2.8%	0.3%	8.6%	100.0%		

Source: ESMAP estimates.

MAIN EDM ELECTRICAL DATA

		1980	1981	1982	1983	1984	1985	1986	1987	Est. 1988
INTERCONNECTED SYSTEM										
Sales	GWh	70.7	66.4	80.1	93.4	100.2	116.4	124.5	134.9	n.a.
Losses	GWh	8.9	15.4	23.6	27.6	32.6	31.3	34.7	37.5	n.a.
	(%)	(11.1)	(18.8)	(22.8)	(22.8)	(24.6)	(21.2)	(21.8)	(21.7)	
Gross generation	GWh	79.5	81.7	103.7	121.0	132.8	147.8	159.2	172.3	182.1
Generation by:										
Sélingué (a) (net)	GWh	13.9	34.9	68.4	92.1	95.5	108.8	129.8	126.1	126.4
Sotuba	GWh	32.1	33.5	35.1	28.6	36.6	37.5	28.4	32.0	34.6
Subtotal	GWh	46.0	68.4	103.5	120.7	132.1	146.3	158.2	158.1	161.0
Dar Salam (therm.)	GWh	33.5	13.3	0.2	0.4	0.7	1.5	1.0	14.2	21.1
Peak power demand	MW	14.9	16.1	20.0	23.0	24.4	28.1	30.5	33.8	37.3
Load factor	%	61.1	58.0	59.2	60.2	62.1	60.0	59.6	58.2	55.7
Customers	No.	15,527	17,114	18,511	19,818	21,773	23,737	24,800	26,866	n.a.
Installed power	MW	23.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5
Firm power (April)	MW	not available						39.5	39.5	39.5
Gross reserve	MW	8.7	51.4	47.5	44.6	43.1	39.4	37.0	33.7	30.2
	%	36.8	76.1	70.4	66.0	63.9	58.4	54.8	49.9	44.7
Net reserve	MW	not available						9.0	5.7	2.2
	%	"						22.8	14.4	5.6
ISOLATED SYSTEMS										
Sales	GWh	9.5	8.6	7.9	8.3	9.5	7.3	7.8	12.6	
Losses	GWh	4.1	(0.9)	2.5	2.5	2.2	3.1	3.9	4.7	
Gross generation	GWh	13.6	7.7	10.5	10.8	11.7	10.4	11.7	17.3	
Customers	No.	8,372	8,664	8,895	9,290	9,427	9,583	9,798	10,163	
Total EDM										
Sales	GWh	80.2	75.0	88.1	101.7	109.7	123.7	132.3	147.5	
Losses	GWh	13.0	14.5	26.1	30.1	34.8	34.5	38.6	42.2	
	(%)	(13.9)	(16.2)	(22.9)	(22.8)	(24.1)	(21.8)	(22.6)	(22.2)	
Gross generation	GWh	93.1	89.4	114.2	131.8	144.5	158.2	170.9	189.7	
Customers	No.	23,899	25,778	27,406	29,108	31,200	33,320	34,598	37,029	

(a) OERHN production bought by EDM.

Source: EDM.

PAST PETROLEUM PRODUCT CONSUMPTION
TONS

	1980	1981	1982	1983	1984	1985	1986	1987	Annual Growth Rate 1980-87	1982-87
LPG	199	238	231	219	240	266	422	536	15.2%	18.3%
Gasoline	63,697	57,503	53,950	51,697	51,492	58,252	60,028	61,976	-0.4%	2.8%
Avgas	530	454	495	402	385	425	446	332	-6.5%	-7.7%
Kerosene	12,586	12,285	12,013	12,181	12,836	13,020	13,387	13,150	0.6%	1.8%
Jet fuel	13,684	12,216	10,480	10,185	13,026	16,402	13,922	12,538	-1.2%	3.7%
Gas oil	48,943	43,137	40,511	36,906	43,475	51,303	52,842	54,427	1.5%	6.1%
Diesel	22,217	16,264	15,964	17,936	20,347	20,970	19,930	22,764	0.3%	7.4%
Fuel oil	5,856	4,442	2,975	7,588	5,289	6,158	5,067	5,377	-1.2%	12.6%
TOTAL	167,712	146,539	136,619	137,114	147,090	166,796	166,044	171,100	0.3%	4.6%
REAL RELATIVE PRICES 1979 = 100										
Gasoline	161	203	217	201	186	146	92	85		
Kerosene	137	163	177	164	152	122	75	70		
Gas oil	155	193	207	192	178	140	88	81		

Deflator 7.4%

Source: GPP + ESMAP estimates

COMPARATIVE ENERGY BALANCES (1987-2010)

	BASE (1987)		1990						1995						2000					
			TREND-BASED			RATIONALIZATION			TREND-BASED			RATIONALIZATION			TREND-BASED			RATIONALIZATION		
	000 TEO	STRUCTURE	87/90 (%/an)	TEO	STRUCTURE	87/90	TEO	STRUCTURE	90/95	TEO	STRUCTU	90/95	TEO	STRUCTURE	95/2000	TEO	STRUCTURE	95/2000		STRUCTURE
Firewood/Biomass	1751	90.70%	2.27%	1872	90.15%:	1.82%	1848	90.23%	2.27%	2095	89.13%:	1.82%	2022	89.40%	2.27%	2344	87.99%:	1.82%	2213	88.49%
Electricity	13	0.67%	8.10%	16	0.79%:	6.00%	15	0.76%	8.10%	24	1.03%:	6.00%	21	0.92%	8.10%	36	1.34%:	6.00%	28	1.11%
Petroleum Products	166	8.62%	4.20%	188	9.06%:	3.50%	184	9.01%	4.20%	231	9.84%:	3.50%	219	9.69%	4.20%	284	10.67%:	3.50%	260	10.41%
Final Energy	1930	100.00%	2.48%	2077	100.00%:	2.00%	2048	100.00%	2.50%	2350	100.00%:	2.01%	2262	100.00%	2.53%	2663	100.00%:	2.03%	2501	100.00%
Commercial Energy	179	9.30%	4.49%	205	9.85%:	3.69%	200	9.77%	4.54%	255	10.87%:	3.70%	240	10.60%	4.60%	320	12.01%:	3.73%	288	11.51%

Source: ESMAP estimates.

2010					
TREND-BASED			RATIONALIZATION		
2000/10	TEO	STRUCTURE	2000/10	TEO	STRUCTURE
2.27%	2933	85.27%:	1.82%	2650	86.41%
8.10%	78	2.27%:	6.00%	50	1.62%
4.20%	429	12.46%:	3.50%	367	11.97%
2.59%	3440	100.00%:	2.06%	3067	100.00%
4.71%	507	14.73%:	3.77%	417	13.59%

FOREST RESOURCES IN MALI AND FUELWOOD INVENTORIES

1. **Geographic location:** Situated between latitudes 10° and 25° North, Mali is a country of the Sahelian type with four main ecological zones ranging from Saharan to semi-humid, distributed as follows: (Annex 2.1, Map 1: Bio-Climate Zones): the northern zone, comprising 50% of the country, with an annual rainfall of 200 mm; the Sahelian zone, comprising 30% of the country, with an annual rainfall of 200-600 mm; the Sudanian zone, covering 15-20% of the country, with an annual rainfall of 600-1,200 mm; and the Sudano-Guinean zone, representing less than 5% of the country, with annual rainfall of over 1,200 mm.

2. The country's natural forests are found in its southern segment, where they vary in composition owing to differences in type of ecological zone, terrain, and soils. As revealed by recent SPOT satellite images, forest covers between 60 and 90% of public lands (over 10 million ha) in the Koulikoro and Sikasso regions and an estimated 60% of them (over 7 million ha) in the Kayes region. In the Ségou and Mopti regions, and particularly the latter, natural forests are considerably less extensive. In overall terms, forest stands in the southern segment of the country therefore cover over 20 million ha.

3. Man-made forest areas are equally important. Although plantations of such tree species as shea, *nere*, baobab and tamarind probably amount to under 20,000 ha throughout the entire country, forest park lands are frequent in those parts of the southern region where annual precipitation exceeds 700 mm. In the Koulikoro and Sikasso regions, such parks cover between 10 and 40% of all public land, a total area probably in excess of 2 million ha.

4. **Reduction of forest cover: Causes and trends.** The shrinking of the forest cover in Mali can to be ascribed to: (1) drought; (2) expansion of agriculture and stockraising; (3) lack of interest on the part of individuals in protecting trees; and (4) over-harvesting in order to provide major urban centers with fuelwood. At present, however, the relative importance of these various factors is not known.

5. The difficulties of geographic location and climate that Mali must contend with at the best of times were made worse by two periods of drought, 1972-1973 and 1982-1984, whose effects on the country's forest naturally differed from one ecological zone to another. The shrinking of this cover is also attributable in part to the increasing need for land for cropgrowing and stockraising as a consequence of population growth: according to official figures, the arable land area has been increasing by 1.8%/year for the last 10 to 15 years, or by approximately 30,000 to 40,000 ha/year. In addition, rural communities have lost interest in protecting the forest because of uncertainties over land ownership or rights to use of the forest, forest policy, and the emphasis given to the policing function of the forestry service agencies; this attitude is evident when bush fires occur, since they are frequently left to burn out of control although the rural population is familiar with firefighting methods. Finally, the increasing pressure of demand for firewood from urban areas is leading to over-exploitation, and in some instances to disappearance, of the natural forest cover in the environs of urban centers and along roads. Unfortunately, little data are available to shed light on the part played by dead wood, on felling areas, or on the environmental consequences of fuelwood harvesting.

6. **Fuelwood inventories: Is Mali facing a fuelwood deficit?** In the Koulikoro and Sikasso regions, forest production potential is not known precisely, since the reliability of existing studies and the conclusions that can currently be drawn is limited. Taking advantage of available data on other Sahel countries, 1/ the volume of fuelwood that can be harvested in the Koulikoro and Sikasso districts may be estimated at over 4 million tons/year, plus approximately 4 million tons of dead wood (Annex 2.1, Tables 1 and 3). As present consumption in these regions and the city of Bamako is estimated at 2 million tons/year, there would currently be a surplus. This is also true as regards supplies for the capital, Bamako itself: if fuelwood supplies for the city are assumed to be drawn from within a radius 150 km, it could be supplied from Banamba *cercle* for a period of three to five years.

7. In the Kayes and Ségou regions, which hold 70% of the Malian population, there appear to be no immediate problems. Kayes is better off in this regard than Koulikoro and Sikasso, while the situation in Ségou can be qualified as satisfactory. Nevertheless, there is a long-term (10-15 years, say) prospect of deterioration unless better ways of managing the forest cover are introduced.

8. In the Mopti, Tombouctou and Gao regions, the situation appears to be less satisfactory, although accurate data are not available. Shortages are frequent in the Niger delta and the main towns in these regions, resulting in intensive use of crop residues and cow dung and the spontaneous development of supply from other rural areas in Mali.

9. Other biomass resources: The few agroindustrial residues available (bagasse, cotton seed from CMDT, and rice chaff from Office du Niger) are already used as energy sources or in the manufacture of animal feed. On the other hand, crop residues (millet, sorghum, maize stalks and cotton stems, rice straw, groundnut shells, etc.) are significant in volume and could provide an estimated 1,150 toe/year (Annex 2.2), but they are generally left in the fields, burned on the spot, or used as litter (cotton stems). Attempts have been made to produce charcoal from cotton stems (as part of the Special Energy Program) but with hardly encouraging results (see also Annex 5.1).

10. **Pourghère**: The possibility of using the oil obtained from pourghère seeds as a motor fuel is being studied under the Special Energy Program. This traditional plant is also used for soil conservation purposes. In the past, trade in pourghère seeds was relatively important but is currently in decline. The economic feasibility of the pourghère project is discussed in Annex 5.1.

1/ *In general, productivity varies from less than 0.2 m^3/ha in the northern savanna zone to 2-3 m^3/ha in the forests in the Sudano-Guinean zone - a range of variation with an order of magnitude in excess of 10.*

Map 1
Annex 2.1
Page 3 of 6

BIO-CLIMATE ZONES

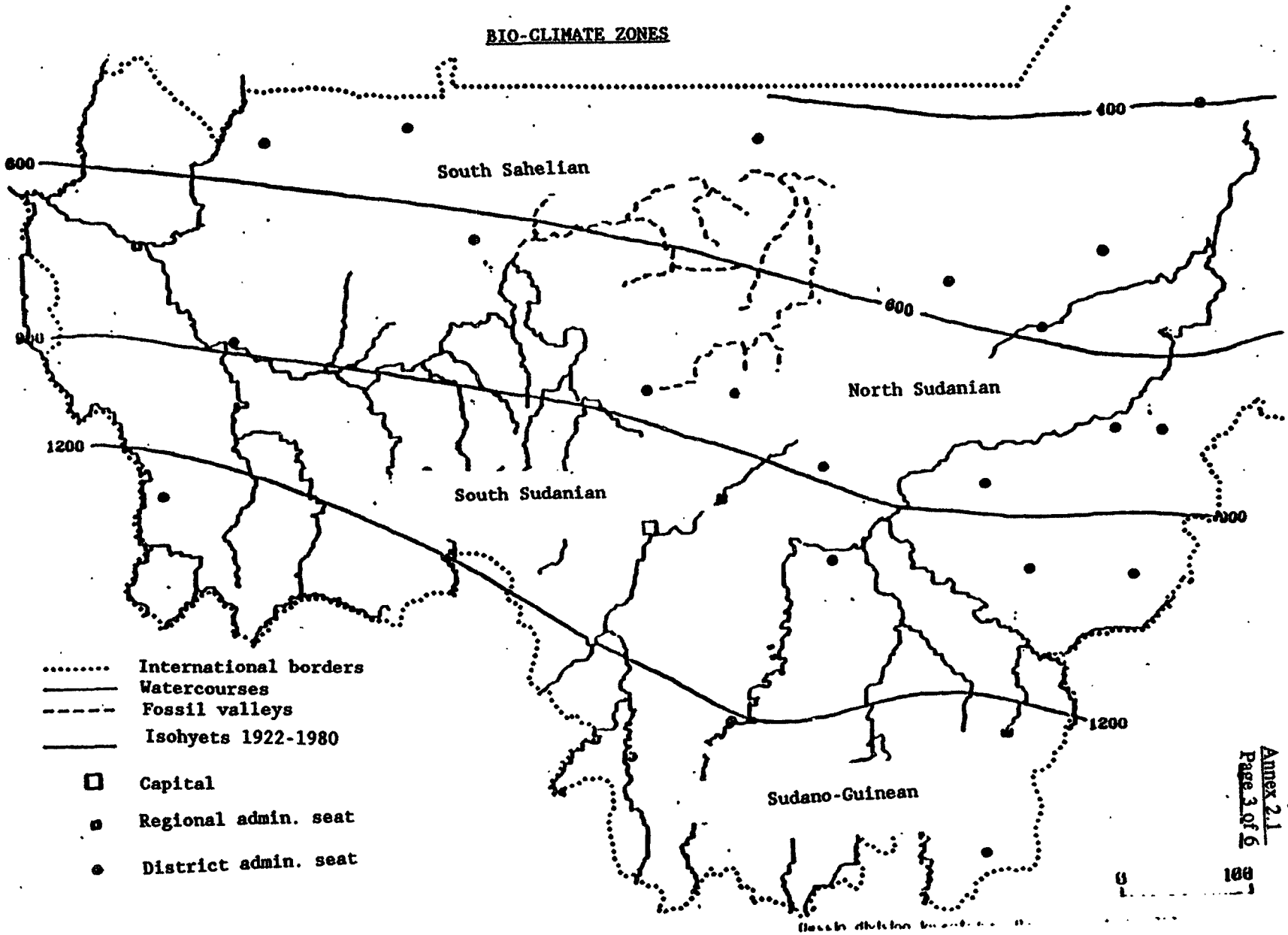


Table 1: LAND USE IN KOULIKORO AND SIKASSO REGIONS
(in thousands of hectares)

REGION/Cercle	Natural Forest: Cercle Area (A)	Natural Forest: Total Area (B)	Natural Forest: State forest % of (A)	Natural Forest: State forest Area	Natural Forest: State forest % of (B)	Cultivated and Fallow Land: TOTAL (C)	Cultivated and Fallow Land: Currently Used Area	Cultivated and Fallow Land: Currently Used % of (A)	Cultivated and Fallow Land: Currently Used % of (C)	Cultivated and Fallow Land: Available Area	Cultivated and Fallow Land: Available % of (B)
KOULIKORO (a):											
Koulikoro	620	449	72%	12	3%	211	140	23%	66%	72	16%
Banamba	750	644	86%			266	106	14%	40%	160	25%
Kangaba	462	402	87%	10	2%	141	45	10%	32%	95	24%
Kati	1,630	1,345	83%	204	15%	775	299	18%	39%	476	35%
Kolokani	1,164	878	75%	95	11%	364	221	19%	61%	144	16%
Subtotal	4,626	3,719	80%	321	9%	1,757	811	18%	46%	946	25%
SIKASSO (b):											
Bougouni	1,860	1,610	87%	133	8%	1,410	251	13%	18%	1,159	72%
Kadiolo	534	469	88%	24	5%	456	65	12%	14%	391	83%
Kolondieba	769	659	86%	40	6%	663	105	14%	16%	558	85%
Koutiala	910	583	64%	12	2%	499	344	38%	69%	155	27%
Yanfolila	931	805	86%	93	12%	485	81	9%	17%	404	50%
Yorosso	511	313	61%	9	3%	292	196	38%	67%	96	31%
Subtotal	5,514	4,440	81%	312	7%	3,805	1,042	19%	27%	1,605	36%

(a) Excluding Nara (3,090,000 ha) and Dioila (1,320,000 ha) cercles.
(b) Excluding Sikasso (1,540,00 ha) cercle.

Source: Particulars of Cercles, Fuelwood Resources Inventory Project (PIRL), 1988
Secretariat of Agriculture/CTFT-DNEF.

Table 2: FIREWOOD RESOURCES IN KOULIKORO AND SIKASSO REGIONS
(in thousands of m^3)

REGION/Cercle	Natural Forest: Standing volume: m^3/ha	Natural Forest: Standing volume: Total volume	Natural Forest: Standing volume: State forests	Natural Forest: Standing volume: Deadwood Volume	Natural Forest: Standing volume: %	Natural Forest: Yield(a) m^3/ha/yr	Stock on cultivated and fallow land: m^3/ha	Stock on cultivated and fallow land: 1,000 m3	Population density inhab./km^2 (d)
KOULIKORO (b):									
Koulikoro	16	7,077	190	1,000	14%	0.54	11	1,500	20
Banamba	13	8,440		1,900	23%	0.13	9	1,000	15
Kangaba	26	10,279	256	300	3%	1.13	30	1,350	12
Kati	20	26,671	4,043	1,200	4%	0.88	25	7,500	21
Kolokani	17	15,040	1,620	1,000	7%	0.31	11	2,500	13
Subtotal	18	67,507	6,109	5,400	8%		17	13,850	
SIKASSO (c):									
Bougouni	27	43,662	3,619	1,300	3%	1.19	30	7,500	12
Kadiolo	31	14,310	736	143	1%	1.70	25	1,600	18
Kolondieba	31	20,276	1,242	600	3%	1.28	30	3,150	13
Koutiala	18	10,500	220	600	6%	0.67	17	6,000	31
Yanfolila	30	24,051	2,782	700	3%	1.45	34	2,800	13
Yorosso	19	5,965	164	400	7%	0.67	18	3,500	20
Subtotal	27	118,763	8,763	3,743	3%		24	24,550	

(a) Clément, J., Estimations des volumes et de la productivité des formations hétérogènes dans les zones tropicales, 1982.
(b) Excluding Nara (3,090,000 ha) and Dioila (1,320,000 ha) cercles.
(c) Excluding Sikasso (1,540,000 ha) cercle.
(d) Based on preliminary 1987 census figures.

Source: Particulars of Cercles, Fuelwood Resources Inventory Project (PIRL), 1988
Secretariat of Agriculture/CTFT-DNEF.

Table 3: FIREWOOD AVAILABILITY IN KOULIKORO AND SIKASSO REGIONS
(in thousands of m^3/year)

REGION/Cercle	Total firewood yield			Firewood availability					
	Natural forest		Cultvd. & fallow land	Natural forest		Cultvd. & fallow land	Dead wood (c) (1,000 m^3)	Wood yield from non-cultvd. land (d)	Firewood stocks on arable land (e) (1000 m^3)
	TOTAL	State forests		TOTAL (a)	State forests				
KOULIKORO (*):									
Koulikoro	243	7	75	146	4	23	600	122	678
Banamba	84		14	50		4	1,140	38	1,257
Kangaba	454	11	51	273	7	15	180	208	1,464
Kati	1,184	179	264	710	108	79	720	459	5,658
Kolokani	272	29	68	163	18	21	600	137	1,476
Subtotal	2,237	227	472	1,342	136	142	3,240	964	10,533
i.e. in tons	1,566	159	330	939	95	99	2,268	675	7,373
SIKASSO (**):									
Bougouni	1,916	159	298	1,150	95	89	780	322	18,856
Kadiolo	797	41	110	478	25	33	86	79	7,162
Kolondieba	844	52	135	506	31	40	360	78	10,298
Koutiala	391	8	230	234	5	69	360	172	1,679
Yanfolila	1,167	135	118	700	81	35	420	349	7,247
Yorosso	210	6	131	126	3	39	240	87	1,093
Subtotal	5,325	400	1,023	3,195	240	307	2,246	1,087	46,336
i.e. in tons	3,727	280	716	2,236	168	215	1,572	761	32,435

(*) Excluding Nara (3,090,000 ha) and Dioila (1,320,000 ha) cercles.
(**) Excluding Sikasso (1,540,000 ha) cercle.
(a) 60% of yield, allowing for access difficulties and local use.
(b) 30% of yield, allowing for traditional soil protection practices.
(c) 60% of stock of dead wood.
(d) Same assumption as for (a).
(e) Excluding cultivated and fallow land and using same assumption as for (a).

Source: Particulars of Cercles, Fuelwood Resources Inventory Project (PIRL), 1988
Secretariat of Agriculture/CTFT-DNEF, and mission estimates.

AGROINDUSTRIAL RESIDUES

Crop	Current production (a) x (1,000 t/yr)	Residue (b) Type	Estimated quantities x (1,000 t/yr)	Calorific value Kcal/kg	Gross energy content x (1,000 toe/yr)
Millet and sorghum	1,300	Stalks	2,600	2,500	637
Maize	200	Stalks	400	2,500	98
		Ears	100	3,500	34
Paddy rice	240	Straw	360	2,500	88
		Chaff	48	2,920	14
Cotton	200	Stems	800	2,500	196
Groundnuts	100	Shells	50	4,250	21
		Straw	250	2,500	61

(a) Basic Statistics (Cereals, Livestock): Office Statistique des Communautés Européennes, Bamako, 1987;
Agricultural Survey 1986-1987: Direction Nationale de la Statistique et de l'Informatique, Ministry of Planning, 1988.

(b) "Agricultural Residues as Fuel in the Third World," Earthcan, 1985.

Source: ESMAP estimates.

FORESTRY PROJECTS IN PROGRESS IN 1988

Project Title/ Description	Region	Amount (CFAF mlns)	Source of Financing	Nature of Activities
1. Second Forestry Project	Koulikoro	6,660	IDA/FAC/CCCE	Strengthening of institutions; management of State plantations by OAPF; nurseries; agro-silvi-pastoral management of village lands.
2. Mali Forestry Support Program (PAFOMA)	Sikasso	1,502	Switzerland	Rural forestry; village nurseries; creation of classified forests; management of State plantations by OARS; training and support for CFPF.
3. Ségou Community Woodlands Program	Ségou	775	Netherlands	Reforestation of village lands; tree nurseries.
4. Mopti Community Reforestation Program (Bandiagara, Djenne)	Mopti	273	USAID	Reforestation in village communities; tree nurseries.
5. Koro Community Agrosilvicultural Program	Mopti	67	CARE-MALI	Agro-forestry plantations.
6. Gao Village and Commercial Tree Plantations Program	Gao	87	UNSO	Tree plantings for soil-protection purposes; evaluation of planting techniques in the Sahel zone.
7. Banamba Village Forest Development and Reforestation Program	Koulikoro	515	Netherlands/FAO	Forest management at village level.
8. Kayes Agro-forestry Systems Extension Program	Kayes		West Germany	Promotion of agro-forestry techniques; forest management; anti-erosion works.
9. Deforestation of Manantali reservoir area	Kayes	3,040	West Germany	Salvaging of wood in the Manantali reservoir area; processing and marketing of the wood.
10. Distribution of improved stoves; measures to improve fuel-wood supplies to town of Kayes	Kayes	147	Norway/UNSO	Distribution of fuel-efficient stoves; organization of forest management and fuelwood marketing.

FORESTRY PROJECTS IN PROGRESS IN 1988

Project Title/ Description	Region	Amount (CFAF mins)	Source of Financing	Nature of Activities
11. Senegal-Mali Acacia Rehabilitation Program	Kayes	450	UNSO	Inventory and management of acacia plantations; technical and marketing improvements.
12. Assistance in preparation for forest resource development in the lake region	Tombouctou	84	FAO	Testing of techniques for anchoring dunes.
13. Support with the equipping and operating of tree nurseries	Everywhere except Kayes and Sikasso	284	European Development Fund	Construction of nurseries; provision of equipment for them.
14. Support for project preparation, appraisal and monitoring unit	DNEF	106	European Development Fund	Provision of information technology and office equipment and supplies; staff training.
15. Fuelwood Resources Inventory Project (PIRL)	Kayes, Koulikoro, Ségou, Sikasso	400	FAC	Inventory and mapping; interpretation of SPOT satellite images.
TOTAL (CFAF)		14,389 million		
i.e. US$		48 million		

Source: DNEF 1987 Annual Report.

MAJOR URBAN AREA FUELWOOD SUPPLY SYSTEMS

Type of Transport	Firewood					Charcoal			
	Bamako (a)	Kayes (b)	Sikasso (c)	Koutiala (c)	Bougouni (c)	Kayes (b)	Sikasso (c)	Koutiala (c)	Bougouni (c)
Truck	64%		32%	21%	3%				
Pickup	14%		21%	7%	5%		9%		
Other (*)	3%		7%	3%	2%		6%	1%	3%
Subtotal	81%	54%	60%	31%	10%	0%	15%	1%	3%
Wagon	11%	28%	32%	64%	69%	42%	6%	92%	14%
Other (**)	0%	5%	8%	5%	21%	49%	79%	7%	83%
Subtotal	11%	33%	40%	69%	90%	90%	85%	99%	97%
Train	5%	6%				6%			
Pirogue	3%	6%				4%			

(*) Private vehicles
(**) Bicycle, moped, on head, etc.

Sources:

(a) Aug. 1987, "Propositions de mesures pour la réduction de la consommation de bois de chauffe à Bamako," DNEF, Jan. 1988.

(b) June-Aug. 1988, "Rapports d'enquêtes sur les filières d'approvisionnement en bois-énergie de la ville de Kayes," DREF/UNSO, Sep. 1988.

(c) April-May 1985, "Marchés urbains des produits forestiers," DNEF-CTFT, OARS June 1985.

FUELWOOD PRICE STRUCTURES FOR SUPPLY BY TRUCK

	Bamako (1988)				Mopti (1988)		Sikasso (1985)	
	Truck hire		Return empty		Truck hire		Truck hire	
	CFAF/kg	%	CFAF/kg	%	CFAF/kg	%	CFAF/kg	%
Felling permit (a)	0.6	4%	0.6	4%	0.6	4%	0.6	9%
Roadside price (b)	6.0	39%	6.0	39%	6.2	35%	3.1	43%
Transport cost (c)	4.5	29%	0.9	6%	3.6	20%	1.6	23%
Handling (d)	0.3	2%	0.3	2%	0.3	1%		0%
Costs	11.4	73%	7.8	50%	10.7	60%	5.3	74%
Mark-up (e)	4.1	27%	7.7	50%	7.1	40%	1.8	26%
Retail price	15.5	100%	15.5	100%	17.8	100%	7.1	100%

(a) Flat rate based on 30 steres per 10-t truck and 60 steres per tractor-trailer. Average actual quantities carried are 9.6 t and 18.8 t respectively.

(b) See Annex 7 for Bamako.

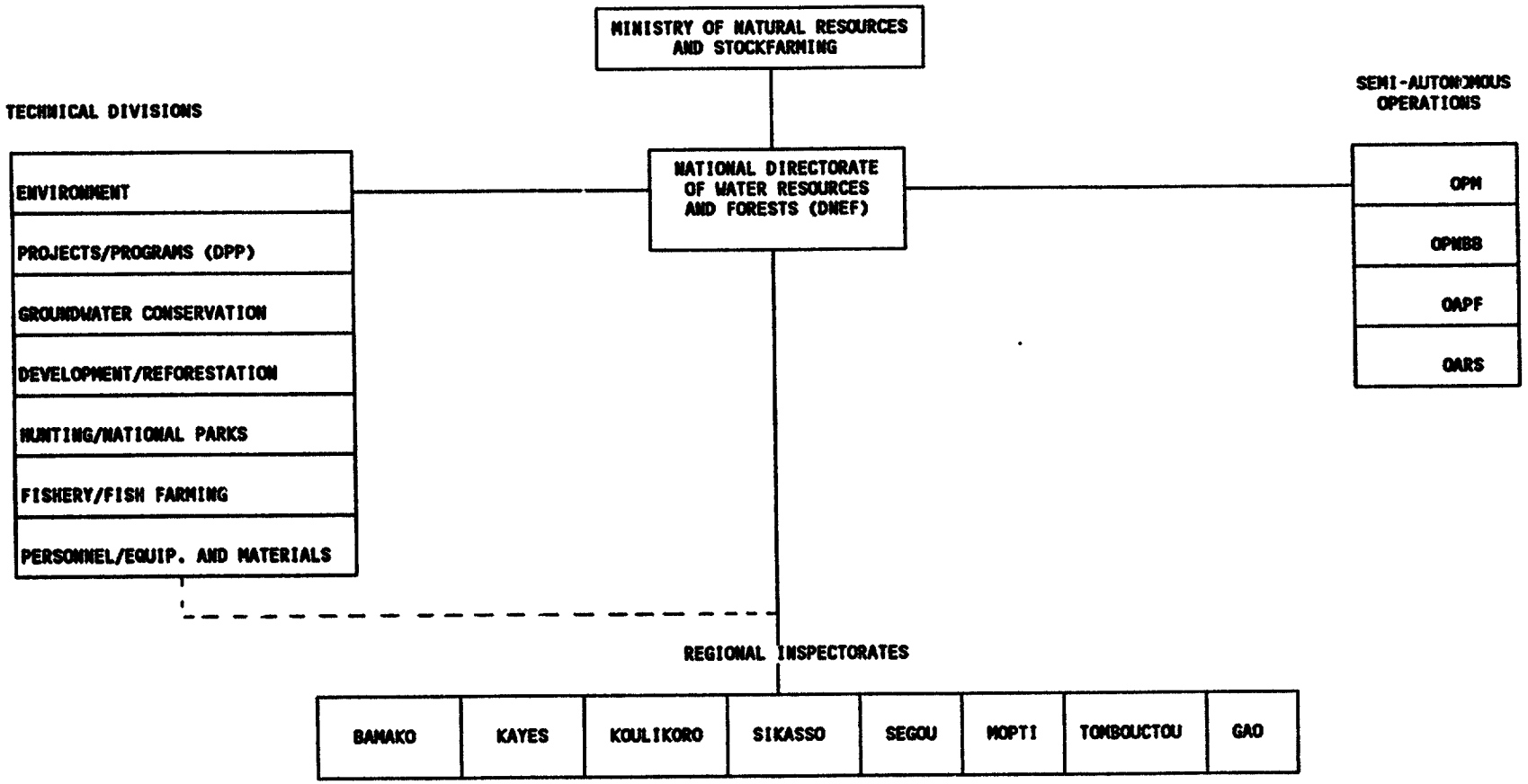
(c) Flat rate per journey for vehicle hire, estimated at 30% of official rates for transport of solid goods (CFAF 25/t/km) per 100 km of "return empty" journey.

(d) Loading and unloading.

(e) Wholesale and retail mark-ups, incl. costs of wood chopping.

Sources: ESMAP estimates for Bamako and Mopti
"Marchés urbains des produits forestiers", DNEF-CTFT and OARS for Sikasso.

SECOND FORESTRY PROJECT (WORLD BANK)
FORESTRY DEPARTMENT ORGANIZATION CHART



RESPONSIBILITIES OF FUELWOOD RESOURCES GROUP, OTHER DNEF GROUPS, AND THE PRIVATE SECTOR

ACTIVITIES	ACTORS: GCL	DNEF	PRIVATE	OTHER	INPUTS	OUTPUTS
Assessment of fuelwood requirements by urban zone (demand)	********			DNEF	Demand surveys	Needs by zone
Identification of zones for development and their production potential		*********	*********		Forest inventories	Development plans
Review of tax policy and fuelwood price regulations	*********	*********	*********	DNEF + Draft Household Energy Project		New tax policies and regulation of prices
Organization of rural community associations and provision of training for them	*********	*********	*********	ESMAT Project	Development plans	Producer associations
Development of production zones		*********			Development plans	
Organization of bush markets	*********	*********	*********		Producer associations	Bush markets
Felling/production			*********			
Control/advise loggers		*********				
Purchasing of fuelwood			*********			
Transport of fuelwood to urban centers			*********			
Checkpoint processing of deliveries to urban areas	*********				Certificate of origin	Data on deliveries, points of origin, taxes paid
Monitoring of supply and demand, by zone	*********				Control data + data on production potential	Supply/demand picture, zone by zone
Monitoring of payment of taxes due					Control data + data on production potential	

Source: ESMAP estimates.

ENERGY CONSUMPTION AND EXPENDITURE IN HOUSEHOLDS AND IN THE INFORMAL SECTOR

Introduction

1. As in most other Sahelian countries, household energy consumption in Mali shows the following characteristics:

(a) Fuelwood (firewood, charcoal) is by far the main source of energy, accounting for approximately 80% of the total consumption of final energy (see Energy Balance, Annex 1.1). Current supply systems pose a threat to the environment, particularly in those areas from which urban centers are supplied or in which charcoal is produced;

(b) A high proportion of energy consumed is used for cooking, and the traditional types of stove, in widespread use, are not fuel-efficient, pose health risks, and are difficult and even dangerous to operate;

(c) Such practical, modern fuels as LPG or kerosene are expensive because of current import prices, high transport costs, and the taxes imposed on them. They are too dear at present for low-income and even middle-income households;

(d) Since these substitute fuels are all imported, they have a major impact on Mali's balance of payments;

(e) In rural areas, although fuelwood resources are generally adequate, modern fuels are in short supply, and their present price levels do not encourage their wider use. Rural electrification is limited to small towns and there is little power supply available to households for such productive activities as pumping water or agro-foodstuff processing; and

(f) Coordination of the activities of the organizations and institutions active in the subsector is limited, so that comprehensive evaluations of the present situation and of both present and future policies and programs are essential if an integrated strategy is to be formulated and put into effect. However, preparation of such a strategy by the DNHE and ESMAP was begun early in 1990.

Demographics

2. With a surface area of 1.24 million km^2, Mali is one of the larger African countries, although its total population in 1987 is estimated at only 7.6 million (Table 1). The country is essentially rural in character: approximately 80% of the population lives in rural areas, the majority in the southern region in the catchment areas of the Senegal and Niger Rivers and their tributaries. Of the urban population (defined as living in towns with more than 5,000 inhabitants), 42% is concentrated in the capital, Bamako, which is seven times larger than Ségou, the second most important urban center in Mali (See IBRD map 19169R and Table 1).

3. Knowledge is lacking about Mali's demographic growth. Current World Bank projections indicate an annual rate of 3.0%, although the preliminary results of the census conducted by DNSI show growth of only 1.7% per annum between the 1976 and 1980 censuses. This low growth rate may be ascribable to narrowing of the gap between birth and mortality rates (the health care system being still rudimentary), to higher emigration than anticipated (the male population traditionally moving away to neighboring countries in search of work), and to errors caused by failure to adhere to census methodology. A demographic growth rate of 3%, in line with the Bank's projections, has been used in this study.

4. Demographic growth rates appear to vary significantly among regions and between rural and urban areas (Annex 2.8, Table 1). Thus, the rural population in the Sahelian-Saharan zones of Mopti, Gao and Tombouctou is stationary or declining, while in the Koulikoro and Kayes zones it is increasing more rapidly than the national rural average of 2.3% per annum. As to the urban population, it is growing more rapidly, at an overall rate of 5.8% per annum, with notable increases over that figure in Gao (9.0%), where the population is drawn from adjacent rural districts, in Koutiala (10.1%), which is located in the center of the comparatively rich cotton-growing region, and in the capital, Bamako (6.7%). The situation in towns in frontier zones varies considerably: for Kayes, where economic activity is declining, the rate is 4.5% p.a., while for Sikasso and Gao, which are very well-placed geo-economically, it is 6.4% and 9.0% p.a., respectively. In Mopti and Ségou, population growth rates are below the national average.

5. With demographic growth of the order of 3% a year, the population of Mali should reach approximately 11.4 million in 2000. In 2000, the urban population (3.2 million) should represent 26% of the total population, while Bamako, with 1.5 million inhabitants, would contain 47% of the urban population and 14% of the total population. 1/

1/ *If Mali's actual population growth rate were 3.0% per annum (the World Bank projection), its population would be approximately 15 million in 2010.*

Table 1: PROJECTED POPULATION GROWTH RATES, BY REGION AND BY MAJOR TOWNS, (1987-2010) (x 1,000 inhabitants)

		1987	Annual Growth 1987-2000 %	1990	1995	2000	2010
Kayes							
	Rural	923	2.7	1001	1146	1312	1719
	Urban	136	4.5	155	192	238	370
	Total	1059	3.0	1156	1338	1550	2083
Koulikoro							
	Rural	1066	3.6	1185	1413	1685	2400
	Medium towns	115	3.9	129	155	187	274
	Bamako	646	6.7	784	1082	1494	2858
	Total	1827	4.7	2097	2650	3365	5327
Sikasso							
	Rural	1128	2.1	1202	1338	1488	1832
	Urban	181	6.4	218	298	407	757
	Total	1309	2.8	1421	1636	1895	2498
Ségou							
	Rural	1143	3.8	1280	1475	1700	2468
	Urban	185	4.6	212	266	334	524
	Total	1328	4.0	1492	1741	2034	3011
Mopti							
	Rural	1144	1.5	1197	1291	1393	1617
	Urban	118	3.3	130	154	181	250
	Total	1262	1.7	1327	1455	1574	1863
Tombouctou							
	Rural	369	-2.3	344	305	271	215
	Urban	84	5.6	99	130	170	293
	Total	453		443	435	441	508
Gao							
	Rural	298	1.2	287	270	254	286
	Urban	85	9.0	110	171	264	625
	Total	383		398	441	519	911
Mali							
	Rural	6071	2.3	6497	7238	8103	10172
	Urban	1550	5.8	1837	2447	3275	5755
	Total	7	3.0	8334	9686	11378	15291
TOWNS							
	BAMAKO	646	6.7	784	1082	1494	2858
	SEGOU	89	5.3	104	135	174	292
	MOPTI	74	5.7	87	115	151	263
	SIKASSO	73	7.9	92	135	197	421
	GAO	55	10.1	73	118	191	500
	KAYES	48	-0.4	47	46	45	43
	KOUTIALA	48	10.1	64	103	167	437
	TOMBOUCTOU	32	8.6	41	62	94	214

Note: The urban population includes administrative seats of Departments, and towns with at least 5,000 inhabitants.

Sources: DNSI, World Bank, ESMAP.

6. Low population density in rural areas is another characteristic of Mali's demographics (Annex 2,8, Table 2). This is true not only of semi-desert regions like Gao and Tombouctou, where average density is one inhabitant/km², but also of agricultural regions like Ségou (29 inhabitants/km²) or Sikasso (17 inhabitants/km²). The cercle with the highest population density, namely 29 inhabitants/km², is located in the Ségou region.

Table 2: DENSITY OF RURAL POPULATION

Region	Inhabitants	Density Average	Minimum	Maximum
Kayes	923	8	6	15
Koulikoro	1066	12	5	19
Sikasso	1128	17	12	26
Ségou	1143	19	9	29
Mopti	1144	15	7	28
Tombouctou	369	1	<1	26
Gao	298	1	<1	3
Total	6071	5	-	-

Source: General Population and Housing Census: Preliminary Results, April 1987.

7. Households are significantly smaller throughout the northeast. In the Gao and Mopti regions, each household has 1.3 persons fewer than in the Kayes, Koulikoro or Bamako regions. An essential factor for the proper understanding of household energy consumption is clear definition of the unit of observation: a household generally consists of one or more small groups who prepare and eat meals together and live in the same compound. A single compound may house several households; on average, however, there are between 1.5 and 2 households per compound, with variations among regions.

Energy Consumption in Rural Households

8. In the rural world, virtually all households use wood for cooking and such customary activities as making millet beer, shea butter, soap, drying farm products, smoking fish, firing pottery and dyeing. Firewood is also often used for lighting whenever supply disruptions or prices make the purchase of kerosene difficult.

9. Firewood is sold only in urban areas and certain parts of the Niger delta, in particular the Djenné zone. Elsewhere, women and children gather enough for their own needs and possibly to sell in the towns. As a rule, wood consumption in rural areas puts no pressure on the environment since adequate supplies are available from pruning of trees, clearing of fallow land, felling of dead trees, collection of twigs, and use of alternative fuels, so that only limited use is made of the forest itself. However, serious constraints are affecting this traditional system of obtaining fuelwood supplies in regions where stocks are limited or endangered, which are used as sources of supply for urban centers, or where population density is high (given the types of farming seen in Mali, 20 inhabitants/km² may be regarded as the limit figure). Finally, animal traction is widely used in certain areas and for certain purposes.

Energy Consumption in Urban Households

10. In urban areas, the main fuel is firewood and it is generally purchased. 2/ In Bamako and Ségou in 1987, virtually 90% of households were buying firewood each day at wholesale prices of CFAF 50-200/bundle (US$0.18-0.70), varying according to volume bought and whether the wood was split or not. Although used mainly for cooking, the supplies were also used for heating water or for small-scale productive activities.

11. Few other fuels besides wood are used for cooking. Charcoal consumption is low at present but increasing very rapidly. In Bamako, 13% of households now use it as their main fuel and practically all use it in small quantities for making tea and coffee, ironing, and broiling (50 g/head/day on average, according to estimates given in a 1984-85 study on energy planning); 3/ expenditure on charcoal rarely amounts to more than 10% of the household energy budget. LPG is an expensive fuel used by only 15-17% of Bamako households as a second fuel for rapid cooking or heating liquids, and by only 1% of households (mainly expatriates) as the main fuel. Given current LPG price levels and the cost of the right equipment (approximately CFAF 16,000, or US$57, for the stove and the deposit on the gas bottle), its use can be expected to increase only slowly, and then merely as a back-up fuel; nevertheless, the construction of new storage facilities (nearing completion in Mopti and in the planning stage for Gao) may mean that a small market for it will develop in Ségou, Mopti and Gao. Lastly, kerosene is hardly used at all for cooking (except in frequent, small quantities to start fires in the wet season) because of the high price and short life of kerosene stoves and their unsuitability to Malian cooking habits.

12. As for electric power, fewer than 30% of urban households live in compounds connected to the Energie du Mali (EDM) network. According to findings from surveys in Bamako and Ségou, a significant proportion of electrified households (probably between 5% and 10%) resell power to neighbors. Electricity is used mainly for lighting, with monthly consumption figures rarely exceeding 100 kWh/compound/month; nonelectrified households use kerosene, gas, candles and vegetable oil for lighting. It is worth noting that, in the majority of compounds without electricity, spending on batteries, mainly for radios and torches, can equal half what is spent on firewood, but while firewood consumed is equivalent to 30-40 kWh/month (at EDM's subsidized tariff of CFAF 58/kWh, or US$0.21) battery energy consumed is equivalent only to a few kWh/month.

Consumption of Firewood

13. It is difficult to estimate wood consumption accurately. Consumption levels depend on many factors, the key one being household size and the secondary ones being environment and location, availability of supplies, household income level, season, wood prices, end uses, types of equipment operated, and relative importance of the various fuels relied on. Few surveys allow for these factors and few are based on representative samples; only average consumption figures are available, and should therefore be treated with caution.

2/ *Results of the detailed 1987 survey of 850 households in Bamako and Ségou, conducted as part of the Improved Stoves component of the SEP.*

3/ *TRANSENERG Energy Planning Study, 1984/85.*

14. Where urban zones are concerned, the results of the 1987 surveys in Bamako and Ségou and the inspection of 200 households in Bamako by LESO in 1986 do, however, provide good indications regarding firewood consumption. Average consumption appears to range between 0.9 and 1.3 kg/head/day (0.9 in Bamako, 1.1 in Ségou), to which must be added charcoal consumption (Annex 2.8, Tables 3 and 4). As noted earlier, per capita urban consumption ranges from 2.7 to 0.8 kg to 0.5 kg/head/day in 2-person, 12-person and large households, respectively.

15. Where rural zones are concerned, consumption for cooking purposes also appears to vary as a function of household size, but not significantly from one ecological zone to another; 4/ ranging from 1.3 kg/head/day in Sahelian zones to 2 kg/head/day in zones like Sikasso where relatively large quantities of wood are used for household productive activities. In view of these disparities and the general unreliability of survey data, the 1984/85 Energy Planning Study gave the following figures: for Bamako, 1.7-1.9 kg/head/day (1978 data); for other urban centers, 1.1-2.1 kg/head/day; 5/ and for rural areas, 0.7-2.4 kg/head/day. Additional surveys will be conducted as part of the ESMAP study on the preparation of the Household Energy Strategy.

Table 3: HYPOTHESES FOR WEIGHTED UNIT CONSUMPTION OF WOOD
(Firewood and wood for cooking)

Trend-based scenario and consumption structures unchanged) a/		Kg/person/day
KAYES	Rural	1.4
	Urban	1.61
KOULIKORO	Rural	2.05
	Urban	2.7
SIKASSO	Rural	2.05
	Urban	3.08
SEGOU	Rural	1.4
	Urban	1.26
MOPTI	Rural	1.05
	Urban	1.42
TOMBOUCTOU	Rural	0.8
	Urban	1.2
GAO	Rural	0.8
	Urban	1.2
BAMAKO		1.55

a/ Includes results of surveys on the use of wood and charcoal as principal and secondary fuels. It also incorporates a kiln efficiency of 12%.

Source: Various surveys, ESMAP estimates.

4/ *One of the most reliable surveys on rural areas was conducted in 1984 and 1985 by LESO in 20 village communities located in four different ecological zones (Gao, San, Bougouni and Nioro).*

5/ *Rural Polytechnic Institute surveys at different times.*

Table 4: SUMMARY OF HOUSEHOLD ENERGY CONSUMPTION
using (a) trend-based scenario and (b) diversification strategy

	Trend-based scenario			Diversification Strategy	
	Tons per Year		% Growth Rate	Tons per year	% Growth Rate
	1987	2000	1987/2000	2000	1987-2000
Firewood					
Urban	614	1,093	4.5	909	3.1
Rural	3,331	4,141	1.7	4,099	1.6
Total	3,945	5,234	2.2	5,008	1.8
Charcoal					
Urban	53	130	7.1	78	3.0
Rural	-	-	-	-	-
Total	53	130	7.1	78	3.0
Other biomass					
Urban	-	-	-	-	-
Rural	247	329	2.2	329	2.2
Total	247	329	2.2	329	2.2
LPG					
Urban	0.5	6.2	21.4	22	33.8
Rural	-	-	-	-	-
Total	0.5	6.2	21.4	22	33.8
Kerosene					
Urban	5.2	7.2	2.5	15.2	8.6
Rural	7.3	8.8	1.5	12.8	4.4
Total	12.5	16.0	1.9	28.0	6.4

Source: ESMAP estimates.

See Annex 2.8.

Household Energy Balance

16. Firewood consumption by Malian households in 1987 is estimated at approximately 4.3 million tons (air-dried), of which roughly 3.3 million tons was consumed in rural areas. Charcoal consumption by urban households is estimated at 53,000 tons; for rural areas, it is included in the figure for firewood, since rural households themselves generally produce what little charcoal they need. Consumption of other types of biomass (crop residues, dung, etc.) is estimated at 0.25 to 0.30 million tons -- as a percentage of firewood consumed, using available data on each ecological zone. This corresponds to final energy consumption by households of more than 1,700,000 toe, while total consumption of fuelwood and biomass is put at over 1,750,000 toe (Annex 2.8, Table 5). Firewood is clearly predominant, even in terms of useful energy (i.e. after the efficiency rates of the various kinds of equipment are taken into account). It is the key household fuel, with annual sales estimated at CFAF 6.5 billion (approximately US$23 million), or 40% of household sector energy sales (Annex 2.8, Table 6).

Table 5: 1987 ENERGY BALANCE: FIREWOOD AND OTHER BIOMASS
(1000s of toe)

Sector	Primary Energy		Final Energy			
	Firewood	Other Biomass	Firewood	Charcoal	Other Biomass	Total
Households a/	1777	86.5	1597	37	86.5	1720.5
Commercial b/	7.5	(c)	2.5	1	(c)	3.5
Industrial	1.5	25	1.5	(d)	25	26.5
Subtotal	1766	111.5	1601	38	111.5	1750.5

Notes:
(a) Including all household uses (e.g. making of millet beer, shea butter).
(b) Estimated at 5% of consumption by urban households.
(c) Negligible. Including, e.g., rice straw for pottery making in Delta region.
(d) Negligible. Including, e.g., consumption by Bamako Tobacco and Match Factory (SEGMA).

Conversion factors:

1 t air-dried wood = 1 t other biomass = 0.35 toe
1 t charcoal = 0.67 toe

Source: ESMAP estimates.

Table 6: ESTIMATED 1987 HOUSEHOLD ENERGY SALES

Energy	Consumption	Price (CFAF/unit)	Sales (millions of CFAF)	%
Electricity	68,395,000 kWh	58	3,966,910	25.3%
Kerosene	12,500,000 kg	250	3,125,000	19.9%
Firewood (a)	433,500,000 kg	15	6,502,500	41.5%
Charcoal	29,000,000 kg	66	1,914,000	12.2%
LPG	536,000 kg	320	171,520	1,1%

(a) Using following assumptions:
Daily consumption: 1 kg/head
Wood purchases: 90% of households in main urban centers
50% of households in secondary centers
Excluding purchases of wood in rural areas.

Source: ESMAP estimates

Likely Future Trends in Household Energy Consumption

17. A first scenario for household energy consumption over the next 20 years can be based on the hypothesis of a continuation of present trends: (a) consumption per capita and utilization rates of charcoal will not change; (b) in rural areas, wood consumption per capita and utilization rates will remain constant; and (c) in urban areas, the wood utilization rate will decline slowly (the lowest estimated rate after 20 years being 85% in Bamako), as will per capita consumption of wood (thanks to distribution of improved stoves). At the same time, the rate of utilization of LPG in urban areas will rise slightly (initially in Bamako, next in Ségou, Mopti, Gao and Tombouctou, and then in other urban centers), as will per capita consumption, reflecting the proportion of households that use LPG as their main fuel (25%

of consumers) or as a back-up fuel (the remainder). The rate of utilization of kerosene for lighting purposes will decline slowly in urban areas as power supply services are extended, while consumption per user will remain constant in both rural and urban areas.

18. According to these trend-based assumptions, firewood consumption should rise from 4 0 million tons in 1987 to 5.2 million tons in 2007 (Annex 2.8, Table 4). The urban component of this consumption should rise from 614,000 tons in 1987 to 1,093,000 tons in 2000, thereby exerting very considerable additional pressures on forest production zones and adding urgency to the need to control and improve the present supply system. At the same time, LPG consumption will increase rapidly from the 1987 figure of 470 tons to 6,800 tons in 2000 (in urban areas only and despite initial levels which are very low except in Bamako).

19. However, the reality could prove very different if effective government policies were instituted in such areas as: alignment of fuelwood prices with underlying economic costs; major macro- and microeconomic adjustments (balance of payments improvements, higher standards of living, improvement/deterioration of supply networks, etc.); and major changes in petroleum product prices. For instance, kerosene could play a greater role as a substitute for firewood. In any event, there is a need for detailed evaluation as soon as possible of various realistic scenarios for the household sector. A diversification scenario is shown in Table 4.

The Informal Sector

20. Income derived from the informal sector in urban zones frequently makes an important contribution to household income. In addition to transportation and trading activities, this sector includes certain occupations dependent on high wood consumption (artisan bakers, street food vendors, jewelers, blacksmiths, potters, dyers, soap-makers, etc.). A program of simple measures to reduce their firewood and charcoal consumption would undoubtedly be successful as this group is small, adaptable and responsive to incentives; it would also be warranted, as the group's consumption per user rate is so high.

Role of Women

21. As the primary role Malian women play in household activities has not always been either examined or understood, their importance where strategy implementation is concerned has been minimized and underestimated. In rural areas, besides preparing food and collecting firewood, women also engage in energy-intensive activities such as the processing of farm products (drying of crops and so on, and also fish, grinding of grain, etc.), the pumping of water and the making of such necessities as millet beer, soap, clay pots, etc.

22. In urban areas, women play an equally important part, they buy fuel, use cooking equipment, and manage the household budget, 6-10% of which is spent on fuel. Production and popularization of improved stoves (portable ones in urban areas, improved three-stone models in rural areas), will therefore depend to a large extent on women. In addition, women handle some of the urban retailing of fuelwood and are in partial control of the supply networks.

Energy Expenditures and Household Budgets

23. Generally speaking, expenditures on energy absorb no more than a low percentage of Malian household budgets. Average expenditure on energy and water varies between a minimum of 3.3% of the family budget in Sikasso and a maximum of 6% in Kayes, while spending on food can absorb anywhere from 73% of the budget in Gao to less than 50% in Bamako (Annex 2.8, Table 7). Energy and water costs can vary between 6% and 10% of food costs, in Gao and Bamako, respectively.

24. Although data are not available, it is clear that energy expenses, since they cannot be reduced, have a much greater impact on urban low-income household budgets. These households have few or no possibilities of collecting their own fuel or recovering what they spend to buy the firewood and charcoal needed for cooking. Moreover, they are generally smaller, which means that per capita consumption of fuelwood is higher than in larger families. (Consumption appears to be in inverse proportion to family size.)

25. The findings of the surveys on the allocation of expenditure to the consumption of electric power, liquid fuels (kerosene and LPG), and solid fuels (firewood, charcoal) are presented in Annex 2.8, Table 7. Even though figures on the distribution of the users of each type of energy are not available for establishing weightings, it is to be noted that expenditure on solid fuels is the highest, although the average figure does not exceed CFAF 2,500/month (approximately US$9/month).

Table 7: ANNUAL EXPENDITURE OF URBAN HOUSEHOLDS (1985)

Category	Kayes CFAF	%	Koulikoro CFAF	%	Sikasso CFAF	%	Ségou CFAF	%
Food	361,677	62.8	497,233	50.2	343,382	51.8	473,861	50.6
Energy and water	34,765	6.0	56,170	5.7	22,102	3.3	48,033	5.1
Other	179,240	31.1	436,371	44.1	297,647	44.9	414,776	44.3
TOTAL	575,682	100.0	989,774	100.0	663,131	100.0	936,670	100.0

Category	Mopti CFAF	%	Tombouctou CFAF	%	Gao CFAF	%	Bamako CFAF	%
Food	370,207	62.2	424,746	75.1	572,388	73.2	433,500	48.2
Energy and water	28,900	4.9	28,495	5.0	33,900	4.3	43,681	4.9
Other	196,532	33.0	112,258	19.9	175,182	22.4	422,906	47.0
TOTAL	595,639	100.0	565,499	100.0	781,470	100.0	900,087	100.0

Source: Urban Household Expenditure Survey, DNSI, 1987.

Individuals per household:

Kayes:	8.3	Mopti:	7.0	Sikasso:	6.0	Gao:	7.4
Koulikoro:	5.1	Tombouctou:	7.2	Ségou:	6.9	Bamako:	7.0

ANNUAL EXPENDITURE OF URBAN HOUSEHOLDS (1985)

Category	Kayes CFAF	%	Koulikoro CFAF	%	Sikasso CFAF	%	Ségou CFAF	%
Electricity	4,265	14.5	7,483	15.3	1,459	7.9	1,236	2.9
Liquid fuels	2,015	6.9	11,897	24.3	3,959	21.6	14,705	34.1
Solid fuels	23,068	78.6	29,565	60.4	12,938	70.5	27,238	63.1
TOTAL	29,348	100.0	48,945	100.0	18,356	100.0	43,179	100.0

Category	Mopti CFAF	%	Tombouctou CFAF	%	Gao CFAF	%	Bamako CFAF	%
Electricity	756	2.9	797	3.4	3,306	13.8	9,595	23.0
Liquid fuels	2,966	11.5	1,181	5.1	2,563	10.7	7,560	18.1
Solid fuels	22,116	85.6	21,132	91.4	18,099	75.5	24,580	58.9
TOTAL	25,838	100.0	23,110	100.0	23,968	100.0	41,735	100.0

Source: Urban Household Expenditure Survey, DNSI, 1987.

Cost of Cooking Fuels

26. On the basis of both current market prices and economic costs, wood is by far the cheapest fuel; given present price levels and structure, 6/ no quick, significant energy substitution can therefore be expected (Annex 2.8, Table 8). The cost of cooking with wood (including stove depreciation) is 1.7 to 2.3 times less than with the alternatives. When economic costs are used as the basis of calculation, however, kerosene becomes very attractive while LPG and, in particular, charcoal become more expensive than firewood. Nevertheless, if kerosene use for cooking is to expand, consumers must first have access to affordably priced stoves adapted to their cooking customs, and their prejudices regarding disagreeable odors and taste must be overcome.

27. Regrettably, knowledge of the preferences, motivations and expectations of the various consumer groups in Mali is not very precise. In addition to questions of household income levels and energy budgets, other factors come into play: ease of use, modernity, guaranteed supplies, time saved, etc. A careful analysis of consumer preferences is necessary for understanding what energy substitutions can be expected and deciding which of them are to be fostered. This is a very important prerequisite to formulation of any energy strategy focused on households.

6/ *Annex 2.8, Table 8 provides estimates of useful energy costs for the various cooking fuels available in Mali (after allowance for fuel-effectiveness of appliances, market prices of fuels, and their theoretical and real economic costs). "Theoretical economic cost" is the cost of direct purchases on international markets.*

Table 8: ENERGY COSTS AND MONTHLY EXPENDITURE ON COOKING AT BAMAKO

		Firewood	Charcoal	Kerosene	LPG
A.	Fuel Prices (CFAF/kg)				
	Current price	18	66	250	320
	Price excluding taxes	17	63	112	300
	Theoretical economic cost	17(a)	63(a)	94	275(b)
B.	Cost of Utilizable Energy				
	At current prices (CFAF/MJ)	5.3	9.1	12.8	14.0
	Relative cost compared to wood	1.0	1.7	2.4	2.6
	Relative cost compared to charcoal	0.6	1.0	1.4	1.5
	At prices excl. taxes	5.0	8.7	5.7	13.1
	Relative cost compared to wood	1.0	1.7	1.2	2.6
	Relative cost compared to charcoal	0.6	1.0	0.7	1.5
	At theoretical economic cost (CFAF/MJ)	5.0	8.7	4.8	12.0
	Relative cost compared to wood	1.0	1.7	1.0	2.4
C.	Annual Cost of Cooking (from Household Surveys)				
	Cost of fuel (CFAF/year)	37800	51100	7300	86000
	Price of a stove (CFAF)	1250	1500	700	16000
	Life of a stove (years)	2	2		4
	Annual payments on stove (CFAF/year)	650	800		2600
	Total cost (CFAF/year)	38450	51900	76000	88600
	Cost as compared to wood	1.0	1.3	2.0	2.3
	Cost as compared to charcoal	0.7	1.0	1.5	1.7

Notes: (a) Minimum cost (for zone with sustainable extraction)

(b) Without taking account of a possible major increase in the tonnage consumed.
Family of 8 persons
Meals: rice with sauce, midday meal
Wood consumption: 0.9 Kg/person/day, of which 0.72 for cooking, of which 40% for lunch
Charcoal consumption: 330 g/person/day, of which 265 g for cooking, of which 40% for lunch
Kerosene consumption: 0.15 L/person/day, of which 0.125 for cooking, of which 40% for lunch
LPG consumption: 115 g/person/day, of which 92 for cooking, of which 40% for lunch.

Source: ESMAP estimates.

MALI

ENERGY SECTOR EVALUATION
Current Power Generating Equipment

A. INTERCONNECTED NETWORK

	Installed Capacity	Seasonal Capacity Dry MW	Seasonal Capacity Rainy MW	Year taken into Service
1. Hydro				
(a) Sotuba	2 x 2.6	4.5	5.0	1966
(b) Sélingue	4 X 11	25.0	44.0	1981
Subtotal	49.2	29.5	49.0	
Ferme		29.5	38.0 a/	
2. Thermal (Diesel)				
Dar Salam:				
Alsthom 16PA4-V185	3 x 1.1	2.0	2.0	1965-71
Alsthom 12PC2.2V400	4.2	3.5	3.8	1974
Alsthom 16PC2.2V400	2 x 5.4	9.0	10.0	1972, 1977
Subtotal	18.3	14.5	15.8	
Confirmed		10.0 a/	15.8	
Interconnected network total				
Installed		67.5	67.5	
Available		44.0	64.8	
Confirmed		39.5	53.8	

B. ISOLATED SYSTEMS

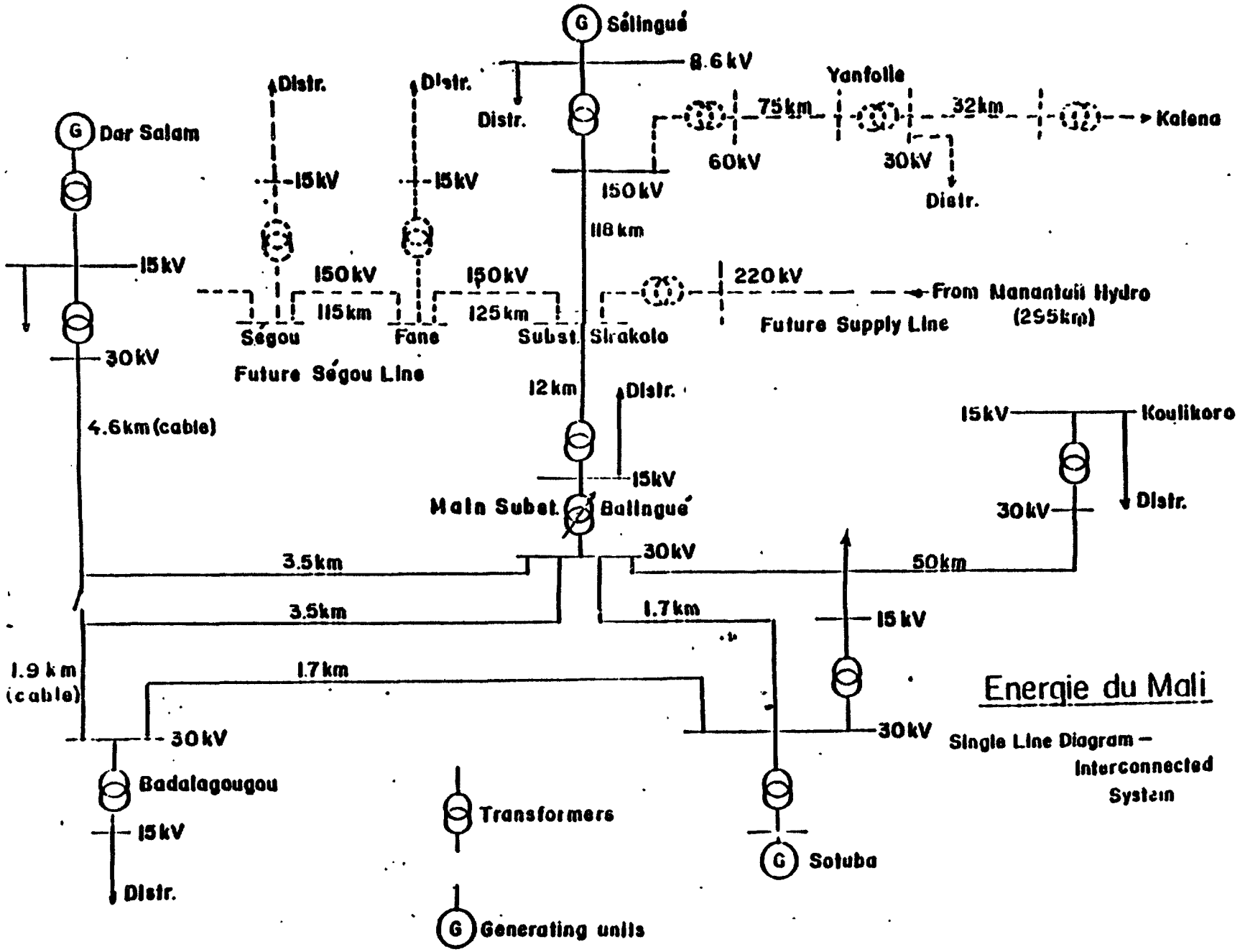
	Number of generator sets	KVA installés	Capacity, KW approx.
Kayes	2	2,665	2,200 b/
Fana	2	350	300
Kita	2	525	450
Bougouni	3	600	500
Sikasso	3	1,285	1,100
Koutiala	2	560	480
Ségou-Markala	6	2,162	1,800
Mopti-Sevare	3	3,180	2,700
Tombouktou	4	775	650
Goa	4	1,105	940
Total	31	13,207	11,120

Available capacity estimated at approx. 75% of installed capacity.

C. APPROXIMATE PRIVATE GENERATING CAPACITY

	(kW)	Principal Owners
Kayes	360	Tannery, irrigation
Fana	420	CMDT (cotton)
Kita	1,000	SEPAMA (nuts)
Bougouni	410	CMDT
Sikasso	1,400	CMDT
Koutiala	3,100	CMDT
Ségou	10,000 c/	Comatex, barracks, hotels, banks, IMAP
Kalana	1,750	Gold mine
Mopti Sevare	260	Ranaga Hotel, rice mill
Tombouctou	360	Azalai Hotel, irrigation
Total	19,080	

a/ Largest unit in reserve.
b/ Including 500 KW capacity at Félou.
c/ Tentative estimate; Comatex was rehabilitating its diesel generators, reducing capacity from approx. 5200 kW to 3150 kW.

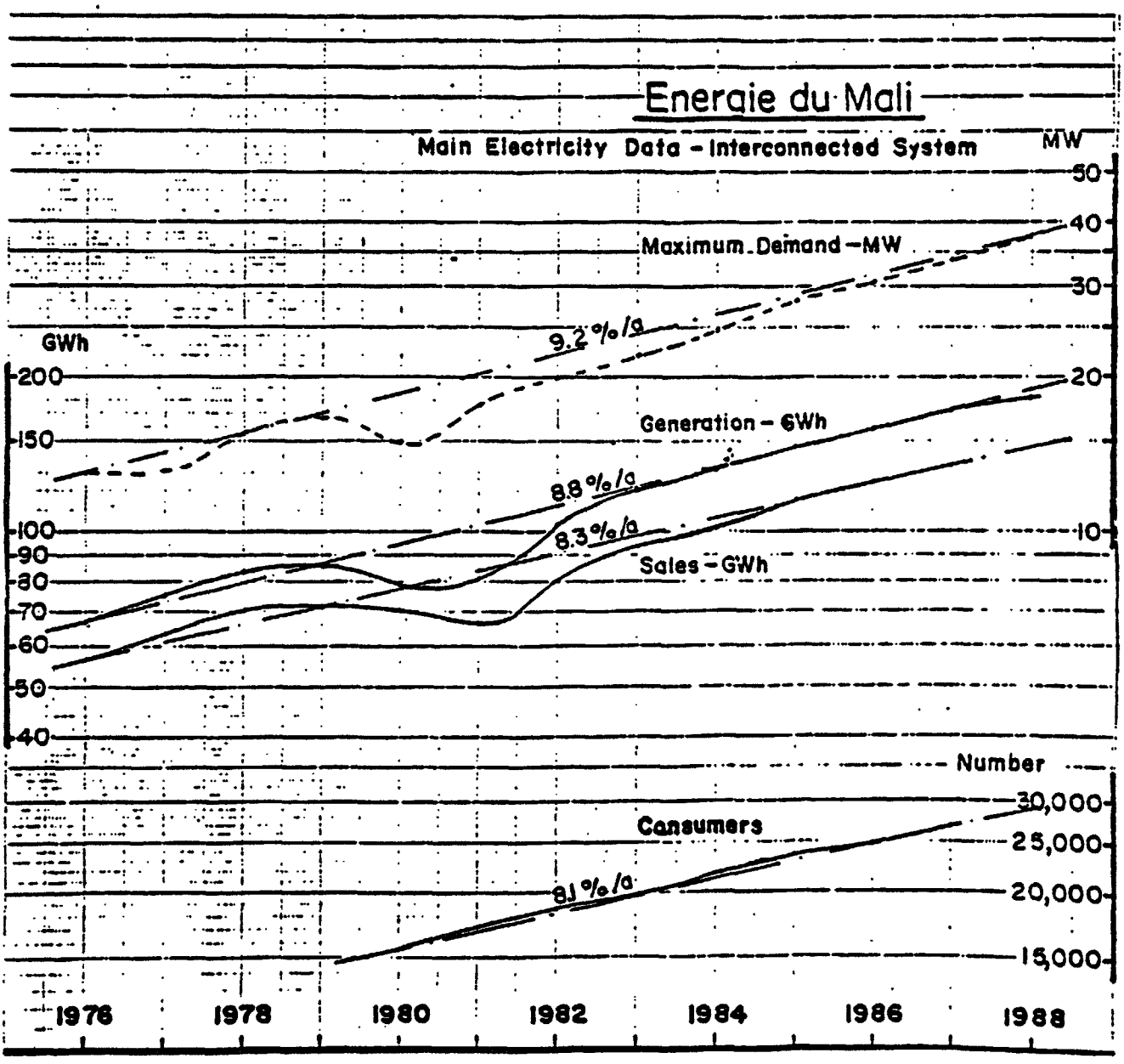

Sélingué
8.6 kV
Distr.
Yanfolila
75 km
32 km
Kalena
60 kV
30 kV
Distr.
150 kV
118 km
Dar Salam
15 kV
Distr.
Distr.
15 kV
15 kV
150 kV
150 kV
115 km
125 km
220 kV
From Manantali Hydro
(295 km)
Future Supply Line
Ségou
Fane
Subst. Sirakolo
Future Ségou Line
30 kV
12 km
Distr.
4.6 km (cable)
15 kV
Koulikoro
15 kV
Main Subst.
Balingué
30 kV
Distr.
3.5 km
30 kV
50 km
3.5 km
1.7 km
15 kV
1.9 km
(cable)
1.7 km
Energie du Mali
30 kV
30 kV
Single Line Diagram –
Interconnected
System
Badalagougou
Transformers
15 kV
Distr.
Soluba
Generating units

MAIN EDM ELECTRICAL DATA

		1980	1981	1982	1983	1984	1985	1986	1987	Est. 1988
INTERCONNECTED SYSTEM										
Sales	GWh	70.7	66.4	80.1	93.4	100.2	116.4	124.5	134.9	n.a.
Losses	GWh	8.9	15.4	23.6	27.6	32.6	31.3	34.7	37.5	n.a.
	(%)	(11.1)	(18.8)	(22.8)	(22.8)	(24.6)	(21.2)	(21.8)	(21.7)	
Gross generation	GWh	79.5	81.7	103.7	121.0	132.8	147.8	159.2	172.3	182.1
Generation by:										
Sélingué (a) (net)	GWh	13.9	34.9	68.4	92.1	95.5	108.8	129.8	126.1	126.4
Sotuba	GWh	32.1	33.5	35.1	28.6	36.6	37.5	28.4	32.0	34.6
Subtotal	GWh	46.0	68.4	103.5	120.7	132.1	146.3	158.2	158.1	161.0
Dar Salam (therm.)	GWh	33.5	13.3	0.2	0.4	0.7	1.5	1.0	14.2	21.1
Peak power demand	MW	14.9	16.1	20.0	23.0	24.4	28.1	30.5	33.8	37.3
Load factor	%	61.1	58.0	59.2	60.2	62.1	60.0	59.6	58.2	55.7
Customers	No.	15,527	17,114	18,511	19,818	21,773	23,737	24,800	26,866	n.a.
Installed power	MW	23.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5
Firm power (April)	MW	not available						39.5	39.5	39.5
Gross reserve	MW	8.7	51.4	47.5	44.6	43.1	39.4	37.0	33.7	30.2
	%	36.8	76.1	70.4	66.0	63.9	58.4	54.8	49.9	44.7
Net reserve	MW	not available						9.0	5.7	2.2
	%	"						22.8	14.4	5.6
ISOLATED SYSTEMS										
Sales	GWh	9.5	8.6	7.9	8.3	9.5	7.3	7.8	12.6	
Losses	GWh	4.1	(0.9)	2.5	2.5	2.2	3.1	3.9	4.7	
Gross generation	GWh	13.6	7.7	10.5	10.8	11.7	10.4	11.7	17.3	
Customers	No.	8,372	8,664	8,895	9,290	9,427	9,583	9,798	10,163	
Total EDM										
Sales	GWh	80.2	75.0	88.1	101.7	109.7	123.7	132.3	147.5	
Losses	GWh	13.0	14.5	26.1	30.1	34.8	34.5	38.6	42.2	
	(%)	(13.9)	(16.2)	(22.9)	(22.8)	(24.1)	(21.8)	(22.6)	(22.2)	
Gross generation	GWh	93.1	89.4	114.2	131.8	144.5	158.2	170.9	189.7	
Customers	No.	23,899	25,778	27,406	29,108	31,200	33,320	34,598	37,029	

(a) OERHN production bought by EDM.

Source: EDM.


Energie du Mali
Main Electricity Data - Interconnected System
MW
50
40
30
20
10
Maximum Demand - MW
9.2 %/a
GWh
200
150
100
90
80
70
60
50
40
Generation - GWh
8.8 %/a
8.3 %/a
Sales - GWh
Number
30,000
25,000
20,000
15,000
Consumers
8.1 %/a
1976
1978
1980
1982
1984
1986
1988

ACCESSIBILITY AND POWER CONSUMPTION

Year	Total Population (thousands) 1/	compounds (thousands) 1/	Electrification rate (%)	Number of individuals/ compound	Customers 3/	Beneficiaries (thousands)	Output: GWh	Output: kWh/ inhab.	kWh/ cust. 4/	kWh/ benef. 4/
1976	6,394	6,606		9.68			80.8	13		
1977	6,497	6,715		9.68			88.6	14		
1978	6,601	6,826		9.67			99.4	15		
1979	6,707	6,939		9.67			100.3	15		
1980	6,815	7,054	3.4	9.66	23,899	231	93.1	14	3896	403
1981	6,925	7,171	3.6	9.66	25,778	249	89.4	13	3468	359
1982	7,036	7,290	3.8	9.65	27,406	265	114.2	16	4167	432
1983	7,149	7,411	3.9	9.65	29,108	281	131.8	18	4528	469
1984	7,264	7,533	4.1	9.64	31,200	301	144.5	20	4631	480
1985	7,381	7,658	4.4	9.64	33,320	321	158.2	21	4748	493
1986	7,499	7,785	4.4	9.63	34,598	333	170.9	23	4940	513
1987	7,620	7,914	4.7	9.63	37,029	357	189.7	25	5123	532
Growth rate (%/yr)	1.6%	1.7%	4.7%		6.5%	6.4%	8.1%	6.4%	4.0%	4.0%

Notes:

1/ General population census.

4/ Residential and light industry (LV) consumption has represented 47-48% of total since 1980; roughly 50% of this percentage is accounted for by residential customers. Industrial consumption was approx. 0.24 GWh per customer in 1980 and 0.33 GWh in 1987, i.e., an annual growth of 4.75%.

Sources: EDM and ESMAP estimates.

DEMAND AND PRODUCTION REQUIREMENT FORECAST
Interconnected Network

Calendar Year	Hours First half h1y	Hours Second half h2y	Py	Output (GWh) 1/- First half P1y	Output (GWh) 1/- Second half P2y	Sy	Sales (GWh) Low voltage S1y	Sales (GWh) Medium voltage S2y	Losses GWh	Losses %	Peak demand (MW) Apr./May D1y	Peak demand (MW) Oct./No D2y	Load factor %
1985	4,344	4,416	148	76	72	116	56	61	31	21	28	25	60
1986	4,344	4,416	159	83	76	124	57	67	35	22	31	27	60
1987	4,344	4,416	172	90	83	135	65	70	37	22	34	29	58
1988	4,368	4,416	182	97	85	146	69	77	36	20	36	30	58
1989	4,344	4,416	197	103	94	159	75	84	37	19	38	33	59
1990	4,344	4,416	212	111	101	174	83	91	38	18	42	36	58
1991	4,344	4,416	229	120	109	190	90	100	39	17	45	39	59
1992	4,368	4,416	250	131	119	210	99	111	40	16	49	42	59
1993	4,344	4,416	273	143	130	232	110	122	41	15	53	46	58
1994	4,344	4,416	297	156	141	253	120	133	45	15	58	50	58
1995	4,344	4,416	322	169	153	273	129	144	48	15	63	54	58
1996	4,368	4,416	348	183	166	296	140	156	52	15	68	59	59
1997	4,344	4,416	377	198	179	321	152	169	57	15	74	64	58
1998	4,344	4,416	409	215	194	347	164	183	61	15	80	69	58
1999	4,344	4,416	443	232	210	376	178	198	66	15	86	75	58
2000	4,368	4,416	479	252	228	407	193	215	72	15	93	81	59
Growth rate (%/a)			8.2%	8.3%	8.0%	8.7%	8.6%	8.8%	5.7%	-2.3%	8.3%	8.1%	

1/ (a) Assumes Sélingué energy (net) supplied to Bamako Balingué substation; gross Sélingué generation is 7-8 GWh more than the net figure.

(b) Additional losses should be allowed for depending on the type of power station in service (all-thermal or thermal/Manantali).

Source: ESMAP estimates.

MALI
SECOND POWER PROJECT
SUMMARY INVESTMENT PROGRAM
(Thousand US$, Jan. 1988 Prices)

Exch Rate: 300

	1988			1989			1990			1991			1992			1993			1994			TOTAL 1988-94		
	LOCAL	FOR.	TOTAL	LOCAL	FOR.	TOTAL	LOCAL	FOR.	TOTAL	LOCAL	FOR.	TOTAL	LOCAL	FOR	TOTAL	LOCAL	FOR.	TOTAL	LOCAL	FOR.	TOTAL	LOCAL	FOR.	TOTAL
A. GENERATION																								
1. HYDRO																								
1. Repairs to Selingue	0	0	0	39	641	680	28	442	470	0	0	0	0	0	0	0	0	0	0	0	0	67	1,084	1,150
2. Rehab. of Felou	128	1,223	1,351	136	1,236	1,372	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	264	2,459	2,723
3. Rehab. of Sotuba	5	91	96	333	1,666	1,998	353	1,724	2,077	0	0	0	0	0	0	0	0	0	0	0	0	691	3,480	4,171
4. Manantali Power station	0	0	0	0	0	0	47	359	406	1,892	14,003	15,895	1,901	13,724	15,625	1,746	12,295	14,040	1,061	7,289	8,350	6,647	47,669	54,316
Total Hydro Inc. Cont.	133	1,314	1,447	508	3,543	4,051	428	2,525	2,953	1,892	14,003	15,895	1,901	13,724	15,625	1,746	12,295	14,040	1,061	7,289	8,350	7,669	54,692	62,361
2 DIESEL																								
Generation Dispatch Studies	0	150	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150	150
BAMAKO	0	0	0	0	0	0	196	1,489	1,686	316	2,340	2,656	296	2,134	2,429	0	0	0	0	0	0	808	5,963	6,771
KAYES	0	0	0	93	578	670	43	59	101	0	0	0	0	0	0	0	0	0	0	0	0	136	637	773
SIKASSO	0	0	0	26	423	449	28	438	466	0	0	0	0	416	416	0	0	0	0	0	0	53	1,279	1,333
MOPTI/SEVARE	0	0	0	20	255	275	21	264	285	0	0	0	0	0	0	0	0	0	0	0	0	41	519	560
TOMBOUCTOU	20	149	169	21	151	171	7	66	73	0	0	0	0	0	0	0	0	0	0	0	0	47	366	413
FANA	10	87	97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	87	97
BOUGOUNI	0	0	0	54	149	203	67	155	221	0	0	0	0	0	0	0	0	0	0	0	0	120	304	424
KOUTIALA	0	0	0	28	262	290	43	600	643	0	0	0	0	0	0	0	0	0	0	0	0	71	862	933
SEGOU/MARKALA	29	208	238	31	210	242	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	61	418	479
Spares	0	286	286	0	308	308	0	431	431	0	433	433	0	461	461	0	464	464	0	480	480	0	2,864	2,864
Tools	0	78	78	0	116	116	0	120	120	0	124	124	0	128	128	0	133	133	0	137	137	0	833	833
Total Diesel Inc. Cont.	59	956	1,015	272	2,451	2,724	404	3,621	4,025	316	2,897	3,213	296	3,141	3,436	0	597	597	0	618	618	1,347	14,281	15,628
TOTAL GENERATION INC. CONT.	192	2,270	2,462	781	5,994	6,775	832	6,145	6,978	2,208	16,900	19,108	2,197	16,865	19,061	1,746	12,891	14,637	1,061	7,907	8,968	9,017	68,973	77,990
B. TRANSMISSION																								
Power System Protec. Rehab.			0	20	153	172	21	158	179	0	0	0	0	0	0	0	0	0	0	0	0	40	310	351
(a) Bamako-Segou Trans.Line	0	1,389	1,389	576	7,801	8,377	1,376	9,382	10,758	511	2,793	3,304	0	0	0	0	0	0	0	0	0	2,463	21,364	23,827
(b) Selingue-Malano and (c) Segou/Mout.-Segou/Niono	1,171	4,272	5,443	1,248	4,315	5,563	0	0	0	0	0	0	2,286	7,654	10,040	4,961	15,526	20,487	2,697	8,236	10,934	12,463	40,004	52,467
(d) Manantali-Bamako	0	0	0	558	2,176	2,734	592	2,253	2,844	4,227	15,697	19,924	4,942	17,903	22,845	2,719	9,610	12,329	0	0	0	13,039	47,638	60,677
TOTAL TRANS. INC. CONT.	1,171	5,661	6,832	2,402	14,445	16,847	1,989	11,792	13,781	4,738	18,490	23,228	7,228	25,557	32,885	7,680	25,136	32,816	2,697	8,236	10,934	28,005	109,312	137,322
C. DISTRIBUTION																								
BAMAKO	0	0	0	12	201	214	623	2,206	2,829	772	2,646	3,418	744	2,500	3,244	630	2,071	2,701	673	2,209	2,882	3,454	11,834	15,288
KAYES	0	0	0	0	0	0	116	390	506	103	338	441	91	293	384	97	303	400	77	236	313	484	1,560	2,044
SIKASSO	0	0	0	0	0	0	111	374	485	118	387	505	100	321	421	80	249	329	84	258	342	493	1,589	2,082
MOPTI/SEVARE	0	0	0	0	0	0	103	346	449	109	358	467	92	297	389	74	230	304	78	239	317	456	1,470	1,926
TOMBOUCTOU	0	0	0	75	258	333	79	267	346	87	221	298	54	172	225	57	178	234	0	0	0	331	1,096	1,427
KITA	0	0	0	36	126	163	39	131	169	33	108	141	26	84	110	28	87	115	0	0	0	162	535	697
FANA/DIOILA	0	0	0	0	0	0	64	217	281	69	225	293	58	186	244	46	144	190	49	149	198	286	921	1,207
BOUGOUNI	0	0	0	0	0	0	67	227	295	72	235	307	61	195	256	48	151	200	51	157	208	299	966	1,265
KOUTIALA	0	0	0	0	0	0	144	485	629	153	502	655	130	416	545	103	323	426	109	334	443	639	2,060	2,698
SEGOU/MARKALA	0	0	0	0	0	0	491	1,655	2,146	521	1,712	2,233	442	1,418	1,860	352	1,101	1,453	373	1,139	1,512	2,178	7,026	9,204
GAO	0	0	0	162	560	722	172	580	751	146	480	626	116	373	489	123	386	509	0	0	0	719	2,378	3,097
ENGINEERING & SUPERVISION	0	0	0	19	66	85	97	327	424	97	320	417	82	263	345	70	221	291	58	176	233	423	1,372	1,795
TOTAL DISTRIB. INC. CONT.	0	0	0	330	1,472	1,810	2,106	7,205	9,311	2,258	7,534	9,792	1,996	6,516	8,512	1,707	5,444	7,151	1,553	4,996	6,449	9,958	33,067	43,025
D STUDIES	21	172	193	45	347	391	47	359	406	133	984	1,117	106	769	875	0	0	0	0	0	0	352	2,630	2,983
E. BUILDINGS	84	0	84	547	105	652	720	131	851	270	46	316	286	48	334	304	50	353	322	51	374	2,533	431	2,964
F EQUIPMENT/MISCELLANEOUS	0	0	0	0	670	670	0	694	694	0	677	677	0	743	743	0	398	398	0	412	412	0	3,594	3,594
G. TECHNICAL ASSISTANCE	59	518	577	188	1,714	1,902	200	1,774	1,974	177	1,545	1,722	150	1,299	1,449	77	663	740	82	686	768	933	8,200	9,133
H. TRAINING	0	0	0	159	736	895	180	785	964	154	765	918	11	602	614	0	538	538	0	374	374	504	3,801	4,305
I. RURAL ELECTRIFICATION	0	0	0	0	0	0	153	517	670	0	0	0	351	1,128	1,479	224	732	956	277	846	1,123	1,016	3,222	4,238
GRAND TOTAL INC. CONT.	1,527	8,621	10,148	4,460	25,483	29,942	6,227	20,402	26,628	9,937	48,942	58,879	12,426	53,527	65,953	11,746	45,852	57,600	5,962	23,438	29,400	52,317	233,235	285,552

Annexe 3.4

INVESTMENTS AND PRODUCTION COSTS OF HYDROELECTRIC AND THERMAL ALTERNATIVES

Power Station	Investments a/ Million of CFAF	Investments a/ Million of $US b/	Installed Capacity (MW)	Capacity (GWh/yr)	Invest./MW Installed c/ (CFAF/KW)	Invest./MW Installed c/ (US $/KW)	Production Cost c/ (CFAF/KWh) (fc=100%)	Production Cost c/ (CFAF/KWh) (fc=50%)	Production Cost c/ (US $/KWH) (fc=100%)	Production Cost c/ (US $/KWH) (fc=50%)	Variable Cost (CFAF/KWh)	Variable Cost (US $/KWh)
Hydroelectric												
Manantali + line 225 kV	43270 d/	144 d/	200.0	825	292073	974	7.2		2.4			
Félou	65155	217	104.8	371	839306	2798	24.2		8.1			
Gouina	60235	201	104.0	350	781697	2606	23.7		7.9			
Kénié	41400	138	48.0	235	1164375	3881	24.3		8.1			
Mantala + Ségou-line	8672	29	5.2	33	2251385	7505	36.2		12.1			
Sotuba II	10692	36	6.0	42	2405700	8019	35.1		11.7			
		0				0			0.0			
Thermal		0				0			0.0			
		0				0			0.0			
Diesel medium speed 2x8 MW	5440	18	16.0	49	391000	1303	34.3	39.3	11.4	13.1	24.3	8.1
Diesel medium speed 2x6 MW	4200	14	12.0	33	402500	1342	34.6	39.8	11.5	13.3	24.3	8.1
Diesel medium speed 2x16 MW	10080	34	32.0	99	362250	1208	32.4	36.9	10.8	12.3	23.3	7.8
TAG 2x10 MW	4300	14	20.0	62	247250	824	49.4	52.8	16.5	17.6	43.8	14.6

a/ Excluding interest during construction.
b/ 1 $US = 300 CFAF
c/ Included estimated interest during construction.
d/ Dam already built.

Exchange rate: 1 $US = 300 CFAF

Sources: Plan Directeur du secteur de l'électricité - Traditional Electrical engineering - January 1988; ESMAP estimates.

MARGINAL COSTS ESTIMATES

Year	Dar Salam: Diesel 1: 6MW Capital Cost Incl. IDC	Diesel 1: 6MW Annual Cost	Diesel 2: 6MW Capital Cost Incl. IDC	Diesel 2: 6MW Annual Cost	Diesel 3: 12MW Capital Cost Incl. IDC	Diesel 3: 12MW Annual Cost	Diesel 4: 12 MW Capital Cost Incl. IDC	Diesel 4: 12 MW Annual Cost	Ségou Line Capital Cost Incl. IDC	Ségou Line Annual Cost
	$US1,000									
1989										
1990	1,430		1,287						1,389	
1991	2,314	693	2,083	624	2,400		2,400		8,516	
1992	2,287	693	2,058	624	4,080	1,099	4,080	1,099	11,749	2,212
1993		693		624	4,008	1,099	4,008	1,099		2,212
1994		693		624		1,099		1,099		2,212
		etc		etc		etc		etc		etc
Discounted Value (10%)	4482	(16 years in all)	4034	(16 years in all)	7079	(16 years in all)	7079	(16 years in all)	15571	(30 years in all)
O&M Costs (%) 1/ in $US 1,000		(4) 220		(4) 220		(4) 390		(4) 390		(2.5) 820
Annual Costs US$ 1,000		913		844		1,489		1,489		3,032

Year	Annual Cost No.1-6MW	No.2-6MW	No.3-12MW	No.4-12MW	Ségou	Total	Output During year	1988	Incr.	Marginal Cost Cap. Cost +O&M	Comb. 2/	Total 3/
	1.000 $US						GWh			USSc/kWh		
1989							208	190	18			
1990							225	190	35			
1991	913	844	1,489			3,246	243	190	53	6.1	8.6	14.7
1992	913	844	1,489	1,489	3,032	7,767	264	190	75	10.4	8.6	19.0
1993	913	844	1,489	1,489	3,032	7,767	289	190	99	7.9	8.6	16.5
1994	913	844	1,489	1,489	3,032	7,767	314	190	125	6.2	8.6	14.8
									Average - $US/kW	0.076	0.086	0.162
									- CFAF/k	0.2	0.2	0.5

1/ In % of basic investment cost, not including interest during construction.

2/ Economic cost of fuel estimated at CFAF 100/kg = $US357/t.
Yield 240t/GWh: cost (240 t/GWh) x (US$357/t) = US$85,680/GWh.
Marginal fuel cost: US$.086/kWh.
or 24.1 CFAF/kWh.

3/ Excluding private consumption and losses (5%).

Source: ESMAP estimates.

MARGINAL COSTS OF DISTRIBUTION

Year	Isolated diesel centers, Incl.IDC		Distribution (total) Incl. IDC	
1989	189		366	
1990	2,417		2,651	
1991	2,153	856	10,523	
1992		856	10,329	3,871
1993	460	856	8,039	3,871
1994		856	6,950	3,871
Discounted Value (10%)	4,073	etc. (10 years in all)	26,399	etc. (25 years in all)
O&M cost (%) $US1,000	(7)	336	(5)	1,736
Total annual costs $US1,000		1,192		5,607

Production and transportation			Generation					Distribution				
Annual Costs			Increase (5% losses)		Marginal Cost				(15% losses)	Marginal Cost		
HV-Page	Isolated Centers	Total	Gross	Net	Capital Cost +O&M	Fuel	Total	Annual Cost	Sales	Capital Cost +O&M	Generation	Total
$US1,000			GWh		USc/kWh			$US1,000	GWh	$US/kWh		
			18	17								
			35	33								
3,246	1,192	4,438	53	50	8.8	9.1	17.9					
7,767	1,192	8,959	75	71	12.6	9.1	21.6	5,607	61	9.3	25.4	34.7
7,767	1,192	8,959	99	94	9.5	9.1	18.6	5,607	80	7.0	21.9	28.9
7,767	1,192	8,959	125	119	7.5	9.1	16.6	5,607	101	5.6	19.5	25.1
					Average - $US/kWh		0.19			0.07	0.22	0.30
					- CFAF/kWh		53			20	62	83

Source: ESMAP estimates.

MAIN EDM FINANCIAL INDICATORS
(CFAF billion)

	1988	1989	1990	1991	1992	1993
Average earnings (CFAF/kWh)	61	61	61	61	64	67
Total earnings	10.93	12.06	13.21	15.05	17.32	19.92
Total expenses	8.62	9.51	9.90	11.11	13.15	15.69
Net earnings after interest	0.95	1.02	1.98	2.42	2.56	2.49
Operating ratio	79%	79%	75%	74%	76%	79%
Tariff base (a)	9.18	10.18	14.82	23.72	31.02	32.95
Rate of return on tariff base	15.0%	15.2%	17.4%	13.1%	11.4%	11.5%
Debt-service ratio	2.4	2.4	3.5	4.3	4.4	3.5
Devt/shareholder equity ratio	50/50	50/50	51/49	55/45	61/39	65/35
Net cash flow ratio (b)	33%	28%	25%	27%	28%	32%
Working capital ratio	1.4	1.4	1.4	1.6	1.6	1.6

(a) Historical base
(b) Three-year average

Source: Second Power Project Appraisal Report (World Bank)

OIL PRODUCT CONSUMPTION ANALYSIS

Introduction and Overview

1. Mali's total oil product consumption in 1987 1/ is estimated at 171,000 tons (Table 1). This figure is only an estimate, since data for the two main products, gasoline and gas oil (representing 68% of total consumption) are not reliable. Inconsistencies between the various data sources are probably due to the considerable number of independent distributors. Average consumption in 1987 was 22 kg/capita, which is comparable with that of countries with a similar per-capita GNP. The transport sector uses nearly 70% of the products and the industrial sector 15%. Bamako accounts for over 60% of total oil product consumption.

Table 1: PRODUCT ORIGIN, 1987

	Tons		
	Total	GPP	Independents (+ Pétrostock)
Abidjan	45,893	45,893	0
Dakar	75,572	75,572	0
Lomé	42,160	8,338	33,822
Other	7,475	500	6,975
Total	171,100	130,303	40,797

Source: ONT and ESMAP estimates

2. Two subperiods can be distinguished in past consumption history; 2/ 1980-82, during which prices rose in real terms but consumption fell for all products other than LPG, and 1983-87, during which consumption increased while real prices fell (Annex 1.3). Mali's total oil product consumption can be expected to increase by a factor of 1.7, from 171,000 tons in 1987 to 290,000 tons in 2000, i.e. an average annual growth of 4.1% (Table 2). This growth will nevertheless vary substantially from product to product, with consumption of the two main ones, gasoline and gas oil, growing by 5% and 4% per year respectively, while that of LPG rises considerably more rapidly.

1/ *Last year for which data are available.*

2/ *Consumption estimates by product since 1980 are given in Annex 1.3.*

Table 2: PAST PETROLEUM PRODUCT CONSUMPTION
TONS

	1980	1981	1982	1983	1984	1985	1986	1987	Annual Growth Rate 1980-87	Annual Growth Rate 1982-87
LPG	199	238	231	219	240	266	422	536	15.2%	18.3%
Gasoline	63,697	57,503	53,950	51,697	51,492	58,252	60,028	61,976	-0.4%	2.8%
Avgas	530	454	495	402	385	425	446	332	-6.5%	-7.7%
Kerosene	12,586	12,285	12,013	12,181	12,836	13,020	13,387	13,150	0.6%	1.8%
Jet fuel	13,684	12,216	10,480	10,185	13,026	16,402	13,922	12,538	-1.2%	3.7%
Gas oil	48,943	43,137	40,511	36,906	43,475	51,303	52,842	54,427	1.5%	6.1%
Diesel	22,217	16,264	15,964	17,936	20,347	20,970	19,930	22,764	0.3%	7.4%
Fuel oil	5,856	4,442	2,975	7,588	5,289	6,158	5,067	5,377	-1.2%	12.6%
TOTAL	167,712	146,539	136,619	137,114	147,090	166,796	166,044	171,100	0.3%	4.6%
REAL RELATIVE PRICES 1979 = 100										
Gasoline	161	203	217	201	186	146	92	85		
Kerosene	137	163	177	164	152	122	75	70		
Gas oil	155	193	207	192	178	140	88	81		

Deflator 7.4%

Source: GPP + ESMAP estimates.

CONSUMPTION HISTORY AND PER-PRODUCT OUTLOOK

3. LPG. The LPG market, which stood at 536 tons in 1987, is nowadays growing rapidly in urban centers and should continue to expand rapidly until 1996, particularly if a substitution strategy is adopted in relation to residential customers, and if the ongoing efforts of the CILSS and GPP bear fruit; it should then grow more slowly thereafter. However, LPG is considerably more expensive than kerosene and wood for cooking, both in economic terms and for consumers (Annex 2.8).

4. Gasoline. The gasoline market posted its lowest volume in 1984 and then grew 6% in 1987 (Annex 1.3). Demand should, on the average, rise slightly more rapidly than economic growth, i.e. by roughly 5% per year, to reach over 117,000 tons by the year 2000.

5. Aviation gasoline. Aviation gasoline is used by light airplanes. Demand is static if not falling and should therefore remain at its 1987 level, i.e. 330 tons.

6. Kerosene. Kerosene is today mainly used for domestic lighting, and in small quantities for lighting wood fires in the rainy season and for cooking. Historically, demand growth has roughly paralleled rural population growth, which puts it at about 1-2%/year depending on the region. However, consumption should increase more rapidly in the future, since it is a relatively cheap cooking fuel, although growth will depend to a considerable extent on the availability of suitable stoves. Total consumption (households and other customers) is therefore expected to rise from 13,000 tons in 1987 to over 17,000 tons by the year 2000.

7. Jet fuel. Since Air Mali's liquidation, only international carriers have bought jet fuel in Mali. Future demand is uncertain because it depends on air traffic, energy savings in this sector and relative prices in Mali versus other countries. An average growth of 3%, reflecting an increase in air traffic of 6-8% together with energy savings, would seem realistic. Consumption should therefore rise from 13,000 tons in 1987 to 18,000 tons by the year 2000.

8. Gas oil. Gas oil is used for various purposes (transport, industry and agriculture). Demand grew by 1.5% per year between 1980 and 1987 and by 6.1% between 1982 and 1987. Assuming that real prices will remain stable in the medium term and then rise slightly after, consumption could keep pace with economic growth, i.e. grow by approximately 4% per year, thus rising from 54,000 tons in 1987 to nearly 91,000 tons by 2000.

9. Diesel fuel. The two main users are the railway (RCFM) and the national electricity company (EDM). RCFM traffic could remain at its present level, while EDM's requirements will be governed largely by hydropower availabilities; however, thermal power generation could increase substantially if the Manantali delays are confirmed. Industrial demand is dominated by the textile companies (Comatex and Itema), whose plans are not known. An overall demand increase of 5% per year for five years followed by growth of 1% per year up to the year 2000 would appear reasonable. Consumption should therefore rise from 23,000 tons in 1987 to 32,000 tons by 2000.

10. Fuel oil. Comatex is the main user of fuel oil. Another big customer, the Socima cement plant, closed down in 1987; when operating at full capacity this plant used about 5,000 tons per year, whereas Mali's 1987 consumption was 5,400 tons in comparison. Average growth of 3% per year over the period 1987-2000 appears reasonable. Domestic requirements should, therefore, go from 5,400 tons in 1987 to 7,900 tons by 2000.

SUMMARY OF OIL EXPLORATION RESULTS IN MALI

1. History. Mali's sedimentary basin covers an area of some 700,000 km². The largest part is located in the Taoudéni basin, the biggest in Africa (600,000 km²), which Mali shares with Mauritania. The other basins are those of Jullemeden (50,000 km²), Nara (40,000 km²) and the Gao Graben (10,000 km²). Exploration was started in 1970 with geophysical prospecting in the Taoudéni basin (Texaco and Esso) and two dry holes in the Mauritanian part of the basin. In the Gao Graben, Murphy (U.K.), in association with SNEA (France), has run 800 km of seismic lines and drilled a dry well (Asongo-1).

2. In the early 1980s the pace of exploration activities quickened, 1/ with a view to: (1) reassessing the Taoudéni basin and interesting oil companies, and (2) setting up a Hydrocarbons Division with the Directorate of Geology and Mining. Esso and SNEA then drilled two dry wells in the Taoudéni basin. The permits were, however, allowed to lapse in 1986. It would now seem that the Gao Graben basin has the greatest potential, but the means to start an evaluation program are lacking. Mali's petroleum potential therefore, remains to be evaluated, as only three wells have been drilled; it would seem, however, that crude prices would have to rise considerably before operators would again become interested in Mali.

3. There are oil shales at Agamor (135 km north of Gao). An evaluation undertaken in 1982-83 2/ concluded that available reserves were of the order of 870 million tons (90 million barrels). However, the energy required for extraction appears to exceed the energy value of the end product. With present technology, the project would not therefore seem viable.

4. Institutional aspects: Although the Hydrocarbons Division (18 professionals) possesses the technical capability for geological and geophysical evaluations, exploration promotion, data management and sedimentary analysis, the fact that there is not presently any exploration activity and Mali's budgetary constraints considerably lessens this division's productivity.

1/ *IDA Credit 1134-MLI: Petroleum Exploration Project.*

2/ *Study of Agamor region oil shales; SNC; July 1983.*

DETAILED STRUCTURE OF OIL PRODUCT PRICES

Oil Products, excluding LPG

1. Current price levels at the pump. At the beginning of 1989, prices at the pump were as follows:

Table 1: PRICES AT THE PUMP

	CFAF/liter	US$/liter
Gasoline	300	1.07
Gas oil	210	0.75
Kerosene	200	0.71
LPG	363/kg	1.30

2. Simplified cost structure. The simplified gasoline cost structure as of the end of 1988 is presented below (Table 2; for other products, Table 3; detailed ex Dakar figures, Table 4; and ex Abidjan Table 5).

Table 2: SIMPLIFIED GASOLINE PRICE STRUCTURE
(in % of Price at Pump)

Components	Dakar	Abidjan
Ex depot	24	22
Transport	8	11
Taxes	57	56
Services	11	11
Total	100	100

Table 3: COMPARISON OF COST STRUCTURES ACCORDING TO SOURCE OF SUPPLY

	CFAF/hl/ton			US$/bbl		
	Dakar	Abidjan	Diff.	Dakar	Abidjan	Diff.
Gasoline						
Ex port	7,217	6,654	563	41.0	37.8	3.2
Transport	2,252	3,392	-1,140	12.8	19.3	-6.5
Taxes	17,185	16,631	554	97.6	94.4	3.1
Services	3,346	3,323	23	19.0	18.9	0.1
Total	30,000	30,000	-0	170	170	-0
Kerosene						
Ex port	7,863	7,359	504	44.7	41.8	2.9
Transport	2,359	3,392	-1,033	13.4	19.3	-5.9
Taxes	7,249	6,741	508	41.2	38.3	2.9
Services	2,529	2,509	20	14.4	14.2	0.1
Total	20,000	20,000	-0	114	114	0
Gas oil						
Ex port	7,628	7,070	558	43.3	40.1	3.2
Transport	2,329	3,392	-1,063	13.2	19.3	-6.0
Taxes	8,041	7,558	483	45.7	42.9	2.7
Services	3,002	2,980	22	17.0	16.9	0.1
Total	21,000	21,000	-0	119	119	-0
Diesel oil						
Ex port	81,269	76,725	4,544	39.2	37.0	2.2
Transport	27,601	39,909	-12,308	13.3	19.3	-5.9
Taxes	37,929	30,344	7,585	18.3	14.6	3.7
Services	26,142	25,963	178	12.6	12.5	0.1
Total	172,941	172,941	0	83.5	83.5	0.0
Fuel oil						
Ex port	67,904	62,652	5,252	35.9	33.1	2.8
Transport	26,787	36,872	-10,085	14.1	19.5	-5.3
Taxes	4,893	272	4,622	2.6	0.1	2.4
Services	19,986	19,774	212	10.6	10.4	0.1
Total	119,570	119,570	-0	63.1	63.1	0.0

Source: ONT and ESMAP estimates.

Table 4: PRICE OF PRODUCTS DELIVERED AT BAMAKO (Ex-Dakar)
CFAF

	Gasoline (hl)	Kerosene (hl)	Gas oil (hl)	Diesel oil (ton)	Fuel oil (ton)
Ex refinery	7,075	7,721	7,486	80,000	66,646
Handling	142	142	142	1,269	1,258
Ex port	7,217	7,863	7,628	81,269	67,904
Transport					
Dakar-border	1,599	1,660	1,591	18,827	18,085
Border-Bamako	653	699	738	8,774	8,702
Total Transport	2,252	2,359	2,329	27,601	26,787
Taxes					
Paid to Customs					
EMASE	37	40	42	500	500
Licenses	55	59	57	619	534
Guarantee Fund	44	48	46	503	432
Transport duties					
Customs duties	203		207		
Import duties	487	249	373	2,120	2,080
Local tax	1,000	500	400	4,706	4,348
Loan Fund	266	287	278	3,018	2,595
Road Fund	3,710		2,858		
Mining Fund	100		100		
Taxe Intérieure	2,000		1,250		
Subtotal	7,901	1,182	5,612	11,465	10,489
Other payments					
Pétrostock		350		4,118	3,804
OSRP - Stabilization Tax	100	100	100	1,500	1,500
OSRP - Stabilization Fund	9,184	5,617	2,329	20,846	-10,900
Subtotal	9,284	6,067	2,429	26,464	-5,596
Total Taxes	17,185	7,249	8,041	37,929	4,893
Services					
Forwarding agents	145	158	153	1,635	1,368
Oil Companies	3,201	2,371	2,849	24,507	18,618
Total Services	3,346	2,529	3,002	26,142	19,986
Prices at Pump					
Hl/ton	30,000	20,000	21,000	172,941	119,570
Ton	405,405	250,000	250,000	172,941	119,570
US$/ton	1,448	893	893	618	427
US$/bbl	170	114	119	83	63
US$/gallon	4.06	2.70	2.84	1.99	1.50

Source: ONT and ESMAP estimates.

Table 5: PRICE OF PRODUCTS DELIVERED AT BAMAKO (Ex Abidjan)
CFAF

	Gasoline (hl)	Kerosene (hl)	Gas oil (hl)	Diesel oil (ton)	Fuel oil (ton)
Ex refinery	6,478	7,176	6,921	74,988	60,915
Handling	175	183	149	1,737	1,737
Ex port	6,654	7,359	7,070	76,725	62,652
Transport					
Abidjan-border	2,091	2,091	2,091	24,597	22,725
Border-Abidjan	1,302	1,302	1,302	15,312	14,147
Total Transport	3,392	3,392	3,392	39,909	36,872
Taxes					
Paid to Customs					
EMASE	37	40	42	500	500
Licenses	54	58	57	626	530
Guarantee Fund	44	47	46	509	429
Transport duties	77	77	77	907	838
Customs duties	203		207		
Import duties	487	249	373	2,120	2,080
Local taxes	1,000	500	400	4,706	4,348
Loan Fund	263	285	276	3,055	2,576
Road Fund	3,710		2,858		
Mining Fund	100		100		
Taxe Intérieure	2,000		1,250		
Subtotal	7,976	1,256	5,687	12,423	11,302
Other payments					
Pétrostock		350		4,118	3,804
OSRP - Stabilization Tax	100	100	100	1,500	1,500
OSRP - Stabilization Fnd	8,555	5,034	1,771	12,303	-16,335
Subtotal	8,655	5,484	1,871	17,921	-11,031
Total Taxes	16,631	6,741	7,558	30,344	272
Services					
Forwarding agents	134	148	142	1,545	1,263
Oil Companies	3,190	2,361	2,837	24,419	18,511
Total Services	3,323	2,509	2,980	25,963	19,774
Prices					
Hl/ton	30,000	20,000	21,000	172,941	119,570
Ton	405,405	250,000	250,000	172,941	119,570
US$/ton	1,448	893	893	618	427
US$/bbl	170	114	119	83	63
US$/gallon	4.06	2.70	2.84	1.99	1.50

Sources: ONT and ESMAP estimates.

3. Ex-depot price. This is, essentially, the price paid to either of the two refineries, SIR at Abidjan or SAR at Dakar, plus some handling and storage costs. Prices invoiced by the two refineries up to mid-1989 were considerably higher than world prices. Since then, a new basis for pricing has been negotiated, based on import parity plus US$40/bbl for purchases in Côte d'Ivoire and plus US$20/bbl for purchases in Senegal. It would also seem that the two refineries seek to profit from Mali's landlocked situation by obliging it to buy from them and refusing the use of unloading and storage facilities at those two ports. This prevents direct imports at international market conditions and is contrary to international practice.

4. Transport cost. Transport costs in Mali are relatively high because of distances. Dakar to Bamako by rail is considerably cheaper than Abidjan to Bamako by road, the difference being US$5.3-6/bbl (Table 3). However, present consumer pricing practice and operator margins do not encourage seeking more economical sources or routes since operator remuneration is proportional to costs. Assuming that the ex-depot prices remain the same, annual savings of approximately US$1.5 million could be achieved by a better split of supply between the two routes; further savings might also be obtained by using Togo and Nigeria as sources. The lack of reliability of the Dakar-Abidjan railway and considerations of strategic diversification are generally cited as reasons for not making greater use of the Dakar route. However, the railway has overcome the greater part of its difficulties.

5. Another point is that transport costs are fixed by decree on the basis of route category. The transport voucher system designed to control carriers has lapsed since the arrival on the scene of independent distributors, who use foreign carriers for the most part. Currently, the GPP selects and pays carriers according to the official rates; independent distributors appear to pay their carriers less. There are presently 50 different transport rates according to geographic location of towns and sources of supply. However, since Bamako and Ségou consumption represents roughly 80% of national consumption, it would appear justified for practical reasons to apply uniform prices throughout the country, hence offsetting the differences in transport cost.

6. Taxes. Costs today include a great number of differing taxes (Tables 4 and 5). These taxes go (1) directly to the Treasury (customs duties, local taxes), (2) to OSRP, (3) to the Mining Fund (MIHE), and the Road Fund (Ministry of Public Works), and (4) to various agencies, which frequently have no involvement in oil product distribution, and, finally, (5) to Pétrostock. Certain groups of consumers (diplomats, aid projects, NGOs, etc.) are exempted from duties and taxes, while others have to pay. Then from the administrative standpoint, OSRP and the Customs use different codes, making it almost impossible to match the various data. The system is therefore a complicated one and difficult to manage, the more so since the rules applicable to the GPP are different from those applying to the Independents. This sort of system also encourages evasion.

7. Services. Services include forwarding agents' commissions (as a rule 2% of the ex-port value), operators' costs (storage, distribution finance charges, losses) and margins. Forwarding agents' commissions appear high for the services rendered, but are fixed by decree. Operators' margins are also fixed by decree, at pro rata CIF + tax prices (currently 15%), rather than on a basis of certified documents showing real or standard costs, investment programs, etc; any increases in structural cost components therefore increase operator margins. However, in absolute terms, operator margins seem comparable with those authorized in neighboring countries.

Independents' Cost Structure

8. There is very little information available on cost structure for products brought in by Independents from Lomé. The figures given below are estimates (Table 6).

Table 6: ESTIMATED COST STRUCTURE FOR SUPPLIES BROUGHT IN FROM LOMÉ BY INDEPENDENTS
Gasoline (Early 1988)

	CFAF/hl	US$/bbl
Ex-depot price	5,000	28.4
Transport	5,500	31.2
Duties and taxes	16,631	94.4
Independents' margin	2,869	16.3
Price at pump	30,000	170.3

Source: ESMAP estimates.

It is clear that the Lomé-Bamako transport costs are from CFAF 1,600-2,700/hl higher than ex-Abidjan or ex-Dakar costs. Since the independent distributors' margins are estimated at CFAF 2,900/hl (Table 6), it is likely that with the new, lower prices charged by SIR and SAR, the economics of supply from Lomé by Independents will become distinctly less attractive.

LPG Prices

9. LPG prices are not currently controlled in Mali. The structure and levels of prices as of mid-1988 are detailed in Table 7. Several components in this structure appear high. These are SIR ex-depot prices (currently roughly US$500/ton, whereas prices reflecting import parity should be around US$350/t), overhead, services, margins and losses totaling nearly 4% of the retail price. Altogether, LPG prices could therefore be reduced by about 17%.

Table 7: LPG PRICE STRUCTURE
TOTAL-TEXACO MALI
June 1988

		CFAF/ton	US$/ton
1	Ex-SIR price	140,000	500.00
2	Port dues	700	2.50
3	Vridi depot fee	8,000	28.57
4	Transport Abidjan-Zegoua	33,534	119.76
5	C.I.F. border price	182,234	650.84
6	CPS, 3% of 5%	5,467	19.53
7	Cylinder cost amortization	20,143	71.94
8	Cylinder maintenance	9,520	34.00
9	Overhead	14,590	52.07
10	Bamako depot fee	37,940	135.50
11	Subtotal	269,884	968.87
12	Profit 11.1% of item 11	29,957	106.99
13	Transport Zegoua-Bamako	12,901	46.08
14	Delivery costs	7,430	26.54
15	Commissions and disbursements	722	2.58
16	Forwarding agents	10,720	38.29
17	Subtotal	331,614	1184.34
18	Loading losses	704	2.51
19	Transport losses, 2% of item 17	6,632	23.69
20	Filling losses, 2% (17-12)	6,033	21.55
21	Retail margin	18,000	64.29
22	Bamako retail price	362,983	1296.37

REFILLED 6-KG CYLINDER		CFAF	US$
Retail price	2,178 rounded off to	2,180	$7.79
Seller's margin	108 round off to	108	$0.39
Price to seller	2,070 rounded off to	2,070	$7.39

ADMINISTRATIVE ORGANIZATION OF THE HYDROCARBONS SUBSECTOR

Governmental Institutions

1. **ONT (Office National des Transports).** All oil products enter Mali by road or by rail (using the Senegal Railway (RCFS) from Dakar and the Mali Railway (RCFM)). This is the reason why the Ministry of Transport, Telecommunications and Tourism's ONT has become the principal institution of the subsector. In theory, ONT exercises supervision over the subsector and among other things is responsible for the country's supply of oil products, with offices in Dakar, Abidjan and Lomé. In 1983, a Hydrocarbons Department was created within ONT; however, the decree has not yet been promulgated and this department has only one professional.

2. One of ONT's main activities is transport management. It participates in negotiations on allocation of international transport rights, handles trucker certification and sets road transport rates. Up until mid-1988, and within the framework of a committee of carrier representatives, it allocated transport vouchers to ensure equitable distribution of transport business. Today, however, importing members of the GPP select their carriers directly, even though, legally speaking, transport vouchers are still obligatory for entry into Mali. This has come about because of the rapid increase in the number of foreign carriers available, especially from Lomé (Togo).

3. **The Commission Nationale des Hydrocarbures** (CNH), a consultative body created in 1984, is in principle the main institution for formulating policy and preparing recommendations for the hydrocarbons subsector. It is made up of representatives of nine public and private institutions. ONT provides CNH's permanent secretariat, while its activities are handled by ONT's Hydrocarbons Department (which consists of just one person, however). CNH has met eight times since 1988 and has been active in the evaluation of the subsector's main problems and options. CNH has no resources or budget of its own.

4. **The Office National de Stabilisation et de Régulation des Prix** (OSRP), attached to the Ministry of Finance and Trade, plays an important role in setting the prices of the main products. Created in 1986, its objectives are: (1) to stabilize the prices of the main products (in practice, groundnuts, cotton and oil products) that are subject to world market price fluctuations; (2) to promote exports; (3) to ensure prices are uniform throughout the country, and (4) to analyze and finance packing and storage plants for essential products. As a result of decisions taken mid-1989, OSRP no longer intervenes in groundnut and cereal production. Similar decisions could be taken for cotton. OSRP's management committee consists of about 15 representatives of ministries, banks and other institutions; it employs 30 persons, two of whom work full time on oil products.

5. **ORSP** also plays an essential role in the management of the Stabi-lization Fund for oil product prices. This fund is intended to: (1) ensure uniformity of Mali's oil product prices whatever the transport costs; (2) eliminate the relative advantages of supply from Dakar, the cost of which is lower than for hauling from Abidjan, and (3) protect the country's consumers against price fluctuations of imported products. Delays in the GPP's payments to OSRP are relatively frequent, while the situation of independent distributor payments is confused. Tighter management would therefore seem necessary,

but unfortunately the Fund does not possess resources commensurate with its financial responsibilities. It is accordingly unable to: (1) negotiate import prices; (2) verify oil operator costs, which means that it cannot enforce current regulations; (3) compare actual margins with the cost of services rendered; (4) ensure that revenue is consistent with the price structure and quantities sold, and (5) manage oil product market data.

6. The **Direction Nationale des Affaires Economiques** (DNAE) of the Ministry of Finances and Trade: (1) sets the conditions under which oil product import licenses are granted; (2) supervises compliance with price regulations; and (3) regulates and enforces weights and measures laws. DNAE should also supervise import tenders for oil products to be procured with EDF financing. In spite of its responsibilities, DNAE has no personnel specialized in the oil sector.

7. The **Direction Nationale des Mines et de la Géologie** (DNGM) of the Ministry of Industry, Hydraulics and Energy (MIHE) is concerned essentially with exploration. It is responsible for the oil product laboratory, which is used very little, industrial safety and product standards. Two persons are assigned to distribution activities.

8. The other governmental institutions involved in the subsector are Customs (import control, revenue collection), the National Prices and Incomes Committee (CNPR) and the Economic Coordination Committee (CCE), which comments on price adjustment proposals prepared by CNH.

9. **Pétrostock**, a state-owned company, was formed in 1981 to build and manage oil product storage facilities. Pétrostock was also to handle oil product imports for the State. Its personnel currently numbers 16, seven of whom are professionals. Pétrostock's past performance has been rather mixed; it has not built a single storage facility and has imported only small quantities of products, while the operation of the three gas stations it manages in Bamako leaves something to be desired. Nevertheless, Pétrostock has demonstrated the technical feasibility of transport through Nigeria and Guinea -- though the economic viability of this route is less certain -- and has participated in improving the transporting of products to the Tombouctou region.

10. Pétrostock's basic problems appear to be: (1) a lack of financial resources compared with its objectives; (2) lack of definition of its role with respect to that of the private sector; (3) overlapping responsibilities with CNH and ONT; and (4) its lack of expertise in the field. These problems are recognized and suggestions have been made for the joint development of storage with the private sector; the Société Malienne d'Entreposage has in fact been formed for this purpose, but its mandate, methods of operation and financial structure are not yet known. Other proposals have also been prepared with a view to the possible gathering of the various actors within a single institution.

The Private Sector

11. The **Groupement Professionnel de l'Industrie du Pétrole du Mali** (GPP). Historically, the subsidiaries of four multinationals (B.P., Mobil, Shell, Texaco) have always shared the market for oil products in Mali and are generally represented by the GPP, which is chaired by each of the members in turn. These operators import practically all the products from the SAR refinery in Dakar and the SIR refinery in Abidjan, in which they have minority interests. They own the Bamako depot and depots in Kayes and Tombouctou as well as some 120 service stations (45 of which in the Bamako area).

12. **The Carriers.** Products from Dakar are transported by rail by the Régie des Chemins de Fer du Sénégal (RCFCS) and the Régie des Chemins de Fer du Mali (RCFM). 1/ From Abidjan, they are trucked by independent carriers. 2/

13. **Independent importers (The Independents).** Up till 1983, the GPP and Pétrostock had a monopoly position as regards imports of oil products. Since then, independent carriers have been permitted to bring in imports, provided they meet certain minimum requirements. 3/ They actually have a roughly 25% share of the market. Since in practice the independents can only obtain supplies from Dakar or Abidjan with great difficulty, they haul gasoline and gas oil from Lomé and Nigeria to Bamako. Most of the independents have no storage capacity and they have set up their own distribution system. In Bamako, the number of hand pumps and bottles is therefore proliferating. This type of distribution network is a major public safety hazard.

1/ *Using 140 tankcars, owned by the railways and private operators.*

2/ *This fleet is estimated at 205 trucks owned by 75 carriers, mostly Malian nationals.*

3/ *Circular of April 6, 1987. These minimum requirements are that they must: (1) be authorized importers; (2) possess storage capacity -- although how much, the circular does not say; (3) have obtained a DNAE import license; (4) make payments to the Stabilization Fund; and (5) guarantees of payment of customs and import duties.*

PROPOSED ROLE OF THE NEW HYDROCARBONS SUBSECTOR MANAGEMENT INSTITUTION

Introduction

1. Various studies have led to the conclusion that the existing tariff structure for oil products in Mali needs to be revised and the management of State revenue from taxes on these products upgraded, and that improvements are needed in the overall management of the subsector, including action to reduce the number of agencies involved and, if possible, to consolidate all administrative activities into one entity.1/

2. There have recently been major improvements in the price levels and pricing system at the supply points in Abidjan and Dakar; the principle of a reform of oil product taxes has been adopted as part of the Structural Adjustment Program and decisions in principle have been made regarding the general strategy for the reorganization of the subsector.

Proposed role of the new institution

Guiding principles

3. The following principles should guide the proposed reorganization of the subsector:

(a) Distinguish between the tasks of policy-making, strategy setting and overseeing the implementation of these policies and strategies, and the tasks of policy execution and sector management. The roles and responsibilities of the supervisory institution, on the one hand, and management, on the other, must be clearly identified.

(b) Permit the consolidation of execution and management activities within a single entity;

(c) Simplify and clarify decision-making processes; and

(d) Ensure that the personnel involved in technical supervision and in the new management institution for the subsector are sufficiently qualified.

Responsibilities

4. This new management institution will implement the policy and strategies decided on by the Government (e.g. DNHE) with respect to the oil sector. Its responsibilities could include the following:

1/ *See, in particular: Study for the improvement of oil product supply and distribution procedures (Skaarup Oil Corp. - June 1989); internal studies conducted by various Malian ministries and agencies and also the ESMAP study on Mali's energy problems and options (1990).*

(a) The centralization of all data and documentation concerning the oil sector;

(b) Studies and plans for investment projects, study of supply systems, stockpiling needs;

(c) Procedures for imports, including negotiations with supplier countries, including Côte d'Ivoire and Senegal, in particular;

(d) The management of supply and distribution channels;

(e) The management of price structures and the monitoring of tax collection and revenues; cost analyses and studies of import and distribution margins;

(f) The implementation (or responsibility for supervising implementation, if this is entrusted to an existing agency) of quality and public safety controls; and

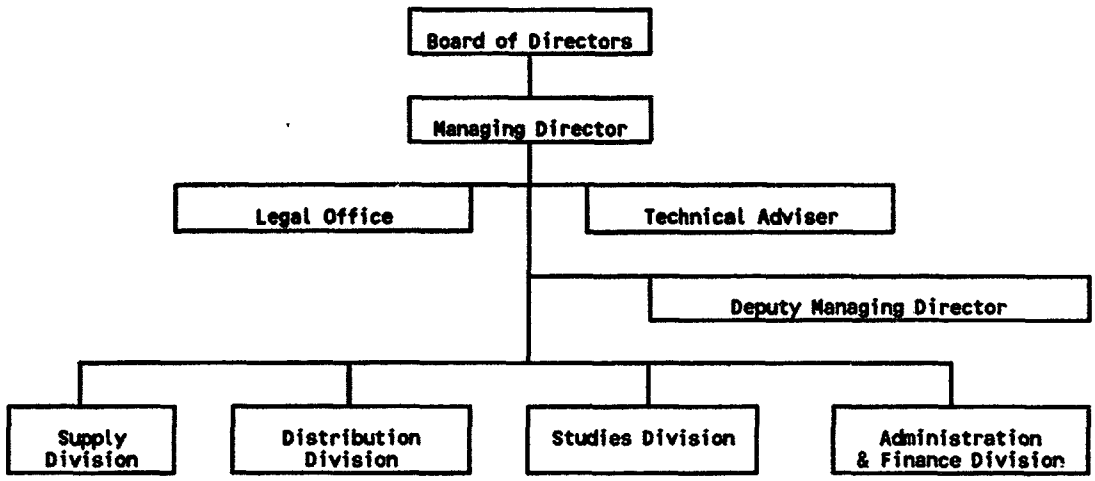
(g) Stocks management.

Organization options

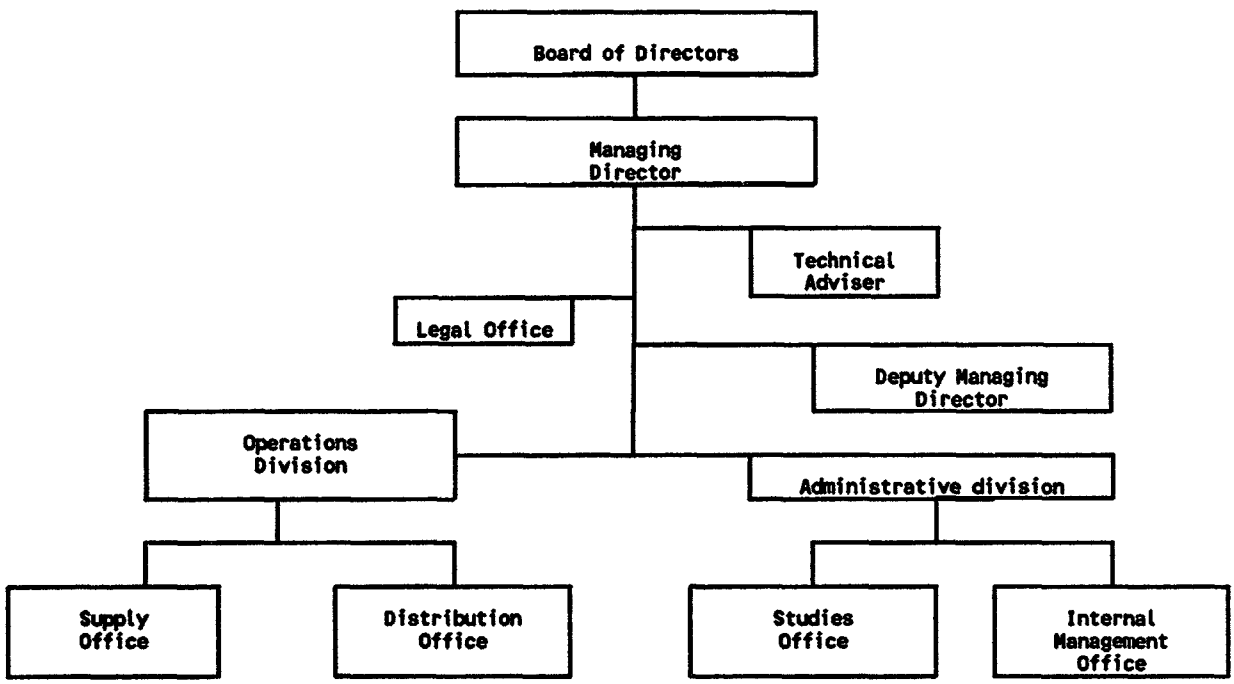
5. Two organization chart options for such an institution are shown below. In any event, it is important that the organization be kept simple and be geared to the skills levels currently available in Mali.

ORGANIZATION CHARTS OPTIONS

Option 1



Option 2



Source: Studies prepared by the Skaarup Oil Corp. for the reorganization of the hydrocarbons subsector.

ADMINISTRATIVE MECHANISMS FOR SETTING PRICES AT THE PUMP

1. As in many French-speaking African countries, prices at the pump for petroleum products and the different components of the price structure (jet fuel and LPG excepted) are state controlled. Taxes account for 60% of the pump price of gasoline and nearly 40% of the price for other oil products. A large number of bodies are involved in setting the price at the pump and the various cost components.

2. **The Stabilization Fund** is an essential component of the price structure; it is in theory intended to: (1) maintain uniform prices throughout the country; and (2) eliminate differences in transport and import costs from Abidjan, Dakar and Lomé. Up until mid-1988, adjustments aligning domestic prices on world market fluctuations depended on supplier countries--which meant in practice SIR-Abidjan and SAR-Dakar--and the adjustments made did not necessarily reflect world price fluctuations. Following the 1989 negotiations, the ex-Abidjan and ex-Dakar depot prices will be based on and therefore aligned on Platts Mediterranean quotations for the various products. The additional charges for handling and storage will be added.

3. **The Malian Commercial Code** prohibits selling at a price lower than the official one. With the current system of the Government setting consumer prices and the components of the price structure, none of the members of the petroleum chain has any incentive to reduce costs but can gain from pushing them up. 1/ The prices at the pump are therefore the result of negotiations with no clear reference to economic realities or an energy pricing policy. Consumers consequently end up as victims of the inefficiencies of the system, while public revenues are lower than they should be.

4. **The Office de Stabilisation et de Régulation des Prix** (ORSP) performs a coordinatory role in the establishment of oil product prices by managing the Stabilization Fund (para. 2). This is primarily coordination, since several pricing components can be modified by decree without corresponding adjustments in the price at the pump.

5. Finally, the **Commission Nationale des Hydrocarbures** (CNH) reviews and gives its opinion on price structure modifications proposed by the OSRP through the Ministry of Finance and Trade. In addition, the National Prices and Incomes Committee (CNPR) and the Economic Coordination Committee (CCE) also prepare proposals. These proposals are then finally submitted to the Government and discussed in the Central Executive Bureau. It is, therefore, a lengthy procedure that does not ensure heightened economic efficiency.

1/ *It thus appears that road transport is insured twice: by the carriers and by the GPP.*

REORGANIZATION OF THE HYDROCARBONS SUBSECTOR
- PROPOSED TERMS OF REFERENCE FOR TECHNICAL ASSISTANCE -

Introduction

1. Various studies have led to the conclusion that the existing tariff structure for oil products in Mali needs to be revised and the management of State revenue from taxes on these products upgraded, and that improvements are needed in the overall management of the subsector, including action to reduce the number of agencies involved and, if possible, to consolidate all administrative activities into one entity. 1/

2. There have recently been major improvements in the price levels and pricing system at the supply points in Abidjan and Dakar; the principle of a reform of oil product taxes has been adopted as part of the Structural Adjustment Program and decisions in principle have been made regarding the general strategy for the reorganization of the subsector.

Proposed Role of the New Institution

Guiding Principles

3. The following principles should guide the proposed reorganization of the subsector:

(a) Distinguish between the tasks of policy-making, strategy setting and overseeing the implementation of these policies and strategies, and the tasks of policy execution and sector management. The roles and responsibilities of the supervisory institution, on the one hand, and management, on the other, must be clearly identified.

(b) Permit the consolidation of execution and management activities within a single entity;

(c) Simplify and clarify decision-making processes; and

(d) Ensure that the personnel involved in technical supervision and in the new management institution for the subsector are sufficiently qualified.

1/ *See, in particular: Study for the improvement of oil product supply and distribution procedures (Skaarup Oil Corp. - June 1989); internal studies conducted by various Malian ministries and agencies and also the ESMAP study on Mali's energy problems and options (1990).*

Responsibilities

4. This new management institution will implement the policy and strategies decided on by the Government (e.g. DNHE) with respect to the oil sector. Its responsibilities could include the following:

(a) The centralization of all data and documentation concerning the oil sector;

(b) Studies and plans for investment projects, study of supply systems, stockpiling needs;

(c) Procedures for imports, including negotiations with supplier countries, including Côte d'Ivoire and Senegal, in particular;

(d) The management of supply and distribution channels;

(e) The management of price structures and the monitoring of tax collection and revenues; cost analyses and studies of import and distribution margins;

(f) The implementation (or responsibility for supervising implementation, if this is entrusted to an existing agency) of quality and public safety controls; and

(g) Stocks management.

Proposed Technical Assistance

Main Activities and Components

5. In order to carry out this reorganization as efficiently as possible and to ensure that it can subsequently operate efficiently, technical assistance is proposed in the following specific areas:

(a) pricing and taxation systems for oil products and improving the management of State tax revenues from the import and sale of these products;

(b) implementation of the institutional reorganization of the subsector, in response to the reorganization decisions taken by the Government;

(c) special studies designed to significantly improve the efficiency of the hydrocarbons subsector; and

(d) training of Malian personnel who will be in charge of managing the systems and implementing the actions proposed.

6. This assistance project could be managed by the Office de Stabilisation et de Régulation des Prix (OSRP) or DNHE on behalf of the Malian Government.

7. The activities could be carried out as follows:

(a) Revision of the pricing of oil products:

(i) Phase I covering diagnostic studies, the development of possible pricing options and the recommendation of one of these options to the Government;

(ii) Government examination of and decisions on the recommendation; and

(iii) Phase II, to be carried out as soon as the Government takes these decisions, will consist of implementing the new pricing system and the management of tax revenues and procedures, training and the periodic monitoring of implementation;

(b) Administrative reorganization of the oil product subsector:

(i) Phase I covering diagnostic studies of organizational aspects and of legislative and administrative texts, the development of reorganization options and the recommendation of one of these to the Government;

(ii) Government examination of and decisions on the recommendation; and

(iii) Phase II, to be carried out as soon as the Government takes these decisions, will consist of implementing the new organization of the subsector and operating procedures, training and the periodic monitoring of implementation;

(c) Specific and detailed study, to begin upon completion of Phase II.

8. It is impossible at this stage to estimate accurately the scope of the work to be carried out during Phase II. This will have to be established before this work begins, together with the exact schedule.

Technical Assistance Costs

9. The technical assistance should include experts in the distribution of oil products, preferably with experience in Western Africa. Its duration would be about two years.

10. The cost of this technical assistance is put at US$660,000.

SUMMARY OF MALI'S EXPERIENCE IN NEW AND RENEWABLE ENERGIES

Solar Energy Utilization

Introduction

1. The uses of solar energy developed in Mali involve both thermal (flat-plate collectors for hot water for domestic or industrial use, dryers, distillers) and photovoltaic applications (pumps, lighting systems, battery chargers, refrigerators, telecommunications relays, beacons). A brief analysis follows of the technical and economic aspects of these applications and the constraints linked to their use in order to satisfy a specific demand for energy at the lowest cost.

Hot Water for Domestic or Industrial Use

2. Household sector. Since 1975 LESO has made about 200 individual solar water heaters (two flat-plate collectors of 1.3 m^2 each and a 200-liter tank with thermosiphon circulation) which in 1975 sold for CFAF 250,000 including installation. The market not having expanded, their manufacture is virtually at a standstill and LESO now merely provides maintenance for existing equipment. There are several reasons for the lack of interest among consumers. First of all, financial factors: the initial cost is twice as high as for an electric water heater, for a service of inferior quality; furthermore, given the seasonal nature of demand for hot water in Mali (in most households, three months a year at the most), annual energy consumption is small, which sharply reduces the return on a solar water heater, despite the high cost of electricity. In addition, corrosion problems with the tanks and solar collectors have not been solved. Finally, promotion and marketing have probably not been handled correctly, since these tasks clearly exceed the responsibilities and capabilities of LESO. It must also be stressed that the market is very tight.

3. Feasibility of Solar Water Heaters for Household Use. Tables 1 and 2 show that in Mali solar water heaters cost about three times as much to buy as electric heaters. Table 3 presents a financial comparison between electric and solar power for a situation of constant demand for hot water throughout the year; given the assumptions used, the annual cost of using the solar water heater is about 25% less than for the electric one, but the payback period is some seven years. The economic comparison would give similar results because: (a) the price of electricity for low-voltage consumers is close to marginal cost; (b) taxes and charges on solar and electrical equipment are identical. Tables 4 and 5 illustrate the more probable situation of four months' use a year. Under the current tax system, the annual cost of the solar water heater is almost 60% higher than that of the electric heater; and Table 5 indicates that even with preferential fiscal treatment (no taxes or duties on solar equipment) the solar solution is still more expensive than electricity.

Table 1: ELECTRIC WATER HEATER
1988 prices in US$

CAPACITY	50 l	100 l	150 l
FOB Europe	108	162	176
CIF Bamako (+20%)	130	195	211
Taxes included (80%)	234	35	380
20% margin included	281	421	456
Installation included (20%)	337	505	547

Efficiency = 85%

Source: ESMAP estimates.

Table 2: SOLAR WATER HEATER
1988 prices in US$

CAPACITY	90 l	120 l
FOB Europe	518	620
CIF Bamako (+20%)	621	744
Taxes included (80%)	1118	1339
20% margin included	1342	1607
Installation included (20%)	1611	1928

Assumptions:
Thermosiphon circulation
Auxiliary electric element
Solar radiation = 4.5 kWh/m^2/day (annual average)
Overall efficiency = 30%

Source: ESMAP estimates.

Table 3: SOLAR/ELECTRIC FINANCIAL COMPARISON
Year-Round Use

CFAF (CFAF280 = US$1)	SOLAR 120 l 4 m^2	ELECTRIC 100 l
Total price	540000	141400
Useful life (years)	10	10
Maintenance	9000	9000
Consumption (kWh/year)	309	2061
Cost of consumption	18540	125721
Annual amortization of investment	88000	23050
Total annual cost	115540	157700

Assumptions:
120 l/day
Temperature gradient = 35°C
Energy need = 146 kWh/month
Solar contribution ratio = 85%

Source: ESMAP estimates.

Table 4: SOLAR/ELECTRIC FINANCIAL COMPARISON
Seasonal Use
Current tax system

CFAF (CFAF280 = US$1)	SOLAR 120 l 4 m²	ELECTRIC 100 l
Total price	540000	141400
Maintenance	9000	9000
Consumption (kWh/year)	309	687
Cost of consumption	18540	41220
Annual amortization of investment	88000	23050
Total annual cost	115540	73270

Assumptions:
120 l/day
Temperature gradient = 35°C
Energy need = 146 kWh/month
Solar contribution ratio = 55%

Source: ESMAP estimates.

Table 5: SOLAR/ELECTRIC FINANCIAL COMPARISON
Seasonal Use
Preferential tax system

CFAF (CFAF280 = US$1)	SOLAR 120 l 4 m²	ELECTRIC 100 l
Total price	300000	141400
Maintenance	9000	9000
Consumption (kWh/year)	309	687
Cost of consumption	18540	41220
Annual amortization of investment	48900	23050
Total annual cost	76440	73270

Assumptions:
120 l/day
Temperature gradient = 35°C
Energy need = 146 kWh/month
Solar contribution ratio = 55%

Source: ESMAP estimates.

4. Hot water for industry and commerce. The use of flat-plate collectors could also be envisaged for heating water for the tertiary sector (hotels, hospitals and health centers, schools, etc.) and small industries (textiles, tanneries, etc.). Indeed, two hotels in Mopti and Tombouctou heat their water using solar energy, as do three hospitals in Bamako. However, technical problems (inadequate size of equipment, corrosion, lack of maintenance) are jeopardizing the smooth operation of these installations. Availability of a reliable flat-plate collector at a reasonable price is therefore a prerequisite.

5. Feasibility of solar water heaters in industry and the tertiary sector. As regards heating water for industry, with insolation of 5 kWh/m²/day, 1 m² of solar collector with an efficiency of 40% (and a useful life of 10 years and annual maintenance costs of CFAF 3,000) could save around 100 kg of fuel oil each year (equivalent to CFAF 10,000 in economic value or CFAF 20,000 in financial value). Using a discount rate of 10%, the break-even point for the solar system is around CFAF 45,000 per m² for collectors imported tax-free (CIF price, including auxiliary systems plus installation cost), or around CFAF 100,000 per m² when all taxes are included. However, with this price range the payback periods for the investment at current electricity prices will be between 6 and 10 years, which clearly indicates how tight the market is.

Solar-Powered Pumps

6. The most extensive application of solar energy is in pumping, and there are now more than 20,000 solar-powered pumps worldwide. Among the Sahelian countries Mali has the largest number of solar pumps; some 150 are in operation at the present time. Most of these are located in two zones: the San region, where Mali Aqua Viva operates, and the region to the north of Bamako (Kolokani, Nara). Most of these pumps are immersed in tubewells (only some 15 are surface pumps), in the 900 to 1,000 pW range. By way of indication, an installed capacity of 1,300 pW enables about 50 m³/day to be pumped over a vertical distance of 20 m, with insolation of 5.5 kWh/m²/day. The main organizations involved are: Mali Aqua Viva, launched in the 1970s, which drills and equips tubewells for village water supply in the San/Ségou region and uses solar energy in part but also diesel-and man-powered pumps (Vergnet foot pumps, for example); CEES installs pumps but is primarily responsible for coordination of maintenance activities, and also plays a part in determining the systems to be installed; the SEP works in the Niono/Ké-Macina and Koulikoro zones (10 pumps); finally, a certain number of NGOs (Ile de Paix, SOS Sahel, etc.) or private companies (Elf, Total, etc.) have made scattered individual contributions. In addition, the preparatory studies for the regional solar-powered pumping program financed by the EC have just begun. In Mali's case this involves installation of about 250 pumps (principally in tubewells and in the same capacity range as the existing pumps) in several phases. The first phase will concentrate on the Mopti region.

7. This proliferation of participants results in a multiplicity of technologies and manufacturers, which complicates maintenance work and the building of stocks of spare parts. Nonetheless, after early missteps, there seems to be a trend toward a uniform technology (immersed electric-powered pump with converter) which has a very low breakdown rate. The weakest point is the converter, but a certain number of breakdowns are also attributable to accidental causes (wells drying up, for example). For surface pumping, mainly irrigation, floating systems using direct-current motors are more recommended.

8. The 1988 price (excluding taxes) of photovoltaic systems ranged from CFAF 4.7 million for a 640-pW system to CFAF 8.6 million for a 1,600-pW system (the 1,300-pW system, able to pump 50 m³/day, costs CFAF 7.3 million). It should be noted that the cost of the panels used in these systems is about US$12 per pW (CIF Bamako), or at least 1.5 times higher than the international price for

adequate quantities. If international prices were used it is probable that the cost of the systems to be installed in, for example, the regional solar-powered pumps program, would be some 20% less than the prices mentioned. The development cost for a typical tubewell (metal tank of 8 m^3, semiburied concrete reservoir of 10 m^3, washing area, pipes, drinking trough, wire netting) is estimated by CEES at between CFAF 2.3 and 2.5 million. Furthermore, depending on its depth, the cost of the tubewell is between CFAF 40,000 and 70,000 per linear meter installed, or CFAF 2.5 millon for a 35 m well, for example. Maintenance costs per pump vary from CFAF 150,000 to 250,000 a year, depending mainly on the frequency of breakdowns in the converter, which alone costs CFAF 600,000, but also on the rate of accidental breakdowns (excluding technological shortcomings); at the moment the pumps have been operating too short a time to enable the accuracy of the manufac-turers' claims regarding their useful life (seven years) to be confirmed.

9. The policy of DNHE, like that of most agencies in the solar-powered pumps sector, is to ask the populations of the beneficiary villages to contribute to these costs. The amount varies according to the particular conditions in each village, reaching its highest level in the Mali Aqua Viva zone, where it ranges from CFAF 1.5 million for 20 m^3/day to CFAF 3 million for 50 m^3/day, or from 20% to 30% of the total investment (including wells and development). It is very likely that this percentage is close to the maximum obtainable, even for the better-off rural population or those (who are to be encouraged) who are most anxious to receive, use and maintain this service. From this it must be concluded that the State or donors will have an important role to play in the development of village water supply. Finally, DNHE emphasizes the villages' total responsibility for the maintenance costs of the systems (travel, parts and labor). These costs will be kept to a minimum if photovoltaic systems continue to be grouped in regions where maintenance teams operate, these if possible being private firms.

10. Although evaluations of the comparative financial returns on pumps of different kinds must be made on a case-by-case basis, it is possible to indicate a band of economic returns for solar-powered pumps in relation to the two principal alternatives, namely man-powered (or animal-powered, especially in the north) pumps for small quantities of water and diesel pumps for larger amounts, it being understood that wind-powered pumps will only be competitive in favorable wind conditions and if maintenance problems are solved. This band extends from approximately 50 to 100 m^4/day (for example, 5 to 10 m^3/day pumped over a vertical distance of 10 m) to 1,000 to 1,500 m^4/day. As regards surface pumps for irrigation, the return on photovoltaic systems is closely connected to the annual duration of their use, in other words, to the presence of year-round crop systems, which are fairly common in the OERHN zone and the fruit and vegetable-producing perimeters around large towns such as Bamako, Ségou, Mopti and Gao. Furthermore, the use of solar-powered pumps must be confined to tubewells whose flow is sufficient to avoid any risk of their drying up (this limit was established at 5 m^3/hour for the regional program mentioned above) and where the pumping height does not exceed a given distance (50 m is regarded as the maximum in the same program). In these conditions solar-powered pumps, within the band indicated, are the least-cost option; the development of the market will depend entirely on the public and private financing available for the development of village water supplies, and on the priority attached to this service as compared to the other needs of rural communities.

Electricity for Small Urban Consumers

11. For urban households without access to electricity, the commonest practice is to use kerosene lamps, perhaps acquire certain small battery-operated appliances (radio, torch, etc.), and to dispense with most of the other services available via the public electricity system. More recently, articles have appeared that are new to Mali: television sets powered by automobile batteries (4-5,000 now in Bamako); fixed or portable lamps using gas or batteries, including batteries recharged from the mains, or powered by individual or shared solar panels. While the number of such television sets is increasing people are much less familiar with the lighting equipment, although a considerable effort in this direction is being made by CEES and the SEP.

12. CEES is studying the prospects for portable lighting and rechargeable battery systems. As part of the Francophone Program, distribution of some 800 portable lamps with individual solar panels began in 1989. A number of credit systems are being tested (consignment leasing-sale, etc.) to overcome the lack of savings. It would seem that on these conditions there is a market for these products, although its size remains to be determined. Furthermore, this market is definitely not limited to semiurban areas, since expenditure on kerosene and batteries in certain rural zones is just as high as in nonelectrified urban areas.

13. Potential consumers seem very sensitive to such factors as the modernity, durability and reliability of the equipment, and to having full ownership of all system components, which does not favor one potential solution viz. having the lamps recharged by a dealer with access to electricity (generator, network or other). Consequently, the five battery-recharging systems set up by CEES in rural areas have not been very successful, for two main reasons: rapid deterioration of the rechargeable batteries (high temperatures, frequent handling, poor quality, etc.); and the fact that the users do not own the system. Nonetheless, this is a financially viable option since CEES estimates the total cost of recharging an R20 type battery at CFAF 50, while the retail price of an R20 battery in Mali is CFAF 100. It should be noted that this calculation is based on imported recharge systems not being taxed, which is not currently the case, since photovoltaic equipment imported outside the scope of various "projects" is equated with electrical equipment and thus pays taxes and duties of some 70%.

14. The SEP is concentrating its efforts on distributing solar kits consisting of a solar panel (40 pW), a charge/discharge regulator and a battery (100 Ah), which enables three 11-W bulbs (equivalent to traditional 70-W bulbs) to be used for three to four hours each day (or a television set for the same length of time). The cost of the solar kit is CFAF 150,000 (CIF Bamako), making the retail price around CFAF 300,000, including applicable taxes and duties and a 20% margin for the distributor. A dozen kits have already been sold (tax free) and installed at Bamako and San. In a second phase the systems will be sold on a tax-included basis, probably on a monthly installment system. The SEP has put the market for this kind of solar kit at between 500 and 800 units a year.

15. Table 6 contains a financial comparison of various lighting options: traditional light bulb, candle, kerosene lamp, gas lamp, lamp using batteries (disposable or rechargeable), lamp attached to a vehicle battery, medium solar-powered lamp, large solar-powered lamp. The cost comparison per lighting hour (in absolute terms or in relation to the luminosity provided) shows that, at equal luminosity,

the "new options" (lamps using disposable or rechargeable batteries, portable solar-powered lamps) are less expensive than kerosene lamps. However, since the consumer accepts the lighting quality provided by the kerosene lamp, this is still, for him, the least expensive option.

Table 6: FINANCIAL COMPARISON OF LIGHTING OPTIONS

	Luminosity (Lumen)	Capital cost (CFAF)	Cost/hour of lighting (CFAF)	(CFAF/klm)
Traditional light bulb	730	2000*	4*	6*
Candle	12	50	10	833
Kerosene lamp	20	4000	5	230
Gas lamp	450	9000	59	132
Disposable battery lamp	240	16000	26	1116
Rechargeable battery lamp	240	46000	7	31
Vehicle battery lamp attachment	540	27000	11	20
Solar-powered lamp (medium)	95	35000	13**	137**
Solar-powered lamp (large)	450	43000	20**	43**

* Excluding cost of electricity connection.
** Excluding cost of recharge system.

Source: ESMAP estimates.

Refrigeration in the Health Sector

16. Refrigerators in health posts and centers are used to preserve vaccines and freeze the ice packs for vaccination campaigns; in Mali as elsewhere they are a very important link in the cold chain of the Expanded Program on immunization (EPI). In Mali the EPI dates only from the end of 1986, but most of the health posts have refrigerators, the majority of which run on kerosene (Electrolux or Sibir models), and also cold-storage boxes for the vaccination campaigns or to return the vaccines to the health centers (which generally have electricity) should the refrigerator break down or run out of fuel. In practice, kerosene supply breakdowns at health centers are relatively frequent, compounding the problems of poor fuel quality (contamination, impurities, etc.). It should, however, be noted that there is no accurate information on the level of these losses and that the precise incidence of factors other than energy problems (for example, negligence by the post director, doses lost because not used once the flask has been opened, refrigerator misused) is difficult to estimate.

17. To remedy these problems, the Ministry of Health has made plans to increase the number of health posts with refrigeration equipment and to progressively convert kerosene refrigerators to LPG. The purchase of photo-voltaic refrigerators is also envisaged, but there are two major obstacles: (a) the capital cost of a photovoltaic refrigerator is some three to four times higher than that of a kerosene refrigerator; (b) the dozen or so photovoltaic refrigerators currently in use in Mali were found to be performing unsatisfactorily in an evaluation carried out in 1985.

18. As shown in Table 7, it would make financial sense to use solar-powered refrigerators in the health posts where the rate of vaccine losses attributable to breakdowns of traditional refrigerators exceeds some 30%, provided that the photovoltaic refrigerator ca guarantee a loss rate below 5%. This has not been achieved with the refrigerators brought into service in Mali at the beginning of the 1980s. However, it seems that equipment now is available that can guarantee the required level of reliability (see the WHO catalog). Consideration should be given to installing this equipment, but only in health posts where the rate of vaccine losses is sufficiently high.

Table 7: ECONOMIC COMPARISON OF SOLAR AND KEROSENE REFRIGERATORS
Cost per dose of vaccine used

	Solar	Kerosene
Installed cost (CFAF)	1,030,000	255,000
Maintenance (CFAF/year)	10,300	23,000
Annual cost of fuel (CFAF/year)	0	43,000
Total annual amortized cost (CFAF/year)	190,000	152,000
Reliability (%)	95	70
Vaccine doses used	7410	5460
Cost per dose (CFAF)	26	28

Assumptions:

Health post
- Area of influence: 15,000 people
- 7,800 doses of vaccine per year
- Annual cost of vaccines: CFAF 320,000

Solar refrigerator
- Average insolation: 5 kWh/m^2/day
- Consumption: 400 Wh/day
- Panel capacity: 115 pW; battery capacity: 280 Ah
- Useful life: panels 15 years; refrigerator 7.5 years; battery 5 years

Kerosene refrigerator
- Consumption: 1.5 l/day
- Economic cost of kerosene: CFAF 115/l
- Useful life: 7.5 years

Source: ESMAP estimates.

Solar Dryers

19. Various models of natural convection solar dryers have been manufactured and tested. At LESO these driers are of the tent and Taos type (separate collector and drying chamber), and problems have arisen regarding their working life (termites). Furthermore, the rural population is reluctant to make an initial investment that is not inconsiderable in comparison to their low incomes; they find it difficult to relate the size of this investment to any realistic prospect of reducing losses of dried products, and prefer to continue using traditional methods of open-air drying.

20. Tent-type dryers (about 2 m^2 of drying area) have been marketed under the SEP; these are built from easily available materials (wood, plastic, wire netting) but still cost CFAF 25,000 and have also encountered the problems described above. Finally, the SEP is developing a semi-industrial dryer (flat-plate collector and drying compartment) for drying products for export, such as certain fruits (mangoes, etc.) and vegetables (onions, tomatoes, peppers, gambo, etc.). According to the latest information from the SEP it would seem that the financial viability of this dryer has been demonstrated and that a valid demand exists.

Other Solar Applications

21. Solar cookers (parabolic concentration and flat-plate collector models) were tested by LESO but quickly abandoned; they are too expensive and too tricky to use as compared to the alternatives (cooking with wood or charcoal). Furthermore they are not suited to cooking habits in Mali and therefore have no future whatever.

22. Two photovoltaic solar mills for grinding grain have been introduced in Mali; one, with a power of almost 7 kW (also used for lighting and pumping), by the Ile de Paix organization near Tombouctou, and the other by LESO in the village of Tonfa. These two mills have experienced similar technical problems (power surge on starting up) and unit operating costs are considerably higher than for the gasoline or diesel mill, which has the additional advantage of costing much less than the solar-powered model.

23. One of the first thermal solar power plants was built in 1980 at Diré, near Tombouctou, to irrigate an area of wheat by pumping water from the river Niger. This technology encountered serious technical problems (furthermore it is probable that, on that scale, diesel-powered pumps were a better economic proposition, even at the international oil prices prevailing at that time) and it has since become obsolete. The Diré plant was thus abandoned, like most installations using thermal solar power.

Substitute Fuels

Vegetable Oils

24. The use of vegetable oils in engines, either directly or in the form of esters, has been the focus of considerable research worldwide. In Mali the first attempts to use pourghère oil directly as a fuel in diesel engines date from 1930; they resulted in engine deterioration problems deriving from the characteristics of the oil. Similar problems encountered in a number of experiments led both to the development of special engines that can use certain vegetable oils without damage and to esterifying the oil to enable it to be used directly in diesel engines.

25. Since 1987 the SEP in Mali has been evaluating the prospects for using pourghère oil, by promoting production and demonstration projects (two vehicles, a 12 kW mill, a 25 kW generator).

The pourghère, whose seed contains one-third oil, is already used in traditional medicine (as a purgative) and to make soap. In certain regions it is also widely planted as a hedge to demarcate and protect fields, and thereby contributes to environmental protection; CMDT has launched a vast program to plant pourghère hedges. Furthermore, the work of planting and of collecting and processing the seeds would increase peasant incomes in the areas concerned. The oil or its ester could be used in small village units processing agricultural products (mills for grinding, for example), especially in zones where access to diesel oil poses problems.

26. One main problem with pourghère oil is the difficulty of obtaining it, which impacts its financial and economic return as compared to the fuels it would replace (diesel oil for stationary motors, kerosene for lamps or cookstoves). It is true that, for small-scale production (for example, by using karité presses, which are fairly common in the pourghère zones), it takes only 2 hours to press a liter of oil (barely usable for lighting) from 5 kg of seeds that are crushed but not husked; but it takes more than 20 hours to produce the same quantity of oil from husked seeds. This oil can only be used in special engines and yields indifferent results for lighting and cooking.

27. The SEP had produced some preliminary hypotheses regarding the costs of the industrial extraction of pourghère oil, using the cost of the similar process for groundnut oil, which is of the order of CFAF 70 per liter of oil. Under these assumptions the production cost of pourghère oil was estimated at around CFAF 140 per liter, including the seeds, which cost CFAF 20 per kg, or about CFAF 70 per liter of oil produced. This is already higher than the economic cost of diesel oil delivered to rural areas, not even counting the extra cost of using the special engines required by direct utilization of the oil (additional capital cost estimated at 30% to 50%). At the beginning of 1990 SEP abandoned the promotion of this application in Mali.

28. Conversion of pourghère oil into ester directly usable in engines, lamps and stoves as a substitute for diesel oil or kerosene can only reasonably be envisaged as an industrial process. The estimated cost of this product is CFAF 150 to 200 per liter (its energy content being similar to that of pourghère oil and slightly below that of diesel oil), i.e. almost one and a half times higher than the economic cost of diesel oil. Although a useful byproduct, glycerine, is created during the conversion process, and its market value can be deducted from the costs of producing the ester, the market for it in Mali is very uncertain. In sum, given current oil prices, the future of vegetable oils in Mali would appear very limited.

Ethanol

29. The World Bank is financing a project (Credit MLI 1403) at the Sukala/Sirabala sugar complex to produce 2,000 m^3/year of anhydrous ethanol for mixing with gasoline, in order to reduce oil imports by an equivalent amount. The plant is nearing completion and commercial production should begin in the second half of 1990. The ethanol produced will then be shipped to the Mobil depot at Bamako, which will have to be modified at an estimated cost of $200,000.

30. This project was evaluated during a World Bank supervision mission at the end of 1989, which found it viable on the basis of its direct production costs, if both capital cost and the cost of the molasses are disregarded. The initial return on the project is now much lower because of the fall in oil prices. The possibility of obtaining a higher return by selling the ethanol as a pharmaceutical or household product at higher prices is also being considered.

Biogas

31. At the beginning of the 1980s LESO embarked on construction of biogas digesters of the Indian (capacity 7 m^3) and Chinese type. The latter model presented fewer problems as regards resistance and availability of the construction materials used. However, in both cases three major problems were identified: (a) difficulties in obtaining the significant quantities of water required for fermentation; (b) the scattered and sometimes irregular (seasonal) availability of the raw material because of the extensive nature of stockraising in Mali; and (c) the lack of financially profitable applications for the gas produced (for example, for cooking food, the chief source of demand for energy at present, biogas is not competitive with wood collected at no cost). Two Indian models have been installed in an agricultural research center and a school/maternity facility, respectively, but are not functioning at the present time.

32. The SEP has also installed some 30 Ferké-type digesters (a model developed in Côte d'Ivoire): 10 in rural schools (community systems) and 20 individual systems. This model has a volume of 11 m^3 and can produce 2 to 4 m^3 of biogas a day from the dung of a dozen cattle. Its installed cost is CFAF 150,000. A daily output of 3 m^3 of biogas would produce some 4 kWh of electricity, or would power four gas lamps (60 Watts equivalent) for five hours, or supply a two-ring cookstove for eight hours. The idea of community digesters has been abandoned; the problems of allocating responsibility for operation and maintenance were compounding the technical difficulties already mentioned (raw material, water and demand). The latter are still very serious obstacles to the distribution of individual biodigesters.

33. Another type of unit for continuous biogas production (Transpaille fermentation technology) has been installed since 1988 in the private experimental center for renewable energies at Teriya Bougou. This metal unit, with a volume of 20 m^3, uses a mixture of millet straw and cattle dung and can produce up to 20 m^3 of biogas a day and 35 tons of compost a year. It supplies a 7-kW generator (flour mill and electric pump) and a four-ring biogas cooker. The installed cost was CFAF 10,650,000 (excluding taxes) in 1988, including the cost of the construction of the fermenter at Bamako, which was CFAF 4,000,000. The payback period is estimated at seven years, fairly close to the useful life of the fermenter. However, this evaluation was made on the basis of very favorable assumptions for the biogas process, viz. commercial value of the compost produced (CFAF 10/kg); maximum savings of diesel oil and butane gas (3,000 liters and 370 kg a year respectively); preferential tax treatment; discount rate of 0; and long useful life of the equipment (10 years). The future of this technology in Mali therefore appears very limited.

34. Finally, biogas production, while no doubt a relatively simple and manageable technology, faces a serious problem in terms of acceptance by the rural population as well as major difficulties regarding its use and the rate of economic return. As there is currently no market in Mali for the fertilizers obtained as byproducts from the digestion process (which is what makes the hundreds of thousands of individual digesters in China, for example, profitable), the economic cost of biogas is uncompetitive in relation to the fuels that it might replace (kerosene for lighting, diesel oil for stationary engines and firewood for cooking).

Crop or Agroindustrial Residues

35. As already mentioned, a major part of the agroindustrial by-products (bagasse and molasses, cotton bolls and groundnut shells, groundnut cakes, rice husks – see Annex 2.2) are currently used as a source of energy or as animal feed in processing units (CMDT plant, HUICOMA, Sukala and Badalabougou sugar refineries, etc.). Mali is a fairly rare example of the practically continuous utilization of two gas-producing units for more than 20 years; the Chinese equipment in question uses rice husks and supplies "dual-fuel" diesel motors that provide savings up to 70% on diesel oil under ideal load conditions. The key to this success lies in the frequent and systematic attention by the operators in both the operation and maintenance of the gas units and engines. Under the SEP, experiments in producing charcoal from cotton stalks have also been carried out in metal drums. These experiments have not been successful, given the poor characteristics of the charcoal (very fine and friable as compared to wood charcoal) and the absence of any market for this product sufficiently close to the cotton-producing areas, where firewood is fairly freely available.

Other Renewable Energies

Hydroelectric Mini-Powerplants

36. Hydroelectric powerplants with an installed capacity of less than a few hundred kW could be considered as a means of generating electricity for isolated centers of demand in the southern part of the Sikasso region. It would be worth evaluating a limited number of sites that seem promising from the standpoint of technical and economic feasibility. Priority consideration should be given to centers with an existing or potential demand in the productive sector: husking and milling of grain, small agroindustries, workshops, etc. In light of the average cost of a kWh generated by a small diesel powerplant (estimated in Mali's conditions at from CFAF 75 to 150, according to the utilization period), the following indicative criteria should be applied in the initial selection of sites: initial capital cost below US$2,000 per kW installed, and annual utilization time in excess of 2,000 hours.

Wind Energy

37. Notwithstanding the constraints regarding wind energy in Mali, this energy could in theory be used for pumping water in the windier areas, and with technologies suitable for lighter winds. Between 1975 and 1985 50 small windmills (SAHORES model) were made and installed in the Ségou region by CPAR. By using simple, locally available materials, the cost of a windmill capable of pumping 10 m^3/day over a vertical distance of 20 m was kept to only CFAF 150,000, including technical training and installation costs. However, even then the windmills were only of interest to the better-off groups. Furthermore, because of their rudimentary nature and the significant amount of maintenance needed, only a few windmills are still operating.

38. From 1980 onward LESO incorporated the principle of the SAHORES-type windmill into the LESO I model, which experienced similar mechanical resistance problems. An improved multiblade model, the LESO II, was then produced. With a rotor 4 m in diameter, this windmill could pump up to 20 m^3/day over a vertical distance of 25 m with an average wind speed of 3 m/second during the day. Its cost is around CFAF 1,500,000, assembled and ready to pump, giving a cost of CFAF 50 to 60 per m^3 of pumped water. This puts wind energy in between man-powered pumps and diesel pumps and in a favorable position in relation to solar-powered pumps, when conditions are favorable (average wind speed above 3 m/second). Nonetheless, there are still some major obstacles: wind availability, the size of the initial investment and maintenance problems. Consequently, the prospects for this equipment are very limited.

MAIN COMPANIES, BUILDINGS AND TRANSPORT FLEETS

Name	Activity	Condens./Cos Phi	Comments
Sofitel - Hôtel de l'Amitié	Hotel	Cond. 60 kVAr	Pipe insulation problem/steam loss
Mali-Lait	Dairy		No insulation/steam loss/condensates not used
Itema	Textiles	Condensers	No air preheating/no heat recovery
Bramali	Brewery	Cos phi = .93	
Soft drinks/ice cream industry	Soft drinks		Possibility of solar heating
Sodema	Soapmaking	Condensers	Possibility of solar water heating/no insulation
Hôpital Gabriel Touré	Hospital		Little concern about energy
Huicoma	Soap-perfume		No insulation/partial use of condensates
Sonatam	Tobacco-matches	Condensers	Steam loss/no air preheating/no condensate recovery
Socima	Cementmaking		Presently closed/rehabilitation planned
Conamousse	Foam manuf.	No cond; cos phi = .4	
Grand Hôtel	Hotel	Cos phi = .718	Automated use of EDM night tariff
BCEA	Bank	Condensers; cos phi = .5	
BIAO	Bank	Condensers	
COMATEX-Ségou	Textiles		Own power/no air preheating/no heat recovery
IMAP - Ind. Malienne du Pneu	Tire retreading		Poor insulation
Dougabougou Sugar Comples	Sugarmill		Own power/poor insulation
CMDT	Cotton		
GMM - Grands Moulins du Mali	Flourmill		
<u>Transport</u>			
SOUMATRA	Haulier		
SMERT Voyages	Travel agency		
Peyrissac	Concessionnaire		

<u>Source</u>: ESMAP survey end 1988.

ENERGY RATIONALIZATION PROJECT
DRAFT TERMS OF REFERENCE FOR TECHNICAL ASSISTANCE

Introduction

1. An improvement in Energy Rationalization in some well-identified fields would appear to offer significant economic benefits. A certain number of actions concerning fuelwood (improved stoves program, substitution programs) and in the electricity subsector (particularly reduction of technical and nontechnical distribution losses) are under way. The Energy Rationalization project itself focuses on practical and economically justified measures in industry, major public and private buildings and also but to a lesser degree in transport.

2. The potential for improvement of energy efficiency in Mali has not been clearly determined. 1/ However, on the basis of experience gained in other countries of the region, the surveys conducted in Mali when preparing the evaluation of the energy sector, and also certain earlier studies, the following estimates are presented for industry, buildings and transport:

(a) Industry sector: in 1987, Malian industry consumed about 60,000 toe, of which about 50% in the form of biomass, i.e. 3% of the country's total energy consumption and 15% of its commercial energy. Industry consumed 50% of its electricity and 13% of its petroleum products, the main uses being to produce steam, cold and hot water and for lighting. Malian industry is not highly developed and comprises between 15 and 20 large industries. 2/ Despite the lack of precise data, and on the basis of visits made to Malian industries at the end of 1988 in conjunction with cumulative experience in other countries, the potential savings attainable in Malian industry are estimated at between 13% and 17% of industrial consumption, i.e. between 8,000 and 10,000 toe;

(b) The modern commercial sector's energy consumption is not well known either; to improve this situation an exhaustive analysis of the main consumers' electricity consumptions should be made utilizing EDM's records. 3/ It is estimated, however, that about 15% of peak demand -- i.e. 3-4 MW -- is accounted for by air conditioning. The possible saving is put at 20-25% of present consumption, to be obtained primarily

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1/ *A survey was conducted among the managers of the main industries and buildings in December 1988, and once the data gathered have been thoroughly analyzed its findings will bring the energy savings potentials much more clearly into focus.*

2/ *A survey covering the main industries was conducted by the Directorate of Industry in 1989; this included questions on energy consumption and equipment.*

3/ *This analysis is designed to round out the studies made by EDM which have led to the installation of a number of condensers.*

by better utilization and maintenance of air conditioning and hot water equipment and attention to levels of lighting;

(c) The transport sector consumes nearly two thirds of the country's commercial energy, i.e. almost 122,000 toe in 1987. Very little reliable data is available, however, regarding the composition of the vehicle fleet, which is estimated at around 40-45,000 vehicles in 1988, the breakdown of consumption by type of vehicle, and vehicle age (put at between 7 and 12 years). Going by the findings of the study made by the Agence Française pour la Maîtrise de l'Energie (AFME)/Transenerg in 1985 and experience in various countries, the potential for energy savings in Mali's transport sector is estimated at 15-20%;

(d) To sum up, the energy savings that can be expected in the short and medium term in industry, buildings and transport are as follows (Table 1):

Table 1: SUMMARY OF SHORT AND MEDIUM-TERM ENERGY SAVINGS POTENTIAL
(in % of present commercial energy consumption)

Industry	13-17
Buildings	20-25
Transport	15-20

Source: ESMAP estimates.

Objectives of the Energy Rationalization Project

3. This project is designed to generate concrete energy-saving measures. Its main objectives are the following:

(a) Implementation of measures that are prerequisites and indispensable, such as adjustment of electricity pricing, and of taxes and duties on energy-saving equipment and materials, together with penalization of energy-gobbling equipment;

(b) Identification and evaluation of concrete measures, with priority for the following fields:

(i) For about 15 industrial enterprises:
- Boiler Program
- Cold Program (air conditioning/refrigeration)
- Hot Water Program (introduction of solar heating)
- Lighting Factor Program
- Load Factor Program
- Energy Management Training Program in industry; and

(ii) For the 10 main buildings:
- Air Conditioning Program
- Hot Water Program in the hotels and health sector (introduction of solar heating)
- Load Factor Program
- Lighting Program
- Energy Management Training Program for building managers.

(c) Immediate implementation of measures/recommendations requiring very little investment by the enterprises and/or a small stock of materials and equipment provided by the project;

(d) For measures entailing investments, establishment of detailed costs, study of financing arrangements, possible financing by the Energy Rationalization Fund and implementation by suppliers or service companies;

(e) Organization of energy management workshops for industry, building and truck fleet managers and on the specific topics listed above for maintenance chiefs; and

(f) Training of DNHE coordinators.

Main Activities and Components

4. This technical assistance will perform the following main tasks:

(a) Creating the conditions that are prerequisites for energy savings; this therefore involves the public authorities, especially as regards the organization of this activity, data, methods of work and analysis, etc.;

(b) Identification by means of preliminary and then detailed audits in about 15 industries and 10 or so buildings and evaluation of energy-saving measures and tests in industries and buildings; training/information will be done in parallel;

(c) Next, implementation of measures requiring little or no investment;

(d) Preparation of feasibility studies for measures requiring financing, agreement on arrangements and financing;

(e) Ordering of equipment, materials, etc., and implementation of measures by the manufacturers and Malian or regional service companies, according to the capacity and interest of these private companies; and

(f) Training of DNHE coordinators.

5. To this end, the project includes:

(a) Technical assistance by two persons for a period of one year with measurement, testing and calculation equipment together with audiovisual training equipment, etc., all installed in a vehicle fitted with equipment for making measurements and developing energy systems (Energy Bus) that would visit the installations periodically during the project period.

(b) Provision of the above-mentioned vehicle; and

(c) Establishment of an Energy Rationalization Fund intended for financing the measures adopted.

Project Cost

6. Personnel. The technical assistance should include:

(a) One French-speaking engineer with experience in energy saving, assigned to the project for a period of one year;

(b) One French-speaking economist or engineer specialized in economic and financial appraisal of energy investments. This specialist will also assist the DNHE Energy Unit in setting up energy project and policy appraisal techniques; and

(c) Possibly other ad hoc expertise.

The cost of the technical assistance proper is estimated at US$500,000 and the additional costs of the training programs at US$150,000.

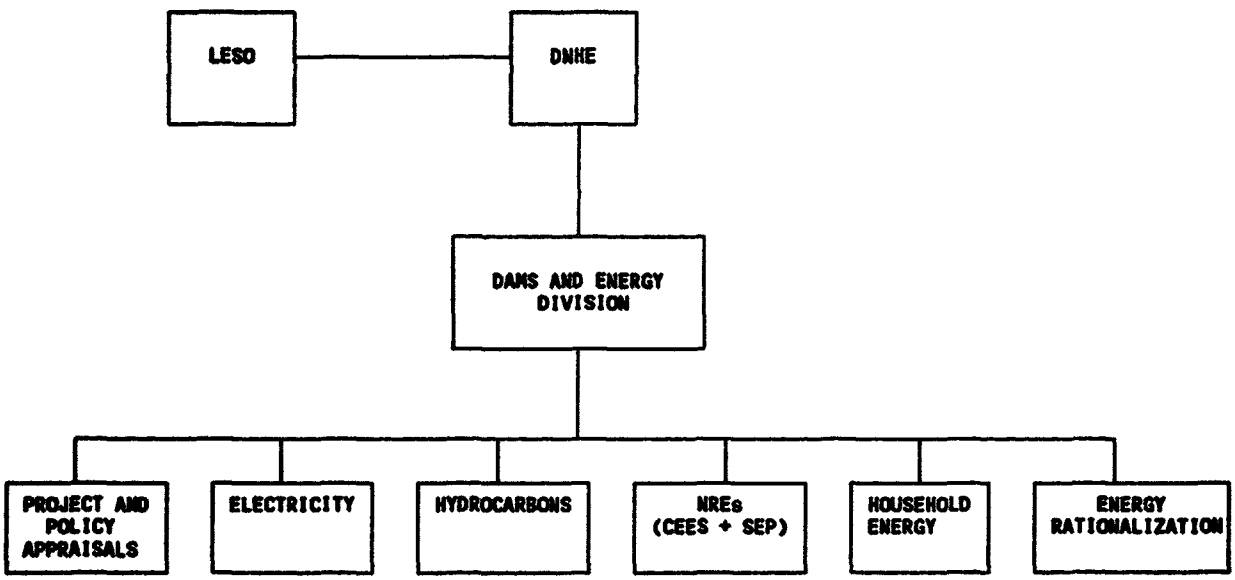
7. One vehicle, which can be called the Energy Bus, would carry measurement, testing and calculating equipment, etc., together with audiovisual training equipment and a certain quantity of materials, parts, etc. The cost of this vehicle and its operation is estimated at US$250,000 and that of a stock of materials and parts at US$300,000

8. Energy Rationalization Fund. This fund is intended for financing energy-saving measures for which the payback period is two years or less. The financing mechanisms are still to be determined, but could take the form of loans on commercial or subsidized terms or else financing tied to the actual energy savings effected. The initial capital for this fund is estimated at US$2 million.

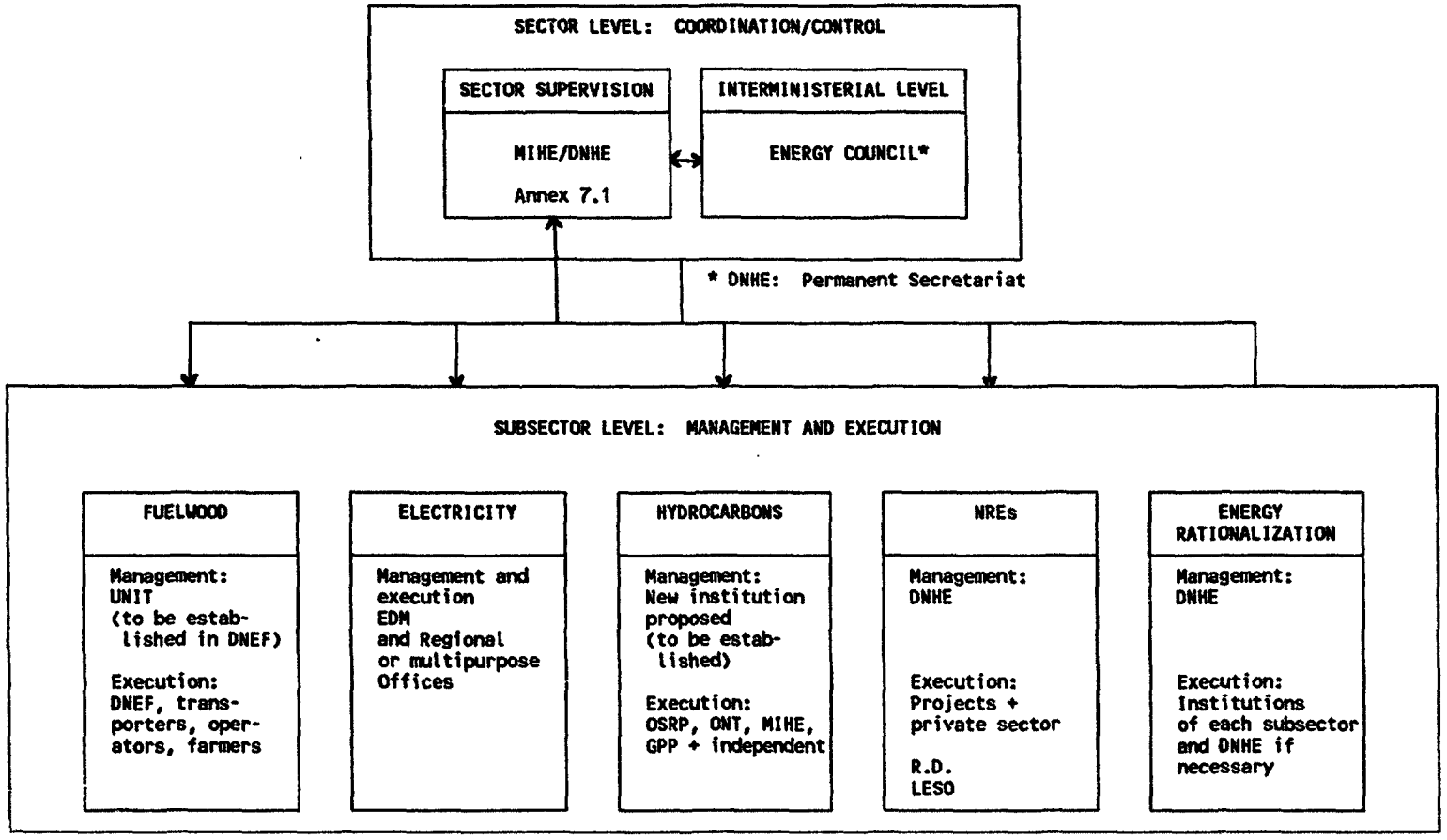
9. The total cost of this Energy Rationalization project is accordingly estimated at US$3 million.

Annex 7.1

PROPOSED DNHE ORGANIZATION CHART



ENERGY SECTOR MANAGEMENT
SIMPLIFIED FUNCTIONAL ORGANIZATION CHART



ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME

COMPLETED ACTIVITIES

Country	*Activity*	*Date*	*Number*
	SUB-SAHARAN AFRICA (AFR)		
Africa Regional	Anglophone Africa Household Energy Workshop	07/88	085/88
	Regional Power Seminar on Reducing Electric Power System Losses in Africa	08/88	087/88
	Institutional Evaluation of EGL	02/89	098/89
	Biomass Mapping Regional Workshops	05/89	--
	Francophone Household Energy Workshop	08/89	103/89
	Interafrican Electrical Engineering College: Proposals for Short- and Long-Term Development	03/90	112/90
	Biomass Assessment and Mapping	03/90	--
Angola	Energy Assessment	05/89	4708-ANG
	Power Rehabilitation and Technical Assistance	10/91	142/91
Benin	Energy Assessment	06/85	5222-BEN
Botswana	Energy Assessment	09/84	4998-BT
	Pump Electrification Prefeasibility Study	01/86	047/86
	Review of Electricity Service Connection Policy	07/87	071/87
	Tuli Block Farms Electrification Study	07/87	072/87
	Household Energy Issues Study	02/88	--
	Urban Household Energy Strategy Study	05/91	132/91
Burkina Faso	Energy Assessment	01/86	5730-BUR
	Technical Assistance Program	03/86	052/86
	Urban Household Energy Strategy Study	06/91	134/91
Burundi	Energy Assessment	06/82	3778-BU
	Petroleum Supply Management	01/84	012/84
	Status Report	02/84	011/84
	Presentation of Energy Projects for the Fourth Five-Year Plan (1983-1987)	05/85	036/85
	Improved Charcoal Cookstove Strategy	09/85	042/85
	Peat Utilization Project	11/85	046/85
Cape Verde	Energy Assessment	08/84	5073-CV
	Household Energy Strategy Study	02/90	110/90
Comoros	Energy Assessment	01/88	7104-COM
Congo	Energy Assessment	01/88	6420-COB
	Power Development Plan	03/90	106/90
Côte d'Ivoire	Energy Assessment	04/85	5250-IVC
	Improved Biomass Utilization	04/87	069/87
	Power System Efficiency Study	12/87	--
Ethiopia	Energy Assessment	07/84	4741-ET
	Power System Efficiency Study	10/85	045/85
	Agricultural Residue Briquetting Pilot Project	12/86	062/86
	Bagasse Study	12/86	063/86
	Cooking Efficiency Project	12/87	--
Gabon	Energy Assessment	07/88	6915-GA

Country	*Activity*	*Date*	*Number*
The Gambia	Energy Assessment	11/83	4743-GM
	Solar Water Heating Retrofit Project	02/85	030/85
	Solar Photovoltaic Applications	03/85	032/85
	Petroleum Supply Management Assistance	04/85	035/85
Ghana	Energy Assessment	11/86	6234-GH
	Energy Rationalization in the Industrial Sector	06/88	084/88
	Sawmill Residues Utilization Study	11/88	074/87
Guinea	Energy Assessment	11/86	6137-GUI
Guinea-Bissau	Energy Assessment	08/84	5083-GUB
	Recommended Technical Assistance Projects	04/85	033/85
	Management Options for the Electric Power and Water Supply Subsectors	02/90	100/90
	Power and Water Institutional Restructuring (French)	04/91	118/91
Kenya	Energy Assessment	05/82	3800-KE
	Power System Efficiency Study	03/84	014/84
	Status Report	05/84	016/84
	Coal Conversion Action Plan	02/87	--
	Solar Water Heating Study	02/87	066/87
	Peri-Urban Woodfuel Development	10/87	076/87
	Power Master Plan	11/87	--
Lesotho	Energy Assessment	01/84	4676-LSO
Liberia	Energy Assessment	12/84	5279-LBR
	Recommended Technical Assistance Projects	06/85	038/85
	Power System Efficiency Study	12/87	081/87
Madagascar	Energy Assessment	01/87	5700-MAG
	Power System Efficiency Study	12/87	075/87
Malawi	Energy Assessment	08/82	3903-MAL
	Technical Assistance to Improve the Efficiency of Fuelwood Use in the Tobacco Industry	11/83	009/83
	Status Report	01/84	013/84
Islamic Republic of Mauritania	Energy Assessment	04/85	5224-MAU
	Household Energy Strategy Study	07/90	123/90
Mauritius	Energy Assessment	12/81	3510-MAS
	Status Report	10/83	008/83
	Power System Efficiency Audit	05/87	070/87
	Bagasse Power Potential	10/87	077/87
Mozambique	Energy Assessment	01/87	6128-MOZ
	Household Electricity Utilization Study	03/90	113/90
Niger	Energy Assessment	05/84	4642-NIR
	Status Report	02/86	051/86
	Improved Stoves Project	12/87	080/87
	Household Energy Conservation and Substitution	01/88	082/88
Nigeria	Energy Assessment	08/83	4440-UNI
Rwanda	Energy Assessment	06/82	3779-RW
	Energy Assessment (English and French)	07/91	8017-RW
	Status Report	05/84	017/84
	Improved Charcoal Cookstove Strategy	08/86	059/86
	Improved Charcoal Production Techniques	02/87	065/87
SADCC	SADCC Regional Sector: Regional Capacity-Building Program for Energy Surveys and Policy Analysis	11/91	--

Country	*Activity*	*Date*	*Number*
Sao Tome and Principe	Energy Assessment	10/85	5803-STP
Senegal	Energy Assessment	07/83	4182-SE
	Status Report	10/84	025/84
	Industrial Energy Conservation Study	05/85	037/85
	Preparatory Assistance for Donor Meeting	04/86	056/86
	Urban Household Energy Strategy	02/89	096/89
Seychelles	Energy Assessment	01/84	4693-SEY
	Electric Power System Efficiency Study	08/84	021/84
Sierra Leone	Energy Assessment	10/87	6597-SL
Somalia	Energy Assessment	12/85	5796-SO
Sudan	Management Assistance to the Ministry of Energy and Mining	05/83	003/83
	Energy Assessment	07/83	4511-SU
	Power System Efficiency Study	06/84	018/84
	Status Report	11/84	026/84
	Wood Energy/Forestry Feasibility	07/87	073/87
Swaziland	Energy Assessment	02/87	6262-SW
Tanzania	Energy Assessment	11/84	4969-TA
	Peri-Urban Woodfuels Feasibility Study	08/88	086/88
	Tobacco Curing Efficiency Study	05/89	102/89
	Remote Sensing and Mapping of Woodlands	06/90	--
	Industrial Energy Efficiency Technical Assistance	08/90	122/90
Togo	Energy Assessment	06/85	5221-TO
	Wood Recovery in the Nangbeto Lake	04/86	055/86
	Power Efficiency Improvement	12/87	078/87
Uganda	Energy Assessment	07/83	4453-UG
	Status Report	08/84	020/84
	Institutional Review of the Energy Sector	01/85	029/85
	Energy Efficiency in Tobacco Curing Industry	02/86	049/86
	Fuelwood/Forestry Feasibility Study	03/86	053/86
	Power System Efficiency Study	12/88	092/88
	Energy Efficiency Improvement in the Brick and Tile Industry	02/89	097/89
	Tobacco Curing Pilot Project	03/89	UNDP Terminal Report
Zaire	Energy Assessment	05/86	5837-ZR
Zambia	Energy Assessment	01/83	4110-ZA
	Status Report	08/85	039/85
	Energy Sector Institutional Review	11/86	060/86
	Power Subsector Efficiency Study	02/89	093/88
	Energy Strategy Study	02/89	094/88
	Urban Household Energy Strategy Study	08/90	121/90
Zimbabwe	Energy Assessment	06/82	3765-ZIM
	Power System Efficiency Study	06/83	005/83
	Status Report	08/84	019/84
	Power Sector Management Assistance Project	04/85	034/85
	Petroleum Management Assistance	12/89	109/89
Zimbabwe	Power Sector Management Institution Building	09/89	--
	Charcoal Utilization Prefeasibility Study	06/90	119/90

Country	*Activity*	*Date*	*Number*
	EAST ASIA AND PACIFIC (EAP)		
Asia Regional	Pacific Household and Rural Energy Seminar	11/90	--
China	County-Level Rural Energy Assessments	05/89	101/89
	Fuelwood Forestry Preinvestment Study	12/89	105/89
Fiji	Energy Assessment	06/83	4462-FIJ
Indonesia	Energy Assessment	11/81	3543-IND
	Status Report	09/84	022/84
	Power Generation Efficiency Study	02/86	050/86
	Energy Efficiency in the Brick, Tile and Lime Industries	04/87	067/87
	Diesel Generating Plant Efficiency Study	12/88	095/88
	Urban Household Energy Strategy Study	02/90	107/90
	Biomass Gasifier Preinvestment Study Vols. I & II	12/90	124/90
Malaysia	Sabah Power System Efficiency Study	03/87	068/87
	Gas Utilization Study	09/91	9645-MA
Myanmar	Energy Assessment	06/85	5416-BA
Papua New Guinea	Energy Assessment	06/82	3882-PNG
	Status Report	07/83	006/83
	Energy Strategy Paper	--	--
	Institutional Review in the Energy Sector	10/84	023/84
	Power Tariff Study	10/84	024/84
Solomon Islands	Energy Assessment	06/83	4404-SOL
South Pacific	Petroleum Transport in the South Pacific	05/86	--
Thailand	Energy Assessment	09/85	5793-TH
	Rural Energy Issues and Options	09/85	044/85
	Accelerated Dissemination of Improved Stoves and Charcoal Kilns	09/87	079/87
	Northeast Region Village Forestry and Woodfuels Preinvestment Study	02/88	083/88
	Impact of Lower Oil Prices	08/88	--
	Coal Development and Utilization Study	10/89	--
Tonga	Energy Assessment	06/85	5498-TON
Vanuatu	Energy Assessment	06/85	5577-VA
Western Samoa	Energy Assessment	06/85	5497-WSO
	SOUTH ASIA (SAS)		
Bangladesh	Energy Assessment	10/82	3873-BD
	Priority Investment Program	05/83	002/83
	Status Report	04/84	015/84
	Power System Efficiency Study	02/85	031/85
	Small Scale Uses of Gas Prefeasibility Study	12/88	--
India	Opportunities for Commercialization of Nonconventional Energy Systems	11/88	091/88
	Maharashtra Bagasse Energy Efficiency Project	05/91	120/91
	Mini-Hydro Development on Irrigation Dams and Canal Drops Vols. I, II and III	07/91	139/91

Country	*Activity*	*Date*	*Number*
Nepal	Energy Assessment	08/83	4474-NEP
	Status Report	01/85	028/84
Pakistan	Household Energy Assessment	05/88	--
	Assessment of Photovoltaic Programs, Applications, and Markets	10/89	103/89
Sri Lanka	Energy Assessment	05/82	3792-CE
	Power System Loss Reduction Study	07/83	007/83
	Status Report	01/84	010/84
	Industrial Energy Conservation Study	03/86	054/86
	EUROPE AND CENTRAL ASIA (ECA)		
Portugal	Energy Assessment	04/84	4824-PO
Turkey	Energy Assessment	03/83	3877-TU
	MIDDLE EAST AND NORTH AFRICA (MNA)		
Morocco	Energy Assessment	03/84	4157-MOR
	Status Report	01/86	048/86
Syria	Energy Assessment	05/86	5822-SYR
	Electric Power Efficiency Study	09/88	089/88
	Energy Efficiency Improvement in the Cement Sector	04/89	099/89
	Energy Efficiency Improvement in the Fertilizer Sector	06/90	115/90
Tunisia	Fuel Substitution	03/90	--
Yemen	Energy Assessment	12/84	4892-YAR
	Energy Investment Priorities	02/87	6376-YAR
	Household Energy Strategy Study Phase I	03/91	126/91
	LATIN AMERICA AND THE CARIBBEAN (LAC)		
LAC Regional	Regional Seminar on Electric Power System Loss Reduction in the Caribbean	07/89	--
Bolivia	Energy Assessment	04/83	4213-BO
	National Energy Plan	12/87	--
	National Energy Plan (Spanish)	08/91	131/91
	La Paz Private Power Technical Assistance	11/90	111/90
	Natural Gas Distribution: Economics and Regulation	01/92	125/92
	Prefeasibility Evaluation Rural Electrification and Demand Assessment	04/91	129/91
Chile	Energy Sector Review	08/88	7129-CH
Colombia	Energy Strategy Paper	12/86	--
Costa Rica	Energy Assessment	01/84	4655-CR
	Recommended Technical Assistance Projects	11/84	027/84
	Forest Residues Utilization Study	02/90	108/90
Dominican Republic	Energy Assessment	05/91	8234-DO
Ecuador	Energy Assessment	12/85	5865-EC
	Energy Strategy Phase I	07/88	--
	Energy Strategy	04/91	--

Country	*Activity*	*Date*	*Number*
Haiti	Energy Assessment	06/82	3672-HA
	Status Report	08/85	041/85
Honduras	Energy Assessment	08/87	6476-HO
	Petroleum Supply Management	03/91	128/91
Jamaica	Energy Assessment	04/85	5466-JM
	Petroleum Procurement, Refining, and Distribution Study	11/86	061/86
	Energy Efficiency Building Code Phase I	03/88	--
	Energy Efficiency Standards and Labels Phase I	03/88	--
	Management Information System Phase I	03/88	--
	Charcoal Production Project	09/88	090/88
	FIDCO Sawmill Residues Utilization Study	09/88	088/88
Mexico	Improved Charcoal Production Within Forest Management for the State of Veracruz	08/91	138/91
Panama	Power System Efficiency Study	06/83	004/83
Paraguay	Energy Assessment	10/84	5145-PA
	Recommended Technical Assistance Projects	09/85	--
	Status Report	09/85	043/85
Peru	Energy Assessment	01/84	4677-PE
	Status Report	08/85	040/85
	Proposal for a Stove Dissemination Program in the Sierra	02/87	064/87
	Energy Strategy	12/90	--
Saint Lucia	Energy Assessment	09/84	5111-SLU
St. Vincent and the Grenadines	Energy Assessment	09/84	5103-STV
Trinidad and Tobago	Energy Assessment	12/85	5930-TR

GLOBAL

Energy End Use Efficiency: Research and Strategy	11/89	--
Guidelines for Utility Customer Management and Metering (English and Spanish)	07/91	--
Women and Energy--A Resource Guide The International Network: Policies and Experience	04/90	--
Assessment of Personal Computer Models for Energy Planning in Developing Countries	10/91	--

IBRD 22069

MALI
ENERGY ASSESSMENT

PAVED ROADS
ROUTES REVETUES

PAVED ROADS UNDER CONSTRUCTION
ROUTES REVETUES EN CONSTRUCTION

EARTH ROADS
ROUTES EN TERRE

TRACKS
PISTES

RAILROAD
CHEMIN DE FER

NAVIGABLE RIVERS (JULY - DECEMBER)
RIVIERE NAVIGABLE (JUILLET - DECEMBRE)

FLOOD AREAS
ZONE D' INONDATION

EXISTING DAM AND RESERVOIR
BARRAGE ET RESERVOIR EXISTANTE

PROPOSED DAM AND RESERVOIR
BARRAGE ET RESERVOIR PROJETEE

IRRIGATION / OFFICE DU NIGER
IRRIGATION / OFFICE DU NIGER

REGION CAPITALS
CHEF - LIEU - DE RÉGION

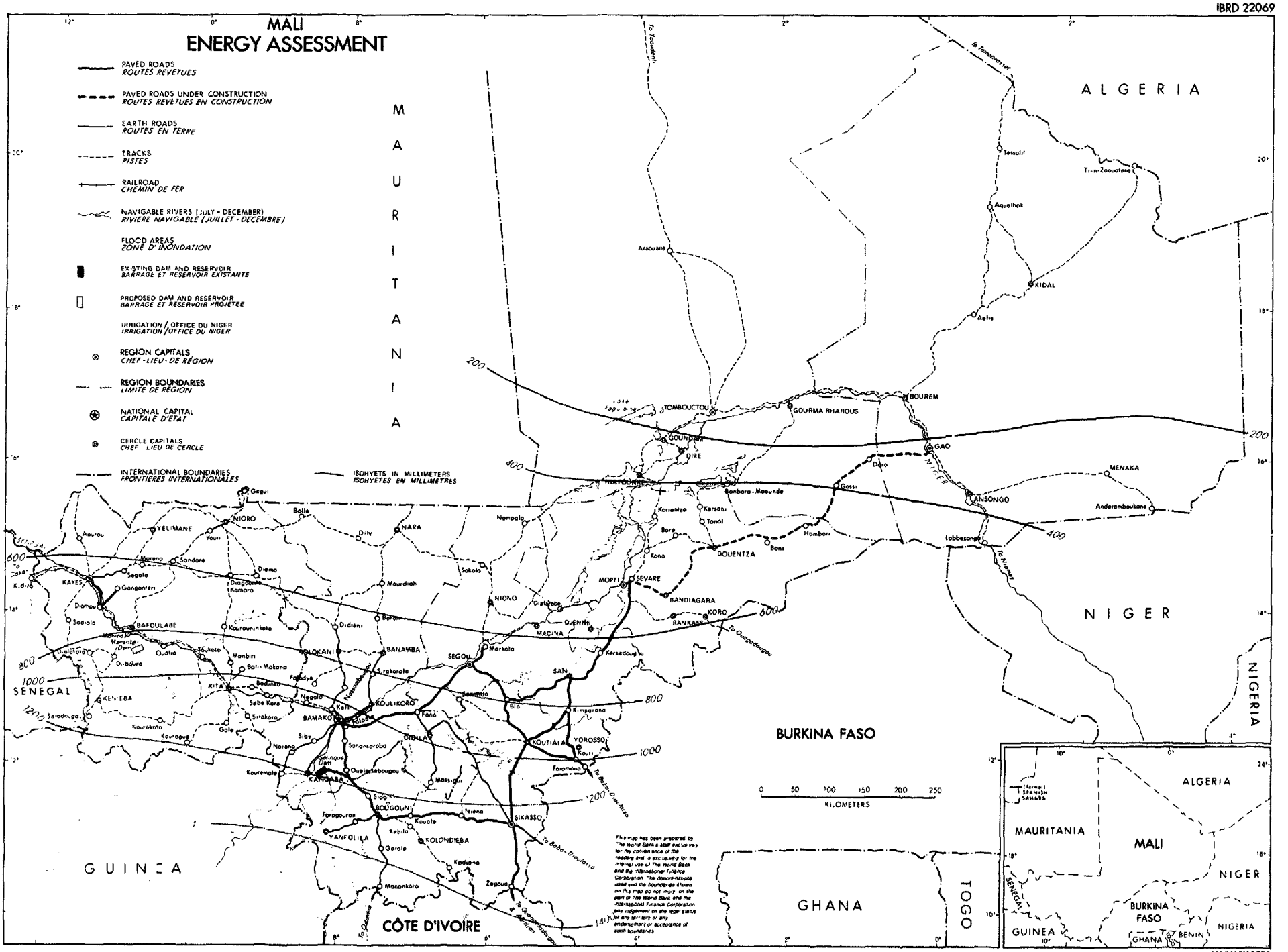
REGION BOUNDARIES
LIMITE DE RÉGION

NATIONAL CAPITAL
CAPITALE D'ETAT

CERCLE CAPITALS
CHEF LIEU DE CERCLE

INTERNATIONAL BOUNDARIES
FRONTIERES INTERNATIONALES

ISOHYETS IN MILLIMETERS
ISOHYETES EN MILLIMETRES



JANUARY 1990

IBRD 19169R

MALI
POPULATION DISTRIBUTION

PAVED MAJOR ROADS
EARTH ROADS
TRACKS
RAILWAY
AREA SUBJECT TO INUNDATION
RIVERS
REGION CAPITALS
REGION BOUNDARIES
INTERNATIONAL BOUNDARIES

0 50 100 150 200
KILOMETERS

ALGERIA
MAURITANIA
SENEGAL
GUINEA
BURKINA FASO
NIGER

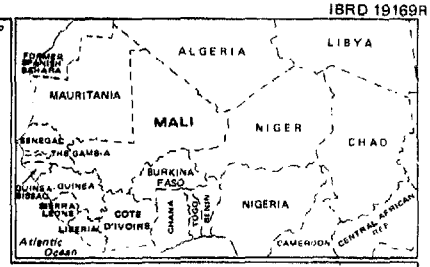
Taoudenni
Tessalit
Arsouane
Kidal
In Tebezzas
Tombouctou
Menaka
Yélimané
Nioro
Segala
KAYES
Mourdiah
Niono
Mopti
Mar
SEGOU
Banamba
Kita
Koulikoro
Kati
Koulikoro
BAMAKO
Dioila
Koutiala
Bougouni
SIKASSO
To Dakar
To Kourouss
To Abidjan
Lake Niangaye
Lake Debo
NIGER

URBAN CENTERS OF MORE THAN
25,000 ESTIMATED POPULATION (1985)

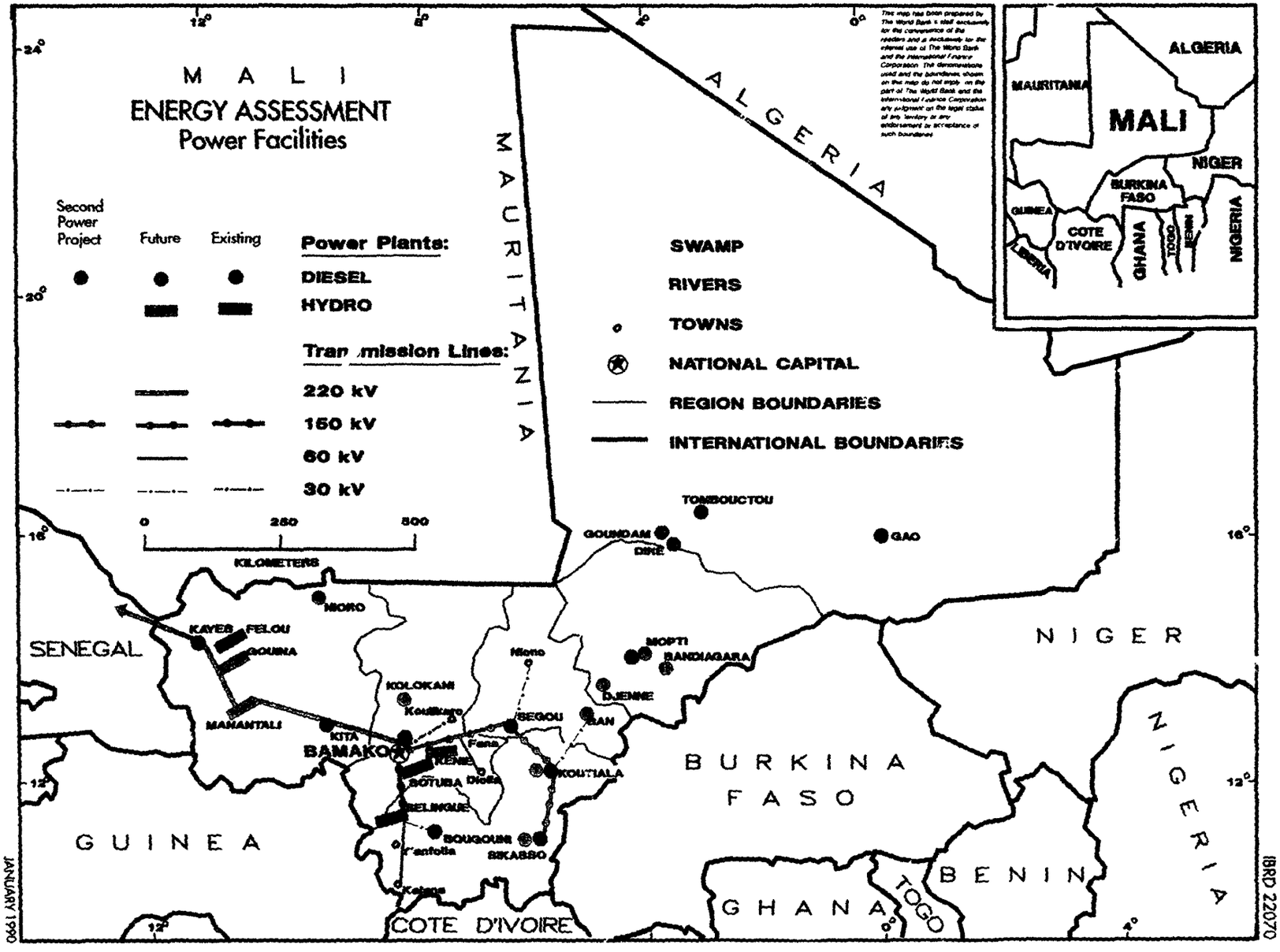
700,000
100,000
75,000
50,000
25,000

RURAL TOTAL DENSITIES
(population / km²)

0.0 - 0.5
0.5 2.0
2.0 - 5.0
5.0 - 10.0
10.0 20.0



MAY 1986


MALI
ENERGY ASSESSMENT
Power Facilities
Second Power Project
Future
Existing
Power Plants:
DIESEL
HYDRO
Transmission Lines:
220 kV
150 kV
60 kV
30 kV
0
250
500
KILOMETERS
SWAMP
RIVERS
TOWNS
NATIONAL CAPITAL
REGION BOUNDARIES
INTERNATIONAL BOUNDARIES
ALGERIA
MAURITANIA
SENEGAL
GUINEA
COTE D'IVOIRE
GHANA
TOGO
BENIN
NIGERIA
NIGER
BURKINA FASO
TOMBOUCTOU
GAO
GOUNDAM
DIRE
MOPTI
BANDIAGARA
DJENNE
SAN
SEGOU
KOUTIALA
MOPTI
KOLOKANI
KITA
BAMAKO
KENIEBA
BOUGOUNI
SIKASSO
MANANTALI
KAYES
FELOU
GOUINA
MOKO
Niono
Fana
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Kolondo
JANUARY 1990
IBRD 22070