Report No. 4642-NIR

Niger: Issues and Options in the Energy Sector

May 1984

Report of the Joint UNDP/World Bank Energy Sector Assessment Program

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NIGER

ISSUES AND OPTIONS IN THE ENERGY SECTOR

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ABSTRACT

Niger's foremost energy problem stems from the fact that the net renewable supply of fuelwood meets only about 35% of total fuelwood demand. This massive overexploitation of the natural forest cover causes desertification, which is of grave concern in a country where only 12% of the land is arable. Possible solutions to the crisis include reforestation and improved forest management, the scope for both of which is limited; dissemination of an improved cooking stove in urban and peri-urban areas; promotion of kerosene for cooking; and replacing fuelwood with domestic lignite, the quantities available and the quality of which need to be ascertained. Given its landlocked position, Niger also faces a high energy import bill. To reduce it, the country can: ensure continued oil exploration and, in particular, appraisal of the recent, limited finds in the Southeast; evaluate its lignite resources and establish priorities for their use; and conserve energy in transport and air conditioning. In the power subsector, the key issue is the development of integrated power system planning. With respect to energy pricing, the Government's policy of pricing electricity to reflect the long run marginal cost of power supply needs to be pursued, and fuelwood needs to be properly priced to stimulate the use of improved stoves and substitute fuels. Finally, the extreme scarcity of qualified manpower in Niger is the main constraint to planning and operational work. The problem can be alleviated by technical assistance and training, which are needed most urgently at the subsector level, but also for overall energy planning.

CURRENCY EQUIVALENTS

US$1.00 = CFA Franc 335

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

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

CONVERSION FACTORS

General Units

1 kilocalorie (kcal) = 3.968 British thermal units (Btu) = 4,187 joules
1 tonne of crude oil equivalent (toe) = 10.2 million kcal
1 barrel (bbl) = 42 U.S. gallons = 159.0 litres

Conversion Factors by Fuel

Unless otherwise noted, electricity is converted to toe in this report at the weighted 1981 average rate of fuel consumption of Niger's gas oil burning plants, about 265 toe/GWh.

Fuel	tonne/m^3	kcal/kg	toe/tonne
Anou Araren coal 1/			
laboratory analysis value	-	3,600	0.353
value used in this report	-	2,315	0.227
Lignite	-	4,000	0.392
Groundnut Shell Briquettes	-	4,500	0.441
Fuelwood	0.450	4,500	0.441
Charcoal	-	7,800	0.765
Butane	-	-	1.05
Gasoline			
Premium	0.734	-	1.03
Regular	0.722	-	1.03
Aviation Gasoline	-	-	1.03
Jet Fuel	0.790	-	1.02
Kerosene	0.790	-	1.01
Gas Oil	0.830	-	1.00
Fuel Oil	-	-	0.96

1/ The calorific value of coal used in this report was arrived at by setting the toe value of the 65,502 tonnes of coal burned in 1981 in the SONICHAR power plant equal to the thermal replacement value (i.e. at 265 toe/GWh) of the electricity thereby produced, taking into account the 257 toe of gas oil also burned to fire up the coal-burning boilers.

Source: SONICHAR, SONIDEP, SONARA, and Bank mission estimates.

ABBREVIATIONS AND ACRONYMS

AFN	Association des Femmes du Niger
AGRHYMET	Center for Applied Agriculture and Hydrological Meteorology
BDRN	Banque de Développement de la République du Niger
CCCE	Caisse Centrale de Coopération Economique
CIDA	Canadian International Development Agency
CILSS	Comité Permanent Inter-états de Lutte contre la Sécheresse au Sahel
COMINAK	Compagnie Minière d'Akouta
CSPPN	Caisse de Stabilisation et de Péréquation des Prix du Niger
CWS	Church World Service
DE	Directorate of Energy
FAC	Fonds d'Aide et de Coopération (France)
FAO	Food and Agriculture Organization of the United Nations
GERDAT	Groupement d'Etude et de Recherche pour le Développement de l'Agronomie Tropicale
GPP	Groupe des Professionels du Pétrole
GWh	gigawatthour
IDA	International Development Association
INRAN	Institut National de la Recherche Agronomique au Niger
KDA	Kandadji Dam Authority
KfW	Kreditanstalt für Wiederaufbau
kV	kilovolt
kW	kilowatt
kWh	kilowatthour
LPG	liquified petroleum gas (propane and butane)
LRMC	long-run marginal cost
MCT	Ministry of Commerce and Transport
MMI	Ministry of Mines and Industry
MPW	Ministry of Public Works
MW	megawatt
NEPA	Nigerien Electric Power Authority
NIGELEC	Société Nigérienne d'Electricité
NIGERGAZ	Société Nigérienne du Gaz
ONAREM	Office National des Recherches Minières
ONERSOL	Office National de l'Energie Solaire
SNTN	Société Nationale des Transports du Niger
SOMAIR	Société Minière de l'Air
SONARA	Société Nigérienne de Commercialisation de l'Arachide
SONICHAR	Société Nigérienne des Charbons d'Anou-Araren
SONIDEP	Société Nigérienne des Produits Petroliers
toe	tonne of oil equivalent
tpa	tonne per annum
UNCC	Union Nigérienne de Credit et de Coopération
UNSO	United Nations Sudano-Sahelian Office
WMO	World Meteorological Organization

This report is based on the findings of an energy assessment mission which visited Niger in October-November, 1982, a progress review mission which took place in January, 1983, and a mission which discussed the draft report with the Government in December, 1983. Mission members included: Messrs. J. Schmedtje (Economist, Mission Leader), N. King (Research Assistant), M. Wilton (Civil Engineer), W. Schiebel (Coal and Lignite Consultant), R. Edwards (Renewable Energy Consultant), J. Gorse (Forestry Specialist), and J. Rochet (Petroleum Geologist). Mr. M. Petcu, the UNSO Resident Energy Adviser to the Government of Niger, also participated fully in the mission (Energy Institutions, Energy Conservation). The mission gratefully acknowledges the support in its field work of Mr. M. Gervais, the World Bank Resident Representative in Niamey, Niger.

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Main Problems

1. One of the least developed countries in the world, Niger has a very low consumption of energy, about 180 kgoe per capita a year. Like other low income countries, Niger faces a double energy crisis: overexploitation of its meager fuelwood resources which, given the predominantly rural nature of the economy, provide four-fifths of the country's gross energy supply (mostly for cooking), and a rising energy import bill. Because its territory is 75% desert, with only 12% of the land considered arable, and given the increasing desertification due to the destruction of the natural forest cover, the fuelwood crisis is actually the more serious of the two. A third major problem is the backlog in integrated power system planning in a country with very limited electrification.

Energy Resources

2. Niger's greatest potential source of energy is uranium, of which it is the fourth largest producer in the world, with a production of 4,370 tonnes (1981) and reasonably assured reserves of about 160,000 tonnes. However, the small size of the foreseeable power demand offers no encouragement for the development of nuclear power, and uranium will probably remain Niger's principal export commodity.

3. The Anou-Araren coal deposits in the north of the country consist of about 9.4 million tonnes at 3,650 kcal/kg, and are now being used exclusively to generate power for the nearby uranium mines. A recent discovery near Solomi, about 30 km north of Anou-Araren, could indicate a significant deposit of higher quality coal (7000 kcal/kg). There have been various indications of lignite deposits further south, the most promising of which (near Tahoua) has probable reserves evaluated at 2.6 million tonnes, with a calorific value of 4,000 kcal/kg.

4. Although the significance of a recent oil discovery in the Agadem basin in the east is still being evaluated, it seems possible that reserves may be large enough to warrant development, at least for the domestic market.

5. Niger's hydro resources are concentrated in the River Niger and its tributaries, where an estimated 2,090 GWh for an average hydrological year could be developed at three sites: Kandadji, W, and Dyodyonga. However, about 830 GWh of this total depends on international agreements and therefore would not be exclusively for Niger's use.

6. As for wood, Niger's natural forest cover is estimated on the order of 15 million hectares, limited in the main to the southern part of the country. Because much of the wood is located far from centers of consumption, only 1.4 of the 4.2 million m^3 of the mean annual increment in 1980 are estimated to have been available.

7. In 1979/80, Niger produced an estimated theoretical maximum energy potential of 2.2 million toe in crop residues and animal waste, but because of competing uses and technical, economic, and social constraints, less than 5% of this amount could have been used for energy conversion.

8. Solar energy is abundant in Niger. In the south, the average total radiation is 6 $kWh/m^2/day$ (an average of about 200 $kgoe/m^2/year$), the average daily duration of sunlight varying from 8.5 to 9.5 hours. However, the only current uses of solar energy are for telecommunications in isolated areas and heating water, so that its contribution to meeting Niger's energy needs is minimal. Wind resources are very poor in Niger, and the potential for small hydro development is insignificant.

Alleviating the Fuelwood Shortage: Household Energy Strategies

9. On a country-wide basis fuelwood demand and supply are roughly in balance at present. However, the total net available increment of fuelwood (1.4 million m^3) accounts for only about 35% of fuelwood demand (4.1 million m^3). The result is a massive overexploitation of the forest cover in those areas near the centers of consumption. The growing scarcity and rising prices of fuelwood mean that many poor urban dwellers cannot afford more than one warm meal a day. Moreover, the overexploitation is causing a decline in soil fertility and desertification, which will result in heavy losses in agricultural production. If current trends persist, Niger's already large fuelwood deficit in and around the areas of consumption will more than double by the year 2000.

10. There are several options for tackling the fuelwood crisis, among them: (a) increasing the supply of wood by reforestation and especially by improved forest management; (b) increasing the amount of useful energy derived from wood by the widespread dissemination of improved cooking stoves; and (c) substituting other sources of energy for fuelwood.

11. Although increasing the supply of fuelwood should be vigorously pursued, the scope for it is limited by several constraints to forest development: (a) poor soils, limited rainfall, and a lack of forestry technical packages well-adapted to marginal lands in these arid and semi-arid zones with only one peak of rainfall; (b) the difficulty of protecting the natural forest cover from overuse (too much cutting, clearing, grazing, burning, etc.); and (c) a difficulty in obtaining full and sustained governmental commitment and popular participation, although some

progress in this regard is being made. Adding the maximum new fuelwood supplies which realistically could be obtained by reforestation and improved forest management (Table 2.3 and Annex 2.2) to the projected net available supply of fuelwood from existing resources will meet only about 30% of the demand in the year 2000 based on current per capita consumption. The other 70% therefore will have to be either eliminated or substituted for by using improved woodstoves or cooking with alternative fuels in order to avoid having to change eating habits (Table 2.4).

12. Many different groups in Niger are attempting to develop and disseminate an improved woodstove in rural as well as urban areas. Efforts have been directed toward a fixed cement or banco stove. The most effective improved stove procedure for reducing the demand for wood in the short term is to focus on developing an appropriate stove model to disseminate to carefully selected groups in urban and peri-urban areas, where the fuelwood shortage is most acutely felt. To this end, it is essential to come up with a wood-burning stove that is portable, provides a significant increase in end-use efficiency over current cooking methods, is inexpensive, and, to the extent possible, is suitable for charcoal, groundnut shell briquettes, and perhaps lignite. The Upper Volta portable metal fuelwood stove would appear to meet most of these criteria (para 2.20).

13. Possible substitutes for fuelwood include: charcoal produced in Niger, domestic coal and lignite, imported kerosene and butane, electricity, locally produced groundnut shell briquettes, and solar energy. Because the main urban areas can still obtain firewood from within a radius of 100 km, only minimal amounts of charcoal are produced and consumed. The ever increasing fuelwood demand from the main population centers and the resulting destruction of the forest cover around them mean that fuelwood supplies will require increasingly longer truck hauls. The production and marketing of charcoal might therefore appear attractive. However, wood from the natural forest of Niger does not lend itself well to charcoal production, and the ecologically detrimental consequences of using large amounts of wood to produce charcoal poses a significant problem.

14. The Anou-Araren coal presents serious difficulties in that, in addition to the high cost of transporting it to populated areas, it requires pre-coking to eliminate noxious tar fumes. In the absence of data on the coal of Solomi, it is not yet possible to determine its possible uses, from an economic point of view. However, preliminary combustion tests, in appropriate stoves, of briquettes made from this coal, have produced positive results from a technical point of view. The Government of Niger has requested technical assistance from the Government of Japan in evaluating the workable deposits and in defining the technology for preparing and using this coal, principally for residential needs. The limited testing to date indicates that the Tahoua lignite is well suited as a fuelwood substitute, having no detrimental tar content. The probable lignite reserves could supply 20% of the cooking needs of all the families in Niger for about eight years, but more information is needed

on the quantities available, the quality of the lignite, and likely consumer acceptance before its potential as a fuelwood substitute can be properly assessed.

15. Taking end-use efficiencies into account, the price of kerosene for cooking, whether subsidized or not, compares favorably with the current market price for fuelwood, even though the latter is well below the wood's economic cost in most areas. However, there is a need for a simple, inexpensive kerosene stove (e.g. the Indian Nutan model) which is better adapted to traditional Nigerien cooking than the models now available. Because of the high cost of butane and electricity, and of the equipment involved, they must be ruled out as cooking fuels for the majority of Nigeriens.

16. Groundnut shell briquettes hold promise as a fuelwood substitute, but only on a much more reduced scale than kerosene and, potentially, lignite. Had all the groundnut shells from the 1980/81 growing season been compacted into briquettes, the 17,000 toe made available would have come to no more than 2% of the total 1981 consumption of fuelwood for the country as a whole. However, 17,000 toe would have amounted to a significant 35% of fuelwood consumption in the city of Niamey for the same year. Groundnut shells thus could help alleviate the fuelwood shortage where it is the most critical. As for solar energy, a cooker well enough adapted to traditional cooking methods to gain popular acceptance has not yet been devised.

Recommendations

17. Given the limits to increasing the supply of wood, relief of the fuelwood crisis can most readily be obtained by improved cooking stoves, while at the moment the most promising substitutes are kerosene, lignite, and, to a minor extent, groundnut shell briquettes. 1/ The mission therefore recommends that the following actions be undertaken simultaneously, all of which are of the highest priority but have been ranked in terms of decreasing short term practical importance:

(a) Concerning improved stoves:

(i) Centralization of efforts concerning improved stoves within the Directorate of Energy (DE) of the Ministry of Mines and Industry. The DE should closely monitor national and international developments in this area with a view to evolving a policy and a plan of action for producing and disseminating appropriate models of improved stoves (para 2.21).

1/ The pricing study recommended below (para. 33) would help determine the least-cost substitutes on an economic basis.

(ii) Dissemination on an experimental basis in Niamey of an adapted model of the metal stove which recently has been successfully introduced in Ouagadougou (para 12). This project should benefit from the equipment of the laboratories of ONERSOL for testing and modifying improved stoves. The woodstove experts whose services will be required under this project could also provide assistance to the DE in managing the tasks described in (i) above.

(b) Concerning lignite:

(i) A systematic drilling program to firm up lignite reserves at Tahoua, and a reconnaissance program, with possible subsequent exploration, in the Filingue area. Estimated cost: US$850,000.

(ii) Combustion tests of the Tahoua lignite to determine the quantities required for preparing typical Nigerien meals. These tests should be integrated with the development of a suitable stove for lignite.

(iii) Depending on the results of (i) and (ii), studies of the demand for lignite as a fuelwood substitute and in industry and power generation, in order to estimate the scale of mining operations and therefore the mining costs (para 4.10).

(c) In evaluating the workable reserves of the Solomi coal and defining the technology for preparing and using this resource (para 14), ensuring that the costs of coal production, transport, preparation, and utilization (e.g. the cost of producing stoves for residential use) are analyzed as a function of a study of the demand for this coal as a substitute for wood or for use by industry (para 4.10).

(d) Promotion of kerosene as a cooking fuel by either acquiring a suitable existing design, or designing and then disseminating a kerosene stove suited to traditional cooking. The DE should serve as focal point in this effort and turn to the laboratories of ONERSOL for research work on these stoves (para 3.5).

(e) Pursuit of the tree planting and improved forestry management objectives outlined in Table 2.3. Estimated cost: about US$9 million p.a. from 1984 through 1988, and US$10 million p.a. from 1989 through 2018. Such a long-term forestry effort would require a specific complementary forestry training program (para 2.17).

(f) Investigation of new forestry technical packages which are well adapted to marginal lands in arid and semi-arid zones (para 2.17).

(g) A study to determine a specific action program to promote the use of groundnut shell briquettes for residential needs. The study should be carried out in parallel with the design of an improved stove suitable for both these briquettes and wood (para 5.17).

Reducing the Energy Import Bill

18. Until early 1981, Niger depended entirely on imports, not only of petroleum products but also of electricity from Nigeria, to supply its commercial energy needs. Since then, domestic coal has substituted for gas oil in generating power for the uranium mines, which saved, on a calorific basis, the equivalent of about 20% of Niger's total petroleum product consumption in 1982. However, given Niger's landlocked position and the resulting high cost of petroleum products (US$54 per bbl in Niamey in 1982, net of taxes and distributors' margin), total energy imports in 1982 still amounted to 18% of the merchandise import bill and nearly 31% of merchandise export revenues. Options for reducing the energy import bill consist of substituting domestic resources and/or cheaper imported alternatives for imported energy, and conservation.

19. With respect to substitution, the main possibilities are: oil from the Agadem basin; Anou-Araren and Solomi coal; Tahoua lignite; hydropower, both Nigerien and as electricity imported from Nigeria; and groundnut shells. From present indications, it seems unlikely that the most recent Agaden permit oil find by the SNEA/EXXON/TEXACO consortium would warrant an export project, but it may be of great value, subject to an economic study, for exploitation for the domestic market. The Government will need to determine what strategy to adopt for further petroleum exploration and development, particularly in view of the fact that the consortium's obligations under the present contract have been fulfilled, and this could lead to a halt in further exploration.

20. More Anou-Araren coal cannot be used for power generation than is currently burned to meet the demand in the adjacent uranium mines and nearby towns of Arlit and Agadez because of the coal deposit's great distance from other centers of power demand. Other possibilities for substituting this coal for petroleum products do not exist at this time because of the coal's excessive ash content and the high cost of transporting it to potential consumers in the south of the country, even though it may be possible to reduce the transport cost by carrying the coal in trucks otherwise making empty return trips to the south. As for the Solomi coal, additional information is needed on its volume, quality and cost of exploitation before its uses as a substitute for petroleum products in industry or power generation can be evaluated. A preliminary analysis of the Tahoua lignite suggests that it is probably suitable for use in the cement industry, among others, as a substitute for gas oil to produce process heat, as well as for power generation. In addition, given large enough reserves it would cost only about 40% as much as gas

oil c.i.f. Niamey. Although of lower quality than the Solomi coal, the Tahoua lignite lies close to the region where electricity demand grows fastest, and therefore its use for power generation should receive priority attention. However, more needs to be known about the quantities and the quality (especially with respect to combustion for cooking) of the lignite before setting priorities for its use as a gas oil or fuelwood substitute.

21. Power imports from Nigeria, currently priced at US¢4.5 per kWh and accounting for about 75% of Niger's non-mining supply of electricity, are in themselves substituting for very costly fuel at diesel generation plants (at US¢11.0 per kWh). As long as secondary energy supplied by Nigeria remains cheaper than any domestic alternative, it is an element to be considered in assessing Niger's own limited hydro potential. A study taking all the relevant alternatives of supply into account in a least-cost system expansion plan has recently begun under an IDA Power Credit.

22. In calorific terms, the 1980/81 cost of groundnut shell briquettes c.i.f. Niamey amounted to about 40% of that of gas oil. These briquettes have displaced gas oil in industry in the past, but this has been discontinued. The company marketing these briquettes, SONARA, is having great difficulty convincing industrial enterprises to substitute these briquettes for gas oil, largely because they consider the supply of briquettes unreliable. Therefore, it seems appropriate to concentrate on using these briquettes for residential needs (paras 16 and 17(g)). An improved stove which is suitable for both wood and briquettes will have to be developed to alleviate householders' fears of an unreliable supply of briquettes.

23. The Agadem oil deposits, the Tahoua lignite and the Solomi coal deserve the greatest attention as possible substitutes for imported petroleum products. With respect to national energy resources in general and Niger's hydro potential in particular, it should be remembered that their development does not always improve the country's balance of payments. In the case of the power plant which burns Anou-Araren coal, for example, savings on the displaced gas oil amount to only CFAF 2.5 billion p.a., compared to debt service payments of about CFAF 4.5 billion p.a. up to at least 1990.

24. Given the small size of Niger's manufacturing sector, the prime areas for conserving imported energy are transport and air conditioning, particularly of office buildings. The largest transport enterprise, the Societe Nationale des Transport de Niger (SNTN), has already reduced its fuel consumption per kilometer by 22% over a four year period, mainly by training in fuel efficient driving. The Ministry of Public Works and the other 400 transport operators in Niger also need to train their drivers in fuel efficiency.

25. Office air conditioning accounts for about 25% of electricity consumption in Niamey. Significant energy savings (25-30%) have been

achieved by equipping new public sector buildings with modern central air conditioning; further gains could be made by enforcing energy efficient design and building standards in future construction. Substantial energy savings remain to be realized in old public buildings with room air conditioning units by means of the measures recommended below.

Recommendations

26. As part of a plan of action to reduce Niger's energy import bill, the mission recommends (in addition to the lignite exploration programs specified in para 17) the following:

(a) The Government's continued urgent consideration of: (i) the feasibility of appraising and producing the Sokhor find, keeping in mind the desirability of proceeding rapidly with such a project to avoid rig mobilization costs (US$10 million); and (ii) determination of a strategy for petroleum exploration and development. The Bank's Petroleum Projects Division concerned is in touch with the Government on both of these points (para 3.13).

(b) Combustion tests to determine the potential for using lignite in industry and power generation (para 4.10).

(c) As mentioned in para 17(c), an analysis of the cost of producing Solomi coal in relation to the demand for its use in industry and power generation (para 4.10).

(d) Institution of a course in fuel-efficient driving techniques open to any driver interested in taking it. This course might be incorporated in the program of the driver training center which is to be established in the Ministry of Public Works under the upcoming IDA Fourth Highway Project (para 7.4).

(e) For conservation in buildings:

(i) ensuring that energy efficient design and building guidelines are followed (para 7.9);

(ii) simple insulation measures ensuring tight closing of windows and doors, to be undertaken without delay in all public buildings as appropriate, once the typical cost and related conservation benefits have been established (para 7.8);

(iii) institution of office temperature norms and their control (para 7.8); and

(iv) replacement of worn out air conditioners by more energy efficient models and introduction of air coolers based on the evaporation of water. A pilot project involving selected public buildings in Niamey should be considered to test the suitability and effectiveness of these more efficient models and air coolers. A prefeasibility study initiated by the mission has been carried out by the Ministry of Public Works in cooperation with the Directorate of Energy. Estimated cost: CFAF 100 million (US$300,000), not counting the cost of new air conditioners (CFAF 297 million) to replace existing ones (para 7.8).

Other measures of less urgency: initiation of a research program to study the economic feasibility of mini-photovoltaic systems in isolated centers (para 5.6); evaluation by the Ministry of Mines and Industry of the potential for energy economies in industry (para 7.9); and Government relaxation of the prescribed level of stocks of petroleum products to an equivalent of 30 days of consumption, instead of investing in additional storage capacity and acquiring the supplementary stocks (para 3.8).

Electric Power Subsector Development

27. Because the existing interconnection with Nigeria will be fully utilized for capacity imports by 1984 and for energy imports by 1992, the main issue in the development of the power subsector is power supply planning for the Niger Valley. The supply problems of the remaining load centers do, however, deserve careful consideration because it is the isolated centers that will require increasing quantities of imported gas oil.

28. With respect to the supply of the Niger Valley, NIGELEC's short-term planning (to about 1989) appears sound, based as it is on the maintenance of sufficient thermal capacity in Niamey to cover the peak, while taking maximum advantage of the interconnection contract with Nigeria to import energy and save fuel expenses. For some time, longer-term planning has been tailored around the assumed commissioning date of the Kandadji hydro-scheme. Other possibilities are the W run-of-river hydro project, the Dyodyonga storage project on the border with Benin, and an expanded interconnection with Nigeria for importing secondary energy and, eventually, seasonal power interchange. All available options ought to be examined to arrive at a least cost program of development.

29. As for the secondary load centers, clusters of small towns and villages should gradually be connected by transmission lines and serviced from one efficient diesel plant. Although the least cost solution may be connection by 20 kV lines, from a longer term perspective it may be preferable to build 66 kV lines initially operated at 20 kV, with substations of 1,000-2,000 kVA.

30. The power system development study, recently begun under an IDA Power Credit, will examine the various options and their possible

combinations with a view to evolving a comprehensive power sector development program to 2020 for the Niger Valley and to 1990 for the secondary centers.

Energy Prices and Taxes

31. The level and structure of current prices for petroleum products in Niger provide the right signals for promoting their efficient energy use. Regarding the electricity tariff, its level and structure were revised in October 1983 to reflect the long run marginal cost (LRMC) of power supply in Niger. Based on an all-diesel investment program for 1985-90, a recent tariff study has developed a "reference" electricity tariff reflecting the estimated LRMC as tempered by considerations of social, financial and administrative expediency (Annex 7.4). The new tariff consists of a fixed component calculated by making an adjustment to the "reference" tariff to permit financial equilibrium of NIGELEC, and a variable component which represents the cost of fuel and the power imported from Nigeria. The Government thus has integrated the "reference" tariff into the current tariff, the latter being subject to modification at the request of NIGELEC from time to time as its financial position may require. The mission supports the recent tariff revision and the pursuit of the Government's policy of electricity pricing to approach long run marginal cost.

32. With respect to fuelwood, its economic cost is reflected by both the cost of reforestation and the cost of deforestation and ensuing desertification. Estimates of this economic cost are certain to show that it is well above the current market prices, high as these may seem, particularly to urban consumers. In addition, as the owner and operator of the national forests, the Government is entitled to a stumpage fee to capture some or all of the excess profits (economic rent) realized by the private operators supplying fuelwood. The second IDA-assisted forestry project (Credit NIR 226) provides for studies of the organization of the fuelwood market and of appropriate prices and stumpage fees for fuelwood from plantations and natural forests which reflect its economic cost. The Credit Agreement stipulates that such prices and fees be established by the end of 1983. Proper economic pricing of fuelwood is the basic prerequisite for conserving it through improved cooking stoves and the use of less costly substitutes, both of which are the prime responses to Niger's fuelwood crisis.

Recommendations

33. The mission recommends:

(a) Establishment of appropriate fuelwood prices and stumpage fees by end 1984 (para 7.19).

(b) Once combustion tests on the Tahoua lignite have been carried out, a comprehensive study should be made of comparative energy prices reflecting economic cost with particular reference to providing energy in urban areas, especially with respect to fuelwood substitution (para 7.22).

Institutional Issues

34. The extreme scarcity of qualified manpower in Niger is the main constraint to planning and operational work, both at the subsector level and for the energy sector as a whole.

35. In the forestry subsector, the Directorate of Forestry and Fauna suffers from limited forestry planning and inventory control. In addition, there is a need for a more organized exploitation of fuelwood resources. With respect to renewable energy other than wood, the principal institutional weaknesses are a lack of overall planning due to the multiplicity of organizations involved, and a lack of economic analysis and market studies.

36. In the petroleum subsector, the Directorate of Energy (DE) lacks the staff and equipment to fulfill its role of acquiring, understanding, and storing the information generated by foreign exploration companies. This is particularly important because the Government may need to promote the areas in question in the future.

37. The three main institutional issues in the power subsector are: (a) the lack of a single agency responsible for overall, long-term power planning; (b) the usefulness of a concession system whereby the State plays a dual role as the authority supervising the management of the electricity concession and, since it owns 90% of NIGELEC's capital, that of the agency being supervised; and (c) the increasing subsidization by NIGELEC's power subsector activities of the company's operation of water supply systems.

38. Given the manpower shortage even at the subsector level and the fact that seven ministries and at least as many operating agencies are directly concerned with energy in Niger, the sector lacks an integrated, overall approach to the country's energy problems. Moreover, no Government agency has responsibility for energy conservation in general. The Directorate of Energy (DE) within the Ministry of Mines and Industry (MMI) is responsible for the formulation of national energy policies in accordance with Government objectives, but, in addition to its staff constraints, its position in the Government does not give it the necessary authority to coordinate energy sector activities.

Recommendations

39. The mission recommends:

(a) Strengthening overall energy planning by appointing an energy economist experienced in general energy supply and demand studies, pricing analyses, optimization techniques, and financing as Energy Adviser to the Ministry of Mines and Industry. (Estimated cost of the economist's services for two years: US$290,000). Excluding the hydrocarbons and coal unit, the DE should focus exclusively on formulating and coordinating national energy policy (para 8.5).

(b) Government examination of the possibility of launching as soon as possible a forestry training program which would complement the planting and improved forest management objectives outlined in Table 2.3. Annex 2.3 gives a preliminary outline of such a program, which would cost about US$1.5 million over five years (para 2.28).

(c) Expansion of the scope of ONERSOL's work. ONERSOL should take the lead in formulating an overall strategy for developing Niger's renewable energy resources and coordinate the activities of the agencies already involved in this field. The mission supports the proposal already made by the Directorate of Energy to the Ministry of Higher Education and Scientific Research, the supervisory Ministry of ONERSOL, to broaden ONERSOL's field of activity as indicated above. Once the exact role of ONERSOL has been determined by the Government, it will be necessary to define technical assistance in terms of training and equipment required by ONERSOL to manage its work program.

(d) Assistance in oil and gas exploration to the DE's hydrocarbons and coal unit, which, according to a preliminary evaluation, would involve: (i) assistance for retrieval and storage of data, including new equipment; (ii) collaboration of expatriate experts with staff of the hydrocarbons and coal unit on well defined specific problems; (iii) assistance in revising the petroleum law and agreements; and (iv) training of Nigeriens in geology, geophysics, economics, and engineering. Estimated cost: about US$1 million over three to four years (para 3.15).

(e) Strengthening the capacity of the DE's hydrocarbons and coal unit to coordinate the overall development of the coal/lignite sector by retaining the services of a visiting coal/lignite specialist. Estimated cost: US$210,000 over three years (para 4.12).

(f) The establishment of a process and the capability for integrated power system planning (para 6.32). The undertaking of a power system development study (para 6.24) and an institutional study of the power sector (para 6.30) under the IDA Power Credit (para 6.24) represent the first steps toward setting up such a planning process and capability. The mission also supports the current examination, under an IDA Water Supply Project (Credit 1309-NIR), of the problem of subsidization of water supply by NIGELEC's power subsector activities, with a view to establishing in due course a separate water supply entity, thus freeing NIGELEC to concentrate on power supply.

(g) Creation of a special energy conservation unit within the Construction Directorate of the Ministry of Public Works, especially to implement the conservation measures recommended in para 26(e) above. Setting up such a conservation unit will require equipment (including vehicles), the services of an expatriate specialist for two years, and the training of Nigerien personnel in air-conditioning engineering. Estimated cost: about US$125,000 (para 7.9).

Other equally important but less urgent recommendations relating to energy sector institutions include: (a) Government encouragement for setting up private organizations for the transport of fuelwood while increasing Government control over the wood supply chain, including transport (para 2.25); and (b) pursuit of current efforts, under the IDA Power Credit, to come up with a staff development plan for NIGELEC (para 6.32).

I. ENERGY IN THE ECONOMY

The Economy

1.1 Landlocked in the Sahel and with a population of 5.8 million, Niger is one of the least developed countries in the world. Its territory (1,267,000 km^2) is mainly desert (75%); only 12% of the land is considered arable, and only 2.5% is actually under cultivation, with soil fertility low and declining. Rainfall is low and irregular, resulting in periodic droughts. Per capita income was estimated at US$330 in 1980 and, with population growing at 2.8% p.a., has actually declined over the past decade, despite the short-lived uranium boom. The present adult literacy rate is 8% and life expectancy at birth 43 years. The urban population accounts for only 10% of the total but is rapidly growing, especially in Niamey. Sixteen percent of the rural population is nomadic.

1.2 Niger's natural resource base is both limited and geographically unbalanced. Scarce water supplies limit agriculture to the Niger Valley and the zone along the Nigerian frontier where 90% of the population lives. The rich uranium deposits discovered in the 1960s, coal and some small tin deposits are all located in the north central desert region, 600-800 km away from the heavily populated areas. Iron ore deposits have been discovered near Say, 50 km southeast of Niamey, with probable reserves of 51-53% grade iron estimated at 650 million tonnes. Farther downstream on the Niger Valley, especially in the so-called W Parc region bordering Upper Volta and Benin, phosphate rock holds promise for development. Identified reserves amount to 500 million tonnes. However, exploitation of these low value/high volume mineral resources is impeded by Niger's landlocked position. The nearest ports in Benin and Nigeria are more than 800 km away. In 1979 and again in 1982, small quantities of petroleum were discovered in the Agadem rift basin close to the Chad border. Evaluation of these finds and follow-up action is in progress.

1.3 Economic activity consists mainly in subsistence agriculture with emphasis on millet/sorghum and livestock production. In 1981, rural sector activities accounted for 49% of GDP, whereas energy intensive sectors such as mining contributed 10%, construction 6%, transport 4% and manufacturing industry 1%; the rest was provided by government and other services. The Government's goal of food self-sufficiency, with little industrial development planned, will reinforce this economic structure.

1.4 Recent economic growth has been marked by two major overlapping events: (a) the Sahel drought of 1973-74, resulting in heavy losses to agriculture and livestock and a declining economy; and (b) the start-up of uranium mining in 1971, and the rapid expansion of this industry until 1981 when it contributed 70% of export earnings and an important share of government revenues. The recovery from the drought was speeded up by the return of favorable weather conditions and government policies aimed at rapid restoration of the cattle population and food self-sufficiency. Given the remote location of the uranium deposits, the mining industry has remained an economic enclave in the desert with linkage effects limited mainly to the power, construction and transport industries. Reflecting these developments, real GDP growth turned again positive in 1976 and accelerated from 3.5% in 1977 to 13.6% in 1979. However, in the wake of the second large rise in oil prices in 1979-80 and the ensuing world economic recession, the growth rate dropped to 5% in 1980 and close to zero in 1982.

Energy in the Economy

1.5 Like other low-income countries, Niger faces a two-pronged energy crisis: a rising energy import bill and overexploitation of its meager fuelwood resources. Because of its potentially disastrous consequences, the fuelwood crisis is actually the more serious problem of the two.

Fuelwood Crisis

1.6 Reflecting the predominantly rural nature of Niger's economy, fuelwood provides four-fifths of the country's gross energy supply, mostly for cooking needs. Rising with population growth, fuelwood consumption is rapidly depleting the sparse forest cover. As a result, fuelwood is becoming increasingly scarce and expensive so that less well-off urban dwellers can afford only one warm meal a day. Moreover, soil fertility is declining and land erosion has become a serious problem, aggravating the threat of further desertification.

Import Dependence

1.7 Until early 1981, Niger depended entirely on imports to supply its commercial energy needs. Since then domestic coal has been substituted for diesel oil in the generation of power for the uranium mines, but the petroleum import bill has kept rising, though at a lower rate. In addition to petroleum products, Niger imports electricity from Nigeria to supply the bulk of its public system (non-mining) demand.

1.8 Energy import dependence in 1982 amounted to 18% of the merchandise import bill and nearly 31% of non-energy merchandise export revenues including uranium 1/ (Table 1.1). These percentages have more than doubled since 1978, the increase in part reflecting the 1980-82 devaluation of the CFAF vis-a-vis the US dollar by about 35%. In fact, the 1980-82 rise in the value of petroleum product imports masks a de-

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1/ As it is not used for energy production in Niger, uranium is treated here as a non-energy commodity.

cline in the volume of these imports as indicated by the corresponding figures of their consumption (Table 3.1). The future cost of electricity imports is bound to at least double once the recently concluded (10/82) tariff increase with Nigeria has become effective. The previous contract expired on September 30, 1981.

Table 1.1: ENERGY AND THE BALANCE OF TRADE, 1978-82
(Billions of current CFAF)

	1978	1979	1980	1981	1982
1. Petroleum Product Imports	9.8	16.8	32.6	36.8	38.4
2. Petroleum Product Re-exports a/	1.1	1.3	2.0	2.4	2.9
3. Net Petroleum Product Imports	8.7	15.5	30.6	34.4	35.5
4. Electricity Imports	0.3	0.3	0.5	0.9	1.1
5. Total Energy Imports	9.0	15.8	31.1	35.3	36.6
6. Merchandise Imports c.i.f.	103.3	140.1	171.6	189.8	202.5
7. Non-Energy Merchandise Exports f.o.b.	62.8	100.2	123.0	132.2	119.7
(5) as a % of (6)	8.7	11.3	18.1	18.6	18.1
(5) as a % of (7)	14.3	15.8	25.3	26.7	30.6
Memory Item: Rate of Exchange CFAF/US$	225.6	212.7	211.3	271.7	327.6

a/ Estimated jet fuel sales to international air carriers.

Source: IMF staff estimates, NIGELEC, SONIDEP and GPP data.

Energy Consumption Trends

Overview

1.9 Data on energy consumption in Niger are fragmentary and inconsistent. Total gross energy consumption 2/ in 1981 is estimated at 1,030,000 toe (Annex 1.1), or about 180 kgoe/capita, one of the lowest levels in the world. Of this, 81.5% consisted of fuelwood, 14.1% petroleum products, 3.0% electricity and 1.4% coal. All of the coal was converted into electricity, as was one-fifth (in the form of gas oil) of the petroleum products.

2/ Excluding jet fuel sold to international air carriers.

Table 1.2: PATTERN OF NET DEMESTIC ENERGY CONSUMPTION BY SECTOR, 1981 (Percent)

Sector	Petroleum Products	Electricity	Total Commercial Energy	Total Energy b/
Mining	16.05	42.52	20.22	2.87
Industry & Construction	30.68	14.96	28.20	12.83
Transport	48.37	0.79	40.88	5.81
Public Administration	0.03	14.57	2.32	0.33
Households/Residential	4.01	20.86	6.66	77.91
Agriculture/Commerce/ Other	0.86	6.30	1.72	0.25
TOTAL	100.00	100.00	100.00	100.00
Total (toe)	115,529	21,590 a/	137,119	964,277

Note: The figures indicate direct, final consumption, net of all conversion losses and, in the case of electricity, of transmission and distribution losses as well.

a/ Calculated at the maximum theoretical heating value of electricity, 85 toe/GWh.

b/ Includes fuelwood (estimated at 824,615 toe), charcoal (estimated at 2,425 toe), and groundnut shells (about 118 toe).

Source: National Energy Balance (Annex 1.1).

1.10 Net energy consumption by sector (Table 1.2) reflects the predominant role of fuelwood; its almost exclusive domestic/residential use makes this sector account for 78% of the total net consumption. The balance went mainly into industry and construction (13%), transport (6%) and mining (3%).

1.11 The picture is different for the sectoral distribution of net commercial energy consumption. Transport took the lion's share - 41% of the total and 48% of (directly consumed) petroleum products, followed by industry and construction (28% and 31%). Mining stands out as the biggest electricity consumer (43%) and ranks third in total commercial energy consumption (20%). The relatively high electricity consumption of households (21%) and public administration (15%) reflects the widespread use of air conditioning, particularly in Niamey.

Commercial Energy Consumption and GDP

1.12 Commercial energy consumption grew much faster than real GDP during the period under review (Table 1.3). Its implied elasticity with respect to total GDP was 2.6 between 1976-79, at the height of the uranium boom, and 3.6 over the following three years when GDP growth decelerated to almost zero in 1982. Since mining has provided the engine of growth, a more useful relationship is the elasticity of commercial energy consumption with respect to modern sector GDP only. This is estimated at the much lower figure of about 1.5. The fact remains, however, that over the 1976-82 period commercial energy intensity has increased by two-thirds, from 0.38 to 0.63 toe per million CFAF of total GDP. Even more significantly, commercial energy intensity kept rising while GDP/capita was actually declining (1979-1982). The same phenomenon is observed as well in other developing countries at similar income levels, e.g. Senegal.

Table 1.3: COMMERCIAL ENERGY CONSUMPTION a/ AND GDP, 1976-82

	1976	1979	1982 b/	Growth Rate % p.a. 1976-1979	Growth Rate % p.a. 1979-1982
Total Consumption, '000 toe	91.5	164.4	208.2	21.8	8.2
Consumption per capita, kgoe	19.3	31.9	35.9	18.2	4.0
GDP (billion CFAF, 1976)	241.2	307.1	329.0 c/	8.4	2.3
GDP per capita ('000 CFAF, 1976)	51.0	59.5	56.7	5.3	(1.6)
Energy per million CFAF of GDP, toe	0.38	0.54	0.63	12.4	5.3

a/ Gross consumption, i.e. including conversion losses in power generation as well as transmission and distribution losses. Electricity calculated at thermal equivalent value of 265 toe/GWh. Excludes butane and jet fuel, which is sold to international air carriers.
b/ Extrapolated from data through September 1982.
c/ IMF staff estimate.

Source: Ministere du Plan, GPP, NIGELEC, SONICHAR.

Overview of Energy Resources

Uranium

1.13 Niger's present known energy resources are dominated by uranium, of which it is one of the largest exporters in the world. Sizable uranium ore deposits exist in the northern part of the country, on the southern and western borders of the Air Massif (IBRD Map 17253). Lesser discoveries were made in the northeastern Djado region. Most ores grade

3 kg of uranium per tonne. The Nigerien yellowcake (uranium oxide $U_3 O_8$) contains about 70% uranium metal. Production began in 1971 and output expanded from 450 tonnes of uranium equivalent in that year to 4,370 tonnes in 1981. Reasonably assured reserves are estimated at 160,000 tonnes, with an additional 53,000 tonnes of probable reserves. Although uranium, when measured in terms of burn-up rates of nuclear reactors, represents Niger's largest source of energy, the small size of the foreseeable power demand offers no encouragement for development of nuclear power, and uranium will probably remain Niger's principal export commodity.

Coal and Lignite

1.14 The Anou-Araren coal deposits in the north of the country consist of about 9.4 million tonnes at 3,650 kcal/kg (3.4 million toe). The coal is being used exclusively (at the current rate of 100,000 to 200,000 tpa) in a 32 MW power plant which supplies the nearby uranium mines and adjacent areas. A recent discovery near Solomi, about 30 km north of Anou-Araren, could indicate a significant deposit of higher quality coal (7000 kcal/kg). There have been various indications of lignite deposits in the south, the most promising of which has a resource potential tentatively evaluated at 2.6 million tonnes, with a calorific value of 4,000 kcal/kg (1 million toe in all).

Petroleum

1.15 No commercial discoveries of petroleum have occurred in Niger as yet. However, petroleum exploration has intensified in recent years, with encouraging finds in the Agadem basin (250 km from the border of Chad). The reserves are being evaluated to determine their production possibilities.

Hydropower

1.16 The hydro resources of the country are concentrated in the southwestern part where the Niger River traverses about 420 km of Nigerien territory. The potential for hydro power development is limited. Two sites, Kandadji and W, are estimated to have a combined annual energy capability of 1,250 GWh (330,000 toe) for an average hydrological year. Subject to international agreements (with Mali and Benin, respectively) a second stage of Kandadji could add another 750 GWh (199,000 toe), and on the international stretch of the Mekrou tributary another site (Dyodyonga) could be developed with an annual output of 80 GWh (21,000 toe).

Fuelwood

1.17 In 1980, given the lack of precise data, the FAO estimated Niger's natural forest cover, which is limited mostly to the southern part of the country, at 15.1 million hectares (ha). The net available increment of fuelwood in the same year amounted to $0.09m^3$/ha which gives a total net available increment of 1.4 million m^3 (280,000 toe). This, however, was only about 35% of fuelwood consumption (825,000 toe).

Biomass Other Than Wood

1.18 In 1979/80, Niger produced crop residues and animal waste with an estimated theoretical maximum energy potential of 2.2 million toe but, because of competing uses as well as technical, economic, and social constraints, only a very small fraction (i.e. probably less than 5%) of this figure could have been used for energy conversion. Other than the unknown amounts of crop residues and dung burned for cooking in areas of severe fuelwood shortages, the largest quantity of biomass energy produced and consumed in 1980 and 1981 was in the form of groundnut shell briquettes. In 1980/81, 336 tonnes of briquettes (148 toe) were produced. This constitutes less than one percent of the overall theoretical groundnut shell potential which in the same season could have produced about 39,000 tonnes of briquettes (17,000 toe).

Solar and Wind Energy, Small Hydro

1.19 Solar insolation is excellent in Niger. In the southern part of the country, average values of total (direct and diffuse) radiation on a horizontal surface range from 5.6 to 6.3 kWh/m^2/day (i.e. 170 to 200 kgoe/m^2/yr), and the average daily duration of sunlight varies between 8.5 and 9.5 hours.

1.20 Niger's wind resource is very poor; maximum wind speeds only reach 3.9 m/s, at Tahoua. Similarly, the small hydro resource also seems to have a limited potential.

II. FUELWOOD

2.1 In tackling Niger's fuelwood crisis (para 1.6), a concerted effort is needed both to increase the supply of fuelwood and to reduce the demand for it. Increasing the fuelwood supply means better management of the natural forest cover and reafforestation, the scope for which, however, is limited in Niger and which anyway has a long gestation period; importing charcoal does not seem to be a viable alternative. Reducing the demand for fuelwood, on the other hand, can be achieved through an array of measures, foremost among which are conservation through improved fuelwood stoves, and substitution of other energy resources. The demand side offers the most scope for substantially relieving the fuelwood crisis.

Fuelwood Resources

2.2 In the absence of precise data, a recent FAO report 3/ has tentatively estimated Niger's total forest cover in 1980 to be 15.1 million hectares, of which (in million hectares) 5.5 are tree savannas, 3.0 bush fallows, 3.0 sylvo-agricultural formations, 2.1 woodlands and savanna woodlands, and 1.5 shrub savannas. Included in these 15.1 million hectares are: (a) one million ha of forest and fauna reserves, parks, and controlled forestry areas in proportions of 20% forest reserves to 80% fauna reserves; and (b) some 20,000 equivalent ha of forest plantations, mostly for fuelwood and building poles. Population growth is seriously encroaching upon and threatening many of these reserves.

2.3 Forests in Niger are not dense areas of trees but are rather dispersed tree formations. Moreover, most of these forests belong to "agropastoral" or "sylvopastoral" formations which produce little fuelwood and few building poles. Most of the fuelwood resource potential exists in the narrow, rain-fed strip of the southern part of the country, stretching from west to east below the northern limit of cultivation. The FAO estimates the total mean annual increment to have been 4,200,000 equivalent m^3 of roundwood (1,890,000 tonnes) in 1980. In terms of a national average, that amounts to a growth of 0.28 m^3 of roundwood per hectare of natural forest cover a year. However, given the overexploitation of the natural forest cover around populated areas, much of Niger's remaining fuelwood resources are at such great distances from consumers that access to them is becoming more and more difficult. Therefore, in 1980 only 1,400,000 m^3, or 33% of the mean annual increment, is considered actually to have been available. Given this total net available increment, the average net available increment of fuelwood per hectare of

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3/ M. N. Keita, Availability of Fuelwood in the Sahel (Present Position and Prospects), FAO, Rome, 1982.

natural forest cover was only 0.09 m^3 of roundwood a year in the same year. About 10% of this amount would be used for building poles. 4/ Annex 2.1 provides a breakdown of the total mean annual increment and the net available increment of fuelwood in 1980 by type of forest cover and geographic zone (see also IBRD map 16937).

Fuelwood Consumption

2.4 There are no accurate data on woodfuels consumption in Niger. What is certain is that very little wood is consumed in the form of charcoal because the main urban areas can still obtain firewood from within a radius of 100 km, so that only minimal amounts of charcoal are produced and consumed, mostly for ironing and making tea. However, given the ever increasing fuelwood demand from the main population centers, the irremediable destruction of the fragile forest cover around these centers means that fuelwood supplies will require increasingly long truck hauls. Charcoal is less expensive than wood to transport on a calorific basis because the heating potential of charcoal by volume is higher than that of wood, and volume rather than weight determines transport cost. Even though charcoal production and marketing might prove to be economically feasible, such a course of action is hardly indicated since wood from the natural forest of Niger does not lend itself well to charcoal production, using large amounts of wood to produce charcoal poses an ecological danger, and Niger has no expertise in large-scale charcoal manufacturing.

2.5 According to the 1981 CILSS/OECD Report, 5/ the average per capita consumption of woodfuels, including cooking and heating, amounts to an estimated 0.9 kg of dried wood per day, or about 0.75 equivalent m^3 of roundwood per year. Based on this assumption, the total fuelwood consumption reached 4.1 million equivalent m^3 of roundwood in 1980, of which 0.8 million m^3 (20%) was consumed in the urban areas and 3.3 million m^3 (80%) in the rural areas. This total consumption comes to nearly three times the net available increment of fuelwood (1.4 million m^3) in the same year.

2.6 The FAO estimates 0.60 equivalent m^3 of roundwood per capita per year to be the amount of fuelwood needed for cooking and heating, or about 20% less than actually seems to be consumed in Niger. But even on this basis, 72% of the population faced an acute scarcity of fuelwood in 1980, 24% a deficit, and 4% a prospective deficit. Moreover, the continuing depletion of the accessible forest cover is causing a decline in

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4/ As this percentage falls within the margin of error of these production estimates, no special allowance for building poles is made in the totals.

5/ Forestry Sector Analysis and Proposals: Niger, CILSS/OECD, 1981.

soil fertility, and desertification will intensify, resulting in heavy losses in agricultural production.

2.7 Unless prompt action is taken both to protect and develop the natural forest cover and to change current patterns of fuelwood use, the total net available increment of fuelwood per year will decline to 1.0 million m^3 by 2000, almost 30% less than in 1980 (Table 2.1).

Table 2.1: EVOLUTION OF NATURAL FOREST COVER AND FUELWOOD SUPPLY BASED ON CURRENT TRENDS, 1980-2015 a/

	1980	Index	2000	Index	2015	Index
Woodlands and savannas (000 ha)	9,100	100	6,900	76	5,300	58
Bush fallows (000 ha)	3,000	100	2,800	93	2,600	87
Sylvo-agricultural formations (000 ha)	3,000	100	5,000	167	6,600	220
Total natural forest cover (000 ha)	15,100	100	14,700	97	14,500	96
Mean annual increment per ha (m^3/yr.)	0.28	100	0.22	79	0.18	64
Net available increment per ha (m^3/yr.) b/	0.09	100	0.07	78	0.07	78
Total mean annual increment (000 m^3)	4,200	100	3,200	76	2,600	62
Total, net available increment (000 m^3) b/	1,400	100	1,000	71	1,000	71

a/ i.e. with no effort to develop fuelwood resources and no change in fuelwood consumption per capita from the 1980 rate.
b/ i.e. the amount of the mean annual increment that is accessible.

Source: FAO.

2.8 This means that Niger's already large fuelwood deficit will more than double by the year 2000 (Table 2.2).

Main Forestry Sector Constraints

2.9 The main constraints to forestry development are:

(a) poor soils, limited rainfall, and a lack of forestry technical packages well-adapted to marginal lands in these arid and semi-arid zones with only one peak of rainfall;

Table 2.2: FUELWOOD RESOURCES, CONSUMPTION AND NEEDS BASED ON CURRENT TRENDS, 1980-2015 a/
('000 m^3)

	Actual 1980	Projected 2000	Projected 2015
A. Total, net available increment b/	1,400	1,000	1,000
B. Total consumption (at 0.75 m^3/capita/year)	4,100	7,200	10,900
Deficit (A - B)	2,700	6,200	9,900
C. Total needs (at 0.60 m^3/capita/year)	3,300	5,800	8,700
Deficit (A - C)	1,900	4,800	7,700

a/ i.e. no protection or development of the forest cover and no change in fuelwood consumption. Based on a growth rate of about 2.8% p.a., the population figures used to calculate consumption and needs have been rounded off to 5.5, 9.6 and 14.5 million inhabitants in 1980, 2000 and 2015, respectively.
b/ i.e. total accessible mean annual increment.

Source: CILSS/OECD and FAO.

(b) the difficulty of preventing the natural forest cover from overuse (too much cutting, clearing, grazing, burning, etc.);

(c) a difficulty in obtaining full and sustained governmental commitment and popular participation. Recent initiatives show an increased awareness of the problem by both the Government and the people, and indicate progress in this regard.

2.10 With most of the country receiving less than 400 mm of rain per year and with rainfall being erratic, forestry in Niger technically is severely limited. Because only 12% of the land is considered arable, forestry plantations compete directly with agriculture for good soils. Agrarian as well as livestock pressures on land in the southern rain-fed belt mean that all forestry plantations need to be efficiently fenced and guarded, an expensive undertaking. Due to the lack of a productive technical package, initial results from ongoing projects show that for the average hectare of rain-fed tree plantations the expected production is only 2 to 3 m^3 per year for well managed plantations and 1-2 m^3 per year for rural woodlots. There is, however, the possibility of producing wood under irrigation (pure stand plantations, tree plantations within irrigated agricultural perimeters, i.e. hedges, wind breaks, groves, thickets, ...) which, if feasible, would play a significant role in alleviating the continued devastation of the fragile forest cover. The feasibility of such plantations is being determined under the second

IDA/FAC/CCCE forestry project. Without prejudging the outcome, one can already say that pure stand plantations are very costly and the scope for tree plantations within irrigated agricultural perimeters, while yielding good results, is limited.

2.11 Competition for the scarce land resources leads directly to the overuse of the natural forest which constitutes the second main constraint to forestry development. Better management of the forest cover would mainly imply protection against over-cutting, over-grazing, over-clearing, and uncontrolled bush fires. Under the best conditions, with effective participation of the rural population and herders, the production from better managed natural forests may be expected to increase by two-thirds, from the current average of 0.30 m^3/ha/year to 0.50 m^3/ha/year.

2.12 The final major obstacle to improving Niger's wood resources was, until recently, the lack of popular as well as governmental support. This lack of support stemmed from the competition for resources between agriculture, pastoralism, and forestry. In the eyes of the Government and of the people, short-term gains such as an increase in the production of food crops and livestock frequently outweighed the benefits to be obtained in the medium to long term from forestry development programs. Moreover, forestry programs implemented to date have not gained popular support, partly because they were conceived without taking into account the need for individual participation by the rural population and partly because the population did not feel as seriously threatened as it does now. However, the difficulty posed by the lack of support is now being resolved as is evidenced by the Government's public awareness efforts, e.g. its proclamation of the year 1984 as the Year of Reforestation, and by linking the National Holiday of August 3 to the National Holiday of the Tree.

2.13 The sensitization of the population needs to be increased for its participation to become more significant. Nevertheless, there are indications that the local population is interested in growing trees. The results of tests in the Majjia Valley have convinced some farmers that wind breaks can increase millet yields by about 20-30%. Farmers are also aware that Gao trees (Acacia Albida) that have traditionally played a fertilizing role for millet land are being cut for wood, threatening to reduce cereal yields, and they have expressed interest in learning more about selective protection of natural regeneration for Gao trees and other local tree species. The national forestry code specifies certain tree species as protected but does not discourage the planting or protection of these species by individuals who can eventually exploit them. As part of its responsibilities, the project unit of the second IDA/FAC/CCCE forestry project is to work through the Directorate of Forestry and Fauna to educate forestry staff and the rural population on the proper interpretation of the forestry code. The first reconnaissance study planned for the rural forestry component of the project aims at locating areas suitable for tree planting either on an individual or family basis, but with the understanding that the trees planted would be the personal property of those who planted them and that project extension staff stand ready to give technical advice on planting and tree maintenance to all families willing to plant.

Increasing Fuelwood Supply

2.14 Since the 1973/74 drought, the Government has recognized the need to protect the remaining forest cover, to develop a sustained supply of fuelwood, and to promote wood substitutes and a better use of wood. In general terms, this translates into a Government strategy of: (a) building up forestry institutions through training; (b) establishing fast growing tree plantations and improving the management of the natural forest cover; (c) encouraging the participation of the rural population in reafforestation; and (d) supporting research into improved forestry technical packages and efficient uses of wood. In practice, however, there has not been an adequate allocation of Government funds, and therefore of equipment or operating supplies to the Directorate of Forestry and Fauna. As it is busy implementing current projects, the Directorate of Forestry and Fauna has not been able to work on inventory control or planning. There is therefore no detailed forestry master plan.

2.15 After taking into account the results of ongoing projects, particularly with respect to expanding the implementation arm of the Directorate of Forestry and Fauna, the mission considers the indicative objectives presented in Table 2.3 for maximum national production from plantations and improved forest management through 2015 to be realistic. According to these estimates, the fuelwood production in the year 2000 from "industrial" irrigated tree plantations, which could all be on the more economic bottom lands, would only contribute about 3% of Niamey's projected fuelwood demand of 750,000 m^3 for that year (based on an average population growth rate in Niamey of about 6% from 1982 to 2000). However, if the absorptive capacity of the Directorate of Forestry and Fauna could be further increased to handle 10,000 rather than 2,000 ha of bottom land plantations by the year 2000, the production from these areas close to Niamey would account for almost 15% of the city's projected demand. Given the competing uses for land in Niger, a program is urgently needed to maximize production from plantations as well as to improve management of the natural forest cover. This will require a comprehensive approach which takes into account the interaction of forestry, agriculture, and pastoralism (agro-sylvo-pastoralism). For example, more intensive livestock and agricultural practices promoted through well balanced and operationally integrated schemes would help reduce the damage to the fragile natural forest cover. Such an approach will require a great deal of goodwill and coordination between herders, farmers, and various Government agencies.

Table 2.3: MISSION PROPOSALS ON CUMULATIVE OBJECTIVES FOR FUELWOOD PRODUCTION a/ FROM PLANTATIONS AND IMPROVED FOREST MANAGEMENT IN 2000 AND 2015

	2000			2015		
	Total Area (000 ha)	Annual Productivity (m^3/ha)	Annual Production (000 m^3)	Total Area (000 ha)	Annual Productivity (m^3/ha)	Annual Production (000 m^3)
State-managed "industrial" irrigated tree plantations b/	2	15.0	30	5	15.0	75
Tree plantations within irrigated agricultural perimeters c/ d/	2	10.0	20	5	10.0	50
State-managed rain-fed tree plantations	40	2.5	100	60	2.5	150
Rural rain-fed tree plantations d/	100	1.5	150	150	1.5	225
Subtotal tree plantations	144	2.1	300	220	2.3	500
Better management of natural forest cover	2,000	0.5	1,000	4,000	0.5	2,000
Total annual production			1,300			2,500

a/ i.e. including wood for building poles (about 10% of the total).
b/ i.e. planting on terraces and bottom lands.
c/ Hedges, wind breaks, groves, thickets, ...
d/ Total area planted listed in terms of equivalent hectares.

Source: Bank staff

2.16 Adding the maximum possible "new" fuelwood supplies to the projected net available supply of fuelwood from existing resources, and comparing the result with the projected demand calculated on the basis of 0.75 m^3/capita/year shows that by the year 2000 Niger will have to either eliminate or substitute for about 70% of its fuelwood demand by using improved woodstoves or cooking with alternative fuels (Table 2.4). In terms of the more conservative FAO estimate of fuelwood needs at 0.60 m^3/capita/year, about 60% of these projected needs would have to be met through conservation and substitution.

Recommendations

2.17 Excluding any actions with respect to conservation of and substitution for fuelwood discussed below, the mission recommends that the Government commit itself to:

Table 2.4: MISSION PROPOSALS FOR MEETING PROJECTED FUELWOOD DEMAND IN 2000 AND 2015

	Actual 1980		Projected 2000		2015	
	(000 m^3)	(%)	(000 m^3)	(%)	(000 m^3)	(%)
Demand with no change a/	4,100	100	7,200	100	10,900	100
Available resources with no change b/	1,400	34	1,000	14	1,000	9
Tree plantations c/	-	-	300	4	500	5
Better management of natural forest cover c/	-	-	1,000	14	2,000	18
Better use of wood, use of substitutes d/	-	-	4,900	68	7,400	68
Overcutting of accessible forest cover	2,700	66	-	-	-	-

a/ At 0.75 m^3/capita/year.
b/ i.e. total accessible mean annual increment.
c/ Negligible in 1980.
d/ Does not apply in 1980.

Source: CILSS/OECD and Bank staff.

(a) pursuing the planting and improved management objectives outlined in Table 2.3 and described in greater detail in Annex 2.2. The planting program should include a vigorous forestry extension effort to help establish individual or family woodlots in order to secure the support of the rural population, while the program for better management of the natural forest cover should be based on the agro-sylvo-pastoral approach referred to in para 2.15. As shown in Annex 2.2, the estimated costs of these planting and improved management proposals, excluding complementary forestry training and extension work, amount to about US$9 million (1982) p.a. from 1984 through 1988, and US$10 million p.a. from 1989 through 2018. Presently the Directorate of Forestry and Fauna can handle about US$5 million worth of work per year. A long-term forestry effort would therefore require a specific complementary forestry training program (para 2.27).

(b) investigating new forestry technical packages which are well adapted to marginal lands in arid and semi-arid zones for local and exotic tree species by experimentation with vegetative multiplication, mycorrhiza, and symbiotic microorganisms, such as rhizobia and frankia.

Conservation

2.18 Substantial savings of fuelwood could be achieved by the early introduction of an improved fuelwood stove which ideally also would handle fuelwood substitutes. Many different groups in Niger are attempting to develop and disseminate a woodstove that is more energy efficient than the widely used three stone fire and the junk metal stove ("foyer malgache") which is employed mostly in urban areas. These organizations include the Church World Service (CWS), the Young Farmers' Training Center (Centre de Formation des Jeunes Agriculteurs, CFJA), the Nigerien farmers' cooperative organization (Union Nigerienne de Credit et de Cooperation, UNCC), the Association of Nigerien Women (Association des Femmes du Niger, AFN), the U.S. Peace Corps, the French Volunteer Association (Association Francaise des Volantaires du Progres, AFVP), two Catholic Church groups in the Tapis Vert project, UNSO, and CILSS. All of the efforts to date have been on a test basis, with the actual building of stoves and the training of people in their construction limited to a very small scale. The AFN-CWS project, designed to closely monitor the acceptability of the cement "Kaya" model in Niamey, has been the largest one, producing 800 stoves.

2.19 The European Economic Community (EEC) and UNSO are proposing two additional improved stove projects. The EEC project involves the construction and dissemination of 6,000 clay ("banco") stoves over three years in Niamey, Maradi and Zinder. Under its Preliminary Plan of Improving Wood Stoves in Niger, UNSO proposes to build 100 demonstration stoves for use in medical centers, schools, maternities, etc. in the provinces of Zinder, Maradi, Dosso and Tahoua, and to ensure construction and monitoring of 260 stoves to be placed with families where their operation has the best chance of success. There is evidence of a growing consensus among the organizations involved on the need for overall coordination of the various improved woodstove efforts. Another means of promoting fuelwood conservation, and one which does not seem to have been pursued in Niger, is teaching more fuel efficient ways of cooking with the traditional three stone fire. Proper use of the open fire can increase its thermal efficiency from 8% to 15%.

2.20 The mission considers that the most expedient procedure for reducing the demand for wood by means of improved woodstoves is to focus on developing appropriate stove models for dissemination to carefully selected groups in urban and peri-urban areas. In these areas, the lack of fuelwood poses the most severe problem because there are no readily available, inexpensive substitutes. In contrast, rural areas have crop residues and animal wastes which can be burned (although this practice should be avoided because it reduces soil fertility). The improved stove models should: (a) be portable enough to appeal to renters; (b) provide at least a 30-50% increase in end-use efficiency over the prevailing method of cooking (three stone fire or foyer malgache) in these urban and peri-urban areas; (c) be able to be manufactured locally; (d) be cheap enough so that, for a certain efficiency level, their use leads to significant cash savings in buying wood; (e) be socially acceptable, which should be greatly facilitated by the financial savings they provide; and (f) be designed for wood but, if possible, be suitable also for charcoal, groundnut shell briquettes, and perhaps lignite. The Upper Volta portable metal fuelwood stove which recently was introduced successfully in the Ouagadougou market place, would appear to meet most of these criteria. Its end-use efficiency is reported to be 25-30% (compared to an efficiency of about 19% for the "banco" stove and 15% for the three stone fire). It is manufactured locally from scrap metal and reportedly sells at about CFAF 1,000 (about US$3 equivalent) without subsidy.

Recommendations

2.21 The mission recommends:

(a) Centralization of efforts concerning improved wood stoves within the Directorate of Energy (DE) of the Ministry of Mines and Industry. The DE should closely monitor developments in this area at the national level and keep itself informed of progress of similar efforts on the international plane with a view to evolving a policy and a plan of action for producing and disseminating appropriate models of improved stoves.

(b) Dissemination on an experimental basis in Niamey of a version of the "Ouaga stove" mentioned above. This would involve the careful selection of a target group of people likely to be interested in using an improved stove, closely monitoring the use by this group of an "Ouaga" type stove and modifications of this stove in light of the experience gained. This would allow gradual increases in the scale of production and marketing for models which already have received consumer acceptance. This experimental project should benefit from the equipment of the laboratories of ONERSOL for testing and modifying the particular stove model distributed. The woodstove experts for this project could also provide assistance to the DE in managing the tasks described in (a) above.

Substitution

2.22 Possible substitutes for fuelwood include charcoal, coal, lignite, biomass other than wood, solar energy, petroleum products, and electricity. Substitution of the first four would be greatly facilitated by the dissemination of a multi-fuel stove as discussed above. Also, as discussed above (para 2.4), charcoal production in Niger would require further study. The potential of the other substitutes for meeting cooking needs is analyzed in subsequent chapters.

Forestry Sector Institutions

2.23 Organized into eight field districts, the Directorate of Forestry and Fauna (Direction des forêts et de la faune) of the Ministry of Hydraulics and of the Environment manages Niger's natural forest cover. Forestry research forms part of the activities of Niger's agricultural research institute, INRAN, which reports to the Ministry of Higher Education and Scientific Research. Under the second IDA/FAC/CCCE forestry project, the forestry research division of the institute will work on seedling production, soil requirements for forestry, establishing tree plantations, improving the natural forest cover and tree plantations, improving planting stock, and forestry economics.

2.24 Exploitation of the forest cover for fuelwood in Niger does not take place on an organized basis; it is commercialized mainly for urban consumption. The commercial setup involves gathering the fuelwood, transporting it, and the reselling of it by retailers. The Directorate of Forestry and Fauna theoretically controls the entire wood supply chain, from production to final sale. Because of manpower constraints, the Directorate, in fact, controls mainly the transport phase, as people who want to sell wood must first obtain a permit from the Directorate of Forestry and Fauna. The price of the permit is fixed on a monthly basis according to the means of transportation involved, whether donkey, camel, pick-up, or truck. In practice, this is difficult to police. However, the receding forest cover around major population centers has led to an increasing use of trucks by wood sellers, and this improves the chances for better Directorate of Forestry control.

Recommendation

2.25 The mission recommends that the Government pay much greater attention to controlling the wood supply chain, provided that, because of its very high costs, the transport phase remain private, subject to control by the Directorate of Forestry and Fauna. It would even be appropriate for the Government to encourage the setting up of private organizations for the transport of fuelwood. Besides facilitating the Directorate's control over fuelwood exploitation, notably through the policing of permits, an efficiently organized transport system would increase the amount of the mean annual increment of wood that is accessible.

Manpower Issues and Training Needs in the Forestry Sector

2.26 Given the magnitude of Niger's forestry problems, the Directorate of Forestry and Fauna, with a total staff of 301 in 1981, remains understaffed even in spite of recent improvements. There is little planning and inventory control, and the situation is made worse by an inadequate allocation of funds, equipment, and operating supplies from the

Government budget. As a result, the Directorate cannot fulfill a large part of its responsibilities, such as providing the necessary reafforestation or erosion control programs on a significant scale. Two current projects are designed to improve the situation by providing operational inputs, training, vehicles, and equipment: the second IDA/FAC/CCCE forestry project and the USAID forestry and land use planning project, which in particular is trying to build up an inventory control unit within the Directorate.

2.27 Senior forestry officers (level A), until recently have been trained abroad (nine in 1981), but in the future they will be trained at the agronomy school (Ecole Supérieure d'Agronomie) in Niamey. An institute for rural development (Institut Pratique de Développement Rural) at Kolo provides education for level B and C staff, but there is no formal training for level D personnel, who are supposed to learn on the job, although they are the executing agents. Forestry education curricula should place greater emphasis on reafforestation and natural forest management, and field staff should be provided with refresher courses in these areas. In addition, junior level staff lack minimum training in forestry techniques. The second IDA/FAC/CCCE forestry project is addressing these needs by establishing a small training center in Niamey to provide regular training courses for field forestry staff, especially level D. However, given the magnitude of training needs in forestry, a long-term commitment to develop forest resources as recommended by the mission would require a specific complementary forestry training program. As a rough estimate, the Directorate of Forestry and Fauna would need to appoint about five new level A, ten new level B, and fifteen new level C staff every year until 1990.

Recommendation

2.28 The mission recommends that the Government, in pursuing the planting and improved forest management objectives proposed in para 2.17, closely consider the need to launch, as soon as feasible, the complementary forestry training program mentioned above. Such a program would cost roughly US$1.5 million to run for five years, as shown on an indicative basis in Annex 2.3. Preparation and feasibility studies would need to be carried out to define such a program more precisely.

III. PETROLEUM

Consumption of Petroleum Products

3.1 The consumption of petroleum products more than doubled between 1973 and 1980 and then declined by 5.2% p.a. in the following two years (Table 3.1). Most of the increase occurred between 1976 and 1980, at an annual rate of nearly 15%, reflecting the uranium boom. The subsequent decline was due to the substitution of domestic coal for gas oil in supplying power to the mining district during 1981/82. As a result, gas/diesel oil consumption dropped by 11% p.a. The consumption of gasoline, on the other hand, continued to rise unabated, even though the second drastic world price increase in 1979/80 was immediately passed on to consumers. Much the same goes for kerosene, whose retail price has remained above its import level even despite subsidization (see para 7.12). Again, because of the substitution of coal for gas oil, there was some change in product composition away from the heavy preponderance of gas/diesel oil, which dropped from its peak of 74% of total consumption in 1980 to 64% in 1982. As a corollary, the share of gasoline rose from 23% to 32% over the same period, and kerosene increased from 3% to 4%. Gas oil was preferred over the less expensive fuel oil because individual consumers consider the quantities they need too small to justify the cost of maintaining the fuel oil's viscosity at a useable level.

3.2 Of the approximate 145,000 toe of petroleum products consumed in 1981, 6/ transport accounted for 39%, power generation 20%, construction (mainly roads) 19%, mining (excavation equipment) 13%, industry only 5%, households 3%, and other sectors the remaining 1% (Annex 1.1).

3.3 Niger consumes very small amounts of butane and kerosene for household purposes (Table 3.1). Detailed information on their consumption is lacking but, on a calorific basis, the estimated total amount of both fuels used for cooking and lighting comes to less than 1% of Niger's household consumption of wood. Almost exclusively an urban fuel, butane is used for cooking in higher income households, including those of mining personnel, in Government residences, and also in hotels. The total amount consumed for this purpose has remained constant at about 400 toe (380 tonnes) p.a. In terms of fuel end-use efficiencies, butane by itself costs, at a subsidized price, about the same amount to cook with as fuelwood burned by the three stone method (Table 7.3). However, the least expensive equipment for cooking with butane retails for about 15,000 CFAF (US$45) in Niamey and the deposit on the bottle comes to about 6,000 CFAF (US$18). These costs, together with the unfamiliarity of handling a highly flammable material, prevent the majority of families from using butane for cooking.

6/ Includes gas oil for power generation and butane, but excludes reexported jet fuel.

Table 3.1: CONSUMPTION OF PETROLEUM PRODUCTS, 1973-1982 a/

	1973		1976	1979	1980		1981	1982 b/		Growth Rate % p.a.		
	'000 toe	% share	'000 toe	'000 toe	'000 toe	% share	'000 toe	'000 toe	% share	1973-76	1976-80	1980-82
Gasoline	19.2	(26.2)	22.2	31.8	35.2	(22.7)	40.6	44.6	(32.1)	5.0	12.2	12.6
Aviation Gasoline	0.5	(0.7)	2.3	2.4	1.3	(0.8)	0.7	0.5	(0.2)	66.3	-13.3	-38.0
Kerosene	2.8	(3.8)	3.4	4.2	4.2	(2.7)	4.5	5.0	(3.6)	6.7	5.4	9.1
Gas/Diesel Oil c/	50.7	(69.3)	60.8	105.2	114.1	(73.7)	98.9	88.9	(64.0)	6.2	17.0	-11.7
TOTAL	73.2	(100.0)	88.7	143.6	154.8	(100.0)	144.7	139.0	(100.0)	6.6	14.9	-5.2

a/ Total consumption, including for power generation. Excludes jet fuel (re-exported), butane (e.g. 471 toe in 1981), and petroleum products for non-energy uses.
b/ Extrapolated from data for January to September 1982.
c/ Includes small amounts of fuel oil (e.g. 600 toe in 1973 and 3500 toe in 1982).

Source: GPP

3.4 As for kerosene, most of the 4,460 toe (4,415 tonnes) consumed in 1981 was for lighting. The consumption of kerosene did increase by about 7% a year between 1973 and 1982, but again not for cooking, although on that score, even at an unsubsidized price, it compares more favorably with fuelwood than butane does (para 7.21). Simple kerosene stoves are now available in Niamey for 5000 CFAF (US$15). However, these stoves are not well adapted to traditional Nigerien cooking, not being strong enough to heat large pots. More solid, multi-wick kerosene stoves do exist elsewhere, for example, the Indian "Nutan" model, which has a calorific efficiency of about 36%. Because of its lower cost, greater ease of distribution and use, and the fact that it already is widely consumed for lighting, kerosene holds more promise as a fuelwood substitute than does butane. Substituting kerosene for fuelwood would add only marginally to the energy import bill. If, for example, 40% of the population in Maradi, Niamey, Tahoua, and Zinder in 1982 had cooked exclusively with kerosene on a stove such as the Nutan, the country's net energy import bill would have increased only by an estimated 3%. 7/

Recommendation

3.5 Because of the severity of the fuelwood shortage and the need for immediate substitutes, the mission recommends that kerosene be promoted as a cooking fuel. To this end, the design for a kerosene stove suited to traditional cooking methods needs to be either acquired or developed, and then imported or produced locally, for example, by the newly created SONIEN (para 5.2). As a promotional measure, such a stove might initially be sold at a subsidized price, depending on the results of the study of comparative energy prices recommended in para 7.22.

Projected Petroleum Product Consumption

3.6 Given the Government's emphasis on self-sufficiency in food and the absence of any plans for a major development of industry, the future consumption of petroleum products in Niger will depend primarily on the development of uranium production, directly and through its linkage effects on other sectors of the economy. At present, uranium production is expected to resume its upward trend by 1985, with a third mine coming on stream in 1986. In addition, some independent growth of gas oil consumption for thermal power generation will occur, particularly in the isolated provincial centers and as a result of planned capacity additions at Goudel in 1984 and 1986 (para 6.10). Accordingly, total petroleum

7/ Based on a per capita wood consumption of .75 m^3/year, cooking on a three stone fire (8% efficiency); populations of 61.4, 351.45, 39.9, and 78.1 thousand people; and c.i.f. prices of 123.14, 117.78, 126.6 and 123.14 CFAF/liter for Maradi, Niamey, Tahoua, and Zinder, respectively.

product consumption is projected to grow by 2.4% a year during the 1982-1985 period, and by 5.3% a year from 1985-1990 (Table 3.2). These projections include substitution of kerosene to meet fuelwood for the cooking needs of 15% of the populations of Maradi, Niamey, Tahoua, and Zinder in 1985 and 40% of the populations of these cities in 1990, but do not allow for a planned 300,000 tpa cement plant whose economic justification is doubtful at this stage.

Table 3.2: PETROLEUM PRODUCT CONSUMPTION, 1982-90
('000 toe)

	1982 (Provisional)	1985	1990	Growth Rate, % p.a. 1982-85	Growth Rate, % p.a. 1985-90
Gasoline	45.1	51.6	61.3	4.6	3.5
Kerosene	5.0	8.5 a/	17.3 a/	19.3	15.3
Gas/Diesel Oil	85.4	85.5	186.8 b/	0.0	16.9
Fuel Oil	3.5	3.8	4.5	2.8	3.5
Total	139.0	149.4	193.5	2.4	5.3

a/ Allows for substitution of kerosene for fuelwood in cooking by 15% of the population of Maradi, Niamey, Tahoua, and Zinder in 1985 and 40% of the populations of these cities in 1990, assuming: (1) a total population for these cities of 564,100 in 1983, with a growth rate of about 6.3% for 1983-1990; (2) a per capita wood consumption of .75 m^3/year, cooking on a three stone fire (8% efficiency); and (3) use of a kerosene stove with 36% efficiency.

b/ Of which 106,800 toe for power generation; allows for 10,000 toe for the third uranium mine (SMTT) as from 1986.

Source: GPP and Bank staff estimates.

Petroleum Product Supply

3.7 The Ministry of Commerce and Transport (MCT) supervises the importation, distribution, and pricing of petroleum products. The parastatal company SONIDEP has the monopoly on importing all petroleum products except for fuel oil and butane. SONIDEP buys in the international market, although state-to-state agreements involving purchases of crude to be processed elsewhere have been known in the past. Since the commissioning in 1981 of the Kaduna refinery in northern Nigeria, increasing quantities of product imports have been supplied by that refinery; the balance -- again mainly of Nigerian (Port Harcourt refinery) origin -- continues to come in through the port of Cotonou in Benin. Cotonou supplies the western (Niamey) part of Niger, Kaduna/Kano the eastern part

(Maradi, Zinder), the dividing line between the two supply areas depending on relative transport cost. Other possible sources of supply include Togo (via the established supply route to Upper Volta) and Algeria. The Government of Niger has set a requirement for stocks of petroleum products equal to 72 days' worth of average consumption. The current stocking capacity amounts to 30 to 35 days' worth.

Recommendation

3.8 In spite of Niger's landlocked position, its supply of petroleum products supply is assured by a number of possible sources. The mission therefore recommends that the Government lower the requirement for stocks to cover 30 days' demand, rather than invest in expanding the stocking capacity and acquiring the extra supplies themselves.

3.9 SONIDEP supplies the network for distributing petroleum products in Niger, which consists of Total, Shell, BP, Mobil and Texaco. These companies, which together form GPP (Groupment Professional du Petrole), themselves import most of the small amounts of fuel oil consumed (about 2,800 toe in 1981), while another private company, NIGERGAZ, imports and distributes the insignificant quantities of butane consumed (about 500 toe in 1981). The MCT authorizes other imports of petroleum products by private companies, but only to supply isolated areas or, in the case of fuel oil, to directly meet the company's own needs.

Petroleum Exploration

3.10 The surface geology, geophysics, and drilling to date have demonstrated the presence of various rift basins in Niger of different sizes, depth, and sedimentary fill. The largest and deepest of all these rifts is the Agadem basin which extends over a length of 600 km in the east of the country, with an overall width of nearly 300 km. A considerable thickness of sediments, in excess of 6,000 m, has accumulated in the central part of the basin. There are several other rift basins, including the Bilma basin in the northeast, but they are smaller and shallower than the Agadem basin.

3.11 Exploration to date has focused on the Agadem basin in the southeast which offers possibilities for discovering hydrocarbons. The SNEA/EXXON/TEXACO consortium now holds the Agadem permit (about 100,000 km^2) where two wells, Madama and Yogou 1 (drilled in 1975 and 1979/80 respectively), gave oil flows. Test results of Yogou 1, however, suggested the presence of only small reserves - 1 to 2 million barrels, with 300 to 600 bpd producible for a few years - too little to justify appraisal or development in such a remote area. Continued exploration by the consortium led to a new find in the same basin in the Sokhor area towards the end of 1982. By April 1983, three wells were drilled, one of which was dry while the other two produced good quality oil (API 34°). Present indications make it unlikely that this discovery would warrant an export project. It may nevertheless be of great value in exploitation for the domestic market. However, the extent of the reserves would need to be confirmed by drilling at least two appraisal wells. Also, an economic study will have to be carried out to determine the feasibility of developing this discovery. To examine possible refinery options, the study will have to evaluate the market for the domestic oil produced, particularly with respect to the use of fuel oil in power generation.

3.12 From what is known to date, Niger in general and the Agadem basin in particular offer possibilities for further discovery of oil reserves and therefore more exploration is warranted. The Agadem permit expires in early 1985 and it is possible that the present consortium (SNEA, EXXON, TEXACO) or some of its members may wish to renew the contract for at least another three years. Negotiations are under way with the consortium, and the Government has indicated that the drilling of two, and possibly three, appraisal wells immediately on the Sokhor structure would be a prerequisite to renewing the permit. To help the Government promote and accelerate exploration, an advance from a World Bank Project Preparation Facility will finance:

(a) a technical/economic study of the feasibility of developing the Sokhor discovery, including a brief review of the discovery;

(b) assistance to the Government in its current negotiations with the oil industry;

(c) an evaluation of the technical assistance needs of the sector, including the need for and cost of providing experts, equipment, and training; and

(d) an evaluation of the need for and cost of an independent evaluation of the petroleum potential of Niger that would serve as a basis for developing an exploration promotion strategy.

Recommendations

3.13 In view of the high cost of imported petroleum products in Niamey, 8/ the mission supports the Government's urgent consideration of:

(a) the feasibility of appraising and producing the Sokhor find;

(b) the desirability of proceeding rapidly with such a project so that the Government could avoid mobilization and demobilization costs of rig (US$10 million); and

8/ Equivalent in 1982 to US$54 per bbl, net of taxes and distributor's margins.

(c) determining a strategy for petroleum exploration and development.

3.14 The hydrocarbons and coal unit of the Directorate of Energy (DE) of the Ministry of Mines and Industry coordinates oil and gas exploration in Niger. Given the recent developments in the sector, it would be to the advantage of this unit to obtain technical assistance to ensure the successful outcome of its work. The exploration that already has been carried out and probably will be carried out in the coming years by foreign companies requires that the information be properly acquired, understood, and stored by the Government. This information can then be used as a basis for making the independent evaluation of Niger's petroleum potential referred to in para 3.12.

Recommendation

3.15 As mentioned above, a World Bank Project Preparation Facility will evaluate the technical assistance needs of the petroleum sector in Niger. A preliminary assessment indicates that to fulfill its role, the DE will require: (a) assistance for retrieval and storage of data, including new equipment; (b) collaboration of expatriate experts with staff of the hydrocarbons and coal unit on specific well-defined problems; (c) assistance in revising the petroleum law and agreements; and (d) training of Nigeriens in geology, geophysics, economics, and engineering, i.e. two technicians each year for a period of six months each. As shown in Annex 3.1, the total estimated cost of such a three or four year program comes to about US$1 million. The staff of the DE which will have benefitted from this assistance would form the nucleus of a future national oil company, if such a company proves necessary. The cost of the program does not cover a general geological and geophysical evaluation of the basins which would still be necessary before 1985 to give the Government the basic knowledge to develop its future strategies.

IV. COAL AND LIGNITE

Exploration and Reserves

4.1 There has been no systematic exploration for coal or lignite in Niger, as the known deposits were discovered while searching for uranium and water. Coal and lignite exploration falls within the activities of the wholly Government-owned Office National des Recherces Minieres (ONAREM), which is supervised by the Ministry of Mines and Industry, but in practice ONAREM's work in this area has been very limited.

4.2 Coal deposits exist approximately 180 km south of the uranium mines near Anou-Araren, about 1,000 km northeast of Niamey. Measured and indicated reserves amount to 6.4 million tonnes, possible reserves 3.0 million tonnes. The coal is sub-bituminous, with an average ash content of 51% and a calorific value of 3,650 kcal/kg. The total reserves therefore add up to 3.4 million toe. Coal also has been discovered recently in seams of five to eight meters thick near Solomi, about 30 km north of Anou-Araren. Not enough information is available yet to estimate the size of the resource, but based on the samples taken to date, it is of much higher quality (7000 kcal/kg, ash content 14%) than the Anou-Araren coal.

4.3 Numerous isolated lignite discoveries have been made in Niger (e.g. southeast of Tahoua, north of Zinder), but the most promising one is located northwest of Tahoua, about 300 km northeast of Niamey, near Salkadamma. A first evaluation based on limited data suggests probable reserves of 2.6 million tonnes of (average) 30% ash content and 4,000 kcal/kg (one million toe). Additional exploration appears likely to locate further reserves. Of the other lignite discoveries, the indications near Filingue, about 200 km northeast of Niamey, particularly appear to warrant systematic investigation.

Current Uses

4.4 The only current use of coal or lignite in Niger is the burning of the Anou-Araren coal to supply power to the nearby uranium mines. The recently constructed 2 x 18.8 MW (gross) power plant can serve the needs of four uranium mines, the known coal reserves being sufficient to support at least a 30-year operation. The SONICHAR company, of which the Government owns about 68% of the capital, mines the coal, produces electricity at the mine, and sells it wholesale to the power company NIGELEC for transmission and distribution to the uranium mining companies and to the surrounding areas.

4.5 The Anou-Araren coal has substituted for the imported gas oil otherwise burned by the mining companies to generate their own electricity. At the (estimated) 1982 level of SONICHAR's power generation, the import savings amounted to about 26,000 toe, or about 20% of Niger's total petroleum product consumption in that year. These savings will increase if and when uranium production resumes its upward movement. Unfortunately, with the recent decline in both mining activities and real petroleum prices, the very costly investment in SONICHAR's coal-fired power plant has turned out to be uneconomic, though it appeared justified when the investment decision was taken. In terms of foreign exchange, SONICHAR's debt service is expected to roughly offset savings on the oil import bill at least until 1990.

Prospective Uses

4.6 There are no uses for Anou-Araren coal in industry at this time. The coal is not suitable for use in Niger's cement factory or for generating industrial process heat in general because of its excessive ash content and the high cost of transporting it to potential consumers in the south of the country. Although these transport costs might be reduced by using the spare capacity of the 95% of the trucks returning empty from the uranium mines (para 7.5), the ash content would still present a significant problem. For household cooking with this coal, there is an additional difficulty in that burning it releases noxious tar fumes, ruling out its use in closed rooms. Pre-coking would eliminate the contaminating tar contents but also raise the coal's ignition temperature to more than 1000°C, seriously impairing its suitability as a fuelwood substitute. Given the limited work done on the subject to date, further studies are needed to determine the feasibility of using Anou-Araren for household purposes.

4.7 In the absence of data on the quantity, quality and cost of developing the Solomi coal, it is not yet possible to envisage its possible uses. However, preliminary tests of briquetting and burning it in a special stove have shown positive results from a technical point of view. The Government of Niger has made a request to the Government of Japan for technical assistance in evaluating the workable deposits and defining the technology for preparing and using this coal, principally for residential needs. This project would cost about CFAF 450 million (US$1.3 million) and consist of two phases. Phase 1 would comprise drilling to determine the boundaries of the deposit, analysis of the drill cores and technological studies concerning the preparation and combustion of the coal. Depending on the results of Phase 1, Phase 2 would cover feasibility studies of exploiting this coal for local and regional uses and of a compacting plant to produce briquettes.

4.8 More information also is needed on the quality and quantity of lignite occurrences at Tahoua (Salkadamma) and near Filingue to determine their possible uses. A preliminary analysis of the Tahoua lignite suggests that it is probably suitable for use in the cement industry as a substitute for gas oil, and that it should also be suitable for power generation. A rough estimate of the Tahoua lignite mining costs (open-cast, soft overburden) works out at about CFAF 3,500/t (1982 prices), assuming the reserve potential is large enough. At a transport cost of CFAF 27/tkm and a distance of 630 km, the cost in Niamey would be about CFAF 20,500/t of lignite, or CFAF 52,300/toe. Compared to the 1982 cost of CFAF 143,410/toe of gas oil c.i.f. Niamey, Tahoua lignite would cost only about 40% as much. Because of differences in transport cost, this comparison would be even more favorable in terms of delivery at the cement factory of Malbaza, only 200 km away from the lignite deposits. Although the Tahoua lignite is of lower quality than the Solomi coal, the possible use of Tahoua lignite for power generation should receive priority attention because it lies close to the region where electricity demand grows the fastest.

4.9 The Tahoua lignite also seems to be a promising substitute for fuelwood in that it has no detrimental tar contents, it ignites relatively easily and burns with a stable flame. The quantities required for preparing meals have not been determined yet but, based on such tests of Anou-Araren coal, may be assumed to be 4 kg of lignite and 0.4 kg wood chips for two meals per family a day. The probable resources of 2.6 million tonnes of lignite thus could supply 200,000 families in Southern Niger (corresponding to 20% of the total population of one million families) for a period of about eight years. Given the further advantage of relatively low transport costs, the Tahoua lignite could be supplied to final consumers in Niamey at an estimated cost of CFAF 25/kg 9/ and would be very competitive with fuelwood (Table 7.3).

Recommendations

4.10 The mission recommends the following measures:

(a) with respect to lignite:

(i) an immediate, systematic exploration drilling program for firming up the lignite reserves at Salkadamma/Tahoua and a reconnaissance program in the Filingue-Salkadamma area, the latter to be followed by an exploration program if it yields positive results. These programs are estimated to cost US$850,000, as shown in Annex 4.1;

(ii) combustion tests to determine the quantities of lignite (and kindling material as necessary) required for preparing typical meals in Niger. These tests should be integrated with the development of improved cooking stoves which, if at all possible, also should be able to handle other

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9/ 20.5/kg c.i.f. Niamey plus about 20% retail margin.

fuelwood substitutes (para 2.21). Combustion tests should also be carried out to define the potential for using lignite in industry and power generation;

(iii) studies of the demand for lignite as a fuelwood substitute and in industry and power generation in order to provide a reliable basis for estimating the mining cost, which would depend critically on the scale of mining operations to be envisaged.

(b) with respect to coal:

(i) In evaluating the workable reserves of the Solomi coal and defining the technology for preparing and using this resource (para 4.7), ensuring that the costs of producing, transporting, preparing and utilizing the coal (e.g. the cost of producing stoves for residential use) are analyzed as a function of a study of the demand for this coal as a substitute for fuelwood or for use in industry and generating electricity.

4.11 The only organizations currently involved in the coal sector are SONICHAR, which focuses exclusively on mining Anou-Araren coal for power generation, and ONAREM, which has engaged to a very minor extent in exploration for lignite. As mentioned in para 3.14, the hydrocarbons and coal section of the Directorate of Energy (DE) has been preoccupied with oil and gas exploration in Niger.

Recommendations

4.12 Given the work which needs to be carried out on lignite and coal (para 4.10), a central unit needs to formulate and regularly update a general strategy for exploration and development, and coordinate its implementation as well. To this end, the mission recommends strengthening the DE's hydrocarbons and coal unit through the services of a visiting coal/lignite specialist. As described in Annex 4.2, such a specialist would help the unit coordinate the activities recommended in para 4.10 to determine the best possible uses of the coal and lignite, given the quantities found to be available and their quality. The specialist's services should extend over a period of three years and cost about US$210,000. If the lignite exploration, combustion tests, and demand studies indicate that it could be extensively used by industry or in households, a corporation should be set up to produce and commercialize the lignite. The same corporation should commercialize Solomi coal, if the proposed tests and studies show that its extensive use is economically feasible.

V. RENEWABLE ENERGY

Solar Energy

5.1 Given its latitude and climate, Niger is a country very rich in solar energy, with an average of 3,200 hours of sunlight per year, the average daily duration of sunlight varying from 8.5 to 9.5 hours. Data on solar insolation are limited, but average values of total (direct and diffuse) radiation on a horizontal surface available for the south of the country range from 5.6 to 6.3 $kWh/m^2/day$, i.e. 170 to 200 $kgoe/m^2/yr$. Therefore, purely from a standpoint of resource availability, Niger can deploy a variety of solar thermal and solar photovoltaic devices to produce thermal, mechanical, or electrical energy for a number of end uses.

5.2 A semi-autonomous state organization, ONERSOL (Office National de l'Energie Solaire), was founded in 1965 to carry out applied research in solar energy, including the study of existing and possible future types of apparatus for using solar energy, and especially the development of its own prototypes of solar apparatus. In 1975, its charter was expanded to include the manufacture and marketing of solar equipment. ONERSOL comes under the control of the Ministry of Higher Education and Scientific Research and its Board of Directors, chaired by the Minister of Higher Education and Scientific Research, is composed of the ministers of seven other Nigerien ministries, the Director of the BDRN, the Director of INRAN, and the Secretary General of the National Workers Union. ONERSOL's research section has recently moved into a new building, while retaining its old laboratory, machine shop, storage space, and equipment. The manufacturing and marketing section has been formed into a separate company, SONIEN (Societe Nigerienne des Energies Nouvelles), as discussed below (para 5.25).

5.3 Seeking to establish an adequate solar data base, ONERSOL has been taking solar insolation measurements at Niamey, Agadez, and Zinder since 1966. However, these measurements have not been adequately processed and stored. Furthermore, ONERSOL has not coordinated these efforts with those of the national weather service, the Meteorologie Nationale, which has received help from AGRHYMET, the Center for Applied Agriculture and Hydrological Meteorology run by the WMO, in collecting insolation and wind speed measurements throughout the country.

Recommendation

5.4 As the lead institution for solar energy, ONERSOL should provide the necessary technical assistance to the Meteorologie Nationale to ensure the quality of solar insolation data, and interpret and store the information which the meteorological service collects.

5.5 To date, ONERSOL's work has focused mainly on solar-thermal pumps, solar water heaters, solar furnaces, and solar cookers. With respect to photovoltaic panels, twenty-two of them at ten watts each are used to power television sets for schools in Niger, and there are plans to use panels to power small telecommunication stations, but ONERSOL's own research on their application is for the moment limited to a crop drying experiment. The limited current information suggests a significant need for small, low-lift pumping systems at sites along the River Niger and in locations with aquifers at shallow depths. Most of these sites now being irrigated use diesel or gasoline driven pumps. ONERSOL has not sought to apply photovoltaic cells to this type of irrigation pumping, but rather has concentrated on solar-thermal pumps and is now working on a 10-kW unit of the SOFRETES design at Karma, on the Niger River about 50 km north of Niamey. Although the absence of records on the pumps makes it difficult to assess its performance, its cost is very high (US$45,500/kW) and it requires continued and intensive maintenance. Two French engineers work at the site full time to keep the pump working. In general, such pumps are not cost-effective in various locations in Africa where they have been installed. The cost of photovoltaic cells, US$9,000-11,000 per panel kW in 1982, excluding the "balance of system" costs, is very high relative to that of diesel generators and, in particular, prevents their immediate use in irrigating areas larger than one hectare. However, some applications of the panels (e.g. livestock watering, irrigation of one ha landholdings, educational television) may be competitive today in certain locations. The cost of the panels is expected to decrease enough by perhaps 1988 to make them more cost competitive with diesel generating systems for other applications, in particular, for irrigating some of the sites mentioned above which require small, low-lift pumping systems.

Recommendation

5.6 The mission recommends initiation of a research program to study the technical and economic feasibility of mini-photovoltaic systems for lighting, refrigeration and small scale pumping in isolated centers.

5.7 ONERSOL's largest research and development effort has been in the design, fabrication, and testing of a solar water heating system. The smallest size system has a 200 liter storage tank and 2 m^2 of flat plate collector area. The system has no pump. Instead, water circulation is brought about through thermosiphoning. The stated peak efficiency is 60%, but one would expect the actual daily average efficiency to be much lower. The water heaters are manufactured, mostly from imported materials, at ONERSOL's factory in Niamey (400 units p.a. capacity). Currently 550 of these systems are installed in Niamey, and this appliance has accounted for most of ONERSOL's sales. Unfortunately, a marketing study which concluded that 300 of these systems a year could be sold in Niger proved overly optimistic. Given the relatively high cost of the water heaters (about US$535 for the 200 liter system) for the average Nigerien family, only the most affluent families and Government ministries (by a 1975 law) have had them installed. Sales have declined from a peak of 80 units in 1980/81 to 60 in 1981/82. The domestic market appears to be nearly saturated, even though the systems are already sold at a loss, production costs adding up to about US$570. There is a potential foreign market in the larger West African cities, but transport costs would probably significantly reduce the appliance's marketability there.

5.8 Industrial uses for the solar water heaters have not been thoroughly explored. Based on preliminary data on energy consumption in Nigerien industry, and assuming a 20% solar penetration of the potential market, an estimated 340 toe of petroleum products (mainly gas oil) could be replaced by solar energy each year, specifically in the textile and brewing industries. This comes to 20% of industry's estimated direct consumption of gas oil in 1981.

Recommendations

5.9 The mission recommends:

(a) evaluating the potential for solar water heating in industry; and

(b) depending upon the results of this evaluation, installing existing solar water heaters at a brewery in Niamey as a pilot demonstration project to show the applicability of solar water heating to that industry. Such a project would cost about US$25,000 and require one and a half years, including construction time and a period of testing and evaluation.

5.10 ONERSOL also has been working on a solar furnace consisting of two heliostats, a 100 m^2 parabolic reflector, and a central structure to house the oven cavity. Construction has been halted because of a shortage of funds. The furnace is designed to displace petroleum products in the brick and cement industries. A solar furnace could reach the necessary temperatures, but the estimated capital cost of the system (US$150,000 for 35 kW peak energy) is too high to justify its use at present.

5.11 ONERSOL has experimented with a solar cooker as an alternative to wood-burning stoves. The cooker consists of a parabolic reflecting dish 1.5 meters in diameter, made of an aluminium reflector glued to a fiberglass and epoxy backing. At the focal point of the reflector stands a platform on which to place the pot. This solar dish sells for about 25,000 CFAF (US$75) but has few takers so far. The price is too high for most Nigeriens, and the design is not adapted to traditional Nigerien cooking.

Recommendation

5.12 The mission recommends that ONERSOL discontinue work on the solar furnace and critically review its program on solar cookers. If cost effective solar cookers which are suited to Nigerien cooking needs cannot be developed, the program should be discontinued.

Biomass Other Than Wood

5.13 In 1979/80, Niger produced an estimated theoretical maximum energy potential of 1.32 million toe in crop residues, but given competing uses, (animal fodder, construction materials, fertilizer) only about 2% (32,300 toe) were available for energy uses (Annex 5.1). The estimated theoretical maximum energy potential for animal waste in 1979/80 was 900,000 toe, which reduces to 400,000 toe when animals in roaming herds are excluded (Annex 5.2). As in the case of crop residues, probably only a small fraction of even this figure can be used for energy conversion because of technical, economic and social constraints.

Groundnut Shell Briquettes

5.14 Other than the unknown amounts of crop residues and dung burned for cooking in areas of severe fuelwood shortages, the largest quantity of biomass energy produced and consumed in 1980 and 1981 was in the form of groundnut shell briquettes. At a cost of 26,100 CFAF/tonne in 1981/82 (Annex 5.3) and a calorific value of 4,500 kcal/kg, these briquettes appear attractive as a substitute for gas oil and fuelwood. In 1980/81, SONARA, which has a monopoly on the commercialization of Niger's groundnut crop, produced 336 tonnes of briquettes in its two press compaction plant (5,000 tpa capacity) in Dosso. SONARA can only attract 1% to 2% (1,200 to 2,400 tonnes) of the total groundnut crop, which currently amounts to about 120,000 tpa. The total crop would give about 39,000 tonnes of briquettes (17,000 toe). Farmers obviously find it more profitable to dispose of the groundnuts themselves, including exporting them to Nigeria.

5.15 To date, the SONICERAM brick factory and the SICONIGER groundnut oil refinery have been the only industrial clients for SONARA's briquettes. The 1980/81 cost of briquettes c.i.f. Niamey in calorific terms amounted to about 40% of that of gas oil - CFAF 59,200/toe vs. CFAF 143,400/toe. This cost would certainly be even more attractive at full capacity utilization of SONARA's plant. Since then, the brick factory has acquired a new unit which runs on fuel, so it no longer uses the briquettes. Despite its efforts, SONARA has great difficulty in convincing industrial enterprises to substitute these briquettes for gas oil, largely because these enterprises question the reliability of supply of the briquettes.

5.16 Given the limited success it has had with industrial enterprises, SONARA now is concentrating on use of the briquettes as a cooking fuel. Assuming that all the groundnut shells of the 1980/81 crop had been compacted into briquettes, the 17,000 toe thus available would have represented only 2% of the total national consumption of fuelwood in

1981. However, these 17,000 toe would have represented 35% of the 1981 fuelwood consumption in Niamey. Groundnut shells thus could alleviate the fuelwood shortage where it is the most serious. An improved stove with a chimney needs to be designed to eliminate the smoke the briquettes give off when burned in a three-stone fire, and thereby make this cooking option more attractive to households.

Recommendations

5.17 The mission recommends a study to define a specific action program to promote the use of groundnut shell briquettes for residential needs. This study should be carried out jointly with the development of an improved stove which is suitable for both these briquettes and wood. It would be particularly appropriate to examine the possibility of burning the briquettes in a stove model adapted from the "Ouaga stove" discussed in para 2.21.

Other Crop Residues and Animal Wastes

5.18 Other crop residues and animal wastes presently are used as energy only for cooking in areas of severe fuelwood shortages, but there is an effort being made to convert them to biogas. Two approaches are being pursued: fermentation of crop residues and manure on farms, and fermentation of animal waste at slaughterhouses.

5.19 INRAN (Institut National de la Recherche Agronomique au Niger), together with the French agronomy institute within GERDAT, is carrying out an experimental project at Lossa to produce biogas from crop residues and oxen manure. The methane runs a modified diesel engine to pump water for irrigation and to grind millet into flour. To properly assess the economic viability of such biogas installations, data on cost in general and operation and maintenance in particular need to be studied in greater detail.

5.20 Producing biogas at a slaughterhouse is potentially more economic than on farms because there is more substrate concentrated in one location and also because the slaughterhouse itself presents numerous immediate uses for the energy derived. GERDAT is already pursuing a biogas project at the Niamey slaughterhouse, where a pilot mini-digester is now operating. The operation should be working full scale next year, with the methane replacing diesel fuel for steam raising and the sludge being used for fertilizer in Niamey gardens. Biogas from slaughterhouses can also be used to generate electricity in areas not hooked up to a power grid, with the sludge used either for fertilizer or as a substrate for animal feed.

Recommendations

5.21 Ongoing experimentation with bio-digesters should be continued, with the emphasis on cost-effectiveness and replicability on a practical scale. In particular, biogas projects in other slaughterhouses should be considered, building on GERDAT's experience in Niamey.

Wind, Small Hydro

5.22 Niger's wind resource is very poor, maximum speeds reaching only 3.9 m/s, at Tahoua. Even this speed is only marginally suitable for water pumping and completely inadeaquate for pumping electricity. Although no accurate figures on small hydro availability are obtainable, this resource also seems to have only a limited potential. A few sites are being studied for small dams for irrigation purposes, but these probably cannot supply electricity as well. Therefore, additional research into either wind or small hydro is not a priority at this time.

The Organizational Framework for Renewable Energy Activities

5.23 The multiplicity of government, private, and international organizations working on renewable energy results in a lack of planning which, along with a lack of economic analysis and market studies, constitutes the main weaknesses of renewable energy activities in Niger. With respect to groundnut shell briquettes, the Ministry of Planning, the Ministry of Commerce and Transport, and the Ministry of Hydraulics and of the Environment address the question of boosting production of the groundnuts themselves, while SONARA deals with the production and marketing of the briquettes. With respect to biogas, in addition to the work of INRAN, GERDAT, and the Niamey slaughterhouse, ONERSOL is planning a small project similar to INRAN/GERDAT's to be carried out by the University of Niamey.

Recommendations

5.24. (a) The mission supports the proposal made by the Directorate of Energy to the Ministry of Higher Education and Scientific Research, the supervising ministry of ONERSOL, that ONERSOL expand the scope of its work and act as the focal point for all efforts related to renewable energy in Niger. ONERSOL should take the lead in formulating an overall strategy for developing Niger's renewable energy resources and coordinate the activities of the agencies already involved in this work. To facilitate this coordination, ONERSOL's Board of Directors should be drawn from these agencies and, given the MMI's supervisory role with respect to major energy sector organizations, ONERSOL's Director should report directly to this Ministry rather than to the Ministry of Higher Education and Scientific Research.

(b) ONERSOL should seek primarily to adapt known technologies whose commercial value has been proven in other countries and/or which are likely to be cost effective in Niger. For example, it should carry out the research program proposed in para. 5.6, to study the technical and economic feasibility of using in isolated centers photovoltaic mini-systems already available on the international market. Given the seriousness of the fuelwood shortage, ONERSOL laboratories should also support the development of improved wood and appropriate kerosene stoves (para 2.21) and assist the consultants in their comprehensive study of the comparative prices of energy for cooking (para 7.24). Once ONERSOL's exact role has been determined by the Government, it will be necessary to define technical assistance in terms of training and equipment required by ONERSOL to manage its work program. Particular attention should be paid to the lack of overall planning, engineering, economic analysis and market study capabilities in ONERSOL.

5.25 As mentioned above (para 5.2), ONERSOL's manufacturing and marketing division has been separated from its research division to form SONIEN. The Government currently holds most of SONIEN's capital, but envisions gradually opening it up to the private sector. The Center for Industrial Development (CDI) in Belgium has been asked for assistance to carry out a complete feasibility study of SONIEN. Specifically, the study will address SONIEN's potential product line, market prospects, financial viability, etc. CDI would solicit the participation of companies which are interested in the venture and which would also participate in the feasibility study. An agreement is to be established between ONERSOL and SONIEN under which ONERSOL could propose prototypes to SONIEN, and the latter could ask ONERSOL for specific studies.

Recommendation

5.26 The mission supports the formation of SONIEN and believes full consideration should be given to its producing a wide variety of energy related apparatus. Furthermore, the mission supports private participation in SONIEN and recommends that it be turned into a strictly private sector operation.

VI. ELECTRIC POWER SUBSECTOR DEVELOPMENT

6.1 This chapter concentrates on the past and projected growth of electricity demand and the associated development of the public supply system. Conservation and pricing issues are discussed in Chapter VII.

Growth of Demand

6.2 Spurred by the uranium boom, gross electricity consumption 10/ in Niger more than tripled over the 1974-1982 period, to 183 GWh for NIGELEC's public supply system alone, and 256 GWh in all (Table 6.1, Annex 6.1). The most rapid growth occurred from 1977-80 when public system consumption increased by 26% p.a. and that of the uranium mines by 36% p.a. Reflecting the subsequent decline in uranium mining activities, demand growth has decelerated since then and become negative for the mines themselves. Even so, consumption by the public system grew by 11% p.a. during 1980-82 and by 8% in 1982 over the previous year. While Niamey continues to account for the bulk of public system consumption -- 70% in 1981 -- the provincial centers have been catching up fast, nearly sextupling their consumption since 1974 to a share of 30% in the 1981 total. Reflecting the rapid growth of air conditioning, particularly of government office buildings, power demand in Niamey grew more rapidly than energy demand, which is reflected in the drop in load factor from roughly 51% to 46% between 1975 and 1980. In 1982, peak demand in Niamey had reached 36 MW, i.e. more than three times the peak registered in 1974 (11.2 MW), and somewhat higher than the sum of all peak demands of the public systems in 1981 (34.4 MW).

6.3 The pattern of electricity consumption by the public system remained unchanged between medium voltage (MV) and low voltage (LV) consumption (Annex 6.2): MV accounted for 55% of the total in both 1974 and 1981, and LV for the remaining 45%. However, in the MV category, the share of public administration rose to 33% from 29% in 1978 while that of private consumers declined. This trend will probably reverse itself once the public construction boom has run its course and the level of economic activity increases again. In the LV category, the near doubling of consumption between 1978 and 1981 by the special tariff category, i.e. small consumers, points to the potential for further demand growth as power supply becomes more widely available, particularly outside Niamey.

10/ This is actually gross electricity supply, i,e. generation plus purchases by NIGELEC, used here as a proxy for electricity sales to consumers, statistics for which are deficient.

Table 6.1: GROSS ELECTRICITY DEMAND, 1974-1982 a/
(GWh)

	1974	1977	1980	1981	1982	Growth Rates, % p.a. 1974-77	1977-80	1980-82
Niamey	50.8	64.3	107.9	118.3	n/a	8.2	18.8	n/a
Other Centers	8.5	21.1	41.7	50.6	n/a	35.4	25.5	n/a
NIGELEC Public System	59.3	85.4	149.6	168.9	183.2	12.9	20.5	10.7
Uranium Mines	18.8	38.4	95.7	87.0 b/	73.0 d/	26.8	35.5	-12.7
Total	78.1	123.8	245.3	255.9	256.2	16.6	25.6	2.2

a/ Actually, gross electricity supply, i.e. generation plus purchases by NIGELEC, plus autogeneration by the uranium mining companies (until 1981). Used here as proxy for electricity sales to consumers.
b/ 42 GWh supplied by NIGELEC plus an estimated 45 GWh of autogeneration.
c/ Preliminary
d/ NIGELEC supplies only. Remaining autogeneration insignificant.

Source: NIGELEC, Mining Companies.

Demand Projections

6.4 Of the several power demand projections made for Niger in recent years, particularly in the context of feasibility studies of the Kandadji hydro project, the mission has retained those underlying the 1982 tariff study prepared for the Ministry of Public Works (Table 6.2). While these projections are fairly summary, they provide a rough estimate of the magnitude of load growth and its structural change up to 1990. The 1980-90 growth rate projected for the public system as a whole is similar to that observed over the 1970-80 period, about 14% p.a. Given the very low level of electricity consumption in Niger at present, continued high growth rates seem reasonable. Demand in other centers as a group is projected to grow faster (16.6%) than in Niamey (12.4%) but more slowly than in the previous decade, at the beginning of which supply outside Niamey amounted to just 5 GWh in all. Energy demand by the uranium mines will level off, once the two additional mines planned for development between 1985-1990 have come on stream. As a result of these projected trends, the mines' share in total electricity consumption would drop from 39% in 1980 to 22% in 1990. Niamey, on the other hand, would increase its share from 44% to 50%, and that of other centers would grow the fastest, from 17% in 1980 to nearly 28% in 1990.

Table 6.2: PROJECTIONS OF GROSS ELECTRICITY CONSUMPTION, 1980-1990 (GWh)

	1980	1985	1990	Growth Rates, % p.a. 1980-90	1970-80
Niamey	107.9	210	350	12.5	12.4
Other Centers	41.7	92	193	16.6	22.9
NIGELEC Public System	149.6	302	543	13.8	14.5
Uranium Mines	95.7	151	157	5.1	..
Total	245.3	453	700	11.1	33.6

Source: Ministere des Travaux Publics et de l'Urbanisme, Etude de la Tarification de l'Electricite au Niger, Ingenieurburo Oskar von Miller GmbH, December 1982.

6.5 More detailed and longer range power demand projections are needed to define a long term power sector investment program. They should include the relevant price and income elasticities of electricity demand and probabilistic assumptions on alternative growth scenarios. The power system development study mentioned above will develop such projections to 1990 for the secondary load center -- existing and new ones -- and to the year 2020 for the Niger Valley interconnected system.

Electricity Supply

6.6 Public electricity supply is now concentrated in the Niger Valley system linking Niamey, Dosso and Tillabery, and for the rest, is scattered over about a dozen provincial towns along the Nigerian border and the towns of Agadez and Arlit in the North. Based on 5.5 persons per household, it is estimated that in 1980 31% of the population of Niamey had access to electricity. For the other major urban centers of Zinder and Maradi, about 31% and 24% of the population is served, respectively. On a national basis, only 3.3% of the population has access to electricity; this is one of the lowest percentages in the world.

6.7 As of September 1982, the serviceable generating capacity of NIGELEC totalled 49 MW. The largest station is Niamey II, comprising four diesel units of 3 MW and two 12-MW gas turbines, for a total installation of 36 MW. The remaining 13 MW is made up by 54 high-speed diesel units distributed over various provincial towns and ranging from 25 to 1100 kW capacity.

6.8 Actually, most of the load of the Niamey-Dosso-Tillabery system is supplied from the Nigerian interconnection over a single circuit 132 kV line. Because the interconnection supplies non-firm power, it is NIGELEC's policy to maintain sufficient capacity to meet the peak in Niamey with zero reserve in case of a line outage. The rapid load growth in recent years combined with financial constraints have caused occasional capacity deficits. As the peak in Niamey in May 1982 was 36 MW at a time when the installed capacity was 24 MW, a line outage would have seriously disrupted service.

6.9 As a source of fuel displacement energy, the NEPA interconnection is operating satisfactorily, as evidenced by the low proportion of the Niamey load supplied by local generation (1978-29%, 1979-11%, 1980-2.2%, 1981-5.0%). However, the need for back-up capacity or reinforcement of the interconnection is clear from the nature of some recent interruptions:

1982 - one week total outage because of NEPA strike;

1981 - three week outage because of faulty circuit breaker at Birnin Kebbi; and

1979 - four week outage because four towers in Nigeria were toppled in a storm; damage was repaired with NIGELEC assistance.

NIGELEC has installed protective equipment to operate the Niamey II generating plant and the interconnection in parallel, if required.

6.10 Niamey City is supplied from the Niamey II substation (8 feeders, 15 kV) and the Goudel substation on the northwest, which is also the site of a planned new power station (4 feeders, 20 kV). NIGELEC has decided to standardize on a 20-kV primary distribution voltage, which will require the installation of a number of 15/20 kV autotransformers in the city. Connection charges are relatively high. Prospective customers pay all these charges, which in early 1980 ranged from FCFA 65,000 ($315) for a single phase 6 kW connection to FCFA 200,000 ($965) for a three-phase 10 kW connection. In 1982 connections of less than 1 kW to low-income customers cost FCFA 30,000 (US$110). However, for small consumers, one-third of these charges are due in the form of a down payment, with the other two-thirds payable in installments over five years. Demand therefore tends to be restrained not so much by high connection charges, but rather by the lack of distribution networks.

6.11 Among other load centers many small diesel units are moved around as required, with the aim of gradually rationalizing the supply by standardizing unit sizes, stocks of spare parts, and optimizing fuel consumption. After the addition of the planned two 1,100 kW units, Malbaza probably will become the central supply of a future Konni-Madoua-Tahoua (KMT)-Malbaza subsystem.

6.12 The reliability of supply appears to be fair except where some localized distribution problem exists. The problems in the distribution system can be judged from sales statistics and apparent loss percentages, with particular reference to 1979 and 1980. One would expect most problems in the smaller isolated load centers, but the contrary appears to be the case (see Annex 6.3). Many of the smaller centers report losses of 6-15%, a quite plausible range, whereas in the larger centers they go up to 25-30% (Zinder) and 20-30% (Maradi), 20-34% (Agadez) and 10-22% (Niamey). In Niamey, reported sales in 1979 were about the same as in 1978, while generation plus purchases increased by 14.3%. Such high apparent losses point to inadequate billing and power theft. Long delays in reporting and compiling data are probably also responsible for errors going undetected. A survey of connections (for both water and power) has just been completed under the 1983 IDA Water Supply Credit and should shed some light on the problem.

6.13 In the mining district, the loads of the mines and the adjacent mining towns of Arlit and Akokan were supplied until 1981 by captive power plants of SOMAIR (7.2 MW) and COMINAK (13.5 MW). To replace imported gas oil by the nearby Anou-Araren coal, the Societe Nigerienne de Charbon (SONICHAR) built a coal-fired steam plant of 2 x 16 MW (net) capacity which has taken over the supply of the mining district since then. This plant is also designed to supply the needs of two additional mines originally planned to come on stream by 1985, but because of the current slump in the world uranium market, at least one of the mines has been deferred until later. As a result, only half of SONICHAR's capacity is actually used since there is no alternative use for the power, the cost of a transmission line to the Niger Valley system being prohibitive. In any event, the supply of energy to the mining district appears to be assured for many years to come.

Supply: Options for Expansion

Hydro Resources

6.14 The Niger River traverses the western-most part of the country, entering Niger from Mali, flowing southeast for 420 km, and then forming the border with Benin for another 140 km before reaching Nigeria. It is Niger's only major water resource, and the flat gradient and the topography of the Niger Valley limit the possibilities for hydroelectric development. Two sites have been identified: (1) Kandadji (125 MW), located at the river's entrance to Niger, about 200 km upstream from Niamey; and (2) W (105 MW), about 120 km downstream from Niamey. 11/ A third site, Dyodyonga (26 MW), is of interest; it is located on the

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11/ W is so named because of the shape of the river's meanders at that location.

international stretch of a tributary to the Niger River, the Mekrou River. Table 6.3 summarizes the technical characteristics and costs of these projects.

Table 6.3: HYDRO RESOURCES

	Kandadji Stage I Dam Crest 228	Kandadji Stage II Dam Crest 241	W a/ Variant 4	W a/ Variant 5	Dyodyonga a/
Installed capacity (MW)	125	105	84	105	26
Average energy capability (GWh/yr) b/	707	751	465	551	82
Costs (billion CFAF) c/					
dam and plant d/	89.0	72.2	62.0	69.8	11.4
transmission and substation	10.8	9.4	6.7	7.2	3.3
resettlement e/	22.2	41.1	10.5	10.5	-
Total	122.0	122.7	79.2	87.5	14.7
(Total $US million)	(420.7)	(423.1)	(273.1)	(301.7)	(50.7)
Investment cost per GWh of average annual energy (US$ thousand)	595	563	587	548	618

a/ Reference datum is Kandadji datum plus 36.07 m.
b/ Delivered at Niamey, after deduction of transmission losses.
c/ Constant CFAF of January 1, 1982.
d/ For W, excludes shipping lock, includes access raod to site.
e/ For Kandadji Stage II, includes CFAF 22 billion in Mali.

Source: For Kandadji, Kandadji Dam. Complementary Studies. Sofrelec, EDF, Sir Alexander Gibb and Partners, March 1982.
For W, Kandadji Dam. Extension of Complementary Studies, Sir Alexander Gibb and Partners, September 1982.
For Dyodyonga, World Bank data and estimates.

Kandadji Stage II would entail flooding in Mali, while the Dyodyonga site is on the border with Benin. Assuming, for illustrative purposes, that all of the additional energy produced by Kandadji Stage II would go to Mali and that one half of the energy produced by Dyodyonga would be used by Benin, the total energy capability of these resources available to Niger would amount to about 1,300 GWh (345,000 toe) for an average hydrological year.

Power Planning

6.15 Because the existing interconnection with Nigeria will be fully utilized for capacity imports by 1984 and for energy imports by 1992, power supply planning for the Niger Valley is the dominant issue in the power sector. The supply problems of the remaining load centers are not complex, but nevertheless deserve careful consideration because it is the isolated centers that will require increasing quantities of imported gas oil.

6.16 NIGELEC's short-term planning for supply to the Niger Valley (until about 1989) is based on the maintenance of sufficient thermal capacity in Niamey to cover the peak, while taking maximum advantage of the interconnection contract with Nigeria to import energy and save fuel expenses. The price of imported energy for the next five years is about to be substantially increased but is still attractive to Niger. NIGELEC has requested an increase of the contract limit from 30 MW to 40 MW (i.e. close to line transfer capacity) and actually already has received deliveries of up to 36 MW (1982). Belgian financing has been secured for the 66-kV transmission line Niamey-Say-Kollo (to be completed in 1984).

6.17 CCCE has agreed to finance a new power station at Goudel comprising three 12-MW medium speed diesel units, of which two units would be installed in 1985, at an estimated cost of US$19.2 million (in 1982 dollars). Because of the standby function of the plant, a case could be made for cheaper gas turbines, but NIGELEC has opted for diesel units in anticipation of the need for complementary thermal power once a hydro plant on the Niger River is in operation.

6.18 The short-term strategy of NIGELEC appears sound. For some time, the longer-term planning has been oriented by the desire of the Government to build the Kandadji Project. The underlying reasons for this preference appear to be much more closely related to security of water supply, irrigation and food production than to energy supply. The Kandadji Project (either first stage or non-raisable) is indeed the only multi-purpose project in Niger. It would permit control of the Niger River, thus facilitating irrigation; it would indeed provide a measure of security of water supply (basically protection against a repetition of the extreme drought of 1974); and it would also be a source of electric power. However, it does not follow from the eventual multi-purpose utilization of the project that it is the most economical. If security of water supply and electrical energy supply were obtainable by different, separate means, at a lower total cost, the scarce resources saved could be employed more profitably elsewhere in the economy. It is therefore essential to examine the hydro alternatives listed in Table 6.3 first by upgrading the project studies to feasibility level, and second by considering the resources in a system context.

6.19 The role of the existing and future interconnection with Nigeria is a prime consideration in any power planning scenario. The long run marginal cost of energy from NEPA is estimated to be about

US$0.05/kWh. After allowing for only partial utilization of additional transmission until the load in Niamey has grown sufficiently, the levelized cost of secondary (non-firm) energy from NEPA delivered at Niamey may rise to US$0.09/kWh. Diesel-generated energy costs about $0.15/kWh, of which $0.117/kWh is fuel expense. The levelized cost of energy from Kandadji (non-raisable), or W would be $0.10-0.11/kWh if either project were commissioned in 1990. Because most of the hydro output of the Niger plants is secondary energy, the economic advantage of the interconnection with Nigeria is obvious. Energy from Dyodyonga would cost about $0.09/kWh, but because of good regulation most of the plant output is primary energy and, therefore, probably competitive with both thermal power and imports.

6.20 Power planning may have to take into account the desire of govenments to maintain a degree of energy independence. In the case of Niger such independence, in the sense of having a firm domestic supply, is difficult to achieve. At present the country relies heavily on imports of both electrical energy and petroleum fuels. The construction of a large hydro plant on the Niger River will make little difference to this dependence, because these run-of-river projects would require back-up by either complementary thermal (using imported fuel oil) or imports of firm energy during four months of the year.

6.21 Despite these qualifications, all available options ought to be examined in devising a least cost program of development. In broad terms, the practical expansion possibilities for the Niger Valley System may be grouped under the following headings:

(a) Continuation of the non-firm imports from Nigeria only up to the physical transfer capacity (41 MW) of the existing interconnection, accompanied by the addition of thermal capacity, first for peaking service and eventually to supply most of the growth in energy demand.

(b) Continuation of the present strategy, i.e. increasing the transmission capacity from Nigeria for non-firm energy supply, while building up thermal back-up capacity in Niamey.

(c) Development of hydro power in Niger (either Low Kandadji or W). The small storage capacity of Kandadji makes little difference to the output in the dry months. Both Kandadji and W will have a seasonal energy production pattern similar to that of the river flow and contribute little to the supply of primary energy. The large supply of secondary energy could be firmed up by complementary thermal power, by firm imports from Nigeria or by electrical integration of the run-of-river Niger plants with the Dyodyonga storage project. Combinations, also are possible, for example, complementary thermal power in Niamey with seasonal non-firm energy imports from Nigeria to limit fuel expenses.

6.22 The supply of secondary load centers would follow a common pattern. Clusters of small towns and villages should gradually be connected by transmission lines and serviced from one efficient diesel plant. The least costly solution may be connection by 20 kV lines (as at Konni-Malbaza-Madoua) but from a longer term perspective it may be preferable to build 66 kV lines initially operated at 20 kV, with substations of 1,000-2,000 kVA.

6.23 The KMT-Malbaza subsystem could be easily connected with the NEPA system at Sokoto and operated in the same manner as the present Niamey system, i.e. maintaining a local plant as standby and importing a maximum of fuel displacement energy. NIGELEC has programmed the interconnection for 1985-86. The capital cost of a 132 kV single-circuit line of 107 km, including terminals, is around US$10 million.

6.24 A power system development study, recently begun under an IDA Power Credit, will examine the various options and their possible combinations with a view to evolving a comprehensive power sector investment program to 2020 for the Niger Valley and to 1990 for the secondary centers.

Organization of the Power Subsector

6.25 The production, transmission, distribution, and sale of electrical energy in Niger is a state monopoly that can be entrusted to a company by concession or other suitable means (Ordonnance 74-31, November 15, 1974). The Societe Nigerienne d'Electricite (NIGELEC), which is responsible for supplying electricity to urban centers, is the only company holding such concessions. However, the State plays a dual role in this concessionary system: that of the authority supervising the management of the electricity concession and, since it owns about 90% of NIGELEC's capital, that of the agency being supervised. The former comes under the jurisdiction of the Ministry of Public Works and Urbanism (MPW) and the latter under that of the MMI. As the act of conceding public domain to an enterprise operating under a private corporate structure belongs to the Ministry of Public Works, the MPW exercises overall control over NIGELEC. It is therefore responsible for standardization, regulation of construction, safety standards, and control of the concessions. In addition, the MPW carries out electrification of new load centers which it then turns over to NIGELEC for operation and upkeep. For its part, the MMI acts for the State as majority shareholder in NIGELEC and as such reviews: (a) NIGELEC'S financial operations; (b) the investment plans for meeting demand growth in the concessions NIGELEC already holds, before such plans are forwarded to the Ministry of Planning; and (c), together with the Ministries of Planning and Commerce, tariff proposals prepared by NIGELEC before these are submitted to the Government for approval. The Minister of Mines and Industry himself acts as chairman of the board of NIGELEC, and as a majority shareholder the State appoints ten of NIGELEC'S thirteen directors.

6.26 According to the 1974 Ordonnance, the State reserves the right to create other agencies for producing electricity. SONICHAR (para 4.4) is an example; it generates power while the transmission and distribution of that power remain part of NIGELEC's concession. Another example, and the third institution involved in the power subsector, is the Kandadji Dam Authority (KDA), an agency of ministerial rank reporting directly to the President of the Republic which aims to harness the Niger River by constructing the Kandadji dam. To achieve this, KDA is charged with seeking financing, the conception and implementation of all the dam construction works as well as the rebuilding of infrastructure and the resettlement of the people concerned. KDA is also charged with the operation and maintenance of the works within its jurisdiction and with all financial operations pertaining to its objective.

6.27 The fact that the State controls NIGELEC, a utility with a private corporate structure, raises questions as to the usefulness of the concession system as applied in Niger, since the system's basic aim, the attraction of private investment capital to the public utility sector, no longer applies. The practical advantage of having a private corporate structure does remain, as it ensures a degree of independence that would not exist if the State-owned company were relegated to the role of a Government department. Such autonomy has usually helped utilities attract competent staff, set realistic rates, and maintain a sound financial standing. In this case, however, the State's role of supervisor and majority shareholder may impair NIGELEC's autonomy and obscure its relations with various Government organisms.

6.28 NIGELEC also operates water supply systems in a number of load centers as a managing agent of the State. Since NIGELEC's power subsector activities have been, in effect, increasingly subsidizing water supply, these two operations need to be separated, with NIGELEC focussing on power and another agency responsible for water supply. The recently approved IDA water supply project (Credit 1309-NIR) is examining the problem in detail, and provides for first strengthening NIGELEC's Water Department and then converting it into a separate water authority. Cooperation between the two subsectors and a pooling of resources in smaller urban centers could continue, but in Niamey and other larger cities a complete separation of operations would seem to be the only way to resolve the financial problems.

6.29 Under the current institutional setup, no agency has taken responsibility for overall, long-term power planning. NIGELEC is concentrating on extending its thermal power supply and the KDA on Kandadji and alternative hydropower development. Clearly, power system expansion planning has to take into account all the relevant alternatives and as such needs to be carried out by one agency.

Recommendations

6.30 The mission supports ongoing efforts to: (a) establish a process and the capability for integrated power system planning, which is being promoted under the IDA Power Credit, (b) establish in due course a separate water supply entity, as provided for under the current IDA water supply project, thus freeing NIGELEC to concentrate on power supply, and (c) study institutional arrangements in the power subsector, also under the IDA credit mentioned above.

Manpower Issues and Training Needs

6.31 NIGELEC's skilled manpower resources are being taxed to the limit. The shortages are most acute among the management and engineering professionals, of which there are only eight out of a total staff 12/ of about 1,000. Similarly, the number of higher level technicians (about 75) appears to be low considering the dispersion of load centers over a vast region. The supply of lower level technicians is better, and should be further improved by the current training of skilled technicians at NIGELEC's Centre de Metier in Niamey. External technical assistance is available in several key departments, and is now providing seven supporting professionals, but these expatriates do not provide continuity to management. Furthermore, there is an absence of academically trained Nigerien counterparts to whom expertise can be transferred for lasting benefits. This situation will be somewhat rectified over the next five years, as there are now 16 Nigeriens being trained as engineers at the Ecole Superieure Interafricaine de l'Electricite near Abidjan. The college provides training in all the technical aspects of electricity supply and in managing a power utility. Students are sponsored by a power utility, where they must work for a specified length of time after graduating. NIGELEC's weakness in skilled manpower seems to be greatest in the management of connections and customer accounts by the Service de Distribution. Planning capabilities are limited to the Service Etudes Generales et Organisation staffed by one expatriate and one Nigerien.

6.32 The mission supports current efforts under the IDA Power Credit to study NIGELEC training needs and come up with a staff development plan. This manpower survey and training component should be coordinated with the manpower development assistance to NIGELEC planned under bilateral aid. The comprehensive power planning study provided for under the IDA credit mentioned above which will be carried out with NIGELEC staff participation should lead to a better understanding of NIGELEC's technical assistance and training needs in this area.

12/ Workers, lower level technicians, higher level technicians, and professionals.

VII. DEMAND MANAGEMENT: CONSERVATION AND ENERGY PRICING

Conservation

7.1 This chapter deals only with the conservation of commercial energy, as fuelwood conservation was discussed in Chapter II. Given the small size of the manufacturing sector in Niger, the prime areas for conserving commercial energy are in transport and air conditioning, particularly of office buildings. The focus here is on conservation through organizational and technical measures. Possible conservation through taxation and rate setting is dealt with in the context of energy pricing (para 7.10).

Transport

7.2 The largest transport enterprise is the Societe Nationale des Transports du Niger (SNTN) with a fleet of about 500 heavy trucks (25t payload, 42t gross weight), 35 inter-city buses and 50 buses for urban transport. SNTN already has achieved significant fuel savings by (a) modernizing its vehicles; (b) instituting norms on fuel consumption and driving time coupled with performance rewards; (c) training in fuel efficient vehicle operation. The combined effect of these measures and certain road improvements over the October 1977-September 1981 period has been a reduction in SNTN's fuel consumption/km by 22% (Annex 7.1). SNTN considers training in fuel efficient driving the most effective means of fuel conservation. Differences of up to 25% in fuel consumption have been observed between different drivers under otherwise the same conditions. Overall, SNTN estimates fuel savings due to driver training alone to be on the order of 16%. Of course, the other elements of its conservation program have facilitated the introduction and implementation of fuel-efficient driving techniques.

7.3 Fuel saving measures remain to be introduced by the other 400 transport operators in Niger, many of whom have only one vehicle and do not even keep accounts. Some operators with several vehicles are trying to take conservation measures but lack competent personnel to do so.

Recommendations

7.4 Under the upcoming IDA Fourth Highway Project, a training center is to be established within the Ministry of Public Works (MPW) for MPW drivers. Training is to include equipment and vehicle operation. The mission recommends that the training center incorporate in its program the teaching of fuel-efficient driving techniques, which should be opened up to any interested driver.

7.5 Additional, significant fuel economies could be achieved by better coordination of cargo schedules. All too often trucks go out or return empty for lack of freight on the other leg of the trip. SNTN is mindful of this problem and is trying to remedy it by appropriate scheduling of its trucks. One particular case concerns the uranium mines which consume about 30 tonnes of various materials transported to the mines from the South for each tonne of product transported out. With no other freight available, 95% of the trucks return South empty. The unused transport capacity would be more than enough to permit low cost transport to the South of the close-by Anou-Araren coal, should this coal prove feasible as a fuelwood substitute.

Buildings

7.6 Energy conservation in buildings is important in Niger not only to save on imported energy, but also to improve the load curve of its power system so as to reduce peak demands. Electricity consumption for air conditioning, especially of office buildings, has greatly increased in recent years and in Niamey, where this accounts for 25-30% of total demand, it also accounts for the peak demand. Aware of the problem, the Construction Directorate within the Ministry of Public Works ensures that all new public sector buildings are equipped with modern central air conditioning and associated temperature regulation. The savings achieved over room air conditioning units have been substantial: 30-40% in power demand and 25-30% in energy consumption. New public buildings also are required to use solar water heating equipment. Significant additional savings in new buildings could be achieved by developing energy efficient design and building guidelines and following them in future construction.

7.7 Substantial energy savings remain to be realized in old public buildings using room air conditioning units. These buildings are poorly insulated, and doors and windows rarely close tightly. The air conditioners are more or less worn out, which reduces their cooling efficiency. In addition, employees are careless about using the air conditioning, e.g. leaving doors open, over-cooling. Some of these factors also apply to privately-owned older buildings, but probably to a lesser degree because of the direct financial costs involved.

7.8 Several possibilities exist for eliminating this waste of energy:

(a) Simple insulation measures ensuring tight closing of windows and doors. These are relatively cheap and should be undertaken without delay in all public buildings as appropriate, once the Ministry of Public Works in cooperation with NIGELEC has established typical cost and related conservation benefits. In addition, the general public should be made aware of these savings measures.

(b) Institution of office temperature norms and their control, e.g. by in-house senior clerks. A reasonable norm might be a temperature of about 26° C (78° F).

(c) Replacing worn out air conditioners by more energy efficient models and introducing air coolers based on the evaporation of water. Air conditioners designed for the range of outside temperatures that exist in Niger (38°-42° C) and actually used in Middle Eastern countries are 30% more energy efficient than the models currently used in Niger. Using 1982 electricity consumption figures, these energy savings in air conditioning in Niamey would reduce peak demand by an estimated 3 MW, which at US$850/kW installed (1982 prices) translates into investment cost savings of about US$2.5 million. While their capital costs are about the same as those of the aforementioned air conditioners, air coolers provide nearly comparable comfort at only 20% of the energy cost of these air conditioners. Air coolers would appear well suited to the climate of Niger where the relative air humidity during the hot season is only 15%. By humidifying this air to 40%, the temperature will drop by about 10° C (18° F). Air coolers have been effectively used in countries with similar climatic conditions, e.g. Sudan.

<u>Recommendations</u>

7.9 (a) Energy efficient design and building guidelines should be developed, based on related experience in other countries.

(b) The Government should create a special energy conservation unit within the Construction Directorate to continue the current Directorate work of inspecting the plans for air-conditioning in new public buildings, review building designs to ensure that the guidelines recommended in (a) above have been followed, and promote the use of solar hot water heaters. The conservation unit also should systematically pursue all the possibilities for energy conservation outlined in para 7.8. Setting up such a conservation unit will require equipment (including vehicles), the services of an expatriate specialist for two years, and the training of Nigerien personnel in air-conditioning engineering, all of which should cost about US$125,000.

(c) Concerning the use of more energy efficient air conditioners and air coolers, a pilot project involving selected public buildings in Niamey should be considered to test their suitability and effectiveness. A prefeasibility study initiated by the mission has been carried out by the Ministry of Public Works in cooperation with the Energy Directorate. According to this study, the project would consist of two phases. Phase 1 envisages replacement over two years of 550 worn out air conditioners by more efficient ones, installation of some 40 air coolers on an experimental basis in various types of public sector office buildings and evaluation of the results. Phase 2 would establish the proposed energy conservation unit and prepare an investment program in energy saving air conditioning based on the findings of the evaluation study under Phase 1.

The cost of the project is estimated at about CFAF 100 million (US$300,000), not counting the cost of the new air conditioners (CFAF 297 million) to replace existing ones.

(d) With respect to energy savings in industry, the Ministry of Mines and Industry should evaluate their potential and take whatever follow-up action is appropriate.

Energy Prices and Taxes

Petroleum Products

7.10 The Government sets the prices for the four major petroleum products used in Niger (premium and regular gasoline, kerosene and gas oil) and, as of March 1983, for butane; 13/ other product prices are determined by the market place. To stabilize the product prices under its control, the Government operates a price stabilization fund financed by special levies on these products. This fund is used to compensate for increases in the products' import prices until the next adjustment in their domestic retail prices is made. The latter are based on their c.i.f. prices Niamey. Retail prices elsewhere in the country vary according to the transport cost differentials involved.

7.11 Current retail prices for the controlled petroleum products (Table 7.1, Annex 7.2) are well in excess of their economic cost because there were substantial increases in their net taxation as of March 1, 1983; and they remain based on the rather higher c.i.f. prices of February 1982, providing additional government revenues via correspondingly higher surpluses of the price stabilization fund. While these measures were taken to help cope with Niger's current financial crisis, they will also result in further petroleum product conservation.

7.12 Relative product prices at the retail level essentially differ in the degree of net taxation, a matter of government policy. The current relative tax burdens vary from 37-39% of the retail prices for gasoline to -2.5% for kerosene, with gas oil about in the middle at 19%. The mission considers the small net subsidy of kerosene used mainly for lighting particularly in rural areas justified for social reasons. It

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13/ The Government has not yet fixed an official price for butane, the retail prices for which have remained stable since 1977 despite the substantial increase in their international prices since then. It can be expected that, since the Government has included butane in its pricing scheme in order to raise revenues, this implied de facto subsidy will not be perpetuated. In any case it can be ignored, given the negligible quantitative importance of butane in Niger (para. 3.3).

further considers appropriate the preferential tax treatment of gas oil over gasoline. At nearly the same c.i.f. prices but higher fuel efficiency of diesel than gasoline driven vehicles, the use of gas oil in transport should be encouraged. 14/ The closest substitute for gas oil in industrial use (including power generation) is fuel oil, thus far little used in Niger. Here, conversely, the tax burden on gas oil is sufficiently high to encourage the use of the more economical fuel oil, currently taxed at only 8% of its domestic retail price.

Table 7.1: STRUCTURE OF RETAIL PRICES FOR PETROLEUM PRODUCTS IN NIAMEY, MARCH 1983 a/

	Premium Gasoline		Regular Gasoline		Kerosene		Gas Oil	
	CFAF/L	%	CFAF/L	%	CFAF/L	%	CFAF/L	%
Price c.i.f. Cotonou	78.95	32.9	76.31	33.9	81.75	60.6	83.19	48.9
Transport Cost Niamey	39.17	16.3	42.33	18.8	36.03	26.7	35.84	21.1
Price c.i.f. Niamey	118.12	49.2	118.64	52.7	117.78	87.2	119.03	70.0
Taxes and Duties	68.13	28.4	66.11	29.4	12.32	9.1	22.00	12.9
Price stabilization levy/subsidy	26.48	11.0	16.89	7.5	-15.71	-11.6	10.02	5.9
Net taxation	94.61	39.4	83.00	36.9	-3.39	-2.5	32.02	18.8
Distribution Margin	27.27	11.4	23.32	10.4	20.61	15.3	18.95	11.2
Retail Price Niamey	240	100.0	225	100.0	135	100.0	170	100.0
US$/Gal. Equivalent b/	2.67		2.50		1.50		1.89	

a/ Based on c.i.f. prices as of February 1982.
b/ US$1.00 = CFAF 340.

Source: SONIDEP.

7.13 In summary, both the level and structure of current prices for petroleum products in Niger provide the right signals for efficient energy use.

14/ The argument that, because trucks do the most damage to roads gas oil should be taxed more than gasoline, concerns cost recovery of road maintenance expenditures which should not be confused with the efficient pricing of energy.

Electricity

7.14 In October 1983, the level and structure of NIGELEC's tariff were revised to reflect the long run marginal cost (LRMC) of power supply in Niger (Annex 7.3). In particular, the new tariff does away with the previous practice of declining block rates which provided the wrong signal to consumers in that unit rates declined as consumption increased. The current tariff is based on a recent tariff study 15/ which estimates the LRMC of power supply in Niger from an all-diesel investment program for the period 1985-1990, reflecting the LRMC as tempered by considerations of social, financial and administrative expediency (Annex 7.4).

7.15 The Government has integrated this "reference" tariff into its tariff calculations. The tariff is set by way of a fixed component calculated by applying to the "reference" tariff an adjustment to permit the financial equilibrium of NIGELEC, and a variable component which takes into account the cost of fuel and the price of electricity bought from NEPA. The tariff is subject to revision at the request of NIGELEC from time to time as its financial position may require.

Recommendation

7.16 The mission supports the recent revision of the tariff level and structure towards reflecting long run marginal cost - an essential step for NIGELEC's revenues from selling electricity to recover at least the financial costs of its supply - and recommends that this policy be further pursued.

Fuelwood and Charcoal

7.17 Where it cannot be procured "free" for direct family use as is the tradition, fuelwood has to be bought by the consumer, particularly in the urban areas. For want of effective government control, retail prices for fuelwood and charcoal in Niger are left to be determined in the market place. Although the Government requires traders to obtain a permit from the Forestry Department, permit fees have remained unchanged since 1959 and by now amount to less than 1% of the average retail prices for fuelwood and charcoal of CFAF 20/kg and CFAF 50/kg, respectively (Table 7.2). Real prices for woodfuels in Niamey and other major towns are reported to have risen by 5% p.a. in recent years and, given the widening demand/supply gap, are bound to increase further.

7.18 Two issues need to be addressed immediately:

(a) What is the economic cost of fuelwood?

15/ Etude de la Tarification de l'Electricité au Niger, Ingenieurbu>ro Oskar von Miller, GmbH, December 1982.

(b) What is a proper return to the government as resource owner, and how can collection be ensured?

The economic cost of fuelwood is reflected by the cost of reafforestation, and in its absence, by the cost of deforestation in terms of decreasing soil fertility and eventually, desertification. In Niger, both costs have to be considered. Estimates along these lines are certain to show the economic cost of woodfuels to be well above their current market prices, high as these may seem, particularly to urban consumers. As the owner and operator of the national forests, the Government is entitled to a stumpage fee to capture some or all of the excess profits (economic rent) realized by the private operators supplying fuelwood. While establishing a proper stumpage fee is difficult enough, enforcing it in Nigerien conditions is fraught with practical difficulties.

Table 7.2: PERMIT FEES AND RETAIL PRICES FOR FUELWOOD AND CHARCOAL

	Forestry Tax or Stumpage Fee (CFAF)	Average Retail Price (CFAF/kg)
Fuelwood	35/stere = 0.15/kg a/	20
Charcoal	40/quintal = 0.4/kg b/	50

a/ 1 stere = 200 - 250 kg of dried roundwood.
b/ 1 quintal = 100 kg.

Source: Directorate of Forestry and Fauna.

7.19 The second IDA-assisted forestry project (Credit NIR 226) will address these issues by providing for studies of the organization of the fuelwood market and appropriate prices and stumpage fees reflecting the economic cost of fuelwood from plantations and natural forests. The Credit Agreement stipulates that such prices and fees be established by the end of 1983. The mission emphasizes the urgency of meeting this objective. Proper economic pricing of fuelwood is the basic prerequisite for conserving it through improved cooking stoves and the use of less costly substitutes, which are the prime responses to Niger's fuelwood crisis (Chapter II).

Comparative Energy Prices

7.20 Relative energy prices are a determining factor in a consumer's choice between alternative fuels which can substitute for each other in cooking, industrial heating, and thermal power generation. The choice depends on the relative efficiency with which each fuel is used and hence its price per unit of useful energy. End-use efficiencies vary widely between different fuels and applications and even for one fuel in a given application, depending on the equipment used. Fuelwood stoves in Niger are an outstanding case in point: an improved fuelwood stove with an end-use efficiency only three percentage points higher than that of the traditional three stone fire would reduce the price per useful unit of energy by 30% and conserve 30% of fuelwood as well. Available technology actually can do better than that.

7.21 Table 7.3 shows the comparative market prices and relevant end-use efficiences for fuelwood and its possible substitutes in Niger. 16/ For market prices to provide the right buying signals they should reflect the economic cost involved which, for Niger's woodfuels and electricity, are known to be higher than their market prices, and which remain to be established for lignite and groundnut shell briquettes, as noted before. In addition, the investment cost of appropriate cooking equipment needs to be factored in. Table 7.3 nevertheless affords some interesting observations. In the first place, lignite stands out as the prime substitute for fuelwood; even at twice its estimated cost, lignite remains competitive. Similarly, groundnut shell briquettes as costed under a small scale project by SONICHAR (2,800 tpa) appear attractive as a fuelwood substitute, and they should be even more so if produced on a larger scale. On the other hand, electricity compares unfavorably, especially if priced in line with its economic cost and, in addition, the substantial cost of cooking equipment is taken into account. As for the price of charcoal, although lower than fuelwood, it conceals the fact that on a fuelwood equivalent basis charcoal actually costs twice as much. Kerosene compares favorably, even in terms of its unsubsidized price; it may become even more attractive if domestic oil production can make it available at a lower economic cost than at present.

Recommendations

7.22 The mission recommends a comprehensive study of comparative energy prices reflecting economic cost, with particular reference to providing energy in urban areas and taking into account the environmental consequences of fuelwood and charcoal use. The study should include determination of the economic cost of appropriate cooking equipment, stoves in particular, and the related fuel end-use efficiencies in order to arrive at comparisons based on a meaningful cost per unit of useful energy. Only on such a basis can proper pricing and investment decisions concerning inter-fuel substitution be developed. The study should be carried out by consultants in cooperation with the new ONERSOL on the technical side (stoves, end-use efficiencies). The study would require six to eight man-months of appropriate economic and technical expertise and would cost about US$100,000 in all.

16/ Anou-Ar en coal has not been included in this comparison because the many uncertainties concerning its feasibility as a fuelwood substitute must be resolved before even tentative cost estimates can be made.

Table 7.3: RETAIL PRICES OF DIFFERENT FUELS PER USEFUL kWh
(NIAMEY, MARCH 1983)
(Excluding investment costs for stoves,
burners, gas bottle deposit, etc.)

Energy Source	Average Price (CFAF/kg)	Calorific Value (kcal/kg)	Price per Gross kWh d/ (CFAF)	Average Utilization Efficiency	Price per Useful kWh (CFAF)
Fuelwood	20	4,250 a/	4.05	0.07 b/	57.8
Charcoal	50	7,200	5.51	0.15 b/	39.8
Kerosene ("Petrole Lampant")					
subsidized	171	10,300	14.28	0.30	47.6
unsubsidized	175	10,300	14.61	0.30	48.7
Butane	329	10,710	26.42	0.45	58.7
Electricity	-	- d/	58.60-66.80 h/	0.70	83.7-95.4
Groundnut Shell "briquette"					
current	31.82 e/	4,500	6.08	0.10 b/	60.8
projected	21.56 f/	4,500	4.12	0.10 b/	41.2
Lignite (potential)	25.00 g/	4,000	5.38	0.25 c/	21.5

a/ 10% moisture content by weight.
b/ Three stone method.
c/ This efficiency is for an improved (i.e. enclosed) stove, as lignite cannot be burned by the three-stone method.
d/ 1 kWh = 860 kcal.
e/ At an annual production of about 425 tonnes; 22.18 production cost + 3.91 transport cost + 5.73 retail margin.
f/ At an annual production of 2,800 tonnes; 13.77 production cost + 3.91 transport cost + 3.88 retail margin.
g/ Tentatively 17.00 production cost + 3.50 transport cost + 4.50 retail margin.
h/ Electricity prices as of October 1983. 58.6 CFAF for long period use; 66.8 CFAF for short period use. Does not include fixed charge or the fee for power in the case of long period use (910 CFAF/month and 546 CFAF/kW/month respectively), and does not include the fee for power in the case of short period use (91 CFAF/kW/month).

Sources: SONIDEP, NIGERGAZ, NIGELEC, SONARA, SONICHAR, various Government of Niger authorities (including the Ministere du Commerce et des Transports), and mission calculations.

VIII. ENERGY PLANNING, INVESTMENT, AND TECHNICAL ASSISTANCE

Energy Sector Planning

8.1 The extreme scarcity of qualified manpower in Niger is the main constraint to planning and operational work, both at the subsector level and for the energy sector as a whole. Concentrated technical assistance is urgently needed at both levels to foster the development of Nigerien expertise, but first of all within the various subsectors.

8.2 Specific technical assistance requirements in subsectoral planning (i.e. developing long-term investment programs and ensuring adequate project preparation) have been discussed in previous chapters: the complementary forestry training program (para 2.27), assistance to the hydrocarbons and coal unit of the Directorate of Energy (DE, para 3.15), coordination of the exploration and development of coal and lignite (para 4.10), the refocussing of ONERSOL's efforts (para 5.24), the formulation of a staff development plan for NIGELEC (para 6.32), and the setting up of a conservation unit in the Construction Directorate of the MPW (para 7.9). In each of these cases, the training of Nigerien counterparts is essential to carry on the work which expatriate assistance has helped to define.

Recommendation

8.3 The mission recommends that, unless previously specified otherwise, the training of Nigerien counterparts consist of alternating periods of work in the operational/planning unit of their Nigerien organization with periods of work or study in the offices of established consultants (and particularly as participants in consultants' work on Niger), in universities, or in research institutes. Training abroad should be emphasized during the first two or three years of these assistance programs, with subsequent training taking place mainly within the respective units themselves, which by then will be in a position to build on their own experience.

8.4 The multitude of ministries and operating agencies involved in the energy sector and the manpower shortage have impeded the development of an integrated approach to Niger's energy problems. Currently, ad hoc committees with members drawn from these various ministries and agencies do indeed work out a national energy sector strategy for the Government's five-year or interim plans, but this process needs to be reinforced by ongoing, long-term planning. In 1981, the Government sought to establish this by setting up the Directorate of Energy (DE) as a unit of the Ministry of Mines and Industry (MMI), given the MMI's role in overseeing the main energy-related parastatals. The DE is responsible for formulating national energy policies in accordance with Government objectives, and coordination and control of their implementation. Its mandate encompasses all forms and aspects of energy, from research and exploration to supply, transformation, distribution, and use. The three units within the DE cover: (1) hydrocarbons and coal, (2) electricity, and (3) new forms of energy. The DE faces two major obstacles in accomplishing its task: a lack of the necessary authority to coordinate energy sector activities, and severe understaffing, with only five more-or-less experienced engineers and economists, three of whom are more involved in monitoring oil and gas exploration than in overall sector planning.

Recommendations

8.5 The mission recommends that, to strengthen overall energy planning, an energy economist experienced in general energy supply and demand studies, pricing analyses, optimization techniques, and financing be appointed as Energy Adviser reporting directly to the Minister of Mines and Industry. This Energy Adviser should, in particular, draft the terms of reference for carrying out the study of comparative energy prices recommended in para 7.22, and coordinate and monitor its progress. Annex 8.1 presents a detailed description of the position, which is to last two years and cost about US$290,000. With respect to the Directorate of Energy, in addition to pursuing its current work on oil and gas (para 3.14), the DE's hydrocarbons and coal section should coordinate the development of the coal/lignite sector (para 4.12). The rest of the DE should focus exclusively on formulating and coordinating national energy policy, leaving the individual energy agencies (e.g. ONERSOL, the Ministry of Hydraulics and the Environment, NIGELEC) to propose their own detailed, long-run planning, as emphasized above. For its part, the DE should ensure that the Government analyzes the agencies' proposals on investments, pricing, and other such issues with a broad national perspective on the sector rather than from the isolated point of view of each agency. With respect to implementing national energy policy as decided by the Government, the existing ministries and other energy sector organizations should retain their current functions, subject to the other recommendations in this report.

Energy Investment

Past Investment

8.6 Total public and private investment in the energy sector, excluding forestry, came to an estimated 22.6 billion current CFAF (1981 US$83.2 million) in 1981, assuming negligible private investment other than in petroleum exploration and the SONICHAR complex, about 32% of which is privately owned (Table 8.1). This total investment has remained steady at about 4% of GDP and 16% of gross fixed investment for 1979-81.

8.7 For the same period, power investments consistently dominated the total, accounting in 1981 for about 87% of all energy investments, and over 99% of public investments, i.e. excluding the only wholly private investments, which are in petroleum exploration, but including investments in the SONICHAR complex, in which the Government is majority shareholder. Within the power subsector itself, almost all (98%) of the 1981 investments went into the SONICHAR complex, which includes the coal mine, the power plant, transmission and distribution facilities, and the mining town. Petroleum exploration by private oil companies constituted the next largest category of total public and private investment in 1979-1981, adding up to about 2.8 billion current CFAF (1981 US$10.1 million) or about 12% of the total in 1981. Finally, ONERSOL research accounted for the remaining investment in the same period (one percent of the 1981 total). Most of these funds were spent on solar apparatus, with a very minor amount paying for a partial evaluation of Niger's wind resources.

Table 8.1: TOTAL ENERGY INVESTMENT, 1979-1981 a/
(in million current CFAF and %)

	1979		1980		1981	
	million CFAF	%	million CFAF	%	million CFAF	%
1. Power	13,029	63	16,970	77	19,750	87
2. Petroleum	7,577	36	4,735	21	2,750	12
3. Renewable Energy	110	1	498	2	87	1
4. Total Energy Investment	20,716	100	22,203	100	22,587	100
(4) as % of GDP	4.68		4.20		3.78	
(4) as % of gross fixed investment	16.81		14.61		16.41	

a/ Public and private, excluding forestry.

Source: Sous-Commission Energie.

8.8 Data on investments in forestry are scarce, but the main purpose of forestry projects in Niger has been to directly fight desertification rather than to produce fuelwood. The First IDA Forestry Project (Credit 800-NIR), now being continued in the Second Forestry Project (Credit 1226-NIR), is the only project which has as a basic objective improving fuelwood supplies. Investments in the project came to about 465 million current CFAF (1981 US$1.7 million) in 1981.

Investment Requirements

8.9 Table 8.2 shows proposed public investment in the energy sector, excluding forestry, under the interim plan (1984-85), again broken down into investments in the power subsector and in renewable energy. In the power subsector, NIGELEC's investments are a modification of the investment program (Annex 8.2) it drew up in July 1982 as part of its studies with respect to the new Goudel diesel plant (3 x 12 MW) which is to meet growing demand in the Niamey area. The investments shown in Table 8.2 and in Annex 8.2 only include those which seem certain at this time, and not those which will be defined by the IDA-financed study of the longer-term development of the power system (para 6.24). Two of the Goudel units constitute the largest single investment item in the interim plan. This is part of a sound short-term strategy of maintaining enough thermal capacity in Niamey to meet peak demand and in case of a failure in the supply from Nigeria. The mission also supports two priorities in the electrification of secondary load centers, which are the towns of Say and Kolo. The power planning study, recently begun under the IDA Power Credit (para 6.30) is included as an item in the interim plan; it will identify longer-term investment needs in the power subsector.

Table 8.2: PROPOSED PUBLIC INVESTMENT IN THE INTERIM PLAN, 1984-85
(January 1983 million CFAF and 1983 US$) [a/]

	Total Cost	
	(million CFAF)	(million US$)
Power		
Research and Studies		
Long-term planning study	600	1.74
Other studies	1,282	3.72
Subtotal	1,882	5.46
New Generating Capacity		
Goudel diesel plant (2x12 MW)	7,500	21.74
Zinder diesel plant (2x1.1 MW)	750	2.17
Maradi station extension (1x 1.1 MW)	300	0.87
Malbaza station extension (2x2 MW)	1,500	4.35
Subtotal	10,050	29.13
Transmission and Distribution		
Subtotal	7,655	22.19
Electrification of Secondary Load Centers		
Subtotal of 6 centers	687	1.99
Subtotal Power	20,274	58.77
Renewable Energy		
Research and Studies		
ONERSOL	115	0.33
Subtotal Renewable Energy	115	0.33
Total	20,389	59.10

a/ US$1.00 = 345 CFAF

Source: Sous-Commision Energie

8.10 As noted above, the only significant investments in fuelwood production are being made through the second IDA/FAC/CCCE forestry project.

Recommendations

8.11 The mission recommends that the Government pursue the indicative objectives for maximum national production from plantations and improved forest management as described in Table 2.3, which would require additional investments of about 1982 CFAF 2.3 billion (US$7 million) p.a. from 1984 through 1988, and 1982 CFAF 3.4 billion (US$10 million) p.a. from 1989 through 2018, plus an additional 1982 CFAF 100 million (US$300 thousand) p.a. during the first five years for training to ensure that the Directorate of Forestry and Fauna has the necessary manpower for the proposed program (para 2.28). These investments are described in Annex 2.3.

8.12 Three other areas in which energy sector investments should be considered are the development of Solomi coal for household and/or industrial use, lignite exploration and development, and petroleum exploration and development. In the case of Solomi coal, if demand and transportation cost studies indicate it would be economic to use the coal in households and/or industry, investments will be needed for exploiting it and developing a marketing network (stocking facilities, trucks, etc.).

Recommendations

8.13 Given lignite's potential as a substitute for gas oil and for fuelwood, about (1982) CFAF 285 million (US$850,000) should be sought immediately for: (a) a systematic drilling program to detect additional reserves at Salkadamma/Tahoua; and (b) a reconnaissance program in the Filingue-Salkadamma area, with possible subsequent exploration, as recommended in para 4.10 and presented in detail in Annex 4.1. At the same time, the lignite combustion tests and demand studies listed below under technical assistance need to be carried out. With respect to petroleum exploration, the Government needs to consider the possibility of appraising and producing the Sokhor find (Chapter III).

Technical Assistance Needs

8.14 The priority areas for technical assistance are as follows:

General Energy Sector

(a) Strengthening overall energy planning by having an energy economist act as Energy Advisor to the Minister of Mines and Industry for two years, at an estimated cost of US$290,000 (para. 8.5);

(b) A comprehensive study of comparative energy prices reflecting economic cost with particular reference to substituting for fuelwood (para 7.22).

Petroleum

(c) Building up the MMI's capability for acquiring, understanding, and storing petroleum exploration information, at an estimated cost of US$ one million over three or four years (para 3.15).

Power

(d) A review of the institutional set-up of the power subsector (para 6.30), a study of NIGELEC's manpower needs (para 6.32) and a long-term power planning study (para 6.30) are included in the IDA Power Credit.

Coal/Lignite

(e) Lignite combustion tests and studies of the demand for lignite as a fuelwood substitute and in industry and power generation (para 4.10).

(f) In evaluating the workable reserves of the Solomi coal and in defining the technology for preparing and using this resource (para 4.7), ensuring that the costs of exploitation, preparation and utilization are analyzed as a function of a study of demand for this coal as a substitute for fuelwood or for use in industry and generating electricity (para 4.10).

(g) Strengthening of the DE's hydrocarbons and coal unit through the services of an expatriate coal/lignite specialist. Estimated cost: US$210,000 over a period of three years (para 4.12).

Forestry

(h) Investigating new forestry technical packages well adapted to marginal lands in arid and semi-arid zones (para 2.17).

Renewable Energy

(i) A study defining a specific action program to promote the use of groundnut shell briquettes for residential needs. This study should be carried out jointly with the development of an improved stove which is suitable for both these briquettes and wood (para 5.17).

(j) An evaluation of the potential for solar water heating in industry (para 5.9);

Conservation

(k) Creating a special energy conservation unit within the Construction Directorate of the Ministry of Public Works and implementing a pilot project to evaluate the replacement of worn out air conditioners by more recent models. Setting up the conservation unit would cost about US$125,000, and the pilot project would cost an estimated US$300,000, excluding the cost of about US$890,000 for new air conditioners to replace existing ones (para 7.9).

(l) Institution of a course in fuel-efficient driving techniques open to any driver interested in taking it (para 7.4).

The Need for Action

8.15 To demonstrate the urgent need for Government action on both the energy demand and supply sides, the Mission has prepared an indicative summary national energy balance for 1990 (Annex 8.3), based on the various energy demand projections presented in this report. 17/ Annex 8.3 therefore shows Niger's energy situation in 1990 as it would evolve if there were no changes in consumption habits (e.g. no introduction of improved woodstoves, no use of kerosene in cooking, no conservation of power in air-conditioning) and no intensive effort to develop domestic resources (e.g. oil, coal, lignite, wood, groundnut shells). In such a case, total energy consumption (excluding butane, jet fuel, and agricultural and animal residues burned for cooking) would increase by 23% in all, i.e. at an average rate of 2.3% p.a. from 1981 to 1990. This would have serious consequences, particularly with respect to fuelwood supplies and the cost of importing petroleum products. The demand for fuelwood would have grown by nearly 30% by 1990, which would increase the deficit, i.e. the difference between the net available increment of wood and fuelwood demand, by more than 50% over its 1981 level (Table 2.2). This shortage would result in further deforestation and increased burning of agricultural and animal residues, both of which accelerate land erosion and desertification.

8.16 With respect to petroleum products, the demand, projected as growing at 7.6% p.a., would nearly double in volume by 1990. Assuming on

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17/ Except with respect to petroleum products. Table 3.2 assumes some substitution of kerosene for fuelwood which is, however, disallowed here.

top of this an increase of 1.6% p.a. in the real price of crude petroleum, 18/ Niger's recorded import bill for oil products in real terms would more than double over the 1981-90 period, increasing at an average rate of 11.3% p.a. In order to finance this import bill, estimated at CFAF 41.3 billion (US$123 million) in 1990, an increase of CFAF 6.0 billion (US$18 million) over Niger's estimated 1981 petroleum products bill for both recorded and unrecorded imports, Niger's export revenues would have to increase by as much. According to present prospects, an increase in export revenues of this order essentially would have to come from an increase in the volume and/or the real price of Niger's uranium exports, and it is not now possible to judge whether this might happen or not. However, even if export revenues from uranium should rise to the required level by 1990, such additional foreign exchange revenues could obviously be better used for urgently needed investment in Niger's economic and social development.

18/ World Development Report 1983, published for the World Bank by Oxford Unversity Press, 1983, p. 28.

Niger: National Energy Balance, 1981
(tonnes of oil equivalent)

Line		Primary Energy: Hydro	Crude Oil	Coal 1/	Agricultural and Animal Residues 2/	Fuelwood	Charcoal	Electricity 3/	Petroleum Products: Butane	Gasoline 4/	Aviation Gasoline	Jet Fuel	Kerosene	Gas Oil	Fuel Oil	Total	Line Totals	Line
	Gross Supply																	
1	Production			17,025	168	838,590											855,783	1
2	Imports							30,740	502a	41,067	741	17,624	4,362	84,571	2,779	151,646	182,386	2
3	Primary Exports																	3
4	Stock Changes			(2,156)t	(50)t				(31)s	(424)s		(23)s	97s	11,562s		11,181s	8,975	4
5	Total Available			14,869	118	838,590		30,740	471a	40,643	741	17,601	4,459	96,133	2,779	162,827	1,047,144	5
	Conversion																	
6	Petroleum Refining																	6
7	Charcoal Production					(2,425)e	2,425e										0	7
8	Electric Power Generation			(14,869)				44,785r						(29,697)		(29,697)	219y	8
9	Conversion Losses					(11,550)ej		(51,300)									(62,850)	9
10	Transmission/Distribution Losses							(2,635)z									(2,635)	10
11	Net Supply Available				118	824,615	2,425	21,590	471	40,643	741	17,601	4,459	66,436	2,779	133,130	981,878	11
12	Secondary Exports																	12
13	Bunker Sales											(17,601)f				(17,601)	(17,601)	13
14	Net Domestic Consumption				118	824,615	2,425	21,590	471	40,643	741c		4,459	66,436	2,779c	115,529	964,277	14
	Consumption by Sector																	
15	Mining							9,180	64nh					18,476ge		18,540	27,720	15
16	Industry							2,635e	165n					3,500ge	2,779	6,444	9,079	16
17	Small Industry 5/				115	82,460e	2,425	255						1,000ge		1,000	86,255	17
18	Construction (buildings, roads)							340e						28,000ge		28,000	28,340	18
19	Commerce							935e	38n							38	973	19
20	Transport							170e		40,643	741			14,500ge		55,884	56,054	20
21	Households				3	742,155		4,505	170n				4,459			4,629	751,292	21
22	Public Administration							3,145b	34n							34	3,179	22
23	Communications/Miscellaneous							425e									425	23
24	Agriculture													960ge		960	960	24
25	Total				118	824,615	2,425	21,590	471	40,643	741		4,459	66,436	2,779	115,529	964,277	25

Sources: MMI, SONIDEP, GPP, NIGERGAZ, SONICHAR, NIGELEC, SONARA, SOMAIR, COMINAK, SNTN, CILSS, FAO

Notes:
(i) Table does not include an estimated maximum of less than 250 toe (0.9 GWh) p.a. of solar energy used to heat hot water and to power radio and TV.
(ii) Parentheses indicate negative flows.
(iii) Conversion factors listed in the first few pages of this report.

1/ Coal is converted to toe at .227 toe/t (2,315 kcal/kg), arrived at by setting the toe value of the 65,502 tonnes of coal burned in the SONICHAR power plant equal to the thermal replacement toe value (i.e. at 265 toe/GWh) of the electricity thereby produced, taking into account the 257 toe of gas oil also burned to fire up the coal-burning boilers.
2/ Groundnut shells only. Due to lack of data, excludes agricultural residues and dung burned in areas of severe fuelwood shortages.
3/ Electricity is converted to toe at the weighted 1981 average rate of fuel consumption of Niger's gas oil burning plants, about 265 toe/GWh. Conversion losses are then calculated based on an efficiency of about 32%, so that "T/D Losses" and "Net Supply Available" are given in terms of the maximum theoretical heating value of electricity, 85 toe/GWh.
4/ Both premium and regular gasolines.
5/ Includes bakeries, foundries, forges, metalworkers' shops, laundries, salt producing operations, tea drinkers,...

a Average, calculated from figures for March to February 1980-1981 and 1981-1982.
b Includes government offices and street lighting.
c Consumption assumed equal to imports.
f All jet fuel assumed sold to foreign planes.
g Due to lack of data, figures for gas oil consumption by sector are very tentative. They are based on GPP estimates.
h Strictly for household use by mining personnel.
j Based on 10% conversion efficiency by weight.
n Butane consumption by sector based on NIGERGAZ estimates.
r Power generated by NIGELEC, SONICHAR, SOMAIR, COMINAK. Excludes any minor own-generation by other institutions during supply failures.
s Petroleum product stock changes calculated as difference between imports and sales by distribution companies.
t Stock changes calculated as difference between production and consumption.
y This figure is arbitrary in that it reflects the difference between the toe value of electricity used in constructing the table and the actual fuel consumption rates of the Nigerien thermal power plants.
z Includes own use by NIGELEC (255 toe) and SONICHAR (85

ANNEX 2.1

Mean Annual Increment and Net Available Increment of Fuelwood in 1980
by Type of Forest Cover and Geographic Zone a/
(000 m^3 unless otherwise indicated)

	Desertic and Subdesertic Zone	Underpopulated Sahelian and Sudano-Sahelian Zone	Understocked and Over-Populated Savanna Zone	Understocked and Becoming Overpopulated Savanna Zone	Tree Plantations	Row Totals
Woodlands and Savannas						
1. mean annual increment	240	1460	1395	442	-	3537
2. net available increment	12	73	418	221	-	724
[(2) as a % of (1)]	(5)	(5)	(30)	(50)	(-)	(20)
Bush Fallows and Sylvo-Agricultural Formations						
3. mean annual increment	-	255	250	120	10	635
4. net available increment	-	255	250	120	10	635
[(4) as a % of (3)]	(-)	(100)	(100)	(100)	(100)	(100)
Column Totals						
5. mean annual increment	240	1715	1645	562	10	4172
6. net available increment	12	328	668	341	10	1359
[(6) as % of (5)]	(5)	(19)	(41)	(61)	(100)	(33)

a/ "net available increment" refers to that amount of the mean annual increment of fuelwood that was actually available for use in 1980, given the problem of accessibility.

Source: FAO.

Indicative Cost Estimate of the Niger Energy Sector Assessment Mission's Proposals for Fuelwood Plantations and Improved Forest Management, 1979-2018

Five-Year Period		I a/ 1979 1983	II 1984 1988	III 1989 1993	IV 1994 1998	V 1999 2003	VI 2004 2008	VII 2009 2013	VIII 2014 2018
I. Direct Costs	US$/ha								
State managed industrial irrigated tree plantations	10,000								
ha/five years 000		0.250	0.250	0.500	0.500	0.500	1.000	1.000	1.000
ha cumulative 000		0.250	0.500	1.000	1.500	2.000	3.000	4.000	5.000
Direct costs US$000		2,500	2,500	5,000	5,000	5,000	10,000	10,000	10,000
Tree plantations within irrigated agricultural perimeters b/	4,000								
ha/five years 000		0.250	0.250	0.500	0.500	0.500	1.000	1.000	1.000
ha cumulative 000		0.250	0.500	1.000	1.500	2.000	3.000	4.000	5.000
Direct costs US$000		1,000	1,000	2,000	2,000	2,000	4,000	4,000	4,000
State managed rainfed tree plantations b/	1,000								
ha/five years 000		2.5	7.5	10.0	10.0	10.0	10.0	5.0	5.0
ha cumulative 000		2.5	10.0	20.0	30.0	40.0	50.0	55.0	60.0
Direct costs US$000		2,500	7,500	10,000	10,000	10,000	10,000	5,000	5,000
Rural rainfed tree plantations	200								
ha/five years 000		10.0	15.0	25.0	25.0	25.0	25.0	15.0	10.0
ha cumulative 000		10.0	25.0	50.0	75.0	100.0	125.0	140.0	150.0
Direct costs US$000		2,000	3,000	5,000	5,000	5,000	5,000	3,000	2,000
Better management of natural forest cover	20								
ha/five years 000		p.m.	500.0	500.0	500.0	500.0	500.0	750.0	750.0
ha cumulative 000		p.m.	500.0	1000.0	1500.0	2000.0	2500.0	3250.0	4000.0
Direct costs US$000		5,000	10,000	10,000	10,000	10,000	10,000	15,000	15,000
Total Direct Cost US$000 (1982)		13,000	24,000	32,000	32,000	32,000	39,000	37,000	36,000
II. Indirect Costs (50% of direct costs) US$000 (1982)		6,500	12,000	16,000	16,000	16,000	19,500	18,500	18,000
Total Costs US$000 (1982)		19,500	36,000	48,000	48,000	48,000	58,500	55,500	54,000

a/ Current program under the Second IDA/FAC/CCCE Forestry Project (Credit 1226-NIR), a continuation of the IDA Pilot Forestry and Technical Assistance Project (Credit 800-NIR).

b/ Total area planted listed in terms of equivalent ha.

Note: About 10% of the total wood produced from the proposed plantations and improved forest management would be used for building poles. Cost estimates do not include the necessary complementary forestry training.

Source: Bank Staff

ANNEX 2.3

Indicative Cost Estimate for a Five-year Complementary Forestry Training Program

This program, which should be launched in 1984, is designed to meet the training needs of the Forestry Department (Direction des Eaux et Forets) of the Ministry of Hydraulics and of the Environment in the second five years of implementing the planting and improved forest management objectives proposed in para. 2.17 and described in Table 2.3 and Annex 2.3 of this report. The planting, improved forest management, and complementary training programs for the first five years (1979-83) of such a long-term forestry commitment already have been provided for by the IDA Forestry Pilot and Technical Assistance Project (Credit 800-NIR), and its continuation, the IDA/FAC/CCCE Second Forestry Project (Credit 1226-NIR).

The cost estimates listed below cover the training of 25 level A, 50 level B, and 75 level C personnel, as follows:

for level A, three years of which 50% abroad;
for levels B and C, two years all of which in Niger.

Cost Estimate (000 US$)

Investment and equipment	500
Technical assistance and overseas training	500
Local staff	200
Operating costs	300
Total	1,500

ANNEX 3.1

A Preliminary Assessment of the Technical Assistance and Training Requirements of the Ministry of Mines and Industry for Coordinating Oil and Gas Exploration

In view of the recent discovery at the Sokhor well, the requirements for the next three to four years can be estimated as follows (in US$):

(a) Assistance for retrieval and storage of data:	
- Six visits of an expert for a period of one week each time	30,000
- Equipment (storage, reproduction, small laboratory)	80,000
- Training of one Nigerien technician	5,000
(b) Assistance from expatriate specialists working on oil and gas exploration with the staff of the MMI's petroleum unit:	
- Two weeks of an experienced explorationist every two months on average during three years	150,000
- Occasional needs in experts or special studies (interpretation, laboratory, reprocessing) estimated at	400,000
(c) Assistance to revise the Petroleum Law Agreements	100,000
(d) Training:	
- Two Nigerien Technicians each year (geologist, geophysicist, economist, engineer) for a period of six months each	50,000
Total	815,000
Contingencies	145,000
GRAND TOTAL	960,000

Source: Bank Staff.

Lignite Exploration Programs

As it was during an OFEDES search for groundwater over the last few years that the accidental discoveries of lignite were made in the Tertiary strata of the "continental terminal" in the Iullemeden Basin near Salkadamma and Filingue, a systematic perusal of all well construction records, including a stratigraphical-paleogeographical examination, should be carried out in the course of any further exploration for lignite in the area.

A. Exploration at Salkadamma/Tahoua

An exploration program needs to be carried out to calculate the minable reserves of lignite at Salkadamma/Tahoua to evaluate in a prefeasibility study the economics of mining the lignite.

To define the limits of the deposit, in particular towards the east and southeast, this exploration program should consist of approximately 10 drill holes, each up to 100 m in depth, located 0.5 to 1 km apart. At least two additional drill holes should be sunk as far as the lying "siderolitic series of Adar Doutchi" as it is probable that lignite seams exist below 60 m, a possibility that has not yet been explored.

The costs of the 12 drill holes, with an estimated total of 1,300 m (core), are on the order of 40 million CFAF (about US$115,000). To this figure should be added the cost of equipment, expatriate supervision, and studies. The previous ONAREM drilling program was considerably handicapped by the lack of special core barrels for soft soil conditions. Therefore, at least four special double core barrels for soft soil conditions are to be made available at a unit price of US$15,000 (total price US$60,000). Furthermore, a drill rig with 300 m depth capacity and optional percussion or rotary drill is needed, its price being in the range of US$100,000. A foreign master driller experienced in soft soil conditions should assist the ONAREM drilling personnel during the drilling activities over a period of six months (at an estimated two drill holes per month). The total cost of the master driller's services are estimated at US$60,000.

The cost for evaluating the drilling results including quality tests, aptitude tests of the lignite to a pilot-test scale, soil-mechanical investigations, etc. and for preparing a technical-economical prefeasibility study will be on the order of US$200,000, if an internationally known consulting company is entrusted with this task.

The total costs for executing the Salkadamma/Tahoua exploration program - excluding the provision of vehicles, consumption of fuel and oil, accommodation in camps to be arranged for by the CP - are therefore estimated at US$550,000.

B. Exploration in the Filingue-Salkadamma Area

Indications of a seam of lignite 0.50 m thick were discovered at a depth of 68 m in the zone east of Filingue, near Chinyelga. In addition, accumulations of resin encountered at 54 m depth of OFEDES water well No. 75 north of Filingue, near Fadama, suggest extensive plant growth during the "continental terminal." A systematic prospecting program therefore should be carried out in the area between Salkadamma and Filingue. If it yields positive results, it should be followed by an exploration program.

To obtain a preliminary survey of the paleogeographical conditions on the middle "continental terminal" in this region and to evaluate the possibility of further lignite discoveries in the area, 12 drill holes about 100 m deep on average should be sunk 5 to 10 km apart. Including other costs such as for the infrastructure required (construction of roads to the drilling sites, erection of camps, etc.), evaluation of drilling results, and analyses, the prospecting program (extent of total drilling 1200m) should take about 12 months and cost about US$300,000.

ANNEX 4.2

Job Description for the Technical Adviser on Coal and Lignite

Training	- Thermal engineer with 10-15 years experience in industry, of which at least 6 years in industries involved with coal or lignite extraction, preparation or utilization.
Length of Mission	- Total length of 3 years, starting with 4 months followed by 2-week long missions every 2 months.
Location	- Niamey
Title	- Adviser to the hydrocarbons and coal unit of the Directorate of Energy.
Job Description	To work with the hydrocarbons and coal unit staff on the following issues: - The coordination of the results of coal and lignite reserve exploration, as well as the coordination of combustion tests, and of studies of demand and transportation costs. - The evaluation of coal/lignite mining and industrialization projects in order to determine coal/lignite's most appropriate utilization. - The coordination of counterpart activities in all projects designed to develop and utilize coal or lignite. - Technical appraisals of all coal/lignite combustion issues.
Cost of the Assistance	- US$210,000

Potentially Available Energy from Crop Residues, 1979/80

Crop	1979/1980 Production ('000 tonnes)	Residue Coefficients b/	Residue c/ ('000 tonnes)	Unit Energy d/ Content (kcal/kg)	Annual Energy Content ('000 toe) e/	Estimated Fraction of Residue Available	Energy Potentially Available ('000 toe)
Millet	1262.6	1.5÷3.0 a/	2841	3700	1030.58	0	0
Sorghum	367.9	0.5÷0.85	248	3700	90.0	0	0
Cowpeas	266.3	1÷2 a/	400	3700	144.9	0	0
Cassava	162.0	0.1÷0.2 a/	24	3700	8.9	0.5	4.5
Groundnuts	126.1	0.33	42	4500	18.5	1.0	18.5
Sugar Cane	113.1	0.13÷0.25	21	5150	10.9	0	0
Onion	107.8	0.1÷0.2 a/	16	3700	5.9	1.0	5.9
Rice	30.7	0.38÷1.25	25	3550	8.8	0	0
Sweet Potatoes	16.9	0.1÷0.2 a/	3	3700	0.9	1.0	0.9
Voandzou	11.4	0.15÷0.30 a/	3	3700	0.9	1.0	0.9
Corn	10.0	0.55÷1.20	9	3700	3.2	0.5	1.6
Totals	2468.8		3630		1323.48		32.3

a/ Estimated.
b/ From Methane Generation from Human, Animal, and Agricultural Wastes, National Academy of Sciences, Washington, D.C., 1977, unless marked as estimated.
c/ Midpoint of range of residue coefficients used.
d/ Average value from Energy from Biological Processes, Office of Technology Assessment, Washington, D.C., 1980, except in the case of groundnuts (mission estimate from SONARA data) and of sugar cane and rice (from C. W. Hall, Biomass as an Alternative Fuel, Government Institutes, Inc., August 1981).
e 1.00 toe = 10.2 million kcal.

Source: World Bank mission estimates based on various source.

ANNEX 5.2

Potentially Available Energy from Animal Waste, 1981

Animal	Number of Animals (millions)	Quantity of Waste per 500 kgm of Animal (tonnes/year)	Number of Animals Per 500 kgm of Animal	Total a/ Quantity of Waste Produced (million tonnes/yr)	Volume of b/ Biogas per kgm of Waste (m^3)	Methane %	Total Potential Energy ('000 toe/yr.)	Energy c/ Potential Available ('000 toe/yr)
Cattle	3.42	14.0	1.2÷ 2.2	21.8÷40.0	0.3	60	464÷ 860	186÷346
Sheep	3.19	7.3	10.0÷16.7	1.4÷ 2.3	0.3	64	34÷ 51	17÷ 25
Goats	7.12	8.0	12.5÷25.0	2.3÷ 4.6	0.3	60	51÷ 101	25÷ 42
Camels	0.40	9.5	1.1÷ 2.3	1.7÷ 3.5	0.3	60	34÷ 76	17÷ 34
Horses	0.28	10.2	1.2÷ 2.5	1.1÷ 2.4	0.3	60	25÷ 51	8÷ 25
Donkeys	0.48	9.1	1.3÷ 2.6	1.7÷ 3.4	0.3	60	34÷ 76	17÷ 34
Totals	14.89			30.0÷56.2			642÷1,215 d/	270÷506 e/

a/ Includes water contained in the waste.
b/ Volume of biogas produced per kgm of solid waste.
c/ Excludes animals in roaming herds.
d/ Average value: 929,000 toe/year.
e/ Average value: 388,000 toe/year

Source: Ministere du Developpement Rural.

ANNEX 5.3

Production and Transportation Cost of Groundnut Shell Briquettes
Year 1981/82
(FCFA per metric ton)

Packing	4,500	(180 F per 40 kg bag)
Energy	3,535	
Fire Insurance	429	
Oil and Lubricant	503	
Maintenance, Repair	407	
Loading Costs	250	
Permanent Staff	1,142	
Temporary Staff	5,633	
Financial Costs	126	
Amortization Costs	5,652	
	22,177	F per ton = 50,290 F/toe
Transportation	3,911	
	26,088	F/ton (delivered in Niamey) = 59,169 F/toe

Source: SONARA

ANNEX 6.1

Gross Electricity Consumption, 1963-82 a/
(GWh)

Year	Niamey I	Other Centers II	Of which Maradi & Zinder	Total NIGELEC III = I + II	Mining Companies IV	Total Niger b/ III + IV
1963	12,44	2,07 c/	2,07	15,51		15,51
1964	14,29	2,78 d/	2,66	17,07		17,07
1965	15,73	3,08	2,84	18,81		18,81
1966	19,21	3,67	3,33	22,88		22,88
1967	21,11	4,00	3,62	25,11		25,11
1968	24,59	4,67 e/	4,17	29,26		29,26
1969	28,52	4,94	4,19	33,46		33,46
1970	33,39	5,27	4,41	38,66		38,66
1971	36,23	5,68	4,71	41,91		41,91
1972	43,16	6,50	5,51	49,66	17,00	66,66
1973	48,91	7,77 f/	6,22	56,68	17,90	74,58
1974	50,76	8,50	6,32	59,26	18,80	78,06
1975	53,48	10,43 g/	6,00	63,91	21,50	85,41
1976	60,09	16,93 h/	7,02	77,07	29,90	106,97
1977	64,31	21,08	9,19	85,39	38,40	123,79
1978	75,08	26,17 i/	11,78	101,25	63,16	164,41
1979	87,37	34,57 j/	15,56	121,94	91,70	213,64
1980	107,89	41,72 k/	19,21	149,61	95,70	245,31
1981	118,26	50,63	21,60	168,89		
1982 l/	n.a.	n.a.	n.a.	183,20	73,00 m/	256,20

a/ Production alternator terminals, plus purchases.
b/ Does not include own generation by businesses other than the Mining Companies Somair and Cominak.
c/ Maradi et Zinder.
d/ Plus Agadez.
e/ Plus Tahoua.
f/ Plus Dosso.
g/ Plus Filingué.
h/ Plus Konni and Malbaza.
i/ Plus Magaria and Doutchi.
j/ Plus Tessaoua and Madoua.
k/ Plus Diffa.
l/ Preliminary figures, of which some are not available (n.a.).
m/ Supply by NIGELEC only. Does not include minor amount of own generation by mining companies.

Source: Ministry of Public Works and Urbanism, (Ministre des Travaux Publics et de l'Urbanisme), Survey of Electricity Pricing in Niger, Ingenieurbüro Oskar von Miller GmbH, December 1982; NIGELEC; Mining Companies.

ANNEX 6.2

Electricity Produced and Sold by Voltage Level, for all of NIGELEC, 1974-1982

	1974	1975	1976	1977	1978	1979	1980	1981	1982 a/
Energy Produced b/ (GWh)	59,1	61,9	64,9	26,9	45,4	40,0	38,2	41,6	50,3
Energy Purchased (GWh)	0,2	1,2	12,3	60,2	55,7	81,9	111,4	169,2	214,4
Total: Production plus Purchases (GWh)	59,3	63,1	77,2	87,1	101,1	121,9	149,6	210,8	264,7
Energy delivered to Network (GWh)	57,4	61,1	75,3	84,5	92,0	117,0	143,6	202,4	n.a.
Energy sold (GWh)	51,2	54,8	68,8	83,7	88,6	90,8	129,7	188,9	237,4
- in Medium Voltage (GWh)	28,2	30,2	38,4	41,6	46,3	51,6	69,1	122,2 c/	n.a.
- in Low Voltage (GWh)	23,0	24,6	30,4	42,1	42,3	39,2	60,6	66,7	n.a.
Number of Consumers									
- MV	133	168	199	214	241	280	335	396 c/	n.a.
- LT	11880	13840	16425	20358	24518	27814	32929	35228	n.a.
Energy Sold per consumer									
- MV (MWh/cons.)	212	180	193	194	192	184	206	309 c/	n.a.
- LV (KWh/cons.)	1936	1777	1851	2068	1725	1409	1840	1893	n.a.

a/ Preliminary figures, of which some are not available (n.a.).
b/ At alternator terminals.
c/ Including Mining Companies: two consumers who, together, bought 42 GWh in 1981 and 73 GWh in 1982. When these two consumers (who should be itemized under HV) are not included, the other MV consumers have bought an average of 204 MWh/cons.

Source: Ministry of Public Works and Urbanism, Survey of Electricity Pricing in Niger, Ingenieurbüro Oskar von Miller, GmbH, December 1982.

NIGELEC: Generation, Sales and Losses by Load Center, 1977-81

Load Center	1977 Net Gen. + Purchases MWh	1977 Sales MWh	1977 Losses %	1978 Net Gen. + Purchases MWh	1978 Sales MWh	1978 Losses %	1979 Net Gen. + Purchases MWh	1979 Sales MWh	1979 Losses %	1980 Net Gen. + Purchases MWh	1980 Sales MWh	1980 Losses %	1981 Net Gen. + Purchases MWh	1981 Sales MWh	1981 Losses %
Niamey-Lossa	63,746	60,680	4.8	72,868	66,057	9.3	83,322	65,270	21.7	107,293	96,226 a/	10.3	117,711	104,187	11.5
Tilabery	-	-	-	-	222	-	512	474	7.4	789	724	8.2	1,089	1,074	1.4
Dosso	910	738	18.9	1,332	1,253	5.9	1,856	1,743	6.1	2,399	2,240	6.7	2,437	2,421	.6
Filingue	58	39	32.8	99	69	30.3	134	115	14.2	155	130	15.6	217	181	16.6
Doutchi	-	-	-	124	93	25.0	252	221	12.3	324	298	8.0	388	372	4.1
Konni	137	104	24.1	332	263	20.8	489	420	14.2	793	730	8.0	935	924	1.2
Madacua	-	-	-	12	3	75.0	182	178	2.2	333	273	18.0	499	443	11.2
Tahoua	1,163	1,040	10.6	1,723	1,504	12.7	2,305	1,844	20.0	2,896	2,542	12.2	3,341	2,247	32.7
Malbaza b/	6,103	6,103	-	5,640	5,640	-	6,013	6,012	-	5,970	5,363	10.1	6,150	4,966	19.3
Maradi	4,090	3,527	13.8	5,467	4,664	14.7	7,615	5,359	29.6	9,195	7,347	20.1	9,586	8,264	73.8
Tessaoua	-	-	-	300	245	18.3	417	364	12.7	516	447	13.3	796	548	31.2
Zinder c/	5,168	4,350	15.8	5,911	5,041	14.7	7,386	5,494	25.6	9,510	6,539	31.3	11,652	8,005	31.3
Magaria	121	98	19.0	242	137	43.4	294	274	6.8	313	328		319	310	2.8
Arlit	1,561	1,503	3.7	1,561	1,548	0.8	2,980	2,919	2.0	4,421	3,624	18.0	5,613 d/	5,077	9.5
Agadez	1,489	1,349	9.4	2,423	1,877	22.5	3,136	2,553	19.6	4,411	2,903	34.3	4,030	3,459	14.2
Tanout	-	-	-	-	-	-	46	39	15.2	69	35	49.0	286	217	24.1
Diffa	-	-	-	-	-	-	-	-	-	197	169	14.3	979	828	15.4
Total	84,546	79,531	5.9	98,034	88,616	9.6	116,839	93,279	20.2	149,557	130,510	12.7	166,028	143,523	13.6

a/ Niamey-Lossa Sales in 1980 taken from Compte Rendu de Gestion 1980. Compte Rendu d'Activite shows only 88,419 MWh.
b/ Malbaza Generating Station supplied exclusively the cement plant (at high voltage) until 1980.
c/ Statistics for Zinder include Mirriah and Matameye.
d/ Estimated.

Note: Purchased power delivered at substations (i.e. transmission losses excluded).

Source: NIGELEC: Compte Rendu d'Activité 1979, 1980, 1981
Compte Rendu de Gestion 1978.

ANNEX 7.1

SNTN: Specific fuel consumption, October 1977-September 1981

	Period				
	Oct. 1977 - Sept. 1978	Oct. 1978 - Sept. 1979	Oct. 1979 - Sept. 1980	Oct. 1980 - Sept. 1981	% Change between Oct. 1977-Sept. 1981
Mileage (million km)	17.383	21.739	26.657	20.004	+15.1
Fuel Cost (FCFA/km)	41.58	43.28	54.10	56.40	+35.6
Average Gasoil Price (FCFA/l)	75.04	77.25	96.77	130.06	+73.3
Specific Gasoil Consumption (l/km)	0.554	0.560	0.559	0.434	-21.7

Source: SNTN

ANNEX 7.2

Hydrocarbon Price Structure in Niamey in March 1983
(Shipped through Benin)
(CFAF/hl unless otherwise indicated)

	Premium Gasoline	Regular Gasoline	Kerosene	Gasoil
FOB price (Cotonou)				
Price ex-Parakou depot	10,430.20	10,627.76	10,468.64	10,558.45
Road transport PKou-Niamey	1,501.00	1,368.50	1,368.50	1,368.50
c.i.f. price Niamey (not cleared customs)	11,931.20	11,996.26	11,837.14	11,926.95
c.i.f. price Niamey	11,811.89	11,864.30	11,777.95	11,903.10
Statistical tax	15.05	11.13	14.38	14.49
Customs duty	60.18	60.52	57.52	11.59
Entrance tax	589.20	589.80	57.52	394.80
Production tax	329.22	330.37	183.21	260.12
Specific tax	1,800.00	1,800.00	900.00	700.00
Transport costs to Niamey depot	128.10	128.10	128.10	128.10
Tax on transfer costs	19.14	19.14	19.14	19.14
Loss Niamey depot	128.06	128.60	90.68	94.38
Loss transport and transfer	58.09	58.72	56.40	57.86
Amortization, maintenance of equipment	467.92	150.00	115.00	50.00
Overhead expenses	400.00	380.00	350.00	245.00
Financial costs	568.77	570.59	514.42	525.09
Profit	170.00	110.00	115.00	90.00
Transit "HAD"	106.33	105.93	91.47	104.47
Retailer's margin	600.00	600.00	500.00	500.00
Delivery costs to Niamey city	100.00	100.00	100.00	100.00
TOTAL	17,351.95	17,007.20	15,070.79	15,198.14
Stabilization	2,648.05	1,688.80	-2,570.79	1,001.86
Sales price (CFAF/hl)	20,000.00	18,700.00	12,500.00	16,000.00
Sales price at the pumps (CFAF/l)	240	225	135	170

Source: SONIDEP

ANNEX 7.3

Current NIGELEC Prices for Public Supply of Electricity
(Valid since October 1983)

Tariff	Fixed Charge (F/month)	Power Charge (F/kW/month)	Active Energy F/kWh of Interconnected Network March-Oct.	Active Energy F/kWh of Interconnected Network Nov.-Feb.	Isolated Centers	Reactive Energy (0.75E) (F/kVArh)
			P 100.1		72.8	
K-11 HV General	91,000	910	Int 27.4	23.6	45.1	8.5
			OP 24.6	20.8	37.0	
K-12 HV Heavy User	91,000	2,366	32.0	28.2	38.1	8.5
			P 103.5	-	75.3	
K-21 MV General	9,100	910	Int 34.5	30.1	39.2	8.5
			OP 28.1	23.8	38.0	
K-22 MV Heavy User	9,100	2,548	36.5	32.1	39.2	8.5
			P 107.7	-	90.0	
K-31 LV Hourly	1,820	182	Int 68.0	63.0	69.0	-
			OP 32.5	27.5	39.4	
K-33 a/ LV Heavy User	910	546	58.6	58.6	58.6	-
K-33 a/ LV Light User	-	91	66.8	66.8	66.8	-
K-34 Public Lighting						
with meter	-	10,920	31.3	31.3	31.3	-
without meter	-	22,345	-	-	-	-

a/ For general public prices, see table below.

Low Volatage Tariffs, General Public

Billing Code		K-33 Light Users Fixed Charge (F/month)	K-33 Light Users Active Energy (F/kWh)	K-32 Heavy Users Fixed Charge (F/month)	K-32 Heavy Users Active Energy (F/kWh)
K-331, K-321	3 kW	273	66.8	2,548	58.6
K-332, K-322	6 kW	546	66.8	4,186	58.6
K-333, K-323	12 kW	1,092	66.8	7,462	58.6
K-334, K-324	18 kW	1,638	66.8	10,738	58.6
K-335, K-325	30 kW	2,730	66.8	17,290	58.6

Price Categories	(P = Peak	From March to October: 4.5 hrs/day
	(Int = Intermediate	All the time except P and OP
	(OP = Off-peak	12 hours a day, all year round

List of Abbreviations

HV : High Voltage 66-132 kV
MV : Medium Voltage 5.5-15-20 kV
LV : Low Voltage 220-380 V
P : Peak from March to October 10:30 am to 12:30 pm; 3:30 pm to 6:30 pm.
Int : Intermediate hours - 8 am to 1 pm and 3 pm to 10 pm (except peak hours).
OP : Off-peak hours - 10 pm to 8 am and 1 pm to 3 pm.
Active Energy: Energy produced and actually consumed.
Reactive Energy: Energy produced but not consumed.

ANNEX 7.4

Electricity Pricing: Reference Tariff Structure Computed from Marginal Costs Estimates for the Period 1985-90

Tariff	Fixed Charge (F/month)	Power Charge (F/month/kW)	Active Energy Price: Hour Category	Active Energy Price (F/kWh)	Reactive Energy Price (F/kVarh)
K-11: HV General	100 000	1 000	Peak	84.00 + V1	8.40
			Intermediate	3.00 + V1	
			Off-peak	V1	
K-12: HV Heavy User	100 000	2 600	Unique	8.10 + V1	8.40
K-13: HV Interruptible	100 000	2 600	Unique	2.40 + V1	8.40
K-21: MV General	10 000	1 000	Peak	84.00 + V2	8.40
			Intermediate	7.00 + V2	
			Off-peak	V2	
K-22: MV Heavy User	10 000	2 800	Unique	9.20 + V2	8.40
K-23: MV Interruptible	10 000	2 800	Unique	2.80 + V2	8.40
K-31: LV Hourly	2 000	200	Peak	84.00 + V3	-
			Intermediate	39.00 + V3	
			Off-peak	V3	
K-32: LV Heavy User	1 000	600	Unique	30.00 + V3	-
K-33: LV General	-	100 1/	Unique	39.00 + V3	-
K-34: Public Lighting	-	12 000 + 365 V3	-		-

Variable Price Component:

	NIAMEY March-Oct.	NIAMEY Nov-Feb	Other Centers
V1	39.454	14.723	41.760
V2	42.886	16.004	45.391
V3	40.077		50.156

a/ Minimum Billable: F 300.

Source: Ministry of Public Works and Urbanism, Survey of Electricity Pricing in Niger, Ingenieurbüro Oskar von Mill[illegible], GmbH, December 1982.

ANNEX 8.1

Technical Assistance in Energy Planning: Job Description for the Technical Advisor

Training and Experience	-	Economist with energy specialization. 10 -15 years experience required, of which at least 5 years in research, project evaluation and energy sector planning. An experience in the planning department of a public administration would be particularly appreciated. Experience in Africa would be useful but is not required.
Length of Mission	-	24 months.
Location	-	Niamey
Title	-	The expert will be the energy advisor to the Ministry of Mining and Industry.
Job Description	-	To contribute to the planning process of the whole energy sector as a whole, in particular with respect to (1) the regular drafting of demand projections for all types of energy within the framework of the country's economic development (2) the study of ways of meeting the demand, including the evaluation of investments to create new capacities; (3) the setting up of a system to centralize all relevant statistics on the energy sector.
	-	To provide methodological support in the economic analysis of projects in all energy sectors. To evaluate economic studies on pricing and financing policy.
Cost of Technical Assistance	-	US$290,000.

ANNEX 8.2

NIGELEC's Investment Program, Formulated in July 1982
(in million CFA Francs, current values)

	Total	1982	1983	1984	1985	1986	1987	1988	1989	1990
Gas Turbine 12 MW, Niamey 2	1600	1600								
SONICHAR Station	300	300								
Niamey - Say Line	1600	560	900	200						
Goudel Power Station 2 x 12 MW	7700		4400	2800	500					
Maradi Power Station 2 x 1,1 MW	500			300	200					
Malbaza Power Station 2 x 1,1 MW	500			300	200					
Niamey Dispatching	370		40	110	220					
Malbaza-Tahoua-Madaoua Interconnection	1850			1200	650					
Goudel Power Station (ext 1) 1 x 12 MW	5000					2000	3000			
Maradi Power Station (ext) 1 x 1,1 MW	450						250	200		
Goudel Power Station (ext 2) 1 x 12 MW	6000							2500	3500	1/
Miscellaneous Investments	8250	600	700	800	900	1050	1200	1400	1600	
Total 1	34120	3600	6040	5710	2670	3050	4450	4100	5100	
NIGELEC Building	5600	___	100	2500	2500	500	___	___	___	
Total 2	39720	3000	6140	8210	5170	3550	4550	4100	5100	

a/ Another generator will be necessary in the Goudel Station by 1990.

Note: Monetary value increases assumed: 12% per year. In 1982 CFA, the total cost of the program is Million Francs 19,800 for total 1 and Million Francs 24,000 for Total 2.

Source: NIGELEC.

ANNEX 8.3

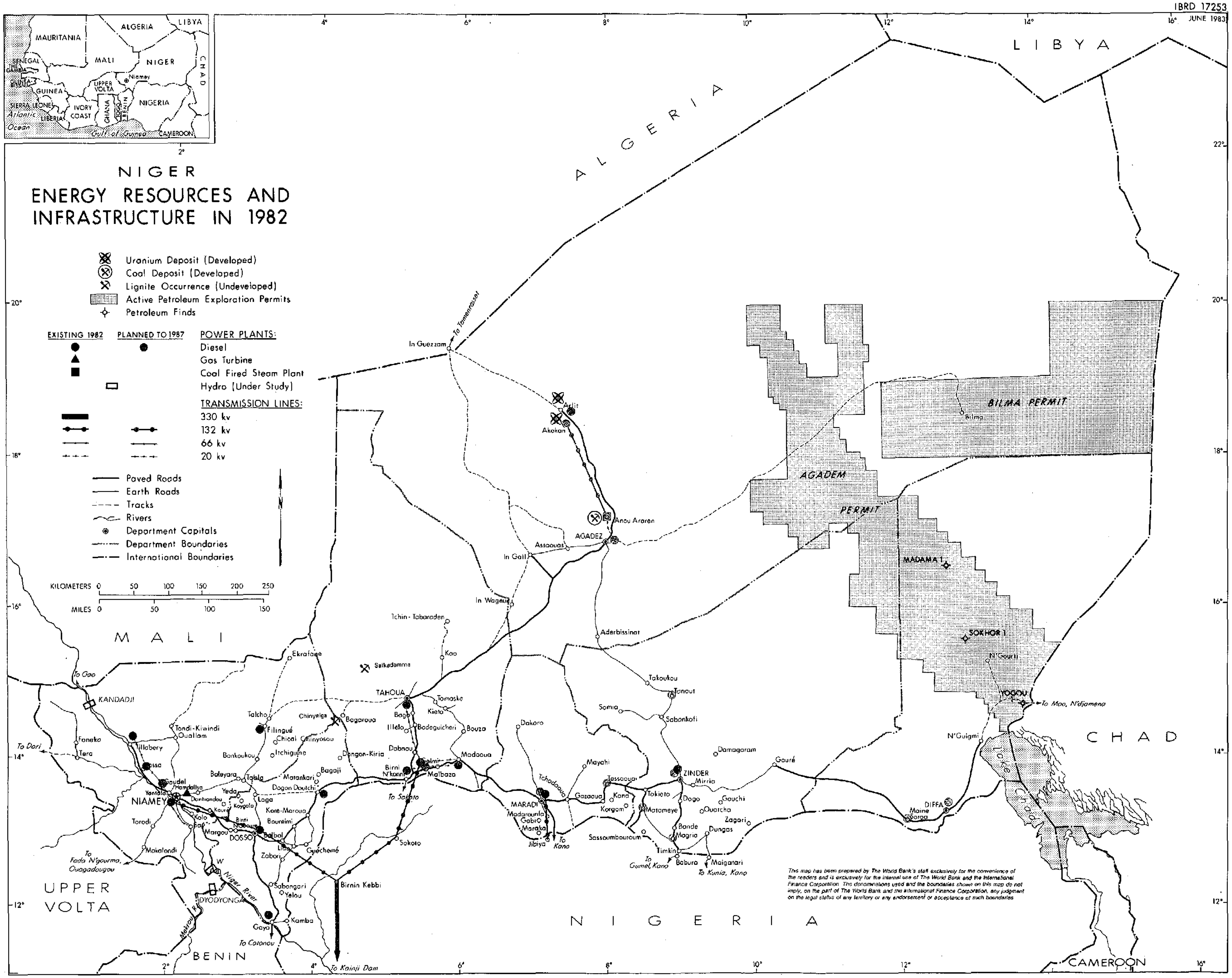
Outline of an Indicative National Energy Balance for 1990
(tonnes of oil equivalent) a/

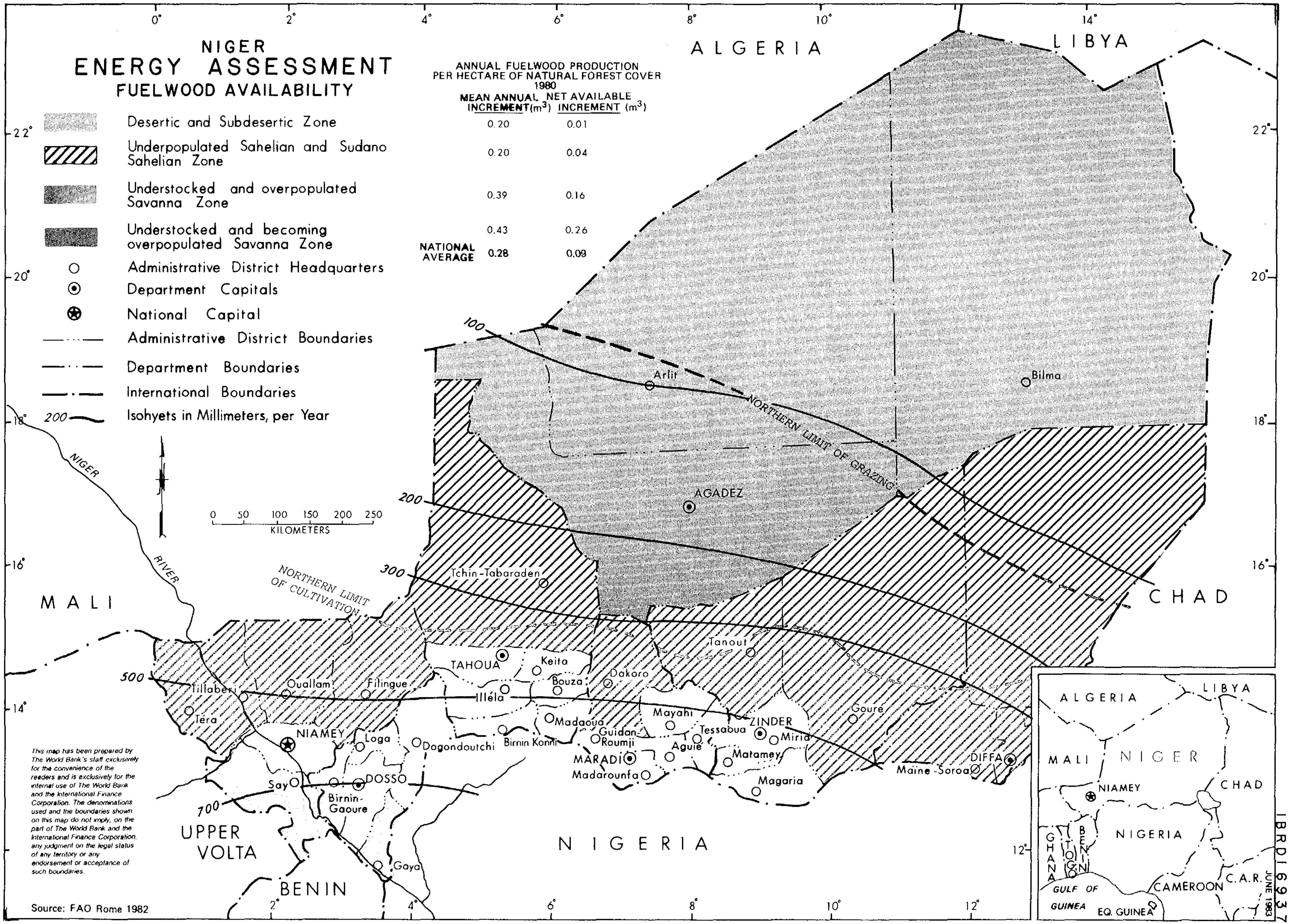
Line		Hydro	Crude Oil	Coal	Agricultural Residues c/	Fuelwood	Charcoal	Electricity e/	Petroleum Products b/ Gasoline f/	Kerosene	Gas Oil	Fuel Oil	Total	Line Totals	Line
	Gross Supply														
1	Production			41,605	310	1,078,230								1,120,145	1
2	Import							37,100	61,300	5,900	186,800	4,500	258,500	295,600	2
3	Total Available			41,605	310	1,078,230		37,100	61,300	5,900	186,800	4,500	258,500	1,415,745	3
	Conversion														
4	Charcoal Production					(3,124)	3,124							0	4
5	Electric Power Generation			(41,605)				148,400			(106,795)		(106,795)	0	5
6	Conversion Losses					(14,882)		(126,140)						(141,022)	6
7	Transmission/Distribution Losses							(6,500)						(6,500)	7
8	Net Supply Available/Net Domestic Consumption				310	1,060,224	3,124	52,860	61,300	5,900	80,005	4,500	151,705	1,268,223	8

Note: This projection presents the situation in Niger in 1990, without any change in Nigerien energy consumption habits and without the development of new domestic sources of energy.

a/ All conversion factors are the same as those used in the National Energy Balance for 1981 (Annex 1.1 of this report).
b/ Excluding butane and jet fuel. Demand projections as in Table 3.2 of this report, except in the case of kerosene. The projections in this annex do not allow for any substitution of kerosene for fuelwood in cooking.
c/ Groundnut shells only.
d/ Demand projections as in Table 2.2 of this report, based on a consumption of 0.75 m^3/capita/year.
e/ Demand projections as in Table 6.2 of this report.
f/ Premium, regular and aviation gasolines.

Source: Bank Staff estimates.


IBRD 17253
JUNE 1983
NIGER
ENERGY RESOURCES AND INFRASTRUCTURE IN 1982
Uranium Deposit (Developed)
Coal Deposit (Developed)
Lignite Occurrence (Undeveloped)
Active Petroleum Exploration Permits
Petroleum Finds
EXISTING 1982
PLANNED TO 1987
POWER PLANTS:
Diesel
Gas Turbine
Coal Fired Steam Plant
Hydro (Under Study)
TRANSMISSION LINES:
330 kv
132 kv
66 kv
20 kv
Paved Roads
Earth Roads
Tracks
Rivers
Department Capitals
Department Boundaries
International Boundaries
KILOMETERS 0 50 100 150 200 250
MILES 0 50 100 150
MAURITANIA
ALGERIA
LIBYA
MALI
NIGER
CHAD
SENEGAL
GUINEA
UPPER VOLTA
Niamey
SIERRA LEONE
IVORY COAST
GHANA
TOGO
BENIN
NIGERIA
LIBERIA
Atlantic Ocean
Gulf of Guinea
CAMEROON
A L G E R I A
L I B Y A
M A L I
C H A D
N I G E R I A
UPPER VOLTA
BENIN
CAMEROON
BILMA PERMIT
AGADEM PERMIT
MADAMA 1
SOKHOR 1
YOGOU
Bilma
In Guezzam
To Tamanrasset
Arlit
Akokan
Anou Araren
AGADEZ
Assaouas
In Gall
In Wagelle
Aderbissinat
Tchin-Tabaraden
Kao
Salkadamna
TAHOUA
Tamaske
Keita
Bouza
Illéla
Badeguicheri
Madaoua
Birni N'konni
Malbaza
Dabnou
To Sokoto
Sokoto
Birnin Kebbi
To Kainji Dam
Takoukou
Tanout
Sabonkafi
Somia
Dakoro
Mayahi
Tchadaoua
MARADI
Madarounfa
Gabi
Maraka
Jibiya
To Kano
Gazaoua
Tessaoua
Kona
Korgom
Matameye
Tokieto
ZINDER
Mirria
Dogo
Gouchi
Ouarcha
Zagari
Dungas
Bande
Magria
Sassoumbouroum
Timkin
Babura
To Gumel, Kano
Maigatari
To Kunia, Kano
Damagaram
Gouré
N'Gourti
N'Guigmi
To Mao, N'djamena
DIFFA
Maine Soroa
Lake Chad
To Gao
KANDADJI
Foneko
Tera
To Dori
Tillabery
Tondi-Kiwindi
Ouallam
Ekrafane
Tahoua
Filingué
Chical
Chinyelga
Bagaroua
Tchigueno
Bonkoukou
Dongon-Kiria
Bagaji
Boleyara
Tolola
Matankari
Dogon Doutchi
Yeda
Sansanné Haoussa
Say
NIAMEY
Torodi
Makalondi
Loga
Koré-Maroua
Boureïmi
Birni N'Gaouré
Margou
DOSSO
Balbol
Zabori
Guéchémé
Sabongari
Yelou
Kamba
Gaya
To Coronou
DYODYONGA
Niger River
W
To Fada N'gourma, Ouagadougou
2° 4° 6° 8° 10° 12° 14° 16°
12° 14° 16° 18° 20° 22°
This map has been prepared by The World Bank's staff exclusively for the convenience of the readers and is exclusively for the internal use of The World Bank and the International Finance Corporation. The denominations used and the boundaries shown on this map do not imply, on the part of The World Bank and the International Finance Corporation, any judgment on the legal status of any territory or any endorsement or acceptance of such boundaries.


NIGER
ENERGY ASSESSMENT
FUELWOOD AVAILABILITY
ANNUAL FUELWOOD PRODUCTION PER HECTARE OF NATURAL FOREST COVER 1980
MEAN ANNUAL INCREMENT (m3)
NET AVAILABLE INCREMENT (m3)
Desertic and Subdesertic Zone 0.20 0.01
Underpopulated Sahelian and Sudano Sahelian Zone 0.20 0.04
Understocked and overpopulated Savanna Zone 0.39 0.16
Understocked and becoming overpopulated Savanna Zone 0.43 0.26
NATIONAL AVERAGE 0.28 0.09
Administrative District Headquarters
Department Capitals
National Capital
Administrative District Boundaries
Department Boundaries
International Boundaries
200 Isohyets in Millimeters, per Year
0 50 100 150 200 250
KILOMETERS
ALGERIA
LIBYA
MALI
CHAD
NIGERIA
UPPER VOLTA
BENIN
NIGER RIVER
NORTHERN LIMIT OF GRAZING
NORTHERN LIMIT OF CULTIVATION
100
200
300
500
700
Arlit
Bilma
AGADEZ
Tchin-Tabaraden
TAHOUA
Keita
Bouza
Illéla
Dakoro
Tanout
Tillaberi
Ouallam
Filingue
Tera
NIAMEY
Loga
Dogondoutchi
Birnin Konni
Madaoua
Guidan-Roumji
Mayahi
Tessaoua
ZINDER
Miria
Goure
Aguie
Matamey
MARADI
Madarounfa
Magaria
DIFFA
Maine-Soroa
Say
DOSSO
Birnin-Gaoure
Gaya
ALGERIA
LIBYA
MALI
NIGER
CHAD
NIAMEY
NIGERIA
GHANA
TOGO
BENIN
CAMEROON
C.A.R.
GULF OF GUINEA
EQ. GUINEA
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Source: FAO Rome 1982
IBRD 16937
JUNE 1983