PDWAC 763

CBY ASSOCIATES, INC.

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May 8, 1987

Dr. Samuel Schweitzer
Renewable Energy Advisory
Office of Energy
U.S. Agency for International
Development
Room 508, SA-18
Washington, DC 20523

Dear Dr. Schweitzer:

CBY Associates is pleased to submit the final report for Contract PDC-5730-I-00-6109-00, Deliver Order 8, entitled, "The Role of Energy in Irrigated Agriculture in Niger" by Dr. Daniel Kohler. The original and two copies are enclosed.

Dr. Kohler has slides of pumping installations he visited in Niger and is available to give an illustrated presentation at AID sometime in May. He will be out of Washington most of June and July. You may contact Dr. Kohler directly regarding a time and place.

CBY Associates appreciates the opportunity to support AID's work and looks forward to further engagements under our IQC contract.

Sincerely,

Charles A. Bankston

Charles A. Bankston

Enclosures

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THE ROLE OF ENERGY IN IRRIGATED AGRICULTURE IN NIGER

by

Daniel F. Kohler

Prepared for
The Agency for International Development

CBY Associates, Inc

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PREFACE

This report was prepared for USAID/Washington's Office of Energy (S&T/EY). It was produced by Daniel F. Kohler, Energy Economist, under a consulting contract with CBY Associates. The views expressed herein are the author's alone, and neither CBY Associates or USAID necessarily agree with them.

ACKNOWLEDGMENTS

I appreciate all the help and cooperation of the WMS II team under the direction of Jack Keller. The WMS II Project Joint Irrigation Field Study/Workshop provided a framework for this research and provided me with lots of useful information.

A number of people have made helpful comments on earlier versions of this report. Especially Jack Keller of Utah State University and Terry Hart of I.T. Power have provided me with careful comments and additional insights. Charles Bankston of CBY Associates, and Sam Schweitzer and Janine Finnell of AID/W(S&T/EY) have also reviewed drafts of this paper and their comments have been appreciated. Any remaining errors and omissions are, of course, mine alone.

Daniel F. Kohler

TERMS AND ABBREVIATIONS USED

Parastatal	a company or institution wholly owned by the government, but with the organizational structure of a private enterprise.
Perimeter	an irrigated and managed area of agricultural land.
ONAHA	Office National des Amenagements Hydro-Agricoles, the national office for irrigated agriculture.
Nigelec	the national electricity company.
SONICHAR	Societe Nigerienne de Charbon, the national coal mining company.
SONIDEP	Societe Nigerienne de Petrol, the national oil import and distribution company.
GPP	Groupement des Professionels du Petrol, the organization of private oil companies.
CSPPN	Caisse de Stabilisation et de Perequation des Prix au Niger, the price stabilization fund.
SONARA	Societe Nigerienne d'Arachides, the national peanut marketing company.
ACDI	Agence Canadienne du Developement International, the Canadian foreign assistance agency.
RINI	Riz du Niger, the government-owned rice processing agency.
OPVN	Office des Produits Vivriers du Niger, the government agency charged with cereals marketing.

CURRENCY AND MEASUREMENT CONVERSIONS

1 liter	=	0.264 US gallons
1 meter	:	3.281 feet
1 m^3	:	1.31 cubic yards
1 ha	:	2.470 acres
1 CFA	:	0.333 US cents

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EXECUTIVE SUMMARY

GENERAL OBSERVATIONS

Energy is one of the most important inputs into irrigated agriculture, and unavailability of energy often presents bottlenecks to the development of the irrigated agriculture subsector. Most of Niger's irrigation development potential will depend on lifting water. The economic costs of the energy needed to lift the water are usually the largest variable costs of irrigation. The choice of the appropriate source of that energy can make the difference between the economic viability or failure of irrigated agriculture.

In a market economy, price signals indicate the scarcity and relative worth of alternative energy sources. In Niger the market functions only within the strictures imposed by the government. Rather than letting the market decide, the government of Niger has to reach a policy decision as to which energy sources are worth how much to the economy.

Niger has over the past few years adopted a set of price policies that provide energy users, including irrigated agriculture, with the incentives to use energy efficiently. It is to the government of Niger's credit that it has avoided fostering that sector with economically unjustified subsidies on energy inputs. Such subsidies only foster inefficient energy use and waste. Irrigated agriculture should be and, under the current policy, is treated like any other energy using sector, i.e. the price it has to pay for the different energy inputs reflects their economic worth.

Given Niger's comparative advantage, and the economic costs of supplying energy inputs in this landlocked country, a very clear hierarchy of economic energy costs for irrigated agriculture emerges. By far the lowest-cost energy source is grid-supplied electricity imported from Nigeria. Its cost to

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Niger's economy is about 17 CFA/kWh (5.7 cts/kWh), or less than 1/3 of the lowest-cost electricity produced domestically (diesel generation). But even if electricity is produced at the higher cost of domestic diesel generation (70 CFA/kWh = 23 cts/kWh), the economies of scale are such that where the grid is closely accessible, electricity is the cheapest power source.

The costs of connecting to the grid, however, can be very high. The World Bank/French Caisse Centrale de Cooperation Economique (CCDE)/Kreditanstalt fuer Wiederaufbau (KfW)-sponsored rehabilitation project for the Office National des Amenagements Hydro-Agricoles (ONAHA) perimeters will connect all ONAHA perimeters in the immediate vicinity of the Tillabery/Niamey/Dosso grid to electricity supplied by Nigelec. Nigelec quotes an approximate price for the power lines of 5 million CFA per km. A typical perimeter that is 20 km away from an existing power line would cost, therefore, around 100 million CFA ($340,000) to electrify--not counting transformers and other miscellaneous costs. This is economical only for large perimeters where the costs of grid connection can be spread over many hectares. In the ONAHA project, the average costs of grid connection are in the neighborhood of 190,000 CFA/ha ($650/ha), and for some perimeters, the are almost double that.

For perimeters that are too far from the grid to make connection economical, the second best alternative from an energy cost point of view are electric pumps driven by power generated locally with diesel generation sets. Such a system is still about 30 to 50 percent more efficient in fuel costs than a direct diesel-driven system.

Some of ONAHA's older perimeters are still driven by diesel engines connected mechanically to pump sets. The energy efficiency[1] of these systems is abysmal. Though built fifteen to twenty years ago with a life expectancy of 30 years, virtually all of them have broken down. Direct diesel-driven pumps are efficient only within a very narrow band of technical parameters such as lift, running speed, etc. If a direct diesel-driven pump is used for a higher lift,

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[1] Energy efficiency of a pumping system is defined throughout this document as the ratio of hydrological energy output to fuel energy input.

or is run at a slower speed than what it was designed for, energy efficiency will be reduced dramatically--much more so than is the case of electric or diesel-electric systems. Most of the installed pump sets work considerably outside of the specifications they were designed for. But even if used efficiently, direct diesel drive pumps probably could not compete with diesel electric systems.

At the high end of the fuel cost spectrum are small gasoline-powered pumps. The fuel costs per hectare of these small pumps are almost double the costs of even the inefficient direct diesel pumps. This is primarily due to the highly inefficient way in which these pumps are used. Nigerien farmers tend to purchase these small pumps in Nigeria, where they are less expensive and more readily available. Rarely, however, are either purchaser or seller aware of the specific conditions of the site to be irrigated. Farmers simply purchase whichever pump they can get their hands on. Hart[2] claims that by simply matching these small pumps better to the sites, efficiency could be tripled. In this case small pumps become competitive with large diesel systems.

ONAHA is currently engaged in a program of making its perimeters more energy-efficient. Electrifying perimeters in the Niger valley, especially those currently being powered by direct diesel systems, not only saves energy overall, but also offers opportunities of taking advantage of imported hydro electricity, a renewable resource available at fairly low costs. The time-of-day (TOD) tariff practiced by Nigelec also provides the cooperatives running the irrigated perimeters with the correct incentives to use electricity during those times of the day when it is cheapest to supply. Unfortunately, the generally practiced "redevance" system by which individual farmers pay for that energy makes it very difficult to pass such incentives, and the associated savings, on to the actual user[3].

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[2] Terry Hart, Improved Water Pumping/Water Lifting in Africa: Rapid Country Review (Niger), I.T. Power Inc., June 1986.

[3] See Section II for a description of the TOD tariff and the description of the management of the ONAHA perimeters for an explanation of the "redevance" system.

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In areas not served by the Niamey grid, the situation is somewhat different. Electricity use in these areas is de facto subsidized, i.e., the prices do not reflect the social costs of providing the service. Electrifying existing perimeters, or installing new electric powered ones in these areas, should be carefully evaluated. The evaluation must not be based on the electricity prices actually charged by Nigelec, but rather on the social costs of providing electric service. Based on a production cost of diesel generated electricity of 70 CFA (23 cts) per kWh (short run variable costs only!), and network and administrative overhead of 18 CFA (6 cts) per kWh, these economic costs must be at least around 90 CFA (30 cts) per kWh--two to three times the off-peak costs of the Niamey grid. Under these circumstances a diesel-electric, or possibly even a direct diesel system might be more economical.

But even on the Niamey grid, not all electricity sold is hydroelectricity imported from Nigeria. When the system reaches its peak so that the complete load can no longer be satisfied with the capacity of the 132 kVolt interconnection with Nigeria, Nigelec has to complement the imported power with electricity produced with domestic diesel generators. Cooperatives or better yet, individual farmers, should be encouraged, through proper price signals, to use electricity whenever it is possible to satisfy their demand with imported power. The currently practiced TOD tariff goes a long way in that direction; however, improvements are possible. For example in Annex 7.4 of the World Bank's Niger: Issues and Options in the Energy Sector, an interruptible tariff is proposed that seems tailor-made for irrigated agriculture. Under an interruptible tariff, the electricity supplier (in this case Nigelec) would have the option to cut off some customers whenever its load started to exceed what could be provided with low-cost base-load systems. The length of individual interruptions and the total length of interruptions are specified, and are usually in the order of a few hours a day. In exchange, the subscriber who is willing to accept the inconvenience of being cut off for a couple of hours on some days, is offered a very favorable price per kWh. In many countries in Europe as well as the United States, enterprises depending on pumping type operations, such as pipelines, typically take advantage of these tariffs and are thus able to carry out their pumping at a fraction of the costs.

If a large number of small holders use water in turn, an interruptible tariff might impose some administrative problems. However, most perimeters are, in fact, quite "elastic" with respect to their water supply, i.e. their water distribution systems have sufficient excess capacity that, if all the canals are full, farmers can continue drawing water for quite some time even if the pumps are not operating.

Note that offering electrified perimeters incentives such as interruptible tariffs does not constitute a subsidy. The low price of electricity under this kind of a tariff is economically justified, because it enables the utility to lower its production costs. Such a solution would be clearly preferable to an outright subsidy as was advocated by some ONAHA representatives during the team's visit.

If small, individual motor, pump-driven systems are used on an appropriate scale, they can be made to be almost competitive with diesel-electric systems, the only lower cost alternative in isolated areas. However, they have to be used for high value crops (i.e. market gardening, onions, etc.). If this is the case, the organizational advantages of individual farmers owning their own pumps may outweigh the disadvantages in fuel costs. As part of USAID's Niger Applied Irrigation Research and Coordination Project, ways should be investigated of making such small scale systems competitive[4].

One obvious way in which this could be helped is by providing local mechanics with the necessary information and training so that they can service such pumps. Changing pistons and rings on such a small combustion engine is not a very intricate operation, and local mechanics, who already are servicing anything from trucks to mobilettes, should be up to the task.

But the most serious problem is the mis-matching of the pumps to the site. The potential payoffs to education of farmers on this topic are tremendous. Admittedly, these pumps will probably never compete in energy efficiency terms with the large scale diesel-electric or grid-connected systems, however they

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[4] See the "Specific Recommendations" below for examples.

are currently being used inefficiently. Their use is also expanding. Hart (op.cit.) estimates that about 2000 of these small pumps were in use in 1986, and that their number was expanding at a rate of about 15 percent per year. If these estimates are correct, up to three thousand of these pumps may be in use by the time the USAID Niger Irrigated Agriculture Research and Coordination Project becomes fully operational. Improving their energy efficiency by only 20 percent on average could result in fuel savings of almost one million liters (260,000 gallons) per year.

Making existing perimeters more efficient should be the primary concern in Niger's irrigation sub-sector. This applies to government- (ONAHA-) sponsored perimeters as well as small private plots. Expanding the irrigated area should clearly take second place behind this concern. There is no immediate need for dramatic increases in cereals production that would justify pushing that reform of agriculture at all costs. If instead the existing perimeters are used more efficiently, i.e. the same output can be produced with less input, resources will be freed up for the development of other agricultural activities and for economic development overall.

SPECIFIC RECOMMENDATIONS

There are a number of things USAID could do to improve energy use in the irrigated agriculture subsector. Some of the things being listed are already part of the new project. They are mentioned here to reinforce the direction that the project is taking. Others fall only marginally within USAID purview, and thus may be more properly considered "pious hopes." But piety aside, there is hope for Niger's irrigated agriculture, at least for high value specialty crops. If the present rational policies are continued, energy should not be a stumbling block.

There are four specific recommendations on how USAID could positively influence energy use in irrigated agriculture in Niger.

1. The proposed technical advisor to ONAHA, charged with improving pumping station efficiency, should be aware of the macro-economic consequences of electricity use. He should be fully informed about electric utility pricing, especially peak-load pricing, so that he can advise the cooperatives on how to minimize their electricity bills.

2. USAID should <u>not</u> support a subsidized electricity rate for agricultural uses. Instead it should use its influence in the policy dialogue to promote the idea of an interruptible tariff. Such a tariff can offer very substantial savings to users willing to put up with occasional short-term blackouts. In pumping applications, such blackouts are usually not of serious consequence.

3. USAID should oppose a special price for diesel fuel used in agriculture. Diesel fuel is already taxed at a very favorable rate, and reducing this tax further would only encourage inefficient use. It would also favor the project (i.e., ONAHA controlled) sector of irrigated agriculture, at the expense of the individually owned and managed perimeters.

4. USAID should use a portion of its resources under the new project to improve energy efficiency in the private motorized pumping sector. Inefficiency in that sector is so high, that even small amounts of education and training are bound to have large payoffs. Ways in which this can be achieved are by a) educating and training farmers on how to properly size and operate a system so that it meets the needs of the site, b) training, and possibly equipping, local mechanics so that they can maintain and repair the small pumps, and c) informing producers of small pumps as to the kinds of pumps needed in the areas where farmers have the means to acquire them. The smallest pumps currently available are often not small enough.

This brief analysis has ignored one portion of the irrigation subsector that is very important, i.e., hand- or animal-powered water lifting. The new USAID project seeks to support primarily that sector, and this emphasis is well-placed. The development of better human powered pumps, especially if they can be produced cheaply enough, promises to make irrigated agriculture accessible to large groups of the population that are currently left out of the system. However, because such pumps have only very small and indirect effects on the national energy balance, they have been left out of this analysis.

I. INTRODUCTION

IRRIGATED AGRICULTURE IN NIGER

Only about 10 percent of Niger's land is arable in normal years. The semi-arid climate, with very marginal rainfall, makes agriculture even in those zones a risky proposition. However, as a landlocked country devoid of much natural resources, Niger will nevertheless have to depend on agriculture as its major source of income. Furthermore, achieving food self-sufficiency has been official government policy since the 1974 drought.

USAID supports this goal, at least in a broad interpretation[5]. The economic costs of attaining food self-sufficiency in the strict (autarkic) sense would be prohibitive. However, for many years to come, Niger will have to depend on its agricultural output, and its traded agricultural surplus, to feed its populations, even if the uranium market should recover.

Irrigated agriculture[6] will have to play an important role in Niger's agricultural strategy. Rainfall is too marginal and too variable to permit reliance solely on rain-fed agriculture. Recognizing this constraint, Niger began in the seventies a vigorous program of expanding irrigated perimeters.

Today, Niger has about 6,600 ha of irrigated perimeters managed by the parastatal Office National des Amenagements Hydro-Agricoles (ONANA) and 1,300 ha of small plots irrigated with motor pumps by individual small-holders[7]. Other sources credit ONAHA with up to 9,000 ha under irrigation[8]. The discrepancies

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[5] See USAID, Country Development Strategy Statement, FY 1988, Niger, March 1986.

[6] The term "irrigated agriculture" covers a wide variety of systems, not all of them requiring commercial energy inputs for their operation as noted below.

[7] Terry Hart, Improved Water Pumping/Water Lifting in Africa, Rapid Country Review: Niger, I.T. Power, Inc., June 1986.

[8] See for example, Annex C of the FY 1988 CDSS for Niger.

may stem from uncertainty regarding which perimeters are, in fact, still in operation and which have been abandoned. In addition, there are a great number of small garden plots where farmers lift water by manual methods, primarily to produce vegetables. Some observers believe that the total area of these micro-irrigation systems is seriously underestimated, and may range up to 4,000 ha[9].

Fessenden (op.cit.) distinguishes 5 types of irrigation systems practiced in Niger.

1. Jointly managed river pumping systems
2. Jointly managed surface dam schemes
3. Jointly managed ground water pumping systems
4. Individually managed micro-irrigation systems
5. Uncontrolled recession and flood agriculture

Of these, only 1, 3, and 4 involve the use of energy inputs other than farm labor and only these are considered here.

The jointly managed perimeters were originally set up by CNAHA with donor financing, but should now be self-supporting. The pump sets are nominally owned by the cooperatives, who are responsible for operation and maintenance. The costs of these items, including amortization and other overhead costs such as the salaries of the pump station attendants are paid by the cooperative. The cooperative in turn collects funds from its members by way of a "redevance," a fee based on actual costs incurred and allocated on the basis of the size of the parcels[10]. The farmers cannot sell or lease the parcels, however they will lose them if they fail to pay their redevance. The cooperative's elected employee, and the local political authorities, decide on the allocation of parcels to individual farmers. Traditionally, a farmer's claim to a parcel is fairly secure, provided he pays his redevance, and he has usually no difficulty transferring it to a member of his family, such as son.

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[9] See A. Fessenden, Irrigation Sub-Sector Update, Annex C to the Niger CDSS (FY 1988), February 1986.

[10] An example of a redevance calculation is provided in Appendix A.

Such jointly managed irrigation systems are located primarily in three areas:

- The River zone: essentially the corridor from Tillabery to Say, along the Niger river, including Niamey. This zone is served by the national electricity grid.

- Ader-Doutche-Maggia (ADM): along an intermittent tributary to the Sokoto river. Irrigation in this zone is based on retaining the seasonal water with dams and using gravity-fed irrigation.

- Maradi: using diesel pumps and in Djiratawa, electricity from the local Nigelec grid. This local grid receives power from a diesel generation station in Maradi.

- Komadougou, near Diffa: using portable gas and diesel pumps.

ENERGY CONCERNS/TERMS OF REFERENCE

USAID recognizes the important role commercial energy plays in irrigated agriculture. USAID/Washington's Office of Energy (S&T/EY) has commissioned this analysis to assure that the energy consequences of different irrigation schemes are adequately considered. The terms of reference for this study were:

1. Analyze potential opportunities to determine a least-cost approach for delivering power to the field sites. Options may include rural power (central or decentralized service), demand management, mechanical pumping, and institutional arrangements, such a farmer cooperatives.

2. Determine the potential of private sector initiatives to meet power needs, particularly for small power systems (1 MW to 2.5 MW).

3. Identify interrelationships between power for water pumping and other rural needs such as agro-processing, cottage industries, community development, and employment generation.

4. Examine development plans for irrigation in Niger. Evaluate these plans by activity and location, and determine their potential impact on power demand.

The remainder of this report is organized along the lines of terms of reference. There is considerable overlap among the different topics, however, so that the correspondence is not as close as might have been hoped. In the following section, the existing systems for supplying electric power and fuel

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in Niger are reviewed. Particular attention is paid to the policy framework and the role of the parastatals within that system. The role of the private sector is strictly circumscribed by the Government of Niger, however, some private sector opportunities may exist. In Section III the use of energy for pumping in the government-sponsored perimeters is analyzed somewhat more closely. A corresponding independent analysis of the private sector was unfortunately not possible within the resources allocated to this task, and we refer to the existing reports, especially Terry Hart's Rapid Country Review for more information. Finally in Section IV the existing development plans and the current projects underway in the irrigation sector will be discussed. Some concluding comments follow in Section V.

II. THE ENERGY SUPPLY SYSTEM

In this section we shall describe the supply system and the policy regime governing the supply of commercial energy, even though commercial energy resources play a relatively small role in the overall energy balance. Of the roughly one million tons of oil equivalent of energy supplied in Niger per year, over 85 percent of it is fuel wood and charcoal supplied by the informal sector. Electricity accounts for only about 22,000 toe and petroleum products for 130,000 toe[11]. In the irrigation sector, however, the commercial energy sources (electricity and petroleum products) are the major providers of power. Shortages in the supply of commercial energy have the potential of seriously hindering further agricultural development.

PETROLEUM PRODUCTS

Niger has no domestic petroleum resource worth exploiting, though low level exploration has been underway at least since 1975. There is also no refinery located in Niger; all imports are in the form of finished products. The parastatal Societe Nigerienne de Petrol (SONIDEP) has the monopoly for importing all petroleum products, except fuel oil and butane. Until recently, SONIDEP was also active in the retail distribution. Under the International Monetary Fund (IMF)/World Bank-sponsored structural adjustment program, the retail distribution function is being phased out.

There are a number of oil companies active in Niger. They purchase petroleum products from SONIDEP and re-sell them at government set prices to consumers. There are also a number of independent traders who deal in fuel oil, and who, with approval from the transportation ministry, import small amounts of other petroleum products to supply isolated areas.

The prices are set by the Ministry of Commerce and enforced by the price control directorate, Direction du Controle de Prix DCP, within that ministry.

[11] The World Bank, Niger: Issues and Options in the Energy Sector, Report No. 4642-NIR, May 1984.

The original legislation foresaw a pricing commission where all interested parties would be represented, however, the actual application of the law has led to a less formal process. The staff of the price control directorate consults separately with the interested parties, SONIDEP, the fund for price stability, the Groupement Professional du Petrol (GPP) representing the oil companies, the electricity company (Nigelec), and the different ministries. The price control directorate prepares a recommended price schedule which is (usually) approved by the Minister of Commerce. Presumably, other ministries have the option of raising pricing issues in the Council of Ministers if they do not concur with the Minister of Commerce's decision.

The retail prices vary by location, to reflect transportation costs. The prices in the isolated areas in the north are generally higher than in Niamey. The electricity company (Nigelec) is the largest consumer of diesel fuel, and benefits from a reduced tax on its purchases. The actual retail prices are given in Table 1.

Table 1

RETAIL PRICES FOR PETROLEUM PRODUCTS IN NIGER
(FEBRUARY 1987)

Product:	Retail Price CFA/Liter	Retail Price US$/Gallon
Premium Gasoline	274 to 280	3.46 to 3.53
Regular Gasoline	243 to 268	3.07 to 3.32
Kerosene	142 to 163	1.80 to 2.06
Diesel Fuel	180 to 193	2.27 to 2.44
Diesel (Nigelec)	157 to 169	1.98 to 2.14

Source: Arrete No. 024/MCT/DCP of May 14, 1985

Embedded in these prices is an intricate tax/subsidy system. Gasoline, and to a lesser extent diesel fuel, are taxed while household kerosene is subsidized. The effective tax rates, including the cross-subsidy are as follows: premium gasoline, 39%; regular gasoline, 37%; diesel, 19%; kerosene -3.4%[12]. The Caisse de Stabilisation et de Perequation des Prix au Niger (CSPPN) is responsible for this tax/subsidization adjustment and also functions as a fund for smoothing out price fluctuations over time. In this manner price changes are held to a minimum. The current prices have been in force for almost two years.

Combustion motor driven pumps for irrigation usually are powered by diesel for large installations, or by gasoline for small, portable pumps. The owners and operators of pumps purchase their fuel in the open market. Up to now, however, most cooperatives active in jointly managed perimeters, have purchased their diesel fuel directly from SONIDEP, because that parastatal accorded them very favorable payment terms. Some cooperatives have experienced delivery delays from SONIDEP and have turned to private dealers.

Motor driven irrigation is practiced primarily along the southern border with Nigeria and in the Niger valley. These areas also represent the major transportation corridors and are, therefore, adequately served by oil companies. There are still substantial reserves of land that could be opened to irrigation in these areas, which would not strain the fuel supply system in any way[13].

The price structure as set by the government clearly favors the large perimeters over the small, independently-operated irrigation systems. The absence of a viable small (<1HP) diesel pump makes it impossible for the independent

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[12] These rates were calculated by the World Bank (op.cit.) and are based on the prices in force in 1982. Rates on current prices might differ slightly.

[13] Farmers in the Air mountains practice some irrigation based on manual lift methods (see Annex C to the FY 1988 CDSS). If introduction of motor pumps were considered in this area, for example, the adequate supply with fuel would have to be considered carefully.

farmers who use motor powered irrigation to take advantage of the relatively favorable tax treatment of diesel fuel. They, therefore, face substantially higher costs of operation than the state sponsored perimeters.

There are currently no special prices for any fuel used in agricultural applications. According to the director of the price control directorate, however, a decision has been made in principle to introduce a special diesel price for irrigation, similar to the system practiced for Nigelec. However, he also mentioned his reservations as to the practicability of such a system, because it would be practically impossible to control the final use of the subsidized fuel sold. More importantly, however, it is our opinion that such a special treatment would further favor the state sponsored sector over the individual farmers and would not be in the interest of a rational agricultural policy.

ELECTRICITY

Niger has one interconnected grid, ranging from Tillabery to Dosso and including the city of Niamey (the Niamey grid). A small grid connects Arlit and Agadez in the uranium producing north of the country. Apart from these connections only local distribution networks confined to each town exist.

The monopoly for transmission and distribution of electricity rests with Nigelec, the Nigerien electricity company. Originally set up as a subsidiary of Electricite de France, it continues to run on the French model. It formally is organized as a private company holding a concession from the state. In fact, however, 90 percent of the capital of Nigelec is held by the government, which places the government in a dual role: that of granting a concession and of concessionaire. Nevertheless, the private corporate structure has enabled Nigelec to preserve a certain amount of independence and attract better staff than what it could were it simply a government department.

Nigelec obtains electricity through imports from Nigeria over a 132 kV line connecting the Niamey grid with Birnin Kebi and the Kainji dam in Nigeria and, for the Arlit/Agadez grid and the uranium mines, by purchase at government-set

prices from the coal mining parastatal SONICHAR. Nigelec also produces electricity in over 20 small (~10 MW) diesel stations throughout the country and a gas turbine station in Niamey. The costs of production vary greatly for the three alternatives, as Table 2 shows.

Table 2

VARIABLE PRODUCTION COSTS OF ELECTRICITY
(FEBRUARY 1987)

Mode of Production	Price	Remarks:
Imports:	17 CFA/kWh (5.7 cts/kWh)	Note: contracts with Nigeria are set in Niara. The recent decline in the Niara relative to the CFA has benefitted Niger.
Diesel:	70 CFA/kWh (23.3 cts/kWh)	It takes about .4 liters of diesel to produce 1kWh. Nigelec buys diesel practically tax free for prices ranging from 162 CFA/1 in Niamey to 167 CFA/1 in Agadez. Therefore, fuel costs alone amount to about 65 CFA/kWh.
SONICHAR:	105 CFA/kWh (35 cts/kWh)	This price is fixed by the government based on SONICHAR's production costs. Nigelec can resell the power to the uranium mines at the same price plus a commission of 7 to 8 percent. Individual consumers in Arlit-Agadez pay about the same price as consumers in Niamey.

Note: Line and distribution overhead adds another 7 to 8 CFA/kWh and administrative overhead is 10 CFA/kWh.
Source: Nigelec

Nigelec has its lowest costs of operation by far on the grid around Niamey where much of the demand can be satisfied with the low cost energy imported from Nigeria. However, Nigelec's tariffs are more or less uniform over the

entire territory, resulting in a substantial subsidy to the rest of the country. Officials of Nigelec are accordingly very concerned about the possibility of demand growing faster outside of the Niamey grid and thus increasing average production costs.

The price at which SONICHAR sells power to Nigelec is also set by the Council of Ministers. Nigelec resells this power to the uranium mines with a modest mark-up (7 to 8 percent), and to private users for the same nationally fixed price as everywhere else in the country. The price granted to SONICHAR is based on SONICHAR's production costs, which appear to be excessively high. The price is so high, in fact, that some reports state that the uranium mining company has begun acquiring diesel generators to avoid purchasing the high priced power from SONICHAR (through Nigelec).

Part of the reason for the very high production costs of SONICHAR may be that, since the recession in the uranium market, SONICHAR has been operating only at half capacity. SONICHAR has two generating stations capable of peak demands equal to 16 MW each. In recent years, however, average demand has been very low and even peaks have not exceeded 25 MW, and as a result only one of the two stations has usually been operating at any one time with short term peak demands being met by diesel generators.

Electricity tariffs are set by the Council of Ministers, and have in recent years covered most of Nigelec's costs. The prices are fixed uniformly over the entire territory for low voltage (220 V) consumers, and are, on average, equal for medium voltage (20 kV) and high voltage (66 kV) users as well. Medium and high voltage users pay a three part time-of-day (TOD) tariff with peak, full, and off-peak prices that go from single to threefold on the Niamey grid and from single to double in the remaining areas[14]. Alternatively, they may select to pay a higher subscription fee and a uniform per kWH charge

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[14] Under a TOD tariff customers pay different prices for electricity depending on the time of day when it is being used. For more detail on the economic rationale for such tariffs see Mitchell, Manning and Acton, "Peak-Load Pricing," Cambridge, MA: Ballinger, 1978.

irrespective of time of use. Table 3 gives the tariffs currently in force for medium and high voltage customers, the category into which electric pumping stations fall.

Table 3

TIME OF DAY TARIFFS FOR MEDIUM AND HIGH VOLTAGE CUSTOMERS OF NIGELEC

Tariff Element:	Customer Class 66 kV	20 kV
Fixed fee (CFA/mo.)	92500	9250
Subscription (CFA/kW)	925	925
Energy use (CFA/kWH)		
Niamey Grid		
March through October:		
Peak	110.3	114.3
Full	36.9	44.4
Off-Peak	34.1	38.1
November through February:		
Peak/Full	30.7	37.5
Off-Peak	28.0	31.1
Rest of Niger		
Peak	80.3	82.8
Full	52.8	56.2
Off-Peak	45.0	46.5
Peak demand charge (CFA/kW)	9.1	9.1

Source: Nigelec

The hours of the day during which the above TOD rates apply vary also with the time of the year for Nigelec customers on the Niamey grid. The detailed rate sheets are reproduced in Appendix A. To provide an illustration, Figure 1 gives the daily price profile for a medium voltage user on the Niamey grid during the summer months. This is the period into which much of the pumping activities of the electrified rice perimeters in the Niger valley fall.

According to the World Bank, Nigelec's tariff structure reflects the utility's long run marginal costs[15]. Using electricity in accordance with the economic incentives provided by this tariff would, in principle at least, be economically efficient. However, this conclusion ignores the regional differences in Nigelec's cost structure that are, by government policy, not reflected in the tariff.

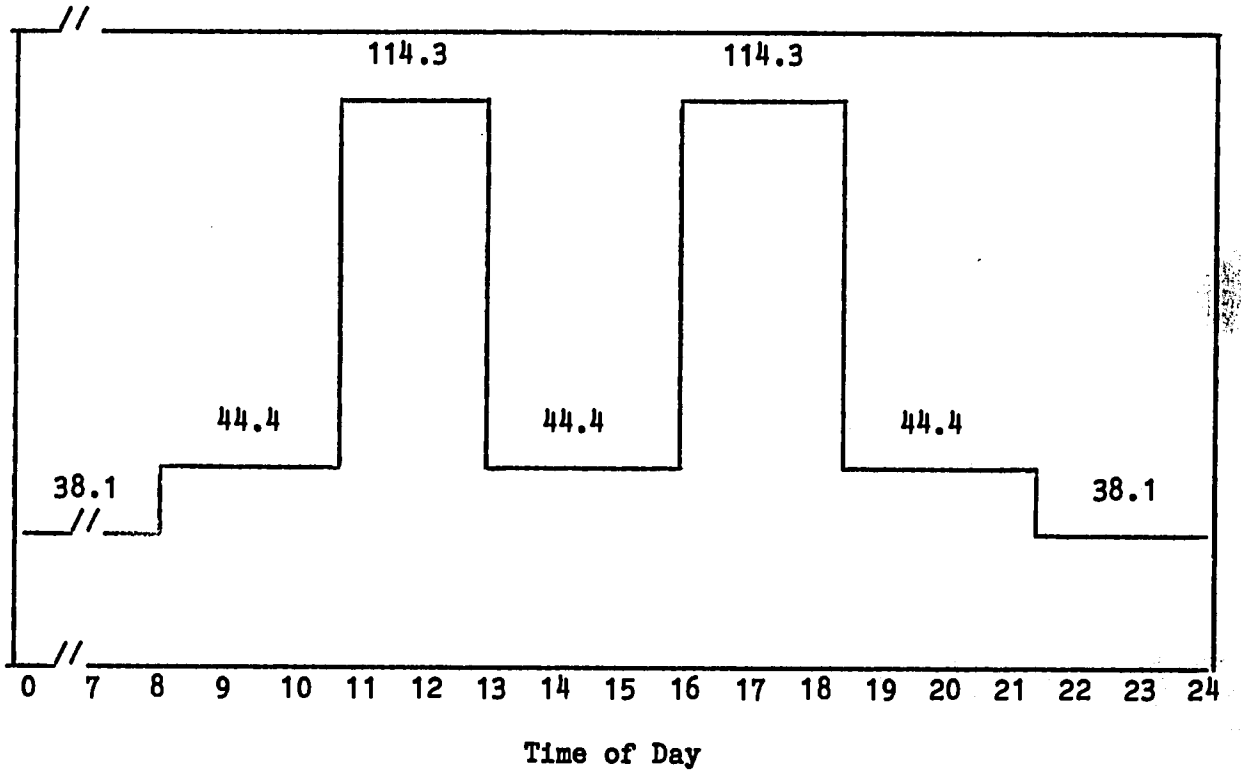

Fig.1. Daily Price Profile for Medium Voltage on Niamey Gri
(March through October)

[15] The World Bank, Niger: Issues and Options in the Energy Sector, Report No. 4642-NIR, May 1984.

The economic costs of providing electricity in areas outside of the Niamey grid are considerably higher than the tariff for these areas. Any expansion of electricity use in these areas, including expansion of irrigation powered by electricity, will have economic costs for Niger in excess of the price charged for electricity. By the same token, the electricity rates charged on the Niamey grid, exaggerate the economic costs of providing electricity there, at least during off-peak hours, and expanding use in these areas will have lower economic costs than what the tariff suggests. It follows, that installing electric-powered irrigation systems, or electrifying existing perimeters, should be undertaken in areas connected to the Niamey grid, even if rate of return calculations based on existing electricity tariff may not fully justify them. As a corollary, we conclude that, in areas outside of the grid, similar projects should be avoided even if they appear economic based on rates charged by Nigelec.

OTHER ENERGY RESOURCES

Attempts at developing alternative sources of energy in Niger have been very limited and so far mostly unsuccessful. The biomass resource is primarily used for domestic heating and cooking and is actually being depleted at an alarming rate. It is too scarce to be converted into commercial energy that might be available as power for irrigation.

The Nigerien groundnut parastatal (SONARA) processes groundnut shells into briquets for fuel. Some technical problems (smoke, etc.) remain, and use of these briquets is not very widespread. More importantly, supply is too erratic to induce anyone to even consider the possibility of using the SONARA briquets in power generation. Despite a theoretical capacity of 5,000 tons p.a., SONARA rarely produces more than a few hundred tons. The brick factory SONICERAM, one of only two industrial users of groundnut shell briquets, has since acquired a new power unit based on fuel oil.

Solar insolation is excellent in Niger. However, solar systems are extremely expensive, and the only experimental solar pump installed at Karma has since

been discontinued, in part due to the lack of spare parts and the shortage of trained personnel.

It does not seem very likely that solar powered pumps will soon be feasible for irrigation in Niger. They would most likely have to compete against the small 3 to 5 hp gasoline pumps currently used. At an insolation of about 1000 W/m^2, solar cells which are currently about 8 percent efficient will yield around 80 W/m^2. To obtain the same power as a 5 hp gasoline engine (4 kW), one would therefore need at least 50 m^2 of solar cells, a rather impressive array for irrigating a plot that is less than one has on average.

Life cycle costs of solar pumps are also prohibitively high. Current capital cost estimates are around $3,000 per installed kW, i.e. over $10,000 for a system that could compete with the small motor pumps. The big advantage of solar pumps is that their recurrent costs are small. Three to five hp motor pumps cost less than $1,000, however they may cost up to $1,000 per year to run. If such a motor pump lasts on average 5 years, and assuming a 15 percent discount rate, we arrive at a life cycle cost of between 5 and 6 thousand dollars. A photovoltaic pump would have to last over 20 years before it would be less expensive than a succession of motor pumps. More realistic, i.e. higher, discount rates make this difference even stronger.

Niger's wind resource is extremely poor. No efforts to use it are underway, and it seems unlikely that any area could be identified where wind-powered systems might be feasible.

III. ENERGY USE IN IRRIGATED AGRICULTURE

Commercial energy inputs are used in irrigated agriculture in any one of four possible ways:

1. Electric energy from the grid to power electric pumps
2. Electric energy produced locally by a diesel generator
3. Direct diesel powered pumps
4. Gasoline-powered pumps

In addition, irrigated agriculture, like rain-fed agriculture, requires energy for working the land (e.g., plowing). In Niger this sort of energy is still provided almost exclusively by human and animal power. Attempts by ONAHA to introduce tractors on irrigated perimeters have failed, primarily due to maintenance problems and frequent equipment failures. Today plowing is done by animal traction.

ORGANIZATION OF IRRIGATED PERIMETERS

For this analysis we concentrate on irrigated perimeters managed by ONAHA and used primarily for rice production. Thanks to the rather reliable water supply of the Niger river, two cropping cycles are possible on all of these perimeters. The rainy season cropping cycle starts around June. The rice is replanted in July and harvested in December. The dry season cropping cycle starts in December, with transplanting in January and should end with the harvest in May. In practice, however, there are frequent delays in that calendar, and both rainy season and dry season cropping cycles tend to take longer than planned.

Farmers on rice perimeters are organized into cooperatives. Ideally ONAHA would like to turn management of the perimeter over to the cooperatives. In fact, most perimeters are managed by an ONAHA official, assisted by one to several extension agents who work together with the leadership of the cooperative. The cooperative is responsible for collection of user fees (redevances) and for marketing the rice through the rice parastatal, Riz du Niger (RINI). The cooperative also purchases all collectively used inputs, such as energy,

and is responsible for the collective upkeep of the infrastructure, including maintenance and repair of the pumps. The cooperative is free to purchase its inputs on the open market and to contract with whomever they wish for repair and maintenance work. In the well-run cooperatives, the redevance includes items such as a sinking fund for replacement of equipment and, in some cooperatives, fertilizer, seeds, and chemicals.

To pay their redevance, farmers sell paddy through the cooperative to RINI. The current purchase price offered by RINI is 70 CFA/kg, down from 100 CFA a few years ago. The free market price is even lower, at approximately 56 CFA/kg, and the cooperatives have to ration purchases at the official price to the amount of the farmer's redevance obligation. With redevances averaging between 40,000 and 60,000 CFA/ha this amounts to about 650 to 850 kg/ha. Yields average about 3.5 to 4 tons/ha, which makes the redevance about 16 to 20 percent of gross production for most farmers.

The redevance is recalculated after each season based on the costs incurred during that season[16]. It is fixed on a per hectare basis, and covers the costs for all collectively-used inputs such as water, infrastructure, extension, management, etc. Individually used inputs, such as fertilizer, plowing services, and farm labor are purchased by the farmers individually, though the cooperative usually does offer fertilizer for sale to its members.

Because all farmers share in the costs of pumping water based on the size of their parcels and not on how much water they actually use, only weak incentives exist to use that resource efficiently. Charging each farmer for the water actually used would probably lead to more efficient usage. However, given that on most perimeters each farmer works only about 1/2 ha, measuring such individual usage would be impractical, if not outright impossible. The problem is compounded in grid-connected perimeters where the costs of pumping water varies by time of day. No systems exist that would give the individual farmers any incentive to use water at those times when pumping costs are lowest.

16 See Appendix A for a sample of a redevance calculation.

ENERGY USE AND COSTS IN GRID-CONNECTED PERIMETERS

A fair number of ONANA's perimeters in the Niger valley are already connected to the national grid, and a program is underway to connect most of the others that are within reasonable distance of the grid as well. There are several reasons that speak for this strategy: (1) electric grid power is less expensive than any other sort of energy for large scale pumping, (2) electrically-powered pumps are more fuel efficient[17] and less prone to breakdowns than other pumps, and (3) electric power supply from the Niamey grid is very reliable. None of the perimeters visited had experienced power outages exceeding a few hours at any time so far. Grid connections, however, are very expensive and can be undertaken only with foreign assistance.

Detailed data on power consumption and other costs of irrigation are available for two grid-connected systems. They are summarized in Table 4.

Table 4

COSTS OF IRRIGATION ON GRID-CONNECTED PERIMETERS
(IN CFA/HA, DRY SEASON 1986)

Perimeter	Total Area	Fixed Costs (1)	+	Variable Costs: Energy (2)	+	Variable Costs: Other (3)	=	Total Costs (4)	Energy as Share of: Total Costs	Energy as Share of: Variable Costs
Karma	125ha	20,369		10,710		17,233		50,083	21.4%	38.3%
Toula	244ha	12,535		15,738		16,194		47,466	33.2%	45.1%

Source: ONAHA, Rapport de Mise en Valeur, Campgne SS 86, Nov. 1986.

The ONAHA report from which the figures in Table 4 were taken points out that the cooperative in Karma consciously tried to avoid using water during the peak periods. This resulted in savings on electricity of about 30 percent,

[17] Throughout this report, the fuel efficiency of pumping systems is defined as the ratio of hydrological energy output to fuel energy input.

relative to the electricity costs at Toula. As a result, farmers in Karma paid only a slightly higher redevance than farmers in Toula, despite the smaller size of the perimeter and the attendant higher fixed costs per hectare.

During the rainy season, water needs tend to be twenty to thirty percent lower than during the dry season. However, all pumping during the rainy season takes place during the months when Nigelec applies its high peak-load tariffs. Accordingly, energy costs may be higher during the rainy season than during the dry season for grid-connected perimeters.

Data on electricity use during the 1986 rainy season was collected for two perimeters, Toula and Say (see Table 5). Neither the cooperative in Toula nor the cooperative in Say made any effort to take advantage of the opportunities offered by the TOD tariff. Had these cooperatives timed their pump use in such a manner as to operate primarily during the off-peak periods, when electricity is cheapest, they could have reduced their operating costs significantly. Instead, the pumping station in Say used over one fourth of its electricity, in quantity terms, during the peak hours when electricity was most expensive, even though peak hours amount to only 4.5 hours out of 24. Even shifting only half of the peak hour usage to other periods of the day could have saved over 20 percent on the electricity bill for both of these cooperatives, which would have amounted to about 10 percent of the total costs.

Table 5

COSTS OF IRRIGATION ON GRID-CONNECTED PERIMETERS
(IN CFA/HA, RAINY SEASON 1986)

	Electricity Use (kWH)			Instantaneous
	Peak	Medium	Off-Peak	Demand (kW)
June	925	1281	995	3018
July	2618	2551	2505	5140
August	4535	6177	6824	9391
September	6504	7132	7659	11592
October	3320	4470	4054	*
November	4376	5408	5097	9335

* Figures for October were not available; usage was imputed from meter readings indicated on the September and October bills.

Note: According to the director of the Toula perimeter, there were about 1.5 million CFA in arrears due to ONAHA when he took over at the beginning of the rainy season 1986. These should be added to the costs in Table 4 and subtracted from the costs in Table 5.

DIESEL-ELECTRIC SYSTEMS

Diesel-electric systems use electric powered pumps, but also generate their own electricity using diesel generation sets. Data on three such perimeters was available from ONAHA and are reproduced in Table 6.

Data on diesel fuel use was available for the dry season only. It is summarized in Table 7.

Table 6

OPERATION OF PUMPING SYSTEMS ON DIESEL-ELECTRIC PERIMETERS

Perimeter	Total Area (ha)	Rainy Season 1985			Dry Season 1986		
		Use of Pumps (hrs.)	Use of Gener. (hrs.)	Volume lifted (m^3)	Use of Pumps (hrs.)	Use of Gener. (hrs.)	Volume lifted (m^3)
Karaigourou	136	1,526	1,082	1,330,318	2,499	1,574	1,965,820
Namarde G.	233	2,494	883	2,781,392	3,644	1,506	3,844,560
Koutoukale	322	2,517	1,159	3,460,588	4,189	1,646	5,390,162

Source: ONAHA, Rapport de Mise en Valeur, Campgne SS 86, Nov. 1986.

Table 7

USE OF DIESEL FUEL ON DIESEL-ELECTRIC PERIMETERS
(DRY SEASON 1986)

Perimeter	Total Area	Fuel Use		Lube Oil	Total	Cost
		liters	'000CFA	'000CFA	'000CFA	CFA/ha
Karaigourou	136	28,156	5,349.5	348.8	4,040.8	29,717
Namarde G.	233	41,752	7,933.0	357.0	7,215.4	30,992
Koutoukale	322	45,873	8,716.0	1,109.2	9,195.8	28,581

Source: ONAHA, Rapport de Mise en Valeur, Campgne SS 86, Nov. 1986.

Cost for the rainy season crop cycle are higher than for the dry season because a greater head must be pumped in the rainy season. The groundwater level varies with the season as a function of variations in the Niger river's water level. As a result of such fluctuations, pumps yield different quantities of water for the same running time. Fuel use per hour of operation of the diesel generators, however, is probably not affected by such seasonal changes. One can, therefore, infer energy fuel and lubricant costs by reference to Table 6. The resulting estimates are given in Table 8.

Table 8

FUEL AND LUBRICANT COSTS

Perimeter	Costs CFA/hr. (1)	Total Costs Rainy S. (2)	Costs /m^3 lifted		Costs/hectare	
			Rainy S.	Dry S.	Rainy S.	Dry S.
Karaigourou	2,567	2,777,494	2,088	2,055	20,423	29,717
Namarde G.	4,791	4,669,653	1,679	1,877	20,041	30,992
Koutoukale	5,586	6,475,043	1,871	1,706	20,109	28,581

(1) Calculated by dividing dry season fuel costs by hours of operation of the generators.
(2) Inferred by multiplying column 1 by the hours of operation of the generators during the 1985 rainy season.

As Tables 6 through 8 show, energy costs of pumping are markedly higher for diesel-electric installations than for grid-electric ones. In the farmer's redevance, the energy costs take on a considerably larger importance. In Table 9 the share of energy costs in the total redevance is calculated in a manner analogous to Table 4.

Table 9

COSTS OF IRRIGATION ON DIESEL ELECTRIC PERIMETERS
(IN CFA/HA, DRY SEASON 1986)

Perimeter	Total Area	Fixed Costs	Variable Energy	Costs Other	Total Redevance	Energy Total	Share of Variable
Karaigourou	136	28,410	29,717	59,580*	103,705	28.6%	33.3%
Namarde G.	233	21,743	30,992	24.744	77,932	39.8%	55.6%
Koutoukale	322	18,121	28,581	21,995	66,018	43.3%	56.5%

* Includes all fertilizer
Source: ONAHA, Rapport de Mise en Valeur, Campgne SS 86, Nov. 1986.

Comparisons between the cost elements of diesel-electric systems and grid-connected systems are made difficult by a number of differences in what is included in the costs for each perimeter. For example, farmers in Karaigourou pay for their fertilizer through the redevance, while in all other perimeters farmers individually purchase fertilizer. Personnel and miscellaneous costs are also about 50 percent higher in Karaigourou than in any other perimeter compared here. For these reasons, Karaigourou should probably be excluded from the comparisons.

The remaining two diesel-electric perimeters show cost structures which, with the exception of energy costs, are comparable to the costs on grid-connected perimeters. The almost 50 percent higher costs of the redevance on these perimeters, compared to the grid-connected perimeters, can be explained almost completely by the difference in energy costs. The fixed costs are sensitive to the size of the perimeters, and they should probably be excluded from the comparison. The average of the variable costs of Namarde Goungou and Koutoukale is 53,156 CFA/ha, while for Karma and Toula it is 29,938 CFA/ha. In other words, the variable costs of production, excluding the inputs purchased individually by the farmers, are almost 80 percent higher on diesel-electric perimeters than on grid-connected perimeters, primarily because fuel costs are

between two and three times higher. If all the cooperatives would take full advantage of the peak-load pricing tariff practiced by Nigelec, the differences would be even more dramatic.

All the fully electrified perimeters considered here are connected to the Niamey grid. It follows that in terms of social cost the advantage of these systems over the diesel-electric ones is even more important. Electricity tariffs on the Niamey grid are higher than social costs, during off-peak hours at least, due to the need of compensating for Nigelec's losses in the rest of the country. On the other hand, diesel fuel benefits from a preferential tax treatment relative to gasoline which reduces its price relative to social costs.

From an energy economic point of view, ONANA's current program of connecting all the major perimeters in the Niger valley to the grid, has to be supported. The program is very expensive, however, and could not be carried out were it not for the foreign assistance in the form of a grant from the German Kreditanstalt fuer Wiederaufbau which finances this component of ONAHA's rehabilitation project (see the Section IV for details).

DIRECT DIESEL-DRIVEN SYSTEMS

Data on directly diesel-driven pumping systems is much less readily available than for either grid-connected or grid electric systems. Most directly diesel-driven installations are also considerably older and in disrepair. The following data come primarily from Hart's Rapid Country Review and should be viewed as rough approximations.

Hart (op.cit.) gives fuel consumption estimates for four direct diesel powered perimeters: Sebery, N'Douga I, Libore, and Saga. Assuming the number of days of irrigation to be about the same as for the diesel electric perimeters (120 days during the rainy season and 150 days during the dry season), per hectare fuel expenses can be estimated for these perimeters. Table 10 gives those estimates.

Table 10

ESTIMATED FUEL USE FOR DIRECT DIESEL POWERED SYSTEMS

Perimeter	Total Area (ha)	Fuel Use (liters/day)	Estimated Fuel Costs	
			Rainy Season CFA/ha ($/ha)	Dry Season CFA/ha ($/ha)
Sebery	350	400	26,057 (86.85)	32,572 (108.57)
N'Douga I	258	400	36,480 (121.60)	45,600 (152.00)
Libore	242	300	28,264 (94.21)	35,331 (117.77)
Saga	350	600	40,115 (133.72)	48,857 (162.86)

These very rough estimates do not include lubrication, which should add another 5 to 10 percent to costs. But even without this, the fuel costs alone are higher than the costs for diesel electric systems. Fortunately these perimeters are also part of the ONAHA rehabilitation projects and will receive diesel electric systems or be connected to the grid.

GASOLINE-POWERED SMALL PUMPS

The majority of private sector pumps listed by Hart (op.cit.) are rated a 3 to 5 hp and typically are used to irrigate less than 1 ha. Many are used on wells that have a tendency to regenerate slower than the pump's capacity, so that running the pump at an efficient rate risks drawing the well dry. Farmers respond to this problem by throttling the motors down, which cuts heavily into energy efficiency.

These small pumps use anywhere from 4 to 6 liters of gasoline per day. Assuming an average use of 5 liters for a 5 hp pump and 150 days of irrigation, one obtains an estimate of fuel consumption of approximately 750 liters per season. Hart (op.cit.) reports an average area to horsepower ratio for these small pumps of .17 ha/hp, implying that the typical 5 hp small pump

considered here would be used to irrigate less than one ha. Using an average gasoline price of 250 CFA/litre, we obtain an estimate of fuel costs for this type of irrigation in excess of 180,000 CFA/ha, clearly higher than any of the large perimeter costs. However, Hart also points out that by better matching the systems to the area to be irrigated, the hectare to horsepower ratio could be tripled, i.e. about 2.5 ha could be irrigated with such a pump. Fuel costs, however, would still be in excess of 70,000 CFA/ha.

In this last case, however, we start approaching fuel costs comparable to the large diesel systems. Note that these pumps run on gasoline, which is taxed considerably heavier than diesel fuel. As a result, the purchase price of gasoline is about 30 percent higher than that of diesel fuel, even though the economic costs to Niger are roughly the same[18]. Evaluating fuel costs for this (hypothetical) ideal case, tripled ha/hp ratio and 5 liters of fuel used per day, at a fuel price comparable to diesel fuel would result in fuel costs of about 57,000 CFA/ha. This is still higher than for diesel systems, however, the organizational efficiency of having one farmer manage his own irrigation system, without the organizational overhead of a large perimeter, and the possibly better yields that such a farmer might be able to produce, could offset that difference. However, given the way small motor pumps are used today, we are still far from that ideal.

Most of the small motor pumps is use in Niger today were purchased in Nigeria. Hart (op.cit.) was unable to identify any domestic suppliers of either motor pumps or service. Given that the infrastructure for supplying and servicing such pumps exists in Nigeria, and is readily accessible to Nigerien farmers as well, it would probably be a waste of resources to try to duplicate it locally in Niger at this time. The private sector has recognized this, and has withdrawn from the Niger market, citing competition from across the border as the main reason.

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[18] In fact, the international price of regular gasoline is slightly less than that of diesel fuel, making the economic costs per liter of gasoline slightly less than those of diesel fuel.

Official policy should not try to run counter to this trend. There is nothing inherently superior in a domestic sales and service network. What counts are the costs and efficiency of the service provided and the proximity to the user, and a dealer in Kano is closer to farmers in the Zinder/Maradi area, for example, than a Nigerien company located in Niamey. A separate supply and service network in Niger would be considerably more costly, probably less reliable, and farther away from most end-users than the Nigerian counterpart.

The importance of service should not be underestimated, however. Proper servicing and optimizing the running regime of any combustion engine can have a large influence on fuel use. Given the continuous use of these small pumps, often in adverse conditions, they are also prone to break down. If that happens at a time of year when irrigation is essential, the consequences could be severe. Citing a survey conducted by ACDI in the Diffa area in 1985, Hart notes that almost half of the pumps in use require maintenance during the first season of use. A very large proportion of the repairs involve changing pistons and rings. This is not a very intricate operation, and can be carried out by an adequately trained mechanic. There is no need for such mechanics to be part of a supplier-controlled service network. Local mechanics, who exist throughout the country and who already repair anything from trucks to mobilettes, could be trained to service such pumps at little additional cost.

IV. PLANS FOR THE DEVELOPMENT OF IRRIGATED AGRICULTURE

OVERALL NATIONAL STRATEGY

Niger is committed to a strategy aimed at achieving food self-sufficiency by the year 2000. If this goal is given a broad interpretation, i.e., it is understood that rather than being autarkic, Niger should be in a position to produce sufficient agricultural output so that a marketable surplus is available that can pay for any possible food imports, the food self-sufficiency goal should be supported. In light of the decline in the uranium market, the country has no choice than to try to develop its agriculture.

In the past twenty to thirty years, agricultural crop land has expanded from about 3 million hectares to over 5 million hectares[19]. At the same time, average yields per hectare have declined precipitously[20], and more and more marginal land came under cultivation. Continuing the traditional extensive cropping methods will require a continued expansion of agricultural crop land at the expense of forests and fallow land. This is likely to put strains on the environment that cannot be absorbed.

To be able to continue expanding agricultural production, and possibly even free up come marginal agricultural lands for reforestation, Niger will have to increase the intensity of production in other areas. This means first and foremost irrigation in areas where such cropping techniques can be efficiently introduced. From an energy standpoint this means in the Niger valley, the only place in Niger where at present cheap (imported) energy can be made available for water lifting.

The potentially irrigable areas in the Niger valley may be as high as 140,000 ha. However, only about 30,000 ha are in lowlands (cuvettes), the rest on high terraces that would require much more substantial investments, such as a

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[19] Juan Seve, Dennis Panther, and Kevin Mullally, Perspective on Niger's Natural Resources, Annex D to USAID's CDSS for Niger, FY 1988.

[20] ibid.

major dam. Of the lowlands, about 16,000 ha can be developed with current techniques[21]. Only about 6,000 has have been developed so far and no large new developments are planned in the near future.

The austerity necessitated by the fall in uranium prices has slowed down new investment throughout the country. The IMF sponsored structural adjustment program rules out any large new initiatives. Instead Niger is attempting to consolidate its gains, and to rehabilitate some of the investment projects undertaken earlier. This is also true in the irrigation subsector (see subsection on ONAHA below).

Two adequate harvests in a row have made that decision easier. Farmers have been able to replenish their traditional reserves, and market prices for cereals have plummeted. The two parastatals, RINI for rice and OPVN for other grains and food stuffs, have been swamped with cereals. Last year, RINI had to stop purchasing and then drop the "guaranteed" price because it ran out of money. In short, the outlets for substantially expanded cereals production do not exist in Niger at present.

This has implications for the development of irrigated agriculture in Niger. Irrigated agriculture will continue to be important, however, in the short run it is unlikely that a large expansion of the irrigated areas for the purpose of cereals production could be justified. The economic value of increased cereals production in Niger is too low to justify the enormous expense of large scale perimeter development.

On the parallel private market, prices for rice, the main crop produced on irrigated perimeters, are considerably below the official price. In spite of this, rice production on ONAHA managed perimeters is still considered profitable by the farmers. All the cooperatives contacted stated an excess demand for allocations of land on irrigated perimeters, more farmers would like to practice irrigated agriculture than can currently be accommodated on ONAHA perimeters. However, if farmers would have to pay for the full cost of the

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[21] World Bank, Niger Irrigation Project Report, CR. 851-NIR, 1985.

perimeter including amortization of the infrastructure, rice production would probably no longer be profitable.

The numbers are somewhat better for high value crops such as onions and garden crops. Much of this production takes place on relatively small plots, with pumps owned by individual farmers. With a diversification into different crops, especially cash crops, the potential for irrigated agriculture may still be considerable. However, this potential does not lend itself easily to government intervention. The best results on diversified garden crops are usually achieved on small, individually managed fields, where the government has very little influence. Thus it would be unreasonable to expect a large expansion of ONAHA/s role in the future of irrigated agriculture development in Niger, and it would indeed be economically unwise to pursue a policy aimed at increasing this role.

There is currently no national development plan in effect, and none is expected to be produced soon. The careful consolidation program underway is reasonable, and does not appear to have any detrimental effects on the country's energy situation. With the minor exceptions of the favored tax treatment for diesel fuel, and the uniformity of the electricity tariff over the entire territory, the pricing policies for commercial energy are sensible, and do not distort the economic incentives.

The fuel wood problem, which is the most serious energy and environmental problem that Niger faces at present, was not part of this analysis. Nevertheless we can observe that the current consolidation program, to the extent that it leads to a more efficient use of the available resources, should have a positive indirect effect on attempts to counter deforestation and desertification. Furthermore, we were able to observe rather extensive plantings of eucalyptus and other fuel wood species along drainage canals in irrigated perimeters.

ONAHA

In line with the overall national strategy, ONAHA is itself engaged in a major restructuring and rehabilitation effort. With assistance from the World Bank, the French Caisse Centrale de Cooperation Economique (CCCE) and the German Kreditanstalt fuer Wiederaufbau (KfW), ONAHA is rehabilitating some of its older perimeters, and connecting those in the Niger valley to the electric grid. At the same time, changes in the management of the individual perimeters are intended to give farmers more influence in the running of the perimeters, and to reduce ONAHA's role. For example, the cooperatives are free to purchase their inputs where they want and to contract with whomever for the maintenance and repair of the installations. If they contract with ONAHA, ONAHA is obligated to charge the cooperatives the full cost of the service.

From an energy perspective, the most interesting component of ONAHA's program is the electrification of the perimeters in the Niger valley. This component is being financed KfW, amounting to roughly one million dollars. The connection to the grid will be carried out by Nigelec, who will charge ONAHA the full cost of the installation. The most important cost element is the new power lines required, which cost approximately 5 million CFA/km (~26,000 $/mile). The perimeters to be connected to the grid, and the costs as calculated by Nigelec are given in Table 11. Terms offered are 100 percent net, prior to beginning work.

As is apparent from Table 11, the costs of electrification vary greatly, depending on the location of the perimeter. The calculated per hectare costs once again underline the importance of economies of scale in such applications. Even though the costs of electrification of N'Douga I&II is over eight times as high as that in Kokomani, the costs per hectare are actually lower because N'Douga has a combined irrigated area almost ten times as large as Kokomani.

Table 11

PERIMETERS TO BE ELECTRIFIED AND COSTS OF CONNECTION

Perimeter	Total Area (a)	Costs of Connection (b)	Costs per hectare (b)/(a)
Daikaina	120	13,124,413	109,370
Kokomani	54	16,586,857	307,164
Saga	350	14,943,836	42,697
Libore	242	82,882,622[1]	342,490
N'Douga I&II	500	136,701,197[2]	273,402
Sebery	350	44,236,905	126,391
Total	1616	308,475,820	190,889

[1] Two pumping stations to be electrified separately at costs of CFA 47,208,734 and CFA 35,673,888 respectively.

[2] Includes electrification of the pump at Kollo used for drainage at a cost of CFA 45,488,735.

All these perimeters to be electrified are currently running direct diesel pumps. In the preceding section the fuel costs for dry and rainy seasons was estimated for some of them. They average about 80,000 CFA/ha per year, i.e., dry and rainy season added together. The corresponding figure for the two electrified systems presented in Table 4 is about 24,000 CFA/ha[22], so that this electrification project will result in fuel savings of approximately 56,000 CFA/ha annually.

The savings in fuel costs would be sufficient to amortize the costs of grid connection within five years. However, switching to electricity as a power source also involved procuring new pumps. Pumps will be donated by the CCCE, at an estimated cost of 735 million CFA total, 455,000 CFA/ha. The total

[22] Table 4 gives an average energy cost of 13,000 CFA/ha for the dry season. Rainy season energy costs are probably slightly less.

investment of the electrification is thus in the order of 650,000 CFA, which would take considerably longer to amortize.

But note that the perimeters in question are all fairly old. The existing diesel pumps, where they still are operational, would soon have to be replaced anyway. At Saga, for example, no permanently installed pumps work any longer, pumping is provided by a number of mobil pumps set up around the outside of the pumping stations. The costs of replacing the diesel pumps would, therefore, have to be taken into consideration. For the overall project, the World Bank computes an economic rate of return equal to 18 percent.

In sum, the energy consequences of ONAHA's plans for the near to medium future are very favorable for Niger. Once the rehabilitation of the six perimeters is complete, the savings of commercial energy could be substantial. The six perimeters currently use about 680,000 liters of diesel fuel each year, which could be replaced almost completely with cheap imported electricity. On a fully electrified system, electricity use amounts to about 550 kWH/ha per year or about 890,000 kWH for the six perimeters combined. Even if all the electricity used on these perimeters were produced locally by diesel generators this would amount to a use of diesel fuel of only 360,000 liters per year. This is due primarily to the better efficiency in Nigelec's large installations for converting diesel fuel into electricity. The project will therefore, "back out" at least 500,000 liters of imported diesel fuel per year.

NIGELEC

There are two directions, not mutually exclusive, which Nigelec can pursue to improve its production structure. One is to increase the interconnection with the Nigerian grid; the other is to develop the modest hydroelectric resources available in Niger itself. A third possibility would be to develop the lignite deposits located in the Tahoua region, but given the less than sterling performance of the existing thermal plants operated by SONICHAR in the Agadez-Arlit area, this possibility seems less promising.

A recent study by a Canadian consultant firm, Lavalin International, reaches the conclusion that a modest hydro-electric site near Ganbou on the Niger river could be exploited economically in the medium term. However, along with the phased development of this and two other sites, the report also recommends increased interconnection with Nigeria. The current contract between Niger and Nigeria calls for sales of up to 30 MW and expires in 1996. It would be to Niger's advantage to seek an extension of this contract and to follow the recommendations of Lavalin International which include the construction of a 220 kV line to augment the existing 132 kV interconnection with Nigeria. Even under the best of circumstances, it is unlikely that hydro-electricity can be produced as inexpensively in Niger as it is being produced in Nigeria. The potential, and thus the scale of the hydro-electric plants in Nigeria is simply much larger. As a result the production costs per kWh are much lower there.

As one of the inputs to its demand forecasts, Lavalin International considered the likely development or irrigated agriculture in areas along the interconnected grid. The base case chosen assumes an expansion of the irrigated areas of about 1000 ha/year, based on the old development plan[23]. Assuming an average investment cost of 6 million CHA/ha, such a program would require about 6 billion CFA of new investments each year, i.e. about 20 million dollars per year. Under the current austerity regime, and given the marginal economic benefits that additional irrigated perimeters would bring, it is most unlikely that such a program will be pursued.

USAID

USAID/Niger has only recently become involved in irrigated agriculture. The FY 1988 CDSS places much more emphasis on this subsector than earlier edi-

[23] This ambitious goal is nevertheless an improvement over the original feasibility study for the Kandadji dam (1979) which had assumed an increase of 3,700 ha/year or the Comite of experts (1981) and the re-evaluation of the Kandadji dam (1982) which assumed increases of 1,500 to 2,000 ha/year.

tions. A number of recent studies[24] are evidence of USAID's renewed awareness of the importance of irrigated agriculture for Niger, and at least one project, the Niger Applied Agricultural Irrigation Research Coordination Project, (683-250) is about to be initiated.

The NAAR project aims at filling the gaps left by ONAHA and its large perimeters. It does foresee a technical advisor to help improve the efficiency and train the personnel of jointly managed (ONAHA) river pumping systems. However, currently the main irrigation technology emphasis seems to be on the development of micro-irrigation systems powered by hand or animal traction[25]. Shifting some of that emphasis to improving the efficient use of small motor pumps would probably have a large return.

As designed, the NAAR project has no detrimental effects on Niger's energy balance, and to the extent that the pumping station advisor is successful, it can have noticeable positive effects. Energy considerations could be included more explicitly, though. For example, the pumping station expert should be aware of how to take advantage of Nigelec's TOD tariff, and should train the pump operators in this. Adding a component aimed at developing the skills of local mechanics to maintain and service small gasoline-powered pumps could also have beneficial effects. A well-serviced and tuned motor pump uses much less fuel per liter of water delivered than an ill-maintained one.

[24] See, for example Zalla et. al., Niger Irrigation Sub-Sector Assessment, USAID, Niamey, July 1984; and Hart, Niger: Rapid Country Review, I.T. Power, June 1986.

[25] USAID, Niger Applied Irrigation Research Coordination Project, (683-250), Project Paper Design.

V. CONCLUSIONS AND RECOMMENDATIONS

GENERAL OBSERVATIONS

Energy is one of the most important inputs into irrigated agriculture, and unavailability of energy often presents bottlenecks to the development of the irrigated agriculture subsector. Except for hand- or animal-powered micro-irrigation systems, the economic costs of the energy needed to lift the water used in irrigation are usually the largest variable costs of production. The choice of the appropriate source of that energy can make the difference between the economic viability or failure of irrigated agriculture.

In a market economy, price signals indicate the scarcity and relative worth of alternative energy sources. In Niger, unfortunately, the market functions only within the stricture imposed by the government. Rather than letting the market decide, the government of Niger has to reach a policy decision as to which energy sources are worth how much to the economy.

Niger has over the past few years adopted a set of rational policies that provide energy users with the proper incentives, including irrigated agriculture. It is to the government of Niger's credit that it has avoided fostering that sector with economically unjustified subsidies on energy inputs. Irrigated agriculture should be and, under the current policy, is treated like any other energy using sector.

Given Niger's comparative advantage, and the economic costs of supplying energy inputs in this landlocked country, a very clear hierarchy of economic energy costs for irrigated agriculture emerges. By far the lowest-cost energy source is grid-supplied electricity imported from Nigeria. Its cost to Niger's economy is about 17 CFA/kWh, or less than 1/3 of the lowest cost electricity produced domestically. But even if electricity is produced at the higher cost of domestic diesel generation, the economies of scale are such that where the grid is closely accessible, electricity is the cheapest power source.

As soon as we leave the immediate proximity of the grid, however, the costs of laying electric lines becomes very high. In these circumstances the second best alternative is electric pumps driven by power generated locally with diesel generation sets. Such a system is still about 30 to 50 percent more efficient in fuel costs than a direct diesel-driven system.

At the high end of the fuel cost spectrum are small gasoline-powered pumps. The fuel costs per hectare of these small pumps are almost double the costs of even the inefficient direct diesel pumps. This is primarily due to the highly inefficient way in which these pumps are used. Nigerien farmers tend to purchase these small pumps in Nigeria, taking whichever pump is available, regardless of the specific conditions of the site to be irrigated. Hart[26] claims that by simply matching these small pumps better to the sites efficiency could be tripled. In this case small pumps become competitive with large diesel systems[27].

That Niger's energy price policy is providing the appropriate signals is evidenced by the fact that ONAHA is currently engaged in a program of making its perimeters more energy-efficient. Electrifying perimeters in the Niger valley, especially those currently being powered by direct diesel systems, not only saves energy overall, but also offers opportunities of taking advantage of imported hydro electricity, a renewable resource available at fairly low costs. The TOD tariff practiced by Nigelec also provides the cooperatives running the irrigated perimeters with the correct incentives to use electricity during those times of the day when it is cheapest to supply. Unfortunately, the generally practiced "redevance" system by which individual farmers pay for that energy makes it impossible to pass such incentives, and the associated savings, on to the actual user.

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[26] Terry Hart, Improved Water Pumping/Water Lifting in Africa: Rapid Country Review (Niger), I.T. Power Inc., June 1986.

[27] In fact they already are competitive if one takes into account the full life cycle costs. The small portable gasoline pumps are much less expensive than larger systems and actually provide a higher internal rate of return than diesel systems, for example.

In areas not served by the Niamey grid, the situation is somewhat different. Electricity use in these areas is de facto subsidized, i.e. the prices do not reflect the social costs of providing the service. Electrifying existing perimeters, or installing new electric-powered ones in these areas, should be carefully evaluated. The evaluation must not be based on the electricity prices actually charged by Nigelec, but rather on the social costs of providing electric service. Based on a production cost of diesel generated electricity of 70 CFA/kWh (short run variable costs only!), and network and administrative overhead of 18 CFA/kWh, these economic costs must be at least around 90 CFA/kWh--two to three times the off-peak costs of the Niamey grid. Under these circumstances a diesel-electric, or possibly even a direct diesel system might be more economical.

But even on the Niamey grid, not all electricity sold is hydroelectricity imported from Nigeria. When the system reaches its peak so that the complete load can no longer be satisfied with the capacity of the 132 kVolt interconnection with Nigeria, Nigelec has to complement the imported power with electricity produced with domestic diesel generators. Cooperatives or, better yet, individual farmers, should be encouraged, through proper price signals, to use electricity whenever it is possible to satisfy their demand with imported power. The currently practiced TOD tariff goes a long way in that direction; however, improvements are possible. For example in Annex 7.4 of the World Bank's Niger: Issues and Options in the Energy Sector, an interruptible tariff is proposed that seems tailor-made for irrigated agriculture. Under an interruptible tariff, the electricity supplier (in this case Nigelec), would have the option to cut off some customers whenever its load started to exceed what could be provided with low-cost base-load systems. The length of individual interruptions and the total length of interruptions are specified, and are usually in the order of a few hours a day. In exchange, the subscriber who is willing to accept the inconvenience of being cut off for a couple of hours on some days, is offered a very favorable price per kWh. In many countries in Europe as well as the United States, enterprises depending on pumping type operations, such as pipelines, typically take advantage of these tariff and are thus able to carry out their pumping at a fraction of the costs.

Note that offering electrified perimeters incentives such as interruptible tariffs does not constitute a subsidy. The low price of electricity under this kind of a tariff is economically justified, because it enables the utility to lower its production costs. Such a solution would be clearly preferable to an outright subsidy as was advocated by some ONAHA representatives during the team's visit.

If small, individual motor, pump-driven systems are used on an appropriate scale, they can be made to be almost competitive, in energy use terms, with diesel-electric systems, the only lower cost alternative in isolated areas. They also offer the considerable advantages of being under the control of the individual farmers, which greatly reduces administration friction and costs. However, such pumps have to be used for crops other than cereals (i.e. market gardening, onions, etc.). If this is the case, the organizational advantages of individual farmers owning their own pumps, being able to manage their water themselves, having the flexibility of responding to market opportunities, will outweigh the remaining disadvantages in fuel costs. Part of USAID's Niger Applied Irrigation Research and Coordination Project should be concentrated on making such small scale systems more competitive.

One way in which this could be done is by providing local mechanics with the necessary information and training so that they can service such pumps. Changing pistons and rings on such a small combustion engine is not a very intricate operation, and local mechanics, who already are servicing anything from trucks to mobilettes, should be up to the task.

But the most serious problem is the mis-matching of the pumps to the site. The potential payoffs to education of farmers on this topic are tremendous. Admittedly, these pumps will probably never compete with the large scale diesel-electric or grid-connected systems, however they are currently being used inefficiently. Most small motor pumps offer optimal energy efficiency, i.e. hydrological energy out/fuel energy in, at heads of over 20 meters (60 feet). In fact most are used at heads of less than 10 meters.

The use of small motor pumps is also expanding. Hart (op.cit.) estimates that about 2000 of these small pumps were in use in 1986, and that their number was expanding at a rate of about 15 percent per year. If these estimates are correct, up to three thousand of these pumps may be in use by the time the USAID Niger Irrigated Agriculture Research and Coordination Project becomes fully operational. Improving their energy efficiency by only 20 percent on average could result in fuel savings of almost one million liters per year.

SPECIFIC RECOMMENDATIONS

There are a number of things USAID could do to improve energy use in the irrigated agriculture subsector. Some of the things being listed are already part of the new project. They are mentioned here to reinforce the direction that the project is taking. Others fall only marginally within USAID purview, and thus may be more properly considered "pious hopes." But piety aside, there is hope for Niger's irrigated agriculture, and, if the present rational policies are continued, energy should not be a stumbling block.

There are four specific recommendations on how USAID could positively influence energy use in irrigated agriculture in Niger.

1. The proposed technical advisor to ONAHA, charged with improving pumping station efficiency, should be aware of the macro-economic consequences of electricity use. He should be fully informed about electric utility pricing, especially peak-load pricing, so that he can advise the cooperatives on how to minimize their electricity bills.

2. USAID should <u>not</u> support a subsidized electricity rate for agricultural uses. Instead it should use its influence in the policy dialogue to promote the idea of an interruptible tariff. Such a tariff can offer very substantial savings to users willing to put up with occasional short-term blackouts. In pumping applications, such blackouts are usually not of serious consequence.

3. USAID should oppose a special price for diesel fuel used in agriculture. Diesel fuel is already taxed at a very favorable rate, and reducing this tax further would only encourage inefficient use. It should also favor the project (i.e., ONAHA controlled) sector of irrigated agriculture, at the expense of the individually owned and managed perimeters.

4. USAID should use a portion of its resources under the new project to improve energy efficiency in the private motorized pumping sector. Inefficiency in that sector is so high, that even small amounts of education and training are bound to have large payoffs. Ways in which this can be achieved are by 1) educating and training farmers on how to properly size a system so that it meets the needs of the site, 2) training, and possibly equipping, local mechanics so that they can maintain and repair the small pumps, and 3) informing producers of small pumps as to the kinds of pumps needed in the areas where farmers have the means to acquire them.

This brief analysis has ignored one portion of the irrigation subsector that is very important, i.e. hand- or animal-powered water lifting. The new USAID project seeks to support primarily that sector, and this emphasis is well-placed. The development of better human powered pumps, especially if they can be produced cheaply enough, promises to make irrigated agriculture accessible to large groups of the population that are currently left out of the system. However, because such pumps have only very small and indirect effects on the national energy balance, they have been left out of this analysis.

COOPERATIVE AGRICOLE
DE KOUTOUKALE
BP 10 987 NIAMEY

APPENDIX A

CALCUL DE REDEVANCE CAMPAGNE SAISON SECHE 1986

SUPERFICIE CULTIVEE : 321,75 HA.

N° COMPTE	DESIGNATION	MONTANT F CFA.
61 171	ESSENCE	518 375 FRS
61 172	GAZ-OIL.....	8 716 000
61 174	LUBRIFIANT.....	1 109 175
61 371	ENGRAIS - PEPINIERES.....	468 175
61 372	PRODUIT-PHYTOSANITAIRE.....	630 000
61 470	FOURNITURE DE BUREAU.....	227 780
61 480	FOURNITURE DIVERSES.....	116 105
62 500	TRANSPORTS CONSOMMES.....	12 000
63 615	HONORAIRES DIVERS.....	36 525
63 623	ENTRETIEN MATERIEL ROULANT.....	445 718
63 628	ENTRETIEN STATION DE POMPAGE.....	1 246 707
65 201	SALAIRE PERSONNEL.....	1 416 366
	CNSS.....	364 644
	APPUI COOPERATIF.....	965 250
	S/TOTAL :	16 272 820
	AMORTISSEMENT PROVISION.....	5 830 355
	FONDS INVESTISSEMENT.....	1 323 400
	TOTAL GENERAL :	23 426 575
	Stock pièces détachées.....	840 000
	STOCK HUILE SAE 40 (400 L X 833).....	333 200
	STOCK HUILE SAE 90 (280 L X 849).....	237 742
	STOCK GRAISSE (7 BOITES X 1 450).....	10 150
	VENTE GAZOILSAE AU MOULIN 950.x.190.....	180 500
	VENTE HUILE SAE AU MOULIN 200 L X 833.....	166 600
	STOCK CARNETS DE RECU (FOURNITURE DE BUREAU)....	140 000
	APPORT ELECTRICITE AU MOULIN.....	45 000
	APPORT CHARGE BATTERIE+ SOUBURE.....	62 900
	VENTE ESSENCE POUR COMPTE COMMERCIALISATION.....	45 000
	REPARATION CAMIONNETTE SUPPORTEE PAR COMPTE MOULIN	124 120
	TOTAL DES PRODUITS.....	2 185 212

REDEVANCES TOTALE..... = 23 426 575 - 2 185 212 = 21 241 363

REDEVANCE A L'HECTARE..... = 21 241 363 : 321,75 HA = 66 018

ARRONDIE A..... = 66 020

PARCELLE DE 0,50..... = = 33 010

PARCELLE DE 0,25..... = = 16 505

1 ARE = 660,2

POUR LA D.R.N.

POUR LA COOPERATIVE
LE PRESIDENT LE SECRETAIRE