Arve Ofstad

EVALUATION OF NORWEGIAN ASSISTANCE TO THE ENERGY SECTOR OF SADCC COUNTRIES

P R O J E C T   P R O F I L E   2:

T H E   C U A M B A

H Y D R O P O W E R   P R O J E C T

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PROJECT PROFILE 2:

THE CUAMBA

HYDROPOWER PROJECT

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L I S T   O F   C O N T E N T S

L I S T   O F   T A B L E S

LIST OF ABBREVIATIONS

EDM	-	Electricidade de Mozambique
FDR	-	Final Design Report
FHR	-	Final History Report
GJ	-	gigajoule (= 10^9 joule)
GWh	-	gigawatthour (= 10^6 KWh)
ha	-	hectare
HCB	-	Hidroelectrica de Cahora Bassa
HEP	-	hydroelectric power
km	-	kilometre
kv	-	kilovolt
km^2	-	square kilometre
KVA	-	kilovoltamere
KW (or kW)	-	kilowatt
KWh (or kWh)	-	kilowatthour (= 10^3kWh)
m^3	-	cubic metre
m^3/s	-	cubic metre per second
MJ	-	megajoule (= 10^6 joule)
mm	-	millimetres
MPAN	-	Moagem de Produtos Agricolas do Norte
MT	-	metical (plural: meticais)
MW	-	megawatt (= 10^3 KW)
MWh	-	megawatthour (= 10^3 KWh)
NARSE	-	New and Renewable Source of Energy
NOK	-	Norwegian Kroner
%	-	percent
SADCC	-	Southern African Development Coordination Conference
t	-	tonne
toe	-	tonnes of oil equipments
TWh	-	terawatthour (= 10^{12} kilowatthour)
US $	-	U.S. Dollar

2. THE CUAMBA HYDROPOWER PROJECT

2.1 Background

Provision of electricity to rural towns is one of the key components of the country's policy for development particularly for remote areas such as the northern provinces, some of which have very important natural resources. Electricity supply for remote centres in Mozambique is in general provided by local power stations and distribution systems based on diesel generators. As fuel prices have escalated, foreign exchange for the purchase of diesel has been constrained. When supplies are constrained, most of the diesel goes to the major towns like Maputo, Beira or Namula. In addition, the internal war has disrupted transport so that supplies are affected even when diesel stocks in the country are sufficient.

Electricity supply, especially that based on diesel operated generators, has been subject to random and frequent interruptions and attacks. The Government of Mozambique is therefore seeking alternative energy sources with special emphasis on renewables as a substitute for diesel operated generators. A saving on diesel for electricity would also release this fuel for running tractors and other equipment for agriculture as well as for transport. One source claims that a saving of 1 million litres of diesel is enough fuel for six 10 tonnes trucks or eight 50 seater buses to operate 40,000 km.

Bearing this in mind, the Electricidade de Mozambique (EDM) asked Norconsult to look into the possibilities of supplying electricity to 6 centres in the northern provinces. Of these, Niassa was given the highest priority by the Government. Two centres in Niassa were identified: Lichinga, the provincial capital and Cuamba, the major town in the south of the Province.

2.1.1 Cuamba Town and environs

Cuamba is located in Amaramba District, one of the twelve districts of Niassa Province. In 1980, it had a population of about 45,000 persons within the town itself and its environs. The town's main economic activities are based on agriculture, silviculture and mining.

Cotton is, by far, the most important cash crop and, in 1955, a ginnery was built in the town. It operates after the harvest which takes place in the dry season from July to November. In the past, it used to operate 2 shifts per day, for 4-5 months, producing 35 bales per day. Production of cotton has declined drastically since 1983 from between 2000 and 5000 tons to about 100 tons a year and the factory now operates for only 1 month a year. Other important crops are beans, maize, potatoes and cassava.

Timber is felled in natural forests within a radius of 70 km of Cuamba. Two saw mills produce furniture and construction materials for the rest of the Province. The larger of the two, the Serracao Manuel Ribeiro Carpentry shop/sawmill, has a total of 47 workers and 12 foremen. The mill can operate continuously or on two 8-hour shifts if there is sufficient power from the Town Council's power plant. The other sawmill has its own generator but it is not in good working condition and this affects productivity.

There is a garnet mine west of Cuamba with its own generator. The industry contributes substantially to the income of the Amaramba district and Cuamba the capital. In addition, there are a few small-scale projects such as the 6 maize mills and the small weaving/oil making factory overseen by two Norwegian volunteers. There were plans to start a large textile mill but this had to be shelved due to problems in cotton production and the poor economic conditions in the country.

Roads and railways connect with Lichinga, the provincial capital, Malawi and the coast. Goods imported at the port of Nacala, 550 km away on the Indian Ocean, and intended for Lichinga, about 300 km to the north, or Malawi to the west have to be transported through Cuamba by road or rail.

A very basic infrastructure has been established in Cuamba Town The important features are street lighting, the hospital, the secondary school and the water supply system. Cuamba obtains its water-supply from the Mepopole River through an intake system and 25km pipeline. No electricity is utilised to pump water to the town.

The rural areas around Cuamba consists of small farms of about 1 hectare each. The chief crops are cotton, maize and cassava. The owners either live on the farms or, more often, in Cuamba town because of insecurity in the areas outside the town.

2.1.2 Energy production and consumption in Cuamba

The main sources of household energy are kerosene for lighting and firewood for cooking. However, some households, the public services and the few industries use electricity supplied from diesel operated generators. The main producer of electricity in Cuamba is the diesel power station owned by the Town Council. The installed capacity is as follows:-

1 Caterpillar mobile generating unit	150 kw
1 Deutz generator	200 kw
1 Bergen diesel generator	420 kw
TOTAL	770 kw

The Town Council supplies power to institutional and to domestic consumers. Energy for lighting, and such appliances as refrigerators and air conditioning, constitute the main domestic demand. In 1983, there were 300 domestic consumers. Institutional demand includes energy for street lighting, the hospital, schools and commercial establishments such as Ribeiro's Saw Mill and shops - 50 consumers in all. Very little of the electricity is actually used for cooking.

The monthly energy production is 50 to 60 MWh with an approximate fuel consumption of 11,000 litres. Present annual production is 0.7 Gwh. The maximum recorded peak power, in 1981, was 130 kw while 260 kw was recorded in October 1978. This drop is attributed to a reduction in domestic and street lighting due to difficulties in obtaining replacements for broken light bulbs. The available installed capacity is more than sufficient to cover the present average daily demand of 80 kw.

In addition there are private producers. The largest of which is Sociedade Algodeira do Niassa (SAN), a cotton ginnery which works seasonally. During an average of five months of operation, the ginnery consumes some 17,000 litres of diesel. Before the inauguration of the hydropower, the ginnery was connected to the town Council generator for lighting; the rest of the energy was supplied by its own generator. After the inauguration, the ginnery was fully connected to the Town Council supplies as a trial - in the words of the works manager, "to see which is cheaper".

Another producer is the Mitcue Primary School and Training Centre whose 20kw generator is so inadequate that, if electric irons are used in addition to lighting, the power supply fails. The centre has a maize mill and a band saw both requiring electricity.

Two saw mills, Ribeiro's Saw Mill and Santo's Saw Mill (MADEMA) also have equipment requiring electricity. The former is connected to the Town Council power plant and consumes about 1.5 Mwh of energy per month. The Mill produces sawn timber for construction and furniture for the whole of the Niassa province. The MADEMA Mill has its own 52 kw generator, but it was reported in poor working condition.

An important industry is the garnet mine which has 2 generators. At present the power is adequate for the mine operation and for the processing plants but there are plans to expand. Other producers and the total energy capacity is summarised in Table 2.1.1.

The installed capacity and energy produced is more than adequate if the units are working at optimum capacity. However, shortages of diesel cause frequent power cuts, some lasting for months on end.

These shortages are due to several factors:-

(i) lack of foreign exchange to import sufficient quantities of diesel in which case the fuel does not get beyond the major cities like Maputo and Beira.

(ii) even when supplies of diesel are available, disruptions in communication caused by the RENAMO bandits make it difficult to deliver fuel to remote areas. For instance, prior to the war situation, there used to be 80 - 100 train arrivals per month in Cuamba - now there are barely 2 - 3 a month. Shortage of spare parts also makes it difficult to maintain the diesel engines.

Table 2.1.1 Installed capacity in the Cuamba region

Power Producers	Installed Capacity (kw)	Estimated Annual Consumption (Gwh)
Cuamba Diesel Power	770	0.69
Sociedade Algodoeira do Niassa (SAN)	224	0.40
Mitucue Training Centre	20	0.11
Santo's Saw Mill	52	0.12
Mining Industry	125	0.57
Direccao National de Estradas	20	1.90

Source: Norconsult: Cuamba Hydropower Project Design Report, 1983

2.2. Project objectives

Like several other remote towns in Mozambique, Cuamba has been supplied by electricity produced be a local disesel-driven thermal power station (with an installed capacity of 770 KW). However, increasing balance of payments problems and consequent shortages of diesel fuel and spare parts, becomming quite serious since 1983, had caused frequent interruptions and shortages of electricity, lasting for months on end. Already in 1984, the technical condition of the machinery at the thermal power plant had begun suffering because of lack of spare parts. Later on, this situation was severely aggravated because of the actions of the Renamo bandits, causing reductions in the train arrivals in Cuamba from 80-100 per month in the early 1980s to an average of 2 to 3 per month, and sometimes none in 1989.

The main objective of the Cuamba hydropower project was to reduce the use of diesel fuel for electricity production in Mozambique and at the same time to secure a minimum of electricity supply to the town throughout the year.

In September 1983, the government of Norway and the People's Republic of Mozambique signed an agreement on the financing and construction of the Cuamba Hydropower Project on the Mepopole River about 30 km north-east of Cuamba Town.

2.3 Project implementation and operation

2.3.1 Project identification and selection

The Cuamba Hydropower Project was identified prior to Independence, in the early 1970s. The project was later included in the Mozambique Hydropower studies (Moz 018) as part of the country programme negotiated in 1979, agreed on by Mozambique and Norway.

Based on the positive experience from Lichinga, EDM expressed their wish to start the construction of Cuamba Hydropower project immediately after completion of Lichinga. Two reports, a Design Report and a Construction Planning Report were prepared and submitted by Norconsult in 1983 under the stage II contract, 1983 to 1986.

The Contract between the Government of the People's Republic of Mozambique and the Government of the Kingdom of Norway controlling the financing and construction of the Cuamba Hydropower Project was signed on 16. September 1983 in connection with the inauguration of the Lichinga Hydropower plant.

Under this Contract, Norway agreed to finance the foreign currency component of the construction. This grant was to be used for:

- procurement and delivery of electro-mechanical equipment, construction equipment and other equipment or material for the project;
- commission Consultants to carry out detailed design, assist

in the procurement of equipment and materials, undertake supervision of construction works and train local personnel.

An agreement to start up the work was established between EDM, NORAD and Norconsult early 1984. The formal contract between NORAD and Norconsult was, however, not signed until 6. June 1986.

The services to be carried out by Norconsult under this Contract were:

- Project management
- Procurement services
- Detailed design, preparation of work drawings and supervision
- Construction management and training of local personnel.

The construction work started in late 1983, with key personnel transferred from Lichinga. The estimated duration of the construction was about two and a half years. The actual construction period lasted for five years and three months. The main cause of this delay was the escalating war situation in the country in general and in the districts near to the project area in particular.

2.3.2 Project design and choice of technology

The project consists of a 21 m high rock/earth fill dam, a 2160 m long headrace pipe and a power plant containing two Pelton turbines with a capacity of one MW (rated capacity per unit 545 KW). The power plant is a high head power plant with 350 m available head. The power is transmitted to Cuamba town along a 28 km long 33 kV transmission line.

According to the Norconsult Design Report (1983) a 15 m high dam was found to be the least cost alternative. Following a request by EDM, a 21 m high dam alternative was investigated. This dam alternative increased both the firm and total energy output. The difference in cost due to increased dam volume was USD 2.3 million or a cost increase of approximately 40%.

With the high dam alternative the mean annual energy potential of the Cuamba plant is 5.6 GWh with a firm power of 320 KW. This compares with an estimated annual demand of 7.8 GWh in year 2002. The peak power demand by November 1989 was 360 KW.

The dam site is very suitable for a rock/earth-fill dam. Even though a concrete dam was considered for the low dam alternative, a fill dam is the obvious choice at this dam site. It was noted during the team's field inspection that alternative locations of the dam had been possible. For instance, some 300 m downstream could have been an alternative location implying an equal saving in length of headrace pipe. We were informed by the Norconsult representative that the exact location had been subject to discussion and the final decision was made by the foundation and fill dam expert (known as one of the top experts in this field in Norway).

A concrete culvert in the dam foundation connects the reservoir to the headrace pipe. This design requires special precautions to avoid leakage which may lead to dam failure. The Final History Report, Volume 2, Drawings by Norconsult, September 1989 seems to reflect that ample precautions have been included in the design.

The spillway consists of a short channel, an unguided overflow crest and a moderate channelisation down the slope towards the river, all unlined rock surface. This is a low cost, but adequate design. The outlet from the spillway is directed towards the headrace pipe, however, and the team would like to point out that some protective action should be considered to avoid damage to the headrace pipe caused by a major flood.

The Cuamba power plant had been in operation for approximately one year when the team visited the plant. The general impression of the area, the dam, the spillway and access road had the usual appearance of a construction site. It is recommended therefore that a maintenance programme is established which will gradually improve the general appearance, which will highlight the importance of maintenance.

The ductile cost iron pipe headrace/penstock can be considered the obvious choice for this high head hydropower plant.

The power house, including store/workshop and switchyard is located in a narrow area close to the river. The overall design and construction, including finish appears to be of ample good quality. No operational problems were reported to the team after one year of operation. The detailed design as well as the quality of turbines, generators and auxiliary equipment is known to vary considerable. The team has not been in the position to study the specifications in detail. It is assumed, however, that the Norwegian suppliers of the powerplant equipment have delivered the high level quality equipment they are known for.

The location of the power house, i.e. the head utilised by the power plant is given by the existing intake structure for Cuamba's water supply. A further 35 m of head exists some 280 m downstream from the intake. To locate the power house at that site and at the same time safeguard the water supply would entail complicated operation and some pumping.

The Cuamba hydropower plant has improved the water supply to the Cuamba town. It was reported to the team that there is and will bean increasing need for more water supply including improved water quality. It is recommended, therefore, that NORAD continue to support water related projects in the Niassa province, further improving the water supply to the Cuamba region should be included, making use of the expatriates who would be working in the region.

2.3.3. Assessment of costs and the internal economies of the project

In Norconsult's Final Design Report (FDR), dated June 1983, total costs of the Cuamba project were estimated at US $ 8.1 mill., equivalent NOK 54 mill. Of the total costs, US $ 4.7 mill. (approx. NOK 31.5 mill.) were assumed to be foreign currency costs, and the remaining US $ 3.4 mill. (approx. NOK 22.5 mill.) local costs to be borne by Mozambique. These estimates were at constant prices, referring to the 1981-price level. (cf. FDR: 2-4 and 9-11).

In the contract between NORAD and Norconsult, which was not signed until 6th June 1986, the estimated total costs of the project had been escalated to US $ 11.0 mill. (NOK 74 mill.), now including inflation from 1981 until the end of the construction period, which was originally assumed to be early 1987. The foreign component of total costs was now estimated at US $ 7 mill. (NOK 47 mill.), implying an increase of 49% compared to the corresponding estimate in the Final Design Report.

The cost estimate in the Final Design Report formed the basis of the assessment of the internal economies of the project and the consequent decision to implement it. The project economy is of course strongly affected by an escalation of the cost estimate by 50%.

The Final History Report, dated September 1989, refers only to the budgeted costs in the attachment to the contract between NORAD and Norconsult (June 1986) when discussing causes of cost overruns. We are then left with the question of what caused the large increase in estimated costs from the Final Design Report (June 1983) to the contract three years later. Inflation could only explain a small fraction of that increase. Hence, it is difficult to avoid an impression that the cost estimate in the

Final Design Report, which formed the basis for the decision to implement the project, was far to optimistic.

In the Final Design Report, the Cuamba Hydropower Project was compared with the only realistic alternative, viz. generation of electricity by means of diesel units. It turned out that the present value of total costs of the project (backed up with diesel) was equal to the present value of the cost of diesel only, at a discount rate of 10.5%. (At a higher discount rate, diesel only would have the lowest present value of costs; at a lower discount rate, the HEP alternative would have the lowest present value of costs).

At a discount rate of 10.5%, the unit energy cost at 1981-prices would be 30 US c per kwh for both HEP and diesel only. The later increase of the cost estimate for the Cuamba Project had, of course, a strong impact on the economy of the project compared with the alternative of diesel only, as well as on the unit energy cost of the project.

Table 2.3.1 shows three versions of the project's foreign currency costs: the estimate in the Final Design Report (1983), the budget attached to the contract between NORAD and Norconsult of June 1986, and the actual, invoiced costs presented in the Final History Report (FHR), September 1989. In the Final Design Report there is no breakdown into local currency and foreign currency costs, respectively, in the detailed cost estimate; only the totals are reported. We have tried to make a rough classification of the detailed cost items into local and foreign costs, in order to sort out the foreign currency cost components. The sub-items of the FDR-estimates in table 2.3.1 should therefore be considered as rough indications only. However, total cost is the same figure as reported in the Final Design Report.

The estimate of total project costs (including local currency costs) was, as already noted, increased from NOK 54 mill. (at 1981-prices, with no allowance for inflation) in the Final Design

Report to NOK 74 mill. in the contract between NORAD and Norconsult of June 1986. The Final Design Report does not report actual local costs; and actual total costs are not known to us.

Table 2.3.1. Foreign currency costs of the Cuamba Hydropower Project. NOK mill.

	Estimate, FDR *	Budget in contract **	Actual, invoiced
Construction management	7.50	17.00	28.19
Procurement, constr. mat. & equipment	11.00	13.00	18.66
Procurement, electro-mec. equipment	13.00	17.00	15.69
Other costs (aeroplane)	-	-	1.90
	31.50	47.00	64.44

* The cost estimate in the FDR, at 1981-prices does not include allowance for inflation. That cost estimate was in US $, and has been converted into NOK, assuming 6.70 NOK = 1 US $. The sub-items in the FDR-estimate represent rough indications only.
** In the Final History Report, the budget in the contract of June 1986 is presented in two versions, on pages 1-4 and 8-15, which are not consistent regarding the sub-items. We have reproduced the version on page 8-15, which compares budgeted amounts with actuals.

Only a small fraction of the difference of 37% between the foreign currency cost estimates in the Final Design Report and the contract between NORAD and Norconsult may be explained by allowance for inflation the latter document. When the contract was signed, Norconsult had more than two years of experience with implementation of the project. The higher figures in the contract budget apparently reflect that experience. But then it is not justified to use only the cost budget in the contract when assessing the cost overruns, as the Final History Report does. A proper assessment of the cost overruns should also have used the cost estimates in the Final Design Report as a yardstick.

It should also be noted, that the economic evaluation of the project in the Final Design Report was invalidated by the far higher cost estimate in the contract between NORAD and Norconsult.

The item Construction management in table 2.3.1 covers all project services carried out by Norconsult in Norway (actual amount: NOK 6.19 mill.) and in Mozambique (NOK 22 mill.), i.e. project management and procurement, construction management and training, work drawings, supervision and commissioning, international travels and subsistence. The expenditures under this item had exceeded the budget ceiling of NOK 17 mill. already in the middle of 1986, at the same time as that budget ceiling was stated in the contract between NORAD and Norconsult. At the end, this item suffered a cost overrun compared to the June 1986-budget, of NOK 11 mill., or 66%. The component Services in Norway experienced the largest budget cost overrun of 88%, whereas the cost overrun of Services abroad was 53%. The FHR presents the following causes of this overrun compared to the June 1986-budget:

- Increase in construction period from originally estimated 39 months (about 3 years) to 69 months (almost 6 years), including 6 months of complete stop of construction activity, due to the security situation;
- increase in salaries due to inflation in the same period;
- irrigation study (carried out in 1986);
- employment of pilots who were not foreseen in the 1986-budget;
- increased number of international travels due to longer construction period;
- pilot services to TTA prior to purchases of own aeroplane;
- local agent in Malawi, and several other unexpected expenses due to the war situation and the extended construction period.

Also Procurements experienced a considerable cost overrun of NOK

4.35 mill. or 15% when the purchase of aircraft is not included. The whole of this overrun was, as table 2.3.1 shows, caused by the item Construction materials and equipment, which experienced an overrun of NOK 5.66 mill. or 44%. The subitems with the largest overrun within this category were, according to the FHR, procurements of cars and trucks, freight and miscellaneous expenses and aircraft operation and maintenance which was not included in the June 1986-budget.

In the FHR it is stated that due to the extension of the construction period, "it has been necessary to purchase new cars and to increase the expense of spare parts, some of which required to be freighted from Norway". (FHR: 8-12).

Construction of the Cuamba Hydropower Project started in late 1983 with an assumed construction period of 39 months. In the first half of 1984 the security situation started to deteriorate, and it was deemed necessary to use air transport for personnel and small goods transport. As time passed, it became increasingly more difficult to operate the project, and it became necessary to use air transport to a larger extent. The total costs of air transport amounted to NOK 8 mill. or 12% of total foreign currency costs. Of this amount, NOK 6.1 mill. were distributed on the budget items Construction management and Procurement of construction materials and equipment (cf. table 2.3.1) contributing to the cost overrun of these items.

According to the FHR, the costs of air transport were as follows:

-	Aircraft purchase:	NOK	1.9 mill.
-	Aircraft operation and maintenance, helicopter rental and TTA rental:	"	1.5 "
-	Salaries to pilot:	"	4.6 "
	Total:	NOK	8.0 mill.

Moreover, due to a finally complete standstill of the rail traffic from Nacala, the project's main import harbour, it became increasingly necessary to use Blantyre in Malawi as construction supply centre. Materials and equipment that would otherwise have been supplied by Mozambique had to be purchased in Malawi, or transported from Mozambique up to Cuamba through Malawi by road, thus greatly increasing costs.

The project was finally commissioned in late 1989, after a construction period of 69 months, including 6 months of complete standstill in construction activity, i.e. almost twice as long as the originally planned period of 39 months.

Compared with the cost estimate in the Final Design Report, which did not make allowance for inflation, the cost overrun was about NOK 32 mill. or more than 100%, some of which should of course be ascribed to inflation. Compared with the budget attached to the project contract of June 1986, the cost overrun was more than NOK 17 mill. or 37% (cf. table 2.3.1).

There can be no doubt that the war situation and the consequent extension of the construction period combined with extra costs for transport and equipment was the major cause of the large cost overrun. However, this situation was well known and the project had been under implementation for about 30 months when the budget was attached to the contract between NORAD and Norconsult, signed in June 1986. We should therefore expect that the budget in the contract reflected the experience with the war situation. In spite of that, the budget was considerably exceeded.

THe Final History Report makes no mention of the cost estimate in the Final Design Report. In our view, that estimate should have been the main yardstick of the assessment of cost overruns. However, we have found no explanation of the cost escalation of almost 50% from the FDR-estimate to the June 1986-budget, of which only a small fraction can be explained by inflation.

2.3.4. Project organisation

The agreement between Mozambique and Norway signed on 16. September 1983 and the contract between Norconsult, EDM and NORAD established early 1984 and signed 6. June 1986 reflects the overall organisation of the project implementation.

These agreements also included the following:

Mozambique was to undertake the full responsibility for the implementation of the project and for the subsequent operation and maintenance. Mozambique agreed to:

- have the overall responsibility for the planning, administration and construction of works to be undertaken;
- inform the local people in the affected area about the project and its consequence, including aiding in resettlement from the reservoir area;
- bear all expenses with the exception of the costs agreed to be covered by the Norwegian grant.

It was agreed that Norway and Mozambique should establish a close contact and collaboration in what concerns safety risk of the personnel.

An appendix to the Contract defines the input by Mozambique and the grant given by Norway.

Electricidade de Mozambique (EDM) was to contribute towards the project by paying for local costs. These costs would be:

- Manpower; all unskilled and wherever possible skilled personnel;
- Supply of locally available materials (cement, diesel, building materials, etc.);
- Local transport;
- Transfer of construction equipment from Lichinga;

- Road construction equipment;
- Transmission line design, construction, and materials (later on, EDM assumed the obligation to supply power transformers for the project);
- Locally available food supplies.

Project construction was to follow a similar model to the one used in the construction of the Lichinga Hydropower Scheme inaugurated in September 1983. In this model EDM was to have the overall responsibility for planning, administration and construction of the works to be undertaken assisted by a Norwegian management construction team. Norconsult was contracted to assist EDM in construction management and work started in late 1983.

The estimated duration of the construction was just in excess of two and a half years. The total construction period lasted for five years and three months. The cause of this delay was the escalating war situation in the country and particularly in districts near the projects area. Already in 1984, the military situation in neighbouring provinces had an effect on construction activities. EDM, NORAD and Norconsult kept in continuous contact with the authorities in Maputo, Lichinga and Cuamba to monitor the situation. Construction of the Project became increasingly difficult as the railway line between Cuamba and the coast was frequently damaged, not only by military activity, but also by climate calamities such as floods. Train arrivals to Cuamba dwindled from about 80 to 100 per month to only two or three, sometimes none.

This caused frequent shortages of construction materials such as diesel fuel, cement and reinforcement steel. In one occasion early in the construction, four Hino trucks that had been especially imported from Japan to work on the steep mountain road were burnt down while on transport by rail between Nampula and Cuamba. Rehabilitation of these trucks was achieved in Cuamba after the necessary components had been received but not without delays. Delays in the transport of the electro-mechanical equipment and the penstock also resulted after the railway line to Nampula/Nacala was closed for almost two years. As the railway line to Malawi remained open with fewer closures it was decided to purchase in Malawi some of the materials that Mozambique had agreed to supply.

Roads out of Cuamba were mined and prone to ambushes, and land transport of personnel by car become dangerous. Alternative transport was therefore necessary, and NORAD and EDM agreed to purchase a small plane for personnel transport and small items in order not to stop the project.

Military activity in the project area was rare except for three occasions. One of the three attacks resulted in the death of one Mozambiquan and one Portuguese foreman. After this incident, the project stopped for six months, during which EDM and the army strengthened the security procedures. A 200 m wide belt was cleared of trees and shrubs along the access road. Norconsult's personnel and other foreign project personnel's presence in the project area had to be reduced in order to minimise the risk.

2.3.5. Summary on work progress

As pointed out above, the contract with Norconsult A/S. was established in 1984, but signed in June 1986. This delay in ratification of the contract was apparently due to the following reasons:

- The war situation made it increasingly difficult to define progress plans and other contract conditions in sufficient detail.
- The Stage II agreement between NORAD and Norconsult could serve as a basis for negotiating short-term work plans, rates and other contractual aspects in line with the situation and progress of work.

The work in the same area started again in September 1985 and was finished in June 1988. The total duration of this work was 45 months as compared to 20 months as originally planned. The reason for this delay was the constant shortage of diesel fuel, cement, steel reinforcement and other materials caused by the deterioration of the rail traffic from Nampula/Nacala.

Work on the penstock foundation started in May 1986 and was completed end of November, whereas erection of penstock tubes started in March 1988. The total duration of this work was 22 months as compared to 13 months as originally planned. The work was not continuously executed. About 50% of the penstock pipes were stranded in Malema until July 1988 due to sabotage on the railway line.

The civil works at the power station started in 1986 and were finished in 1987. Conditions in the railway led to delays which caused shortages of cement and steel reinforcement. Erection of the turbine and electrical equipment started in November 1987. It was finalised in April 1988.

2.3.6. Labour force and staff training

Construction management was planned to be similar to that of Lichinga with about eight expatriate staff assisting EDM in construction of the project. The number of expatriates was gradually reduced to two at the end of the construction period, Norconsult's representative in Mozambique and one expatriate from Portugal. EDM engineers replaced the other expatriates.

The total staffing connected to the project was approximately 175 and the EDM labour force counted approximately 150 workers. Approximately one third of the work force at Lichinga was transferred to Cuamba.

An important aspect of the implementation plan for the Cuamba

Hydropower Plant was the programme for on-the-jobs training. The training was based on the experience from the construction of the Lichinga Hydropower Plant. The training aspect was emphasised by the project management and covered site management, foremen for civil, mechanical and electrical works, and the skilled and semi-skilled employees.

The Final History Report, Sept. 1989 by Norconsult points out the following with respect to the result the training programme:

The continuous emphasis upon every aspect of training proved successful on most counts, not the least as a direct result of the positive attitude and responsiveness on part of the workers themselves. Considerable proficiency covering carpentry, iron and steel works, mechanical works including welding concreting and concrete control, surveying, equipment and vehicle operation and maintenance, besides the actual administration of smaller work operations, was acquired by members of the workforce towards the end of the construction period in Cuamba.

A low accident frequency is largely a tribute to the strong emphasis placed upon safety procedures in particular, and all aspects of training, supervision and control of operations, in general.

Power plant operation was also included in the training programme. Extensive supplies took place during, and in the period immediately following erection and testing of the generating equipment in Cuamba.

The immediate purpose of this training was to provide the regular staff with sufficient knowledge and experience to competently execute the operation of the plant, and to perform maintenance and repair functions, as required.

Following the initial period of training and testing, the Cuamba Hydropower Plant has been operating successfully under direction of the EDM operators.

An additional one month training period was arranged after the plant had been in operation for about 3 months, combined with the execution of some minor remaining erection work.

Although no serious problems have been experienced during the initial operation period, it should be brought to mind that the operation staff have no previous experience in running such a power station. It is therefore recommended that short-time visits by engineers from the manufacturers of the turbines and electrical equipment are arranged.

2.4 Economic aspects

2.4.1 Some general features

In the absence of full data on the economic activities of Cuamba and the uncertainties caused by the war situation, it is difficult to assess the impact of electricity on the economic situation of the area.

Some trends can however, be discerned. About 50 per cent of the households depend on agriculture based on small farms of 2 - 3 acres using only traditional tools. The impact of electricity on these farms is nil. Non-agricultural activities that are likely to develop in the future depend on:

a) the establishment of security,
b) the improvement of the economic situation.

The biggest bottleneck is caused by disruption in transport facilities which affect production, exports and imports. Production of cotton, for instance, has dropped from 3000 - 5000 tonnes in 1983 to less than 100 tonnes in 1988. This affects the amount of cotton available to the ginnery which now functions only 1 month/year instead of 5 months. Timber mills are also affected by lack of transport.

The war in Mozambique is caused by political and military support given by South Africa to the rebels. Recent signs are that this may change radically. Restoration of stability will also improve the economic situation by conserving money now spent on dealing with the war situation. These savings would then be used to maintain transport and stimulate trade.

If the security and transport situation improves, both cotton production and output from the mills will increase. The larger outlying farms that used to produce agricultural surplus for export will also pick up as will the production of the smallholders. The San Cotton Factory, for instance, had its own 20,000 hectare farm about 6 kilometres from Cuamba. The farm had to be abandoned because of the war. Output from this farm, together with that obtained from smallholders, could restore the ginnery to full year round production. Smallholders can produce about 200-250 kilograms per year. At 200 meticais per kilogram, peasants could earn about 40,000 to 50,000 meticais or about twice the current minimum wage. Added to the fact that these farms also produce their own food, such incomes could stimulate increased agricultural production and perhaps enable the factory to operate all the year round.

According to the ginnery manager, there was a good demand for both baled cotton and cotton seed. At the moment, when the mill is in full operation, it uses as much power as the rest of Cuamba Town. In the past it used to use its own 224 Kw diesel generator but it has now been connected to the town's grid. If this connection is maintained, the ginnery can be provided with all the energy it will need for its expanded activities. Such an expansion might be hampered if the factory had to depend upon its own old diesel generators which require frequent and expensive maintenance.

Similar developments could also take place in the other major industrial sectors such as the timber mills and garnet mine. One of the mills is already connected to the town's grid; the other is likely to be connected soon, since its diesel generator is in a state of disrepair. As in the case of the ginnery, there is a strong demand for construction timber and furniture in the province. There are plans also to double the production of the garnet mine. A plan is under consideration to construct a 11 kv transmission line to replace the diesel units. The mine will then operate two 8-hour shifts totalling 88 hours a week and requiring a power demand of 125 kw or an average of 0.57 Gwh per year.

There are also plans to start smaller industries, including a sizeable commercial poultry farm, and an oil extracting factory based on cotton seed or sunflower seed. The resultant increase in employment and cash flow could stimulate services such as shops and restaurants. Commercial use of electricity is therefore bound to increase. EDM's emphasis is to stimulate the industrial, commercial and institutional use of electricity so that even those who themselves do not or cannot use electricity can gain from better services and greater economic opportunities.

2.4.2 Domestic demand

Rural electrification holds little hope for large scale substitution for current domestic fuel use, unless the economic situation changes radically. Ironically, if that happens, the output from the hydropower station will be inadequate to meet the demands for industry, institutions and households.

However, even without radical changes, the possible trends for development in agriculture and industry mentioned above may increase income and create a surplus for investment in electricity at least for lighting and some consumption with music systems, refrigerators and electric irons. The main fuel for lighting is currently kerosene. At the moment supplies are erratic and, even if they do improve, the prices of kerosene are likely to increase not necessarily because of increasing world prices but because of increasing local taxes and transport costs. Electricity will thus be a cheaper alternative. There is also the social status attached to using electricity as opposed to kerosene lamps.

Keeping all this in mind, it is likely that increased demand in energy along the lines of the NORCONSULT projections will occur..

2.5 Social aspects

2.5.1 The setting

Cuamba is situated in Amaramba District, the largest of the 12 districts of Niassa province. The district has an area of 6,610 Km^2 and a population of 84,900, No specific population data was available for Cuamba but, in the 1980 census, the town had a population of 20,000. With the inclusion of the surrounding areas, the population rises to about 45,000. In the absence of data specific on Cuamba, some population indicators for Niassa and Mozambique are used as proxies to indicate the likely demographic status of Cuamba.

This general data shows that about 50 per cent of the population are less than 14 years and this will not change before the year 2000. This has significant implications for the immediate availability of labour and requirements for educational and health facilities. The number of doctors rose from 171 in 1975 to 279 in 1986. During the same period, the number of health facilities rose from 559 to almost 3 times as many. The Cuamba

Health Centre is the second stage of service, falling in between the lowest, which is the health post, and the highest, the hospital.

The most common disease is malaria, followed by malnutrition, acute respiratory diseases (tuberculosis, pneumonia) and parasitosis. Malaria is said to affect one out of four persons during the dry season and 8 out of 10 in the wet season. The high incidence of malnutrition is a matter of grave concern. Marasmus and Kwashiorkor were said to be as high as 20 - 25 per cent, particularly among the children of immigrants fleeing from the war ravaged areas.

The people of Cuamba, like those in Niassa Province, consist mainly of the Macula tribe. Other major tribes are the Yao and the Hyanje. No statistics are available on the social characteristics of the people of Cuamba Town or the environs but, based on the general characteristics of Niassa province, all the rural people and about 50 per cent of the poorer families in the town have farms. Even among the employed, estimated to vary from 3000 to 5000 individuals, about 85 per cent depend on agriculture.

2.5.2 Impact of electricity on social welfare security

Because of the war situation, the most important impact of electricity has been the feeling of security among the people in the area. The provision of electricity has increased security in two ways:

a) the steady supply of electricity provided by hydropower rather than the intermittent supply dependent on unreliable supplies of diesel and poorly maintained diesel generators has ensured street lighting throughout the night and a sense of being better protected. Consequently, many people move into the town at night. The feeling may be more psychological than real; nevertheless it is a feeling expressed by several individuals. Even in the long term, electricity is seen as enhancing security in the town.

b) the hydropower project necessitated the clearing of 200 meters of land on either side of a 35 km road from the town to the dam. This road and the power plant are guarded by a small contingent of about 200 soldiers. The resulting security has attracted immigrants from surrounding districts - the Cuamba Town administrator estimates between 7,000 - 10,000 since the project began.

Health Services

Cuamba Town has a rural hospital, with 80 beds including 7 for emergencies, and an operating theatre. It has an out-patient service that caters for about 40-50 persons per day from the town and surrounding areas within a radius of 30km and a Maternal and Child Care unit. It uses power from the power plant of the Town Council but also has its own generator for emergency purposes. Electricity is used for lighting, sterilisation, cold storage and for the operating theatre; food for the patients is cooked using firewood. Before the hydropower was inaugurated, electricity was available for only 3 - 4 hours and the hospital had to use its emergency 30 kw diesel generator for theatre operations. With the increased supply in electricity, the hospital can better maintain its services and medicines and save money on the diesel. It is also possible that, in future, food for patients will be cooked on electric stoves once the political and economic situation improves. The Centre also has four health posts, two of which already have electricity, thus making it possible to assist in deliveries at night and to keep medicines in cold storage.

The hydropower station will continue to have a positive impact on the provision of health services both by ensuring a steady supply of electricity all the year round and for 24 hours a day as well as through savings in the purchase of diesel. These savings could be applied elsewhere if the Centre had the flexibility to use its savings for other needs. The benefits of rural electrification for improving medical services for the rural towns and their environs are thus indisputable.

Education

The supply of firm power has already had some positive impact on education and training, although the hydropower plant was inaugurated just a year before the visit of the team. Cuamba presently has a secondary school with 570 daytime students. The school had 24 Mozambican teachers of whom only two are women. The curriculum aims at general education with emphasis on science. Students whose homes are far from the school are housed in dormitories. The school also has provision to teach adults who are prepared to pay a 4,000 meticais annual fee to obtain secondary education.

Before the Cuamba hydropower station was inaugurated, classes for adults could only be held during the weekends. Since the power station opened in November, 1988, classes are taught at night. By the February 1989, the enrolment had already increased from 50 to 300.

Another important unit is the Mituke Training Centre which used to train people in making furniture but which now has difficulties getting equipment from the Ministry of Education. It is now a primary school and carpentry is still used to pay for some of the expenses of the school. The 9 workers are paid by the amount of furniture they produce. Not all the problems will be resolved by the provision of electricity but, if the equipment were rehabilitated, the Centre could provide both primary education and skills training.

Other Services

The team was not able to ascertain this but the town Administrator asserted that the provision of all night electricity meant better services in the town. There were more refrigerators and, therefore, greater availability of fresh produce. Restaurants were open until late at night and night life was generally better.

An unexpected bonus was the fact that the reservoir of the dam augmented the town's water supply during the dry season by increasing the water flow from 24 litres per second to 120 litres per second, thus assuring the town of a firm supply.

2.5.3 Gender issues

No data were available on the women in Cuamba, either in the town or the rural areas surrounding the town. However, based on data from Niassa Province, it can be assumed that about 50 per cent of the poorer urban families and all the rural households had farms where the division of labour was strictly on gender lines and very much similar to that prevailing in many parts of sub-Saharan Africa. In agriculture, women predominate in preparing the soil, planting, weeding, harvesting, small-scale horticulture and the keeping of poultry. Women also predominate in tasks usually referred to as "domestic": including providing fuelwood and water, childcare and processing maize into flour. Women are also responsible for finishing house-building and collecting thatch for the roof. Their chief source of income is smallscale horticulture and beer brewing.

Discriminatory access to resources is best illustrated in women's access to education. (Table 2.5.1)

Table 2.5.1 Student's enrolment in Niassa Province

Category	Male per cent	Female per cent
Primary Schools	60	40
Secondary Schools	82	18
Technical Schools	90	10
University	88	12

Source: Norconsult: Mbahu Hydropower Study, 1988.

As a result, out of the 24 Mozambican teachers at the secondary school only 2, or less than 10 per cent, were women.

Perhaps this fact is one of the reasons why women workers feature so little in the whole Project. The only involvement of women with regard to the Project is the fact that a blanket making mill was established as an income generating activity for the wives of the construction workers. In all, about 175 persons were involved in the project consisting of masons, carpenters and steel workers - skills traditionally considered as the male domain. This will continue for quite some time and the chances of women participating in the construction or maintenance of hydropower are remote in the near future. Hydropower has the potential for increasing the scope of small industries, such as the saw mills and the ginnery, but, even here, it is doubtful if the women will benefit. Neither the ginnery nor the saw mills had women workers. The ginnery factory manager said that they had tried to use women workers but they (the women) were found to be "not suitable".

One benefit that the women, particularly in the town, have definitely experienced is in the better services of the 6 maize mills in the town. Maize mills will ease the burden of pounding maize and it is hoped that the rural women will also benefit from this service.

Implications of the Hydropower to Women's Energy Needs

The most commonly used source of energy is fuelwood. In the town, firewood is available on the market but the poorer group cannot afford the cost of 9,000 meticais per month. Purchased firewood is a more expensive form of energy than charcoal and electricity. Therefore, women from both urban and rural households have to go to the bush to collect firewood. No data were available on distances to fuelwood sources.

Fuelwood is used both for cooking and heating of water for bathing. Obtaining fuelwood is a tedious activity and exposes women to great risk in Cuamba. Charcoal, selling for 1,5000 meticais per bag, is another source of energy which is quite popular. A family of five persons uses about 2 - 3 bags per month thus needing to spend about 3,000 to 4,500 meticais.

Ironically, for those who can afford the initial cost of the equipment, electricity is cheaper than charcoal and even cheaper than firewood. Very few households could afford to purchase cookers even if they were available.

Regarding lighting, average consumption was 80 kwh per month, which assumes 3 to 4, 60 watt bulbs; the cost is 1,000 meticais per month. The installation fee of 20,000 meticais is prohibitive for the poorer and largest segment of the urban population and nearly all the people in the rural areas. In the immediate future, the provision of electricity is not going to bring much direct benefit in terms of savings on labour or time. Basically, the majority of people in Cuamba are too poor to be able directly to have the maximum benefit from electricity at the household level.

However, electricity will bring the following benefits immediately:

a) In the town, the supply of firm power to six maize mills will bring welcome relief from the chore of women having to pound grain;

b) Expansion of the health centre facilities will enable women to ensure safer deliveries, and improved maternal and child care.

To the above must also be added the whole question of security for those living in the town and the immediate vicinity.

2.6 Conclusion

Cuamba HEP has definitely given the town a sustainable and reliable source of energy and has contributed a great deal to the general security situation.

Probably mainly because it was constructed in a war situation, the Cuamba HEP became excessively expensive, with large cost overruns. But we are also left with an impression that the cost estimate in the Final Design Report was far too optimistic. We have found no explanation for the escalation of the estimate by 50% from the FDR (1983) to the budget in the contract between NORAD and Norconsult (1986). We would like to add that the project, despite its high costs, will save foreign exchange for Mozambique.

The benefits of electrification should not and cannot be looked at in isolation from other social and economic factors. The full potential of electrification will only be realised with overall improvements in the economic, social and security aspects in Cuamba and Mozambique.

A reliable source of power has boosted the morale of the officials and the people for it has given the inhabitants in the area a sense of security and built the confidence needed for development. Basic social services can be provided and equipment in the offices which requires electricity is able to function. There will even be savings in foreign exchange spending on diesel imports.

For the rural households dependant mainly on subsistence agriculture, electrification is not feasible for the foreseeable future. The same can be said of the poorer households in the rural towns. Therefore, rural electrification can best be effective in supporting agro-industry and basic community services, such as health, education and water supply.

Electrification of rural towns has the potential of supporting and stimulating small scale industry including agro based activities. This may even improve the economic situation of households by providing incentives for increased production and employment for some.

Direct benefits to women in terms of employment in the hydroelectric projects are likely to be negatively affected by discrimination against women in terms of access to education and technical training. The gender based division of labour will continue to be a constraint in women's ability to compete for economic opportunities on equal terms with men.

Rural electrification does not offer a viable and affordable substitute for domestic energy needs, except perhaps for lighting, and this is only for a few better off households only. The pressure on forest resources and the burden on women will continue.

Nevertheless, electrification of rural towns can bring indirect benefits to women by providing such labour saving as conveniences like maize mills and oil presses.

In addition, the capacity of the entrepreneur, such as shop-keepers and small food suppliers, to offer better services has a chance to increase.