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Togo: A preliminary assessment of small hydropower potential

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~~**Attachment**~~
~~"Togo Small Decentralized Hydropower Study," NRECA 1981.~~

Abbreviations and Terms

NRECA - National Rural Electric Cooperative Association

GOT - Government of Togo

CEET - Compagnie Energie Electrique du Togo

AID - U.S. Agency for International Development

C.E.B. - Communante Electrique du Benin

REDSO - Regional Economic Development Service Office (AID)

mm - milimeters

m^3 - cubic meters

cms - cubic meters per second

km - kilometers

kW - kilowatts (power, capacity)

kWh - kilowatt hours (energy)

kV - kilovolts

kVA - kilovolt amperes

PW - present worth

IRR - internal rate of return

ERR - economic rate of return

O&M - operation and maintenance

OCB - oil circuit breaker

Exchange Rate

350 CFA = $US 1

I. Summary

This report revises the preliminary economic analysis that was performed on two small hydropower sites in Togo in April 1983 by an economist under contract to the National Rural Electric Cooperative Association (NRECA). The economist was a member of a team of specialists sent to assess small hydropower development potential in Togo. The economic analysis in question was subsequently found to be incorrect due to a miscalculation of the annual cost flows for both projects. For each of the two sites, capital costs were entered during the initial construction period, and then again as an annual repayment of debt. The revised analysis provided in this report corrects this error by entering capital costs in the construction period only, which improves considerably the rate of return on capital for both projects.

The projects in question, located near the towns of Wonougba and Tomegbe in the southwest region of the country, were shown in the team's report as having internal rates of return of -3.297% and 17.633% respectively. By comparison, the revised analysis, which also changes the assumptions for project lifespan and annual costs for operation and maintenance to values believed to be more realistic, raises the internal rates of return to 13.1% and 27.5%, respectively.

The team found that, in general, small hydropower projects in Togo can produce energy at considerably lower cost than diesel-generated energy. The revised calculations given in this report confirm this finding. The average cost of diesel energy in 1981 was approximately 21¢/kWh. Energy cost for the Wonougba and Tomegbe projects, by comparison, would be roughly 8¢/kWh and 4¢/kWh respectively. To the extent that this cheaper energy could displace energy generated from diesels, therefore, the economic value of small hydropower investments in Togo could be enormous.

The team also found that, due to highly seasonal flow patterns throughout the country, additions to year-round capacity from small hydropower development would be limited. For example, the team estimated that the Wonougba and Tomegbe plants would generate energy roughly equal to half of their rated output potential, on an annual basis. Most of this energy would be generated during the months of May-November. Consequently, the economic benefits arising from these projects would consist of any cost-savings possible from the displacement of higher-cost energy, such as diesel energy, and specifically the fuel cost savings from such displacement. Due to the virtual absence of firm power at the sites studied, there is no basis to assume that additional revenues would be generated from the projects.

Therefore, to provide a more valid assessment of the net investment value of the Wonougba and Tomegbe projects in the context which the team viewed them, the analyses provided in this report include additional calculations which identify the economic rates of return for both projects where benefits are calculated as being cash-savings from the displacement of diesel-generated electricity.

Assumptions. The assumptions and data used in developing the revised calculations in this report are the same as those made in the original report, with certain modifications:

- the exchange rate has been revised to reflect the deterioration in the Franc since April, 1981 (except where indicated otherwise);
- the useful life period for the hydro plants has been extended from 20 to 30 years; and

- annual O&M costs for the Tomegbe project have been reduced from 4.5% to 1.5% of capital cost.

The key assumptions made in the original report, which are retained for purposes of the present analysis, are that the full generating potential of both sites would be absorbed by the national electricity grid (by virtue of interconnection) and that the alternative energy source which the hydro energy would replace would be diesel generators. It should be pointed out that, in requesting this revised economic analysis, AID proposed that the assumption be made that additional power would not be available from the chief source of electrical energy for Togo's grid system, the Akossombo Dam in Ghana (see Appendix B). These assumptions may not be valid, however, as discussed in this report. The unavailability of additional power from Ghana does not necessarily mean that additional energy would also be unavailable, particularly during the wet season. Moreover, there are most certainly other opportunities to generate energy for Togo's grid network more cheaply than from diesel stations. These options, however, are not discussed in the original report, and require further study.

Recommendations. This report is therefore an extension of the preliminary study performed by the team in 1981 and should by no means be read as a conclusive assessment of the economic potential of small hydropower development in Togo. This report does present some preliminary indication of the economic merit of constructing small hydropower projects, based on a comparison with diesel generators (see Summary Table below). It is recommended that further study of specific small hydropower sites be conducted in the context of the overall energy supply program for Togo. Specifically, further information is needed on the hydraulic characteristics of these sites to allow a more exact understanding of the supply consequences of small hydro development in Togo generally, as well as further information on energy supply opportunities other than diesel which may offer a more realistic basis on which to assess the comparative value of small hydropower energy. Finally, more detailed information on the local energy demand circumstances of specific small hydropower sites should be collected to determine the feasibility of developing small hydro projects in areas that remain isolated from the power grid, to assess more accurately the potential role of small hydropower in displacing existing or planned diesel energy supplies.

Summary of Economic Analysis

	WONOUGBA	TOMEGBE
Capital cost/kW installed	$2,400	$1,200
Average cost/kWh[a]	8¢	3.9¢
Internal Rate of Return[b] (original analysis)	-3.297%	17.633%
Internal Rate of Return[b] (revised analysis)	13.1%	27.5%
Net Present Worth of Diesel Cost Savings	$391,000	$24,878,000
Economic Rate of Return[c]	20.1%	33.1%

[a] Thirty-year amortization @ 8% interest rate.

[b] Project benefits based on revenues from the sale of electricity at the average CEET tariff of 12.9¢/kWh

[c] based on diesel fuel savings, where the full energy potential of the plants displace diesel-generated energy.

II. Introduction

In April 1981 NRECA sent a team consisting of an engineer, a hydrologist, and an economist to Togo at the request of the Government (GOT) to conduct a country-wide resource assessment of small hydropower potential. The team was provided under an AID-funded cooperative agreement with NRECA which supports the Small Decentralized Hydropower Program, a technical resource organization within NRECA's International Programs Division which provides assistance to developing countries in small hydropower technology and development. The GOT request was transmitted to NRECA by the AID Mission in Lome in early 1981.

The team spent three weeks in Togo and submitted its final report to AID/Lome in July 1981 (Attachment). Due to the short duration of the team's stay in Togo, the level of effort was limited to a preliminary reconnaissance of ten known sites and a general analysis of the potential role small hydropower could play in Togo's national energy plan. No detailed site assessments were performed, although the team did include in its report some preliminary cost and economic analyses of two representative sites.

The purpose of the team's visit was to provide general information on the order of magnitude of costs, revenues, and economic returns of typical small hydro sites in the regions surveyed. The team was asked to focus on projects in the very small capacity range (under 50 kW) to serve remote rural communities. After visiting the sites, the team determined that the most favorable sites had considerably greater energy potential than 50 kW, and are capable of serving larger energy needs. As a result of this finding, the team recommended that certain sites having significant potential for diesel fuel savings be considered for further study.

Subsequent review of the team's report by AID's Regional Economic Development Services Office for West African (REDSO/WA) and by NRECA has led NRECA to conclude that more detailed analysis of specific small hydropower sites in Togo is strongly warranted, which was already indicated by the team's report. The preliminary economic analysis of the Wonougba and Tomegbe sites given in the report were found to be incorrect due to computer programming error. The computer error had the effect of overstating the discounted cost flows of the sites that were studied. The correction of this error improved the economic attractiveness of the Tomegbe and Wonougba sites to such an extent that further analysis is indicated.

This report has been prepared by NRECA at the request of REDSO/WA (see Appendix B). The purpose of this report is to recalculate the net returns on investment for the Wonougba and Tomegbe sites, using the same basic data collected by the team in 1981. Modifications in the analytic methodology have been made to present a truer economic picture of the potential offered by small hydropower development, but the nature of these analyses remains very preliminary. In order to provide a more exact framework needed for investment decisions at these sites, more information is needed on hydrologic conditions which exist at the project sites, the plant design, the circumstances affecting the demand for energy for each project, and alternative energy supply options available to the GOT. However the preliminary analysis provided herein indicates that this additional in-country level of effort is warranted, not only for the Wonougba and Tomegbe sites, but possibly other sites as well.

III. Context of Analysis

Technical Context

The majority of Togo is dominated by Sahalian physical and hydrological patterns: flat terrain with a very dry climate during much of the year. Average annual rainfall throughout the country is adequate for small hydropower generation--1000+ mm--but the resulting run-off is concentrated in two short wet seasons and groundwater return is very limited since the apparent rock formation beneath the surface prevents any significant water retention in the soil. Evaporation rates are constant throughout the year - in contrast to rainfall patterns which are subject to extreme variations - ranging from 150-300 mm per month. Normal evaporation exceeds monthly rainfall except during wet seasons. In general, flows are relatively high in the summer and early fall, and negligible at other times of the year.

Due to the extreme flow variations of most streams in Togo, power generation from small hydropower plants during dry periods is feasible only if water storage facilities are included in the plant designs. Impoundment dams, however, could result in prohibitively high investment costs for very small projects and would have only minimal impact in the generating capability of many sites since:

- high evaporation rates would remove water rapidly during dry seasons, and
- sediment loads in Togo's rivers are high, which over time would severely limit the usefulness of dams to store water.

With a few exceptions, Togo's terrain is generally unfavorable for small-scale hydropower development. The team began its work by collecting information in those areas where river gradients were known to be steep enough to permit water to be dropped through a turbine over reasonably short distances. Seventeen sites were selected for preliminary reconnaisance. The most favorable area was found to lie along the border with Ghana in the southwest. Seven of the seventeen sites are located in this region. All but one of the remaining ten sites are located in the northern half of the country.

Due to the shortness of time available to the team, only the ten most promising sites were selected for on-site review by the team (see Fig. 1).

Economic Context

Power consumption in Togo, cited in the team's report as being 151 x 10^6 kWh in 1980, is expanding rapidly. Between 1978 and 1980, the overall growth in electricity consumption was 37%. Most of this power is supplied by the Communaute Electrique du Benin (CEB) which purchases power from the huge Akosombo Dam in nearby Ghana. All but 7% of power consumption occurs along the coastal transmission grid in the southern part of the country. The remaining power consumption - in the provincial areas north of the grid - is supplied from diesel generators. Power consumption in these areas between 1978-80 grew by 75%. Until plans to extend the grid northward to serve these areas are implemented, the rapidly growing power demand in the rural sector will have to be supplied by decentralized sources, which for the present are diesels.

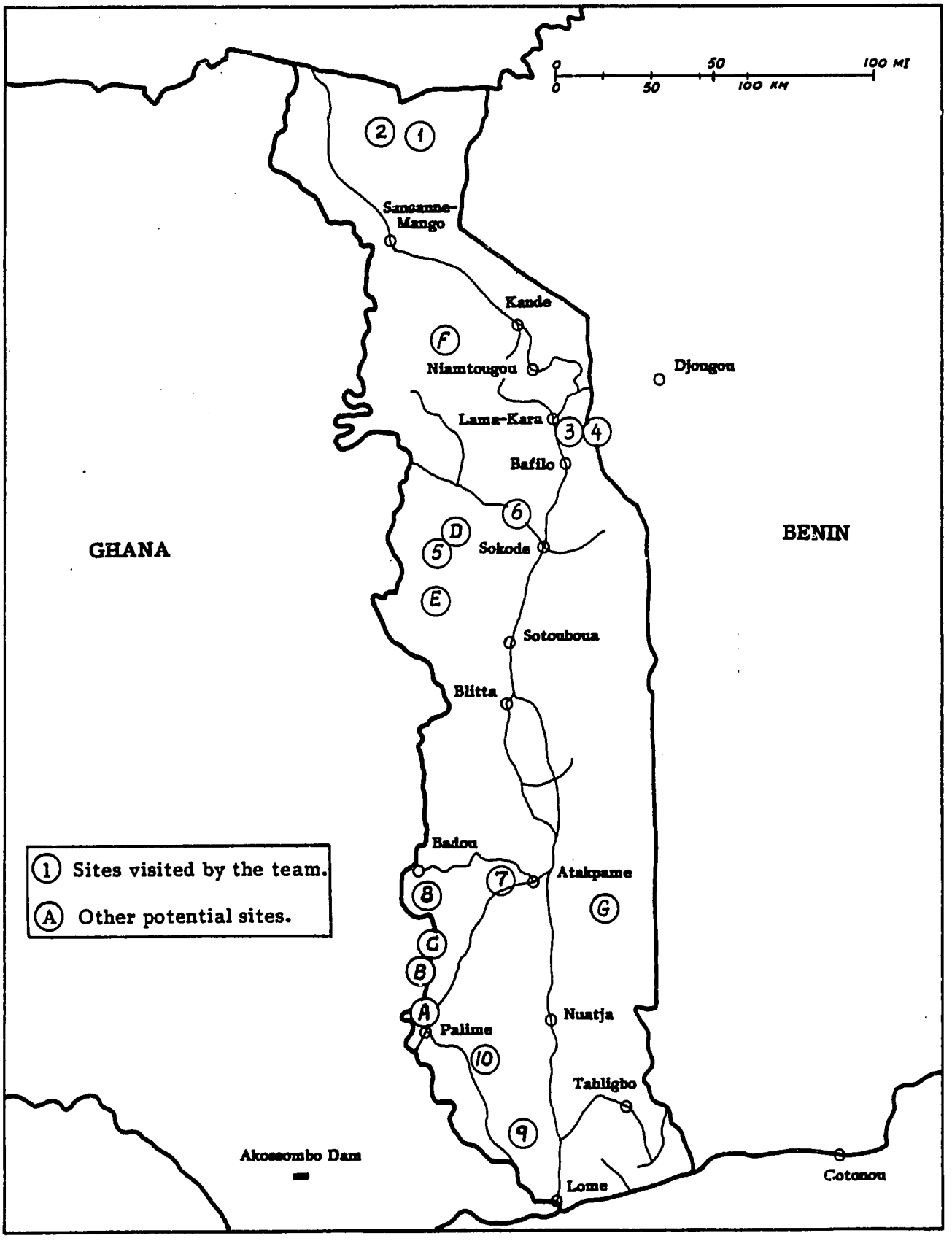

Figure 1. Map of Togo showing potential small hydropower projects.

The CEET estimated that the average full cost of generating power from diesels in 1981 was 21¢/kWh,* two-thirds of that cost going to purchase fuel from foreign sources, which accounts for a $2 million drain on the country's foreign exchange reserves annually. These costs are expected to increase. Electricity tariff rates in Togo in April 1981 reflected an average sales rate of 5.5¢/kWh, meaning that the average CEET subsidy to users of diesel-generated power was 15.9¢/kWh, roughly equal to the entire fuel cost. Recently-announced tariff increases would reduce the cost of this subsidy somewhat, but even at the new average tariff of 9.7¢/kWh, the financial consequences of meeting growing power demand by means of diesel generation remain considerable.

In light of these consequences, the team recommended that decentralized hydropower sources be considered as a fuel-saving strategy for Togo's rural power supply program. Small hydropower plants in Togo, however, would not add generating capacity, due to the absence of any significant year-round firm power at the sites studied. Diesel capacity, or capacity from alternative sources, would still be required until such time as the grid is expanded, to serve power requirements during the dry season. The role of small hydropower development would, for the most part, be to reduce fuel costs.

* all figures given in this report are based on a currency exchange rate of 350 CFA/$U.S., except as noted.

IV. Methodology

Reconnaissance Methodology

At each of the ten sites visited, measurements of head and flow were taken, when possible, to assess or confirm power potentials. Power use potential was also studied by assessing the proximity of potential loads to the plant site and the nature of their energy requirements. Overall plant design characteristics were considered, and in two cases, Wonougba and Tomegbe, preliminary construction cost data were developed.

All of the calculations made were very preliminary in nature. Hence, the data used to prepare this revised analysis are also to be considered preliminary and very general. It should be stressed that the team's objective was to assess only the order of magnitude of power generation and net benefits arising from small hydropower development. In this sense, the main value of the estimates provided by the team was to compare the relative merits of the sites studied, and not to set the basis for investment decisions. More detailed information would be required to allow a feasibility level analysis, for investment purposes. For example, streamflow data was generally available only for the period 1960-70, which was considered to have unusually high precipitation patterns. Several of the ten sites visited by the team, by contrast, were on streams that were absolutely dry at the time they were studied. The team did provide allowances for these conditions in developing flow data, but more in-depth analysis would be necessary to conduct full feasibility analyses of projects. Likewise, cost data were based on very preliminary designs, which would have to be more detailed for actual feasibility assessment purposes.

The ten sites were ranked according to their appearances as "good", "fair" or "poor" projects. Only two of the sites were found to be "good", on the condition that the power would be used to replace diesel-generated power during wet seasons. Two others were rated "fair" as fuel-replacement projects; the remaining six sites were rated "poor", largely due to the absence of adequate flow or demand for energy at the site. Cost and revenue data were developed for one of the "good" sites (Tomegbe) and one of the "poor" sites (Wonougba), where revenues were calculated on the assumption that all of the power generated could be sold by connecting the plants to existing (or future) transmission lines. The revised economic analysis, which follows, indicates that the two sites studied in detail are considerably more attractive as investment options than first believed, particularly if the power generated replaces diesel-generated power. It also suggests that at least some of the sites rated "poor" or "fair" by the team - such as Wonougba - would yield net benefits sufficient to rate them as "good" projects.

Economic Methodology

For each of the ten sites, a general assessment of power potential and power use was made to ascertain whether the site was economically feasible. It was determined that, due to the highly seasonal character of the flow regimes, only sites which could be connected to the grid or where the existing power demand (from isolated diesels) would create a sufficient load for the hydro project to replace costly diesel-generated power, would be considered economically feasible. Consequently, several of the sites were rated "poor" or "fair" in part due to the absence of adequate load. One site, Londa Pozenda-Sara, was ranked "poor" due to the high cost of construction despite the presence of favorable demand characteristics. Four of the sites were located near the existing or

planned grid system, three of which were considered worthy of additional study. Two of these, Tomegbe and Wonougba, were selected for more detailed economic analysis.

The economic analysis for these two sites consisted of two levels. The first involved estimating the annual unit cost of production in order to compare the hydro option with the cost of generating power from diesel generators. Total capital costs were amortized over twenty years at 8% interest to get the annual debt service payment. Added to this were operation and maintenance costs (4.5% of capital cost) and a 3% escrow payment for plant replacement (sinking fund). The total annual cost was then divided by total estimated output (kWh) to get the average unit cost of production.

The second level of analysis involved a discounted cash-flow analysis in order to find the internal rate of return on investment. Capital costs were entered first (over two years for Wonougba and three years for Tomegbe); annual costs thereafter consisted of debt-service, O&M costs, and depreciation. Benefits to the project were considered to be revenues from the sale of power. Revenues were entered for each year after completion of construction by multiplying total annual output (kWh) by 12.9¢. The total 20-year costs and benefits were discounted at 10%. Net discounted cashflows were found by subtracting costs from revenues.

It was in this second level of analysis that the error was made. The annual discounted costs entered in years 3-22 for Wonougba and years 4-23 for Tomegbe were derived from the calculations taken in the first (cost-effectiveness) level. In calculating discounted cash flows, capital costs should be shown in the years these costs are incurred, and not as part of an annual loan repayment. In effect, the analysis given in the report counted both the capital cost and the interest cost of the project twice. Capital costs were entered in the construction period and then again on an annual basis during the balance of the study period. Interests costs were also incorrectly counted as an annual cost. The discounting process automatically takes into account the opportunity cost of capital. The error was evidently made in developing the computer program used for the cash-flow analysis; this also was the reason why the error went undetected since the computer read-outs were not critically evaluated.

Revised Economic Methodology

The economic methodology which is used in this report has been modified to correct the error found in the initial economic analysis, and has been further modified to provide a more detailed understanding of the real potential value of small decentralized hydropower development in Togo. Two levels of analysis are used:

1) Cost-effectiveness analysis to compare the production cost of small hydropower projects with two alternative energy supply strategies, diesel generation and the purchase of power from C.E.B.;

2) Economic rate of return analysis to determine the incremental effect of additional power sector investments in small hydropower projects whose role is to replace diesel-generated energy.

Sensitivity analysis is applied to determine the effect of different assumptions, such as higher capital costs and higher diesel fuel costs. In addition, the internal rate of

return calculations made in the team's report are revised to show the effect of correcting the computation error that was made.

1. **Cost-effectiveness analysis.** This methodology is frequently utilized by public works and public service entities to conduct initial screening of projects. The assumption is already given that a service, such as transmitting electrical energy, must be provided. The purpose is to determine the cheapest way to provide the service. Cost-effectiveness analysis is also often used to rank several projects of a similar nature. In this case, the methodology is used to perform both functions.

Discounting techniques are generally used in this type of analysis. In comparing projects with different investment regimes and annual cost profiles, discounting is usually favored over the undiscounted method in order to reflect the time-value of money over many years of expenditures. Equal sums of money spent today and ten years from today have different real values. In comparing hydro investments with diesel investments, discounting is especially appropriate since hydro investments require the majority of life-cycle expenditures to be incurred initially, whereas expenditures for diesel projects are spread more evenly throughout the life of the project.

In this analysis, discounting will be used in order to reflect these differences. Diesel costs are shown in terms of unit costs multiplied by the number of kWh that could be provided by the hydro plant. Ideally, the diesel costs should be broken into capital costs and variable costs (O&M plus fuel costs), and entered in the years which they occur. The data taken from the team's report does not show what these costs are (e.g. cost/kW installed for a diesel generator, how often plant must be replaced). The report only shows the average total cost per kWh for diesel generator, and the average fuel cost/kWh. The team's report cites a CEET estimate of 75 CFA/kWh, with one-third of this cost attributed to capital, operation and maintenance, and two-thirds to fuel (52 CFA/kWh). Costs for the third alternative, C.E.B. - purchased power, are also based on unit costs given in the report (11 CFA/kWh).

The study period for the analyses performed in this report is thirty years, a useful-life period usually attributed to small hydro plants for purposes of economic and financial analysis. No provision is made for capital recovery, in order to simplify the analysis, but it is assumed that the diesel cost quoted in the report includes the replacement of plant at least once during this period.

2. **Economic rate of return analysis for fuel-replacement projects.** In the second level of analysis, life-cycle costs and benefits are calculated for each project to find the net economic consequences of investing in small hydropower projects in which the role of the hydro project is explicitly to reduce expenditures for diesel fuel. Costs are derived directly from the calculations made in the previous level of analysis. Benefits are equal to total cash-savings achieved from replacing diesel-generated energy with energy generated by the hydropower plant. Benefit values for each year are found by multiplying the total annual kWh production capability for the hydro project by the average diesel fuel cost/kWh quoted in the original report.

It should be stressed that this level of analysis attempts to reveal the economic consequences of small hydropower development to provide energy which would otherwise be supplied exclusively by diesel plants. The assumption is made that diesel generators are used to supply local demand until power from the national grid system is made available, after which time the hydropower would be used to displace diesel-generated energy supplying the grid. The function of the hydropower stations will be to offset

diesel fuel costs incurred both before and after grid extension occurs during the periods when hydrologic conditions permit operation of the hydropower plant.

The basis for assessing the return on investment should be what positive economic results are possible with the installation of hydropower facilities that would otherwise not be gained. In this case, the benefits to the project derive from "avoided costs" in supplying the power to consumers. Revenues or other benefits attributable to electrification should not be counted as benefits since in this case the investment in small hydropower projects does not result in additional kWh sales. This may not be true if the power supplied by existing capacity is not subsidized by the government. Under such conditions, the cheaper hydropower may result in more rapid growth in demand for electricity, and economic growth generally. Again, this is not the case in Togo, since electricity rates are subsidized by the CEET, regardless of the means of generation.

In general, the purpose of this analysis will be to examine the economic advantages of developing hydropower projects to replace diesel-generated energy, as proposed in the team's report. It is therefore assumed that the proposed hydropower projects would be tied to distribution networks which are served by diesel-generated power, and that the full energy generation potential of the hydro projects will be utilized. These assumptions, however, may not be realistic. It is not likely that demand for electricity which is served by diesel-generating sources would be sufficient to allow all the power generated by the hydro plants to be sold on a 24-hour basis. Put differently, it is highly likely that generating potential of the hydropower plants would exceed demand for electricity during off-peak periods in the provincial areas, at least in the short-run. Moreover, the two sites studied are close to the existing (or planned) grid system presently supplied, for the most part, by C.E.B.-purchased (large) hydropower. Thus, the real measure of cost-effectiveness may be C.E.B.-purchased energy (or other energy sources serving the grid) and not energy generated from diesels. The cost-effectiveness level of analysis provides a comparison of the hydro costs with the cost of energy purchased from the C.E.B. at wholesale rates. If connections are not with the main power grid but to local distribution systems supplied by diesels, then further study is needed to assess whether all of the energy generated from these hydro projects can be sold, as is assumed here. More will be said on these issues below.

3. **Revision of original internal rate of return computations.** The purpose of this of analysis is to identify the return on capital in terms of simple net cashflow. The procedure used will be the same as in the second level of analysis, only the benefits will be equal to the revenues from the sale of power. This is the procedure used in the team's report, and will provide a basis for comparison with the team's findings, corrected for the computation error.*

Internal rate of return analysis is the conventional methodology used to judge the investment value of projects. The present worth of total costs and benefits (shown as cash revenues to the project) are compared by finding the discount rate at which they are equal.

The validity of using this approach in this case, as stated above, is undermined by the fact that neither the costs nor the benefits can be easily isolated from the complicating

*The O&M cost for Tomegbe has been reduced to 1.5% of capital cost, and the useful life period for both projects has been extended from 20 to 30 years. The exchange rate of 250 CFA/$U.S. used in the original analysis is also used in the revised IRR calculation.

issue of avoided costs, which is the proper context to be used by the GOT in determining the economic merit of building small hydropower projects. None of the sites visited by the team offers a year-round source of hydropower. In each case, either a back-up diesel is required to provide power during periods when the hydro plants cannot be operated, or the sites must be connected to a grid providing power from other sources. In the former case of a plant isolated from the grid, the benefits should be shown as cost-savings from substituting hydropower for diesel-generated energy. In the grid case, the benefits will depend on the cost of power supplied to the grid from other sources, and whether this power is available. If cheaper power is not available, then the benefits would be based on cost-savings arising from energy displacement of the more costly energy.

Notwithstanding these concerns, this analysis is useful as a basis for comparison with the results of the analysis presented in the team's report. It should also be remembered that the objective of the team was to assess the economic merit of small hydropower development in a general sense, and to identify those sites which exhibited the best net investment potential. In this context, the team's method of determining net return on capital was valid as a measure of the relative investment value of the sites studied.

V. Site Analyses

Although the data used in these analyses do not differ from those used in the team's report, adjustments have been made in two areas. Due to the deterioration in the terms of trade of the Franc since April 1981, the currency exchange rate has been increased from 250 CFA/$U.S. to 350 CFA/$U.S. This has increased the relative value of the foreign component of the hydro capital costs, reflected as reductions in the local currency portions of these costs, as well as O&M costs for the hydro, fuel costs,* and wholesale purchase rates from the C.E.B, which are all stated in terms of $U.S. This has the effect of reducing the comparative value of the hydro project.

Changes have also been made in the formula used to assign O&M costs to the hydropower projects. The team's report places these as being 4.5% of capital cost. For very small plants, such as Wonougba, this may be necessary, but for most larger-sized plants, 1.5% of capital cost is generally used. The O&M cost for the Tomegbe site has therefore been reduced from $450,000 to $150,000. The O&M cost for Wonougba was estimated to be $20,000 in the original analysis. This cost remains unchanged in the present analysis, only it is reduced to $15,000 to reflect the exchange rate differential. These costs will not vary even if capital costs increase, for purposes of sensitivity calculations made in this analysis.

Wonougba

This is shown as site 10 on the map, located on the Sio River southeast of Palime. The team estimated the site to have 3 m of head with a mean annual flow of 6.7 cms, for a plant capacity of 160 kW. Average annual energy production at the site was estimated to be roughly half of rated output since the plant could be operated for only seven months during the year. Whereas negligible local demand for power was evident, the site would be connected to the grid ten kilometers away.

Construction costs were given in the report as $436,000, roughly 45% being local currency costs. The exchange rate difference reduces the total costs (as expressed in $U.S.) to $380,000 of which 37% would be attributed to local currency. The revised cost figures follow:

CAPITAL COSTS FOR WONOUGBA PROJECT

Excavation:

Compressors, drills set up	3,500	
Loaders to move rock	3,000	
870 m^3 of excavation @ $15.50	13,500	
Keyway excavation	1,500	
Turbine excavation	700	
	22,200	22,200

*Fuel costs would normally be counted as a foreign cost in oil-importing countries. It is not known as of this writing what effect the exchange rate difference has had, if any, on the 52 CFA/kWh diesel fuel cost quoted in the report. Therefore no adjustment has been made, although the reader may refer to sensitivity analyses in this report reflecting higher fuel cost.

Rock Masonry		
Dam 640 m^3 @ $140	90,000	
Sluice gate structure	1,500	
Sluice gate	3,500	
Power house	2,000	
	97,000	97,000
Rock Masonry Riprap		
150 m^2 @ $22.50		3,500
Contingencies		18,000
Local Currency SUBTOTAL		140,000
Mechanical/electrical equipment		
160 kW 230/380 volt		
Turbine-generator	100,000	
Freight	20,000	
	120,000	120,000
Auxiliaries, controls, etc. for step-up including provisions for local load at 230 volts, reverse power relays, etc.		4,000
175 kVA .230/21 kV transformer	4,000	
21 kV structure	2,000	
21 kV OCB	3,000	
Controls	2,000	
Radio supervisory control	3,000	
	14,000	14,000
Terminal equipment near Glekope		
21 kV structure	2,000	
21 kV OCB	3,000	
Controls	2,000	
	7,000	7,000
10 km of 21 kV line at $4,000/km		40,000
Design	17,000	
Supervision	17,000	
	34,000	34,000
Contingencies		21,000
Foreign exchange SUBTOTAL		240,000

Summary:

Local costs in equivalent $	140,000
Foreign exchange	240,000
TOTAL PROJECT COST	380,000

Cost-effectiveness. The baseline calculation for Wonougba's cost-effectiveness finds that the proposed small hydropower project would provide energy at considerably less cost than diesel-generated energy, but could not compete with energy bought at wholesale rates from the C.E.B. It is estimated that total annual energy production would be 690,000 kWh. Average unit cost in present worth terms would be roughly 6¢/kWh for the diesel, 2.4¢/kWh for the hydro, and k¢/kWh for the grid-purchase option. In terms of the undiscounted average unit cost,* the hydro would cost 8¢/kWh, as compared to 2k¢/kWh for the diesel and 3¢ for the power purchased from the C.E.B.

Economic rate of return. The preceeding analysis of cost-effectiveness demonstrates that the Wonougba project would produce energy at roughly one third the annual cost of a diesel generator, which, it is assumed, is the next cheapest means of generating the electricity. From a broader economic perspective, however, further analysis is needed to assess whether the net return on investment is sufficient to justify allocating scarce capital to this project at the expense of alternative energy sector investments. It is the return on alternative uses of the capital that provides the benchmark for this level of analysis. Various alternative uses are possible, depending on what other energy projects may be competing for GOT approval. The baseline calculation for Wonougba shows a rate of return of 20.1%, making it a very attractive investment opportunity, given these assumptions.

Sensitivity analysis. In a more inflationary setting, the hydro option appears less attractive, as reflected in calculations #2 and #3. A higher discount rate makes the relative value of expenditures early in the study period greater than those made later. Conversely, should interest rates continue to fall, the hydropower project would become more attractive. If higher inflation is driven by increasing energy costs, on the other hand, the hydropower project's value increases. This effect is reflected in calculations #6 and #7 which assume real annual increases (above the general inflation rate) in the cost of diesel fuel. It should be noted here that the less favorable terms of trade may have already had an effect on the real cost of imported fuel. The hydro capital costs given in the team's report are based on very preliminary design data, and do not take into account construction period interest, which could add as much as 10-20% to total investment costs. Calculations #4 and #5 reflect the consequences of underestimated capital costs. It is not clear from the team's report what rate of increase can be expected for C.E.B.-purchased energy. However, even with the 3% annual escalation factor assumed in calculation #8, the hydro option remains uncompetitive.

Revised internal rate of return. Ideally, the internal rate of return analysis, which is based on net cash flow, is the most useful method of assessing the value of investment. Lending institutions frequently require this type of analysis, as it offers a simple means

*interest on capital @ 10% for 30 years.

COST-EFFECTIVENESS ANALYSIS (WONOUGBA)

Discount rate: 10%

1. Baseline

	Hydro Option			Diesel Option			CEB		Cost Comparison		
Year	Capital	O&M	Total	Capital O&M	Energy Cost	Total	Total	PW Factor	Hydro	Diesel	CEB
1	190,000	0	190,000	0	0	0	0	1.000	190,000	0	0
2	190,000	0	190,000	0	0	0	0	.909	172,710	0	0
3	0	15,000	15,000	45,000	103,000	148,000	22,000	.827	12,405	122,396	18,194
4	0	15,000	15,000	45,000	103,000	148,000	22,000	.751	11,265	111,148	16,522
5	0	15,000	15,000	45,000	103,000	148,000	22,000	.683	10,245	101,084	15,026
6	0	15,000	15,000	45,000	103,000	148,000	22,000	.621	9,315	91,908	13,662
7	0	15,000	15,000	45,000	103,000	148,000	22,000	.564	8,460	83,472	12,408
8	0	15,000	15,000	45,000	103,000	148,000	22,000	.513	7,695	75,924	11,286
9	0	15,000	15,000	45,000	103,000	148,000	22,000	.466	6,990	68,968	10,252
10	0	15,000	15,000	45,000	103,000	148,000	22,000	.424	6,360	62,752	9,328
11	0	15,000	15,000	45,000	103,000	148,000	22,000	.385	5,775	56,980	8,470
12	0	15,000	15,000	45,000	103,000	148,000	22,000	.351	5,265	51,948	7,722
13	0	15,000	15,000	45,000	103,000	148,000	22,000	.319	4,785	47,212	7,018
14	0	15,000	15,000	45,000	103,000	148,000	22,000	.290	4,350	42,920	6,380
15	0	15,000	15,000	45,000	103,000	148,000	22,000	.263	3,945	38,924	5,786
16	0	15,000	15,000	45,000	103,000	148,000	22,000	.239	3,585	35,372	5,258
17	0	15,000	15,000	45,000	103,000	148,000	22,000	.218	3,270	32,264	4,796
18	0	15,000	15,000	45,000	103,000	148,000	22,000	.198	2,970	29,304	4,356
19	0	15,000	15,000	45,000	103,000	148,000	22,000	.180	2,700	26,640	3,960
20	0	15,000	15,000	45,000	103,000	148,000	22,000	.163	2,445	24,124	3,586
21	0	15,000	15,000	45,000	103,000	148,000	22,000	.149	2,235	22,052	3,278
22	0	15,000	15,000	45,000	103,000	148,000	22,000	.135	2,025	19,980	2,970
23	0	15,000	15,000	45,000	103,000	148,000	22,000	.123	1,845	18,204	2,706
24	0	15,000	15,000	45,000	103,000	148,000	22,000	.112	1,680	16,576	2,464
25	0	15,000	15,000	45,000	103,000	148,000	22,000	.101	1,515	14,948	2,222
26	0	15,000	15,000	45,000	103,000	148,000	22,000	.092	1,380	13,616	2,024
27	0	15,000	15,000	45,000	103,000	148,000	22,000	.084	1,260	12,432	1,848
28	0	15,000	15,000	45,000	103,000	148,000	22,000	.076	1,140	11,248	1,672
29	0	15,000	15,000	45,000	103,000	148,000	22,000	.069	1,035	10,212	1,518
30	0	15,000	15,000	45,000	103,000	148,000	22,000	.063	945	9,324	1,386
31	0	15,000	15,000	45,000	103,000	148,000	22,000	.057	855	8,436	1,254
32	0	15,000	15,000	45,000	103,000	148,000	22,000	.052	780	7,696	1,144
Total	380,000	450,000	830,000	1,350,000	3,090,000	4,440,000	660,000		491,230	1,268,064	188,496

Economic Rate of Return (Wonougba)

Discount rate: 10%

1. Baseline

Yr.	PW Factor	Project Costs Nominal	Project Costs Discounted	Benefits (fuel savings) Nominal	Benefits (fuel savings) Discounted	Net Economic Return Nominal	Net Economic Return Discounted
1	1.000	190,000	190,000	0	0	-190,000	-190,000
2	.909	190,000	172,710	0	0	-190,000	-172,710
3	.827	15,000	12,405	103,000	85,181	88,000	72,776
4	.751	15,000	11,265	103,000	77,353	88,000	66,088
5	.683	15,000	10,245	103,000	70,349	88,000	60,104
6	.621	15,000	9,315	103,000	63,963	88,000	54,648
7	.564	15,000	8,460	103,000	58,092	88,000	49,632
8	.513	15,000	7,695	103,000	52,839	88,000	45,144
9	.466	15,000	6,990	103,000	47,998	88,000	41,008
10	.424	15,000	6,360	103,000	43,672	88,000	37,312
11	.385	15,000	5,775	103,000	39,655	88,000	33,880
12	.351	15,000	5,265	103,000	36,153	88,000	30,888
13	.319	15,000	4,785	103,000	32,857	88,000	28,072
14	.290	15,000	4,350	103,000	29,870	88,000	25,520
15	.263	15,000	3,945	103,000	27,089	88,000	23,144
16	.239	15,000	3,585	103,000	24,617	88,000	21,032
17	.218	15,000	3,270	103,000	22,454	88,000	19,184
18	.198	15,000	2,970	103,000	20,394	88,000	17,424
19	.180	15,000	2,700	103,000	18,540	88,000	15,840
20	.163	15,000	2,445	103,000	16,789	88,000	14,344
21	.149	15,000	2,235	103,000	15,347	88,000	13,112
22	.135	15,000	2,025	103,000	13,905	88,000	11,880
23	.123	15,000	1,845	103,000	12,669	88,000	10,824
24	.112	15,000	1,680	103,000	11,536	88,000	9,856
25	.101	15,000	1,515	103,000	10,403	88,000	8,888
26	.092	15,000	1,380	103,000	9,476	88,000	8,096
27	.084	15,000	1,260	103,000	8,652	88,000	7,392
28	.076	15,000	1,140	103,000	7,828	88,000	6,688
29	.069	15,000	1,035	103,000	7,107	88,000	6,072
30	.063	15,000	945	103,000	6,489	88,000	5,544
31	.057	15,000	855	103,000	5,871	88,000	5,016
32	.052	15,000	780	103,000	5,356	88,000	4,576
Totals		830,000	491,000	3,090,000	882,000	2,260,000	391,000

Net present worth:	$391,000
Benefit/cost ratio:	1.8
ERR:	20.1%

Summary Table - Sensitivity Analysis (Wonougba)

Changed Assumption	Cost-effectiveness*			ERR
	Hydro	Diesel	C.E.B.	
1. Baseline	491,000	1,268,000	188,000	20.1%
2. Discount rate 8%	522,000	1,542,000	229,000	20.1%
3. Discount rate 12%	468,000	1,065,000	158,000	20.1%
4. Hydro capital cost +25%	583,000	1,268,000	188,000	16.9%
5. Hydro capital cost +50%	673,000	1,268,000	188,000	14.2%
6. Diesel fuel cost +2% annually	491,000	1,433,744	188,000	23.0%
7. Diesel fuel cost +4% annually	491,000	1,655,000	188,000	25.0%
8. C.E.B.-purchased energy +3% annually	491,000	1,268,000	245,923	20.1%

* Present worth of total costs

Revised Internal Rate of Return (Wonougba)

Discount rate: 10%

Yr.	PW Factor	Project Costs Nominal	Project Costs Discounted	Project Revenues* Nominal	Project Revenues* Discounted	Project Cash Flow Nominal	Project Cash Flow Discounted
1	1.000	218,000	218,000	0	0	-218,000	-218,000
2	.909	218,000	198,162	0	0	-218,000	-198,162
3	.827	26,500	21,916	89,000	73,603	62,500	51,688
4	.751	26,500	19,902	89,000	66,839	62,500	46,938
5	.683	26,500	18,100	89,000	60,787	62,500	42,688
6	.621	26,500	16,457	89,000	55,269	62,500	38,813
7	.564	26,500	14,946	89,000	50,196	62,500	35,250
8	.513	26,500	13,595	89,000	45,657	62,500	32,063
9	.466	26,500	12,349	89,000	41,474	62,500	29,125
10	.424	26,500	11,236	89,000	37,736	62,500	26,500
11	.385	26,500	10,203	89,000	34,265	62,500	24,063
12	.351	26,500	9,302	89,000	31,239	62,500	21,938
13	.319	26,500	8,454	89,000	28,391	62,500	19,938
14	.290	26,500	7,685	89,000	25,810	62,500	18,125
15	.263	26,500	6,970	89,000	23,407	62,500	16,438
16	.239	26,500	6,334	89,000	21,271	62,500	14,938
17	.218	26,500	5,777	89,000	19,402	62,500	13,625
18	.198	26,500	5,247	89,000	17,622	62,500	12,375
19	.180	26,500	4,770	89,000	16,020	62,500	11,250
20	.163	26,500	4,320	89,000	14,507	62,500	10,188
21	.149	26,500	3,949	89,000	13,261	62,500	9,313
22	.135	26,500	3,578	89,000	12,015	62,500	8,438
23	.123	26,500	3,250	89,000	10,947	62,500	7,688
24	.112	26,500	2,968	89,000	9,968	62,500	7,000
25	.101	26,500	2,677	89,000	8,989	62,500	6,313
26	.992	26,500	2,438	89,000	8,188	62,500	5,750
27	.084	26,500	2,226	89,000	7,476	62,500	5,250
28	.076	26,500	2,014	89,000	6,764	62,500	4,750
29	.069	26,500	1,829	89,000	6,141	62,500	4,313
30	.063	26,500	1,670	89,000	5,607	62,500	3,938
31	.057	26,500	1,511	89,000	5,073	62,500	3,563
32	.052	26,500	1,378	89,000	4,628	62,500	3,250
Totals		1,231,000	643,000	2,670,000	763,000	1,439,000	120,000

*Assumes average tariff of 12.9¢/kWh

IRR: 13.1%

of assessing the financial attractiveness of a project. For reasons stated above, this form of analysis is not as appropriate in this case as the foregoing analysis to determine the rate of return based on cost-savings. It can still be valid as a general measuring device of financial feasibility in terms of simple cash flow, however, and as used in the team's report, serves as a preliminary screening and ranking device for the sites studied by the team.

The team found that Wonougba had an internal rate of return of -3.297%, which, it will be recalled, was based on a faulty calculation. With this error corrected, Wonougba shows a positive IRR of 13.1%. As stated earlier, the project life in this revised analysis has been extended from 20 to 30 years, which reduces the sinking fund annual cost from $13,000 to $6,500, assuming an interest rate of approximately 5%.

Tomegbe

This is shown as site 8 on the map, 60 km east of Atakpame. Although the plant would have adequate local demand from the nearby towns of Tomegbe and Badou, the team recommended that this plant also be connected to the grid. The plant capacity was estimated to be 8 MW, at 200 m of head and a mean annual flow of 4 cms. The design envisioned by the team included four 2,000 kW turbines drawing water from a reservoir located 3,000 m upstream from the powerhouse. Water would travel to the turbines by means of a low-pressure pipe covering 2,500 m of this distance, then through a steel penstock 750 m in length. The plant would provide power for eight months of the year.

The construction costs, adjusted to reflect the exchange rate difference, are given below. Other than the rock masonry dam and powerhouse, most of the remaining costs, totalling roughly $8.5 million, would require foreign currency.

CAPITAL COSTS FOR TOMEGBE PROJECT

Cost by major components in 1981 dollars

Rock masonry dam	140,000	
Low pressure pipe	265,000	
Penstock	1,800,000	
Penstock anchors and piers	525,000	
Valves	100,000	
Surge tank	50,000	
	2,880,000	2,880,000
Turbine/generator/governors	2,000,000	
Auxilliary electrical equipment	700,000	
Transformers and controls	300,000	
60 km of 33 kV transmission line to Atekpame	800,000	
Terminal equipment-Atekpame	200,000	
	4,000,000	4,000,000
Structures and improvements		720,000

Design	500,000	
Supervision	500,000	
	1,000,000	1,000,000
Contingencies		900,000
TOTAL PROJECT COST		9,500,000

Cost-effectiveness. Unit capital cost for Tomegbe is about half the unit capital cost for Wonougba, largely due to the high head characteristics of this site and the effect of economies of scale. These facts, combined with the water storage capability at Tomegbe, are reflected in the far better cost-effectiveness of the Tomegbe site. Annual energy production is estimated to be 30,000,000 kWh. Discounted unit energy cost in the baseline calculation for the hydro option is 1.2¢/kWh, compared to 6¢/kWh for the diesel and ₵/kWh for the C.E.B. energy. Average undiscounted cost/kWh for the hydro (assuming the same financing terms as for Wonougba) is 3.9¢/kWh, compared to 21¢/kWh for diesel and 3¢/kWh for the C.E.B. option. Here again, the hydro plant could result in considerable savings to the CEET if the alternative energy source is assumed to be diesel. It is also noteworthy that the hydro unit cost in the case of Tomegbe approaches the cost of purchasing energy from C.E.B.

Economic rate of return. The Tomegbe project is even more attractive as an investment opportunity than Wonougba. The economic rate of return on the baseline calculation shows a rate of return of 33.1%, which indicates that a decision to build this plant would be imperative, given these assumptions.

Sensitivity analysis. Changing assumptions for discount rates and hydro capital costs, and adding escalation factors for diesel fuel and C.E.B.-purchased energy have predictable impacts on the cost-effectiveness of the Tomegbe project and are similar to the results of sensitivity calculations made for Wonougba. It is worth making two important observations, however. Even with assumptions for higher hydro capital costs and a higher discount rate, the hydro energy remains cheaper than the diesel alternative. When fuel cost escalation factors are added, the net effect of hydro project in a diesel replacement role would be to cut the CEET's total diesel fuel subsidy cost in half, by over $1 million a year, in present worth terms. Moreover, if an 8% discount factor is applied to calculation #8 (in which C.E.B.-purchased energy increases by 3% annually over the life of the project), the energy produced from the hydro plant would be cheaper than either alternative.

Revised internal rate of return. The team's report found Tomegbe's financial internal rate of return to be 17.633%. Adjusting project useful life and O&M cost to reflect more realistic values, and correcting for the calculation error, the IRR for this project is 27.5%.

COST-EFFECTIVENESS ANALYSIS (TOMEGBE)

Discount rate: 10%

1. Baseline

	Hydro Option			Diesel Option			CEB		Cost Comparison		
Year	Capital	O&M	Total	Capital O&M	Energy Cost	Total	Total	PW Factor	Hydro	Diesel	CEB
1	3,167,000	0	3,167,000	0	0	0	0	1.000	3,167,000	0	0
2	3,167,000	0	3,167,000	0	0	0	0	.909	2,878,803	0	0
3	3,167,000	0	3,167,000	0	0	0	0	.827	2,619,109	0	0
4	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.751	112,650	4,827,428	708,193
5	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.683	102,450	4,390,324	644,069
6	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.621	93,150	3,991,788	585,603
7	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.564	84,600	3,625,392	531,852
8	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.513	76,950	3,297,564	483,759
9	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.466	69,900	2,995,448	439,438
10	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.424	63,600	2,725,472	399,832
11	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.385	57,750	2,474,780	363,055
12	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.351	52,650	2,256,228	330,993
13	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.319	47,850	2,050,532	300,817
14	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.290	43,500	1,864,120	273,470
15	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.263	39,450	1,690,564	248,009
16	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.239	35,850	1,536,292	225,377
17	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.218	32,700	1,401,304	205,574
18	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.198	29,700	1,272,744	186,714
19	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.180	27,000	1,157,040	169,740
20	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.163	24,450	1,047,764	153,709
21	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.149	22,350	957,772	140,507
22	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.135	20,250	867,780	127,305
23	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.123	18,450	790,644	115,989
24	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.112	16,800	719,936	105,616
25	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.101	15,150	649,228	95,243
26	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.092	13,800	591,376	86,756
27	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.084	12,600	539,952	79,212
28	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.076	11,400	488,528	71,668
29	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.069	10,350	443,532	65,067
30	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.063	9,450	404,964	59,409
31	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.057	8,550	366,396	53,751
32	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.052	7,800	334,256	49,036
33	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.047	7,050	302,116	44,321
Total	9,501,000	4,500,000	14,001,000	59,130,000	133,710,000	192,840,000	28,290,000		9,833,112	50,061,264	7,344,084

Economic Rate of Return (Tomegbe)

Discount rate: 10%

1. Baseline

Yr.	PW Factor	Project Costs Nominal	Project Costs Discounted	Benefits (fuel savings) Nominal	Benefits (fuel savings) Discounted	Net Economic Return Nominal	Net Economic Return Discounted
1	1.000	3,167,000	3,167,000	0	0	-3,167,000	-3,167,000
2	.909	3,167,000	2,878,803	0	0	-3,167,000	-2,878,803
3	.827	3,167,000	2,619,109	0	0	-3,167,000	-2,619,109
4	.751	150,000	112,650	4,457,000	3,347,207	4,307,000	3,234,557
5	.683	150,000	102,450	4,457,000	3,044,131	4,307,000	2,941,681
6	.621	150,000	93,150	4,457,000	2,767,797	4,307,000	2,674,647
7	.564	150,000	84,600	4,457,000	2,513,748	4,307,000	2,429,148
8	.513	150,000	76,950	4,457,000	2,286,441	4,307,000	2,209,491
9	.466	150,000	69,900	4,457,000	2,076,962	4,307,000	2,007,062
10	.424	150,000	63,600	4,457,000	1,889,768	4,307,000	1,826,168
11	.385	150,000	57,750	4,457,000	1,715,945	4,307,000	1,658,195
12	.351	150,000	52,650	4,457,000	1,564,407	4,307,000	1,511,757
13	.319	150,000	47,850	4,457,000	1,421,783	4,307,000	1,373,933
14	.290	150,000	43,500	4,457,000	1,292,530	4,307,000	1,249,030
15	.263	150,000	39,450	4,457,000	1,172,191	4,307,000	1,132,741
16	.239	150,000	35,850	4,457,000	1,065,223	4,307,000	1,029,373
17	.218	150,000	32,700	4,457,000	971,626	4,307,000	938,926
18	.198	150,000	29,700	4,457,000	882,486	4,307,000	852,786
19	.180	150,000	27,000	4,457,000	802,260	4,307,000	775,260
20	.163	150,000	24,450	4,457,000	726,491	4,307,000	702,041
21	.149	150,000	22,350	4,457,000	664,093	4,307,000	641,743
22	.135	150,000	20,250	4,457,000	601,695	4,307,000	581,445
23	.123	150,000	18,450	4,457,000	548,211	4,307,000	529,761
24	.112	150,000	16,800	4,457,000	499,184	4,307,000	482,384
25	.101	150,000	15,150	4,457,000	450,157	4,307,000	435,007
26	.092	150,000	13,800	4,457,000	410,044	4,307,000	396,244
27	.084	150,000	12,600	4,457,000	374,388	4,307,000	361,788
28	.076	150,000	11,400	4,457,000	338,732	4,307,000	327,332
29	.069	150,000	10,350	4,457,000	307,533	4,307,000	297,183
30	.063	150,000	9,450	4,457,000	280,791	4,307,000	271,341
31	.057	150,000	8,550	4,457,000	254,049	4,307,000	245,499
32	.052	150,000	7,800	4,457,000	231,764	4,307,000	223,964
33	.047	150,000	7,050	4,457,000	209,479	4,307,000	202,429
Totals		14,001,000	9,833,112	133,710,000	33,711,000	119,709,000	24,878,000

Net present worth:	$24,878,000
Benefit/cost ratio:	3.5
ERR:	33.1%

Summary Table - Sensitivity Analyses (Tomegbe)

Changed Assumption	Cost-effectiveness*			ERR
	Hydro	Diesel	C.E.B.	
1. Baseline	9,833,000	50,061,000	7,344,000	33.1%
2. Discount rate 8%	10,262,000	62,043,000	9,102,000	33.1%
3. Discount rate 12%	9,483,000	41,306,328	6,060,000	33.1%
4. Hydro capital cost +25%	11,997,000	50,061,000	7,344,000	27.8%
5. Hydro capital cost +50%	14,164,000	50,061,000	7,344,000	24.0%
6. Diesel fuel cost +2% annually	9,833,000	56,596,000	7,344,000	34.7%
7. Diesel fuel cost +4% annually	9,833,000	65,305,000	7,344,000	36.3%
8. C.E.B.-purchased energy +3% annually	9,833,000	50,061,000	9,579,000	33.1%

*Present worth of total costs.

Revised Internal Rate of Return (Tomegbe)

Discount rate: 10%

Yr.	PW Factor	Project Costs Nominal	Project Costs Discounted	Project Revenues* Nominal	Project Revenues* Discounted	Project Cash Flow Nominal	Project Cash Flow Discounted
1	1.000	3,333,330	3,333,333	0	0	-3,333,330	-3,333,330
2	.909	3,333,330	3,030,000	0	0	-3,333,330	-3,030,000
3	.827	3,333,330	2,766,664	0	0	-3,333,330	-2,756,664
4	.751	300,000	225,300	3,870,000	2,906,370	3,570,000	2,681,070
5	.683	300,000	204,900	3,870,000	2,643,210	3,570,000	2,438,310
6	.621	300,000	186,300	3,870,000	2,403,270	3,570,000	2,216,970
7	.564	300,000	169,200	3,870,000	2,182,680	3,570,000	2,013,480
8	.513	300,000	153,900	3,870,000	1,985,310	3,570,000	1,831,410
9	.466	300,000	139,800	3,870,000	1,803,420	3,570,000	1,663,628
10	.424	300,000	127,200	3,870,000	1,640,880	3,570,000	1,513,680
11	.385	300,000	115,500	3,870,000	1,489,950	3,570,000	1,374,450
12	.351	300,000	105,300	3,870,000	1,358,370	3,570,000	1,233,070
13	.319	300,000	95,700	3,870,000	1,234,530	3,570,000	1,138,830
14	.290	300,000	87,000	3,870,000	1,122,300	3,570,000	1,035,300
15	.263	300,000	78,900	3,870,000	1,017,810	3,570,000	938,910
16	.239	300,000	71,700	3,870,000	924,930	3,570,000	853,230
17	.218	300,000	65,400	3,870,000	843,660	3,570,000	778,260
18	.198	300,000	59,400	3,870,000	766,260	3,570,000	706,860
19	.180	300,000	54,000	3,870,000	696,600	3,570,000	642,600
20	.163	300,000	48,900	3,870,000	630,810	3,570,000	581,910
21	.149	300,000	44,700	3,870,000	576,630	3,570,000	531,930
22	.135	300,000	40,500	3,870,000	522,450	3,570,000	481,950
23	.123	300,000	36,900	3,870,000	476,010	3,570,000	439,110
24	.112	300,000	33,600	3,870,000	433,440	3,570,000	399,840
25	.101	300,000	30,300	3,870,000	390,870	3,570,000	360,570
26	.092	300,000	27,600	3,870,000	356,040	3,570,000	328,440
27	.084	300,000	25,200	3,870,000	325,080	3,570,000	299,880
28	.076	300,000	22,800	3,870,000	294,120	3,570,000	271,320
29	.069	300,000	20,700	3,870,000	267,030	3,570,000	246,330
30	.063	300,000	18,900	3,870,000	243,810	3,570,000	224,910
31	.057	300,000	17,100	3,870,000	220,590	3,570,000	203,490
32	.052	300,000	15,600	3,870,000	201,240	3,570,000	185,640
33	.047	300,000	14,100	3,870,000	181,890	3,570,000	167,790
Totals		19,000,000	11,457,000	116,100,000	30,140,000	97,100,000	18,683,000

*Assumes average tariff of 12.9¢/kWh

IRR: 27.5%

VI. Conclusion

Presented in this report is a preliminary analysis of the economic consequences of incremental investments in energy supply—small hydropower installations. The rates of return which are calculated correspond to these incremental investments only, and not to investments for energy supply development, which would require a different set of analytic criteria than used here. Economic analysis of the larger context of electrification would require an assessment of total energy supply costs (including the cost of any small hydropower investments) and benefits arising from this investment. These benefits would be shown as revenues in the case of financial analysis, and revenues plus other indirect benefits (e.g. energy cost savings, increased productivity, leisure income, transmigration stabilization, etc.) in the case of economic analysis.

The calculations bearing the most importance in this report are found in the second level of analysis, economic rate of return for projects whose role is to replace diesel fuel costs. It is evident from the team's report that the CEET is in the process of adding a number of diesel power stations at provincial centers throughout the country, including the area of Palime-Atakpame. Wherever small hydropower projects may be installed to reduce the dependency on diesel generators, the analysis presented here indicates that the CEET could potentially realize a tremendous return on the additional investment in the form of fuel cost savings. Not reflected in the analysis, but also noteworthy is the fact that the substitution of hydropower for diesel-generated power would also likely yield cost-savings in terms of extending the useful lives of the diesel plants.

Whether these economic gains are realized in the public sector or in the private sector (by means of passing the savings on to consumers in the form of reduced tariff rates), the total savings could potentially exceed $1 million per year from the construction of the Tomegbe and Wonougba plants alone. This economic yield could possibly be doubled if other sites, particularly Londa Pozenda-Kara (3), Bongoulou (5), and Ezime (7), were also found to be feasible. Finally, the real value of these benefits are greater than their face-value in the sense that the savings to Togo's economy would be realized in foreign currency.

It is not recommended, however, that decisions to invest be made on these analyses alone. These conclusions rest upon technical and economic assumptions which, like most assumptions, may be subject to change upon more detailed analysis. The reconnaisance methodology used by the team permitted only very general assessments of the hydraulic power potential of the sites studied. Although the team attempted to be conservative in developing output projections, actual annual flow may be less favorable than estimated. Construction and maintenance costs may be considerably higher to achieve the same output, for example, if greater storage capacity is required.

More critical than these considerations, however, are the assumptions made on other supply and demand circumstances. The economic rates of return are predicated on two important factors:

(1) that electricity demand will be sufficient to absorb the full 24-hour output potential of the proposed hydropower projects; and

(2) that this demand will otherwise be served by diesel powerplants.

It is almost inconceivable that the first assumption would bear out if the hydropower plants are to serve loads isolated from the main transmission grid. The total annual electricity consumption outside the capital city of Lome is given in the team's report as

being 80 million kWh in 1981. Assuming annual demand growth to be the same during 1980-82 as it was from 1978-80, present aggregate demand in these areas would be around 150 million kWh. The Tomegbe plant alone would displace one-fifth of this required output; however it is likely that a relatively small percentage of this total demand is found in the Tomegbe-Badou-Atakpame region. Moreover, even assuming a high plant factor for an isolated plant of say, 50%, the demand profile for the Tomegbe project would result in electricity sales far below the assumed 30 million kWh annual rate.*

The team recommended that both the Wonougba and Tomegbe plants would be connected to transmission lines extending from Lome to Atakpame, making the issue of local demand moot for these two projects. This also raises certain problems. First is the issue of timing. Do grid lines currently exist by which energy generated from these plants could be transmitted to other, larger demand centers? If not, when will these lines be constructed? Output values, hence benefits, would have to be adjusted in the years preceeding extension of the grid. Construction costs could also be reduced during this period, however, by installing only one or two of the planned four turbines at the Tomegbe plant. Alternatively, construction of the project could be delayed to coincide with construction of the grid extension. Separate analysis may be needed to determine the relative merits of building the Tomegbe plant in stages. It is probable that the decision to construct the Wonougba project would have to be deferred if local demand was not sufficient, due to its higher unit capital cost and the less apparent opportunity for phased development of that site.

The second problem is that, by virtue of connecting the hydropower project to the grid, the real economic determinant may change from a comparison of generating costs with diesels to the costs of generating energy from the Akossombo Dam, the proposed Mono River hydropower project and possibly other large hydropower and thermal stations serving the grid in the future. If these are seen to be reliable sources of energy, sufficient to meet Togo's growing energy demand, then the economic rates of return for small hydropower development in Togo would be substantially lower, and possibly negative. On the other hand, if Togo's current diesel capacity expansion program is based on a determination that additional capacity from these stations will be necessary even after the grid is extended, then the basis for determining the economic value of small hydropower development to serve the grid will depend on supply and demand forecasts in which the hydropower plants could displace energy supplied by the diesels. These may be limited to peaking periods only, but information presently available to NRECA is insufficient to make these assessments. It should also be recognized that national security considerations may enter the picture as well, in assigning a value to the small hydropower plants as more reliable sources of energy than energy purchased from other countries.

In any case, the ultimate rates of return for the Tomegbe and Wonougba projects could well be lower than shown in this report. More exact calculations must await further assessment of the issues stated above. The methodology used in developing the second level of analysis will continue to be appropriate, only the economic benefits (and possibly costs in the case of Tomegbe) would have to be reduced to reflect lower estimates for energy substitution. Nevertheless, the very high rates of return that are

*If it is assumed that 15 million kWh, only half of the estimated energy output at Tomegbe would be used to displace diesel fuel costs, the ERR drops from 33.1% to 18.2%, but this is still a good rate of return.

indicated suggest that full feasibility assessment is warranted for at least the Tomegbe project, and possibly others as well.

COST-EFFECTIVENESS ANALYSIS (WONOUGBA)

Discount rate: 8%

2. 8% Discount Rate

	Hydro Option			Diesel Option			CEB		Cost Comparison		
Year	Capital	O&M	Total	Capital O&M	Energy Cost	Total	Total	PW Factor	Hydro	Diesel	CEB
1	190,000	0	190,000	0	0	0	0	1.000	190,000	0	0
2	190,000	0	190,000	0	0	0	0	.926	175,940	0	0
3	0	15,000	15,000	45,000	103,000	148,000	22,000	.857	12,855	126,836	18,854
4	0	15,000	15,000	45,000	103,000	148,000	22,000	.794	11,910	117,512	17,468
5	0	15,000	15,000	45,000	103,000	148,000	22,000	.735	11,025	108,780	16,170
6	0	15,000	15,000	45,000	103,000	148,000	22,000	.681	10,215	100,788	14,982
7	0	15,000	15,000	45,000	103,000	148,000	22,000	.630	9,450	93,240	13,860
8	0	15,000	15,000	45,000	103,000	148,000	22,000	.584	8,760	86,432	12,848
9	0	15,000	15,000	45,000	103,000	148,000	22,000	.540	8,100	79,920	11,880
10	0	15,000	15,000	45,000	103,000	148,000	22,000	.500	7,500	74,000	11,000
11	0	15,000	15,000	45,000	103,000	148,000	22,000	.463	6,945	68,524	10,186
12	0	15,000	15,000	45,000	103,000	148,000	22,000	.429	6,435	63,492	9,438
13	0	15,000	15,000	45,000	103,000	148,000	22,000	.397	5,955	58,756	8,734
14	0	15,000	15,000	45,000	103,000	148,000	22,000	.368	5,520	54,464	8,096
15	0	15,000	15,000	45,000	103,000	148,000	22,000	.341	5,115	50,468	7,502
16	0	15,000	15,000	45,000	103,000	148,000	22,000	.315	4,725	46,620	6,930
17	0	15,000	15,000	45,000	103,000	148,000	22,000	.292	4,380	43,216	6,424
18	0	15,000	15,000	45,000	103,000	148,000	22,000	.270	4,050	39,960	5,940
19	0	15,000	15,000	45,000	103,000	148,000	22,000	.250	3,750	37,000	5,500
20	0	15,000	15,000	45,000	103,000	148,000	22,000	.232	3,480	34,336	5,104
21	0	15,000	15,000	45,000	103,000	148,000	22,000	.215	3,225	31,820	4,730
22	0	15,000	15,000	45,000	103,000	148,000	22,000	.199	2,985	29,452	4,378
23	0	15,000	15,000	45,000	103,000	148,000	22,000	.184	2,760	27,232	4,048
24	0	15,000	15,000	45,000	103,000	148,000	22,000	.170	2,550	25,160	3,740
25	0	15,000	15,000	45,000	103,000	148,000	22,000	.158	2,370	23,384	3,476
26	0	15,000	15,000	45,000	103,000	148,000	22,000	.146	2,190	21,608	3,212
27	0	15,000	15,000	45,000	103,000	148,000	22,000	.135	2,025	19,980	2,970
28	0	15,000	15,000	45,000	103,000	148,000	22,000	.125	1,875	18,500	2,750
29	0	15,000	15,000	45,000	103,000	148,000	22,000	.116	1,740	17,168	2,552
30	0	15,000	15,000	45,000	103,000	148,000	22,000	.107	1,605	15,836	2,354
31	0	15,000	15,000	45,000	103,000	148,000	22,000	.099	1,485	14,652	2,178
32	0	15,000	15,000	45,000	103,000	148,000	22,000	.092	1,380	13,616	2,024
Total	380,000	450,000	830,000	1,350,000	3,090,000	4,440,000	660,000		522,300	1,542,752	229,328

COST-EFFECTIVE ANALYSIS (WONOUGBA)

Discount rate: 12%

3. 12% Discount Rate

	Hydro Option			Diesel Option			CEB		Cost Comparison		
Year	Capital	O&M	Total	Capital O&M	Energy Cost	Total	Total	PW Factor	Hydro	Diesel	CEB
1	190,000	0	190,000	0	0	0	0	1.000	190,000	0	0
2	190,000	0	190,000	0	0	0	0	.893	169,670	0	0
3	0	15,000	15,000	45,000	103,000	148,000	22,000	.797	11,955	117,956	17,534
4	0	15,000	15,000	45,000	103,000	148,000	22,000	.712	10,680	105,376	15,664
5	0	15,000	15,000	45,000	103,000	148,000	22,000	.636	9,540	94,128	13,992
6	0	15,000	15,000	45,000	103,000	148,000	22,000	.567	8,505	83,916	12,474
7	0	15,000	15,000	45,000	103,000	148,000	22,000	.507	7,605	75,036	11,154
8	0	15,000	15,000	45,000	103,000	148,000	22,000	.452	6,780	66,896	9,944
9	0	15,000	15,000	45,000	103,000	148,000	22,000	.404	6,060	59,792	8,888
10	0	15,000	15,000	45,000	103,000	148,000	22,000	.361	5,415	53,428	7,942
11	0	15,000	15,000	45,000	103,000	148,000	22,000	.322	4,830	47,656	7,084
12	0	15,000	15,000	45,000	103,000	148,000	22,000	.288	4,320	42,624	6,336
13	0	15,000	15,000	45,000	103,000	148,000	22,000	.257	3,855	38,036	5,654
14	0	15,000	15,000	45,000	103,000	148,000	22,000	.229	3,435	33,892	5,038
15	0	15,000	15,000	45,000	103,000	148,000	22,000	.205	3,075	30,340	4,510
16	0	15,000	15,000	45,000	103,000	148,000	22,000	.183	2,745	27,084	4,026
17	0	15,000	15,000	45,000	103,000	148,000	22,000	.163	2,445	24,124	3,586
18	0	15,000	15,000	45,000	103,000	148,000	22,000	.146	2,190	21,608	3,212
19	0	15,000	15,000	45,000	103,000	148,000	22,000	.130	1,950	19,240	2,860
20	0	15,000	15,000	45,000	103,000	148,000	22,000	.116	1,740	17,168	2,552
21	0	15,000	15,000	45,000	103,000	148,000	22,000	.104	1,560	15,392	2,288
22	0	15,000	15,000	45,000	103,000	148,000	22,000	.093	1,395	13,764	2,046
23	0	15,000	15,000	45,000	103,000	148,000	22,000	.083	1,245	12,284	1,826
24	0	15,000	15,000	45,000	103,000	148,000	22,000	.074	1,110	10,952	1,628
25	0	15,000	15,000	45,000	103,000	148,000	22,000	.066	990	9,768	1,452
26	0	15,000	15,000	45,000	103,000	148,000	22,000	.059	885	8,732	1,298
27	0	15,000	15,000	45,000	103,000	148,000	22,000	.053	795	7,844	1,166
28	0	15,000	15,000	45,000	103,000	148,000	22,000	.047	705	6,956	1,034
29	0	15,000	15,000	45,000	103,000	148,000	22,000	.042	630	6,216	924
30	0	15,000	15,000	45,000	103,000	148,000	22,000	.037	555	5,476	814
31	0	15,000	15,000	45,000	103,000	148,000	22,000	.033	495	4,884	726
32	0	15,000	15,000	45,000	103,000	148,000	22,000	.030	450	4,440	660
Total	380,000	450,000	830,000	1,350,000	3,090,000	4,440,000	660,000		467,610	1,065,008	158,312

COST-EFFECTIVE ANALYSIS (WONOUGBA)

Discount rate: 10%

4. Hydro Cost +25%

	Hydro Option			Diesel Option			CEB		Cost Comparison		
Year	Capital	O&M	Total	Capital O&M	Energy Cost	Total	Total	PW Factor	Hydro	Diesel	CEB
1	238,000	0	238,000	0	0	0	0	1.000	238,000	0	0
2	238,000	0	238,000	0	0	0	0	.909	216,342	0	0
3	0	15,000	15,000	45,000	103,000	148,000	22,000	.827	12,405	122,396	18,194
4	0	15,000	15,000	45,000	103,000	148,000	22,000	.751	11,265	111,148	16,522
5	0	15,000	15,000	45,000	103,000	148,000	22,000	.683	10,245	101,084	15,026
6	0	15,000	15,000	45,000	103,000	148,000	22,000	.621	9,315	91,908	13,662
7	0	15,000	15,000	45,000	103,000	148,000	22,000	.564	8,460	83,472	12,408
8	0	15,000	15,000	45,000	103,000	148,000	22,000	.513	7,695	75,924	11,286
9	0	15,000	15,000	45,000	103,000	148,000	22,000	.466	6,990	68,968	10,252
10	0	15,000	15,000	45,000	103,000	148,000	22,000	.424	6,360	62,752	9,328
11	0	15,000	15,000	45,000	103,000	148,000	22,000	.385	5,775	56,980	8,470
12	0	15,000	15,000	45,000	103,000	148,000	22,000	.351	5,265	51,948	7,722
13	0	15,000	15,000	45,000	103,000	148,000	22,000	.319	4,785	47,212	7,018
14	0	15,000	15,000	45,000	103,000	148,000	22,000	.290	4,350	42,920	6,380
15	0	15,000	15,000	45,000	103,000	148,000	22,000	.263	3,945	38,924	5,786
16	0	15,000	15,000	45,000	103,000	148,000	22,000	.239	3,585	35,372	5,258
17	0	15,000	15,000	45,000	103,000	148,000	22,000	.218	3,270	32,264	4,796
18	0	15,000	15,000	45,000	103,000	148,000	22,000	.198	2,970	29,304	4,356
19	0	15,000	15,000	45,000	103,000	148,000	22,000	.180	2,700	26,640	3,960
20	0	15,000	15,000	45,000	103,000	148,000	22,000	.163	2,445	24,124	3,586
21	0	15,000	15,000	45,000	103,000	148,000	22,000	.149	2,235	22,052	3,278
22	0	15,000	15,000	45,000	103,000	148,000	22,000	.135	2,025	19,980	2,970
23	0	15,000	15,000	45,000	103,000	148,000	22,000	.123	1,845	18,204	2,706
24	0	15,000	15,000	45,000	103,000	148,000	22,000	.112	1,680	16,576	2,464
25	0	15,000	15,000	45,000	103,000	148,000	22,000	.101	1,515	14,948	2,222
26	0	15,000	15,000	45,000	103,000	148,000	22,000	.092	1,380	13,616	2,024
27	0	15,000	15,000	45,000	103,000	148,000	22,000	.084	1,260	12,432	1,848
28	0	15,000	15,000	45,000	103,000	148,000	22,000	.076	1,140	11,248	1,672
29	0	15,000	15,000	45,000	103,000	148,000	22,000	.069	1,035	10,212	1,518
30	0	15,000	15,000	45,000	103,000	148,000	22,000	.063	945	9,324	1,386
31	0	15,000	15,000	45,000	103,000	148,000	22,000	.057	855	8,436	1,254
32	0	15,000	15,000	45,000	103,000	148,000	22,000	.052	780	7,696	1,144
Total	476,000	450,000	926,000	1,350,000	3,090,000	4,440,000	660,000		582,862	1,268,064	188,496

COST-EFFECTIVENESS ANALYSIS (WONOUGBA)

Discount rate: 10%

5. Hydro Cost +50%

	Hydro Option			Diesel Option			CEB		Cost Comparison		
Year	Capital	O&M	Total	Capital O&M	Energy Cost	Total	Total	PW Factor	Hydro	Diesel	CEB
1	285,000	0	285,000	0	0	0	0	1.000	285,000	0	0
2	285,000	0	285,000	0	0	0	0	.909	259,065	0	0
3	0	15,000	15,000	45,000	103,000	148,000	22,000	.827	12,405	122,396	18,194
4	0	15,000	15,000	45,000	103,000	148,000	22,000	.751	11,265	111,148	16,522
5	0	15,000	15,000	45,000	103,000	148,000	22,000	.683	10,245	101,084	15,026
6	0	15,000	15,000	45,000	103,000	148,000	22,000	.621	9,315	91,908	13,662
7	0	15,000	15,000	45,000	103,000	148,000	22,000	.564	8,460	83,472	12,408
8	0	15,000	15,000	45,000	103,000	148,000	22,000	.513	7,695	75,924	11,286
9	0	15,000	15,000	45,000	103,000	148,000	22,000	.466	6,990	68,968	10,252
10	0	15,000	15,000	45,000	103,000	148,000	22,000	.424	6,360	62,752	9,328
11	0	15,000	15,000	45,000	103,000	148,000	22,000	.385	5,775	56,980	8,470
12	0	15,000	15,000	45,000	103,000	148,000	22,000	.351	5,265	51,948	7,722
13	0	15,000	15,000	45,000	103,000	148,000	22,000	.319	4,785	47,212	7,018
14	0	15,000	15,000	45,000	103,000	148,000	22,000	.290	4,350	42,920	6,380
15	0	15,000	15,000	45,000	103,000	148,000	22,000	.263	3,945	38,924	5,786
16	0	15,000	15,000	45,000	103,000	148,000	22,000	.239	3,585	35,372	5,258
17	0	15,000	15,000	45,000	103,000	148,000	22,000	.218	3,270	32,264	4,796
18	0	15,000	15,000	45,000	103,000	148,000	22,000	.198	2,970	29,304	4,356
19	0	15,000	15,000	45,000	103,000	148,000	22,000	.180	2,700	26,640	3,960
20	0	15,000	15,000	45,000	103,000	148,000	22,000	.163	2,445	24,124	3,586
21	0	15,000	15,000	45,000	103,000	148,000	22,000	.149	2,235	22,052	3,278
22	0	15,000	15,000	45,000	103,000	148,000	22,000	.135	2,025	19,980	2,970
23	0	15,000	15,000	45,000	103,000	148,000	22,000	.123	1,845	18,204	2,706
24	0	15,000	15,000	45,000	103,000	148,000	22,000	.112	1,680	16,576	2,464
25	0	15,000	15,000	45,000	103,000	148,000	22,000	.101	1,515	14,948	2,222
26	0	15,000	15,000	45,000	103,000	148,000	22,000	.092	1,380	13,616	2,024
27	0	15,000	15,000	45,000	103,000	148,000	22,000	.084	1,260	12,432	1,848
28	0	15,000	15,000	45,000	103,000	148,000	22,000	.076	1,140	11,248	1,672
29	0	15,000	15,000	45,000	103,000	148,000	22,000	.069	1,035	10,212	1,518
30	0	15,000	15,000	45,000	103,000	148,000	22,000	.063	945	9,324	1,386
31	0	15,000	15,000	45,000	103,000	148,000	22,000	.057	855	8,436	1,254
32	0	15,000	15,000	45,000	103,000	148,000	22,000	.052	780	7,696	1,144
Total	570,000	450,000	1,020,000	1,350,000	3,090,000	4,440,000	660,000		672,585	1,268,064	188,496

COST-EFFECTIVENESS ANALYSIS (TOMEGBE)

Discount rate: 10%

6. Diesel Energy Cost +2%

	Hydro Option			Diesel Option			CEB		Cost Comparison		
Year	Capital	O&M	Total	Capital O&M	Energy Cost	Total	Total	PW Factor	Hydro	Diesel	CEB
1	3,167,000	0	3,167,000	0	0	0	0	1.000	3,167,000	0	0
2	3,167,000	0	3,167,000	0	0	0	0	.909	2,878,803	0	0
3	3,167,000	0	3,167,000	0	0	0	0	.827	2,619,109	0	0
4	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.751	112,650	4,827,428	708,193
5	0	150,000	150,000	1,971,000	4,546,000	6,517,000	943,000	.683	102,450	4,451,111	644,069
6	0	150,000	150,000	1,971,000	4,637,000	6,608,000	943,000	.621	93,150	4,103,568	585,603
7	0	150,000	150,000	1,971,000	4,730,000	6,701,000	943,000	.564	84,600	3,779,364	531,852
8	0	150,000	150,000	1,971,000	4,824,000	6,795,000	943,000	.513	76,950	3,485,835	483,759
9	0	150,000	150,000	1,971,000	4,921,000	6,892,000	943,000	.466	69,900	3,211,672	439,438
10	0	150,000	150,000	1,971,000	5,019,000	6,990,000	943,000	.424	63,600	2,963,760	399,832
11	0	150,000	150,000	1,971,000	5,120,000	7,091,000	943,000	.385	57,750	2,730,035	363,055
12	0	150,000	150,000	1,971,000	5,222,000	7,193,000	943,000	.351	52,650	2,524,743	330,993
13	0	150,000	150,000	1,971,000	5,327,000	7,298,000	943,000	.319	47,850	2,328,062	300,817
14	0	150,000	150,000	1,971,000	5,433,000	7,404,000	943,000	.290	43,500	2,147,160	273,470
15	0	150,000	150,000	1,971,000	5,542,000	7,513,000	943,000	.263	39,450	1,975,919	248,009
16	0	150,000	150,000	1,971,000	5,653,000	7,624,000	943,000	.239	35,850	1,822,136	225,377
17	0	150,000	150,000	1,971,000	5,766,000	7,737,000	943,000	.218	32,700	1,686,666	205,574
18	0	150,000	150,000	1,971,000	5,881,000	7,852,000	943,000	.198	29,700	1,554,696	186,714
19	0	150,000	150,000	1,971,000	5,999,000	7,970,000	943,000	.180	27,000	1,434,600	169,740
20	0	150,000	150,000	1,971,000	6,119,000	8,090,000	943,000	.163	24,450	1,318,670	153,709
21	0	150,000	150,000	1,971,000	6,241,000	8,212,000	943,000	.149	22,350	1,223,588	140,507
22	0	150,000	150,000	1,971,000	6,366,000	8,337,000	943,000	.135	20,250	1,125,495	127,305
23	0	150,000	150,000	1,971,000	6,493,000	8,464,000	943,000	.123	18,450	1,041,072	115,989
24	0	150,000	150,000	1,971,000	6,623,000	8,594,000	943,000	.112	16,800	962,528	105,616
25	0	150,000	150,000	1,971,000	6,755,000	8,726,000	943,000	.101	15,150	881,326	95,243
26	0	150,000	150,000	1,971,000	6,890,000	8,861,000	943,000	.092	13,800	815,212	86,756
27	0	150,000	150,000	1,971,000	7,028,000	8,999,000	943,000	.084	12,600	755,916	79,212
28	0	150,000	150,000	1,971,000	7,169,000	9,140,000	943,000	.076	11,400	694,640	71,668
29	0	150,000	150,000	1,971,000	7,312,000	9,283,000	943,000	.069	10,350	640,527	65,067
30	0	150,000	150,000	1,971,000	7,458,000	9,429,000	943,000	.063	9,450	594,027	59,409
31	0	150,000	150,000	1,971,000	7,608,000	9,579,000	943,000	.057	8,550	546,003	53,751
32	0	150,000	150,000	1,971,000	7,760,000	9,731,000	943,000	.052	7,800	506,012	49,036
33	0	150,000	150,000	1,971,000	7,915,000	9,886,000	943,000	.047	7,050	464,642	44,321
Total	9,501,000	4,500,000	14,001,000	59,130,000	180,814,000	239,944,000	28,290,000		9,833,112	56,596,413	7,344,084

COST-EFFECTIVENESS ANALYSIS (WONOUGBA)

Discount rate: 10%

7. Diesel Energy Costs +4%

	Hydro Option			Diesel Option			CEB		Cost Comparison		
Year	Capital	O&M	Total	Capital O&M	Energy Cost	Total	Total	PW Factor	Hydro	Diesel	CEB
1	190,000	0	190,000	0	0	0		1.000	190,000	0	0
2	190,000	0	190,000	0	0	0		.909	172,710	0	0
3	0	15,000	15,000	45,000	103,000	148,000	22,000	.827	12,405	122,396	18,194
4	0	15,000	15,000	45,000	107,000	152,000	22,000	.751	11,265	114,152	16,522
5	0	15,000	15,000	45,000	111,000	156,000	22,000	.683	10,245	106,548	15,026
6	0	15,000	15,000	45,000	116,000	161,000	22,000	.621	9,315	99,981	13,662
7	0	15,000	15,000	45,000	120,000	165,000	22,000	.564	8,460	93,060	12,408
8	0	15,000	15,000	45,000	125,000	170,000	22,000	.513	7,695	87,210	11,286
9	0	15,000	15,000	45,000	130,000	175,000	22,000	.466	6,990	81,550	10,252
10	0	15,000	15,000	45,000	136,000	181,000	22,000	.424	6,360	76,744	9,328
11	0	15,000	15,000	45,000	141,000	186,000	22,000	.385	5,775	71,610	8,470
12	0	15,000	15,000	45,000	147,000	192,000	22,000	.351	5,265	67,392	7,722
13	0	15,000	15,000	45,000	152,000	197,000	22,000	.319	4,785	62,843	7,018
14	0	15,000	15,000	45,000	159,000	204,000	22,000	.290	4,350	59,160	6,380
15	0	15,000	15,000	45,000	165,000	210,000	22,000	.263	3,945	55,230	5,786
16	0	15,000	15,000	45,000	172,000	217,000	22,000	.239	3,585	51,863	5,258
17	0	15,000	15,000	45,000	178,000	223,000	22,000	.218	3,270	48,614	4,796
18	0	15,000	15,000	45,000	185,000	230,000	22,000	.198	2,970	45,540	4,356
19	0	15,000	15,000	45,000	193,000	238,000	22,000	.180	2,700	42,840	3,960
20	0	15,000	15,000	45,000	201,000	246,000	22,000	.163	2,445	40,098	3,586
21	0	15,000	15,000	45,000	209,000	254,000	22,000	.149	2,235	37,846	3,278
22	0	15,000	15,000	45,000	217,000	262,000	22,000	.135	2,025	35,370	2,970
23	0	15,000	15,000	45,000	226,000	271,000	22,000	.123	1,845	33,333	2,706
24	0	15,000	15,000	45,000	235,000	280,000	22,000	.112	1,680	31,360	2,464
25	0	15,000	15,000	45,000	244,000	289,000	22,000	.101	1,515	29,189	2,222
26	0	15,000	15,000	45,000	254,000	299,000	22,000	.092	1,380	27,508	2,024
27	0	15,000	15,000	45,000	264,000	309,000	22,000	.084	1,260	25,956	1,848
28	0	15,000	15,000	45,000	275,000	320,000	22,000	.076	1,140	24,320	1,672
29	0	15,000	15,000	45,000	286,000	331,000	22,000	.069	1,035	22,839	1,518
30	0	15,000	15,000	45,000	297,000	342,000	22,000	.063	945	21,546	1,386
31	0	15,000	15,000	45,000	309,000	354,000	22,000	.057	855	20,178	1,254
32	0	15,000	15,000	45,000	321,000	366,000	22,000	.052	780	19,032	1,144
Total	380,000	450,000	830,000	1,350,000	5,778,000	7,128,000	660,000		491,230	1,655,308	188,496

COST-EFFECTIVENESS ANALYSIS (WONOUGBA)

Discount rate: 10%

8. CEB Sales Rate +3%

	Hydro Option			Diesel Option			CEB		Cost Comparison		
Year	Capital	O&M	Total	Capital O&M	Energy Cost	Total	Total	PW Factor	Hydro	Diesel	CEB
1	190,000	0	190,000	0	0	0	0	1.000	190,000	0	0
2	190,000	0	190,000	0	0	0	0	.909	172,710	0	0
3	0	15,000	15,000	45,000	103,000	148,000	22,000	.827	12,405	122,396	18,194
4	0	15,000	15,000	45,000	103,000	148,000	23,000	.751	11,265	111,148	17,273
5	0	15,000	15,000	45,000	103,000	148,000	23,000	.683	10,245	101,084	15,709
6	0	15,000	15,000	45,000	103,000	148,000	24,000	.621	9,315	91,908	14,904
7	0	15,000	15,000	45,000	103,000	148,000	25,000	.564	8,460	83,472	14,100
8	0	15,000	15,000	45,000	103,000	148,000	26,000	.513	7,695	75,924	13,338
9	0	15,000	15,000	45,000	103,000	148,000	26,000	.466	6,990	68,968	12,116
10	0	15,000	15,000	45,000	103,000	148,000	27,000	.424	6,360	62,752	11,448
11	0	15,000	15,000	45,000	103,000	148,000	28,000	.385	5,775	56,980	10,780
12	0	15,000	15,000	45,000	103,000	148,000	29,000	.351	5,265	51,948	10,179
13	0	15,000	15,000	45,000	103,000	148,000	30,000	.319	4,785	47,212	9,570
14	0	15,000	15,000	45,000	103,000	148,000	30,000	.290	4,350	42,920	8,700
15	0	15,000	15,000	45,000	103,000	148,000	31,000	.263	3,945	38,924	8,153
16	0	15,000	15,000	45,000	103,000	148,000	32,000	.239	3,585	35,372	7,648
17	0	15,000	15,000	45,000	103,000	148,000	33,000	.218	3,270	32,264	7,194
18	0	15,000	15,000	45,000	103,000	148,000	34,000	.198	2,970	29,304	6,732
19	0	15,000	15,000	45,000	103,000	148,000	35,000	.180	2,700	26,640	6,300
20	0	15,000	15,000	45,000	103,000	148,000	36,000	.163	2,445	24,124	5,868
21	0	15,000	15,000	45,000	103,000	148,000	37,000	.149	2,235	22,052	5,513
22	0	15,000	15,000	45,000	103,000	148,000	39,000	.135	2,025	19,980	5,265
23	0	15,000	15,000	45,000	103,000	148,000	40,000	.123	1,845	18,204	4,920
24	0	15,000	15,000	45,000	103,000	148,000	41,000	.112	1,680	16,576	4,592
25	0	15,000	15,000	45,000	103,000	148,000	42,000	.101	1,515	14,948	4,242
26	0	15,000	15,000	45,000	103,000	148,000	43,000	.092	1,380	13,616	3,956
27	0	15,000	15,000	45,000	103,000	148,000	45,000	.084	1,260	12,432	3,780
28	0	15,000	15,000	45,000	103,000	148,000	46,000	.076	1,140	11,248	3,496
29	0	15,000	15,000	45,000	103,000	148,000	48,000	.069	1,035	10,212	3,312
30	0	15,000	15,000	45,000	103,000	148,000	49,000	.063	945	9,324	3,087
31	0	15,000	15,000	45,000	103,000	148,000	50,000	.057	855	8,436	2,850
32	0	15,000	15,000	45,000	103,000	148,000	52,000	.052	780	7,696	2,704
Total	380,000	450,000	830,000	1,350,000	3,090,000	4,440,000	1,046,000		491,230	1,268,064	245,923

COST-EFFECTIVENESS ANALYSIS (TOMEGBE)

Discount rate: 8%

2. 8% Discount Rate

	Hydro Option			Diesel Option			CEB		Cost Comparison		
Year	Capital	O&M	Total	Capital O&M	Energy Cost	Total	Total	PW Factor	Hydro	Diesel	CEB
1	3,167,000	0	3,167,000	0	0	0	0	1.000	3,167,000	0	0
2	3,167,000	0	3,167,000	0	0	0	0	.926	2,932,642	0	0
3	3,167,000	0	3,167,000	0	0	0	0	.857	2,714,119	0	0
4	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.794	119,100	5,103,832	748,742
5	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.735	110,250	4,724,580	693,105
6	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.681	102,150	4,377,468	642,183
7	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.630	94,500	4,049,640	594,090
8	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.584	87,600	3,753,952	550,712
9	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.540	81,000	3,471,120	509,220
10	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.500	75,000	3,214,000	471,500
11	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.463	69,450	2,976,164	436,609
12	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.429	64,350	2,757,612	404,547
13	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.397	59,550	2,551,916	374,371
14	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.368	55,200	2,365,504	347,024
15	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.341	51,150	2,191,948	321,563
16	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.315	47,250	2,024,820	297,045
17	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.292	43,800	1,876,976	275,356
18	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.270	40,500	1,735,560	254,610
19	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.250	37,500	1,607,000	235,750
20	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.232	34,800	1,491,296	218,776
21	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.215	32,250	1,382,020	202,745
22	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.199	29,850	1,279,172	187,657
23	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.184	27,600	1,182,752	173,512
24	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.170	25,500	1,092,760	160,310
25	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.158	23,700	1,015,624	148,994
26	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.146	21,900	938,488	137,678
27	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.135	20,250	867,780	127,305
28	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.125	18,750	803,500	117,875
29	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.116	17,400	745,648	109,388
30	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.107	16,050	687,796	100,901
31	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.099	14,850	636,372	93,357
32	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.092	13,800	591,376	86,756
33	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.085	12,750	546,380	80,155
Total	9,501,000	4,500,000	14,001,000	59,130,000	133,710,000	192,840,000	28,290,000		10,261,561	62,043,056	9,101,836

COST-EFFECTIVENESS ANALYSIS (TOMEGBE)

Discount rate: 12%

3. 12% Discount Rate

	Hydro Option			Diesel Option			CEB		Cost Comparison		
Year	Capital	O&M	Total	Capital O&M	Energy Cost	Total	Total	PW Factor	Hydro	Diesel	CEB
1	3,167,000	0	3,167,000	0	0	0	0	1.000	3,167,000	0	0
2	3,167,000	0	3,167,000	0	0	0	0	.893	2,828,131	0	0
3	3,167,000	0	3,167,000	0	0	0	0	.797	2,524,099	0	0
4	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.712	106,800	4,576,736	671,416
5	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.636	95,400	4,088,208	599,748
6	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.567	85,050	3,644,676	534,681
7	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.507	76,050	3,258,996	478,101
8	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.452	67,800	2,905,456	426,236
9	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.404	60,600	2,596,912	380,972
10	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.361	54,150	2,320,508	340,423
11	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.322	48,300	2,069,816	303,646
12	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.288	43,200	1,851,264	271,584
13	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.257	38,550	1,651,996	242,351
14	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.229	34,350	1,472,012	215,947
15	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.205	30,750	1,317,740	193,315
16	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.183	27,450	1,176,324	172,569
17	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.163	24,450	1,047,764	153,709
18	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.146	21,900	938,488	137,678
19	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.130	19,500	835,640	122,590
20	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.116	17,400	745,648	109,388
21	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.104	15,600	668,512	98,072
22	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.093	13,950	597,804	87,699
23	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.083	12,450	533,524	78,269
24	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.074	11,100	475,672	69,782
25	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.066	9,900	424,248	62,238
26	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.059	8,850	379,252	55,637
27	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.053	7,950	340,684	49,979
28	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.047	7,050	302,116	44,321
29	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.042	6,300	269,976	39,606
30	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.037	5,550	237,836	34,891
31	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.033	4,950	212,124	31,119
32	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.030	4,500	192,840	28,290
33	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.027	4,050	173,556	25,461
Total	9,501,000	4,500,000	14,001,000	59,130,000	133,710,000	192,840,000	28,290,000		9,483,130	41,306,328	6,059,718

COST-EFFECTIVENESS ANALYSIS (TOMEGBE)

Discount rate: 10%

4. Hydro Capital Cost +25%

	Hydro Option			Diesel Option			CEB		Cost Comparison		
Year	Capital	O&M	Total	Capital O&M	Energy Cost	Total	Total	PW Factor	Hydro	Diesel	CEB
1	3,958,000	0	3,958,000	0	0	0	0	1.000	3,958,000	0	0
2	3,958,000	0	3,958,000	0	0	0	0	.909	3,597,822	0	0
3	3,958,000	0	3,958,000	0	0	0	0	.827	3,273,266	0	0
4	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.751	112,650	4,827,428	708,193
5	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.683	102,450	4,390,324	644,069
6	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.621	93,150	3,991,788	585,603
7	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.564	84,600	3,625,392	531,852
8	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.513	76,950	3,297,564	483,759
9	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.466	69,900	2,995,448	439,438
10	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.424	63,600	2,725,472	399,832
11	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.385	57,750	2,474,780	363,055
12	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.351	52,650	2,256,228	330,993
13	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.319	47,850	2,050,532	300,817
14	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.290	43,500	1,864,120	273,470
15	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.263	39,450	1,690,564	248,009
16	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.239	35,850	1,536,292	225,377
17	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.218	32,700	1,401,304	205,574
18	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.198	29,700	1,272,744	186,714
19	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.180	27,000	1,157,040	169,740
20	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.163	24,450	1,047,764	153,709
21	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.149	22,350	957,772	140,507
22	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.135	20,250	867,780	127,305
23	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.123	18,450	790,644	115,989
24	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.112	16,800	719,936	105,616
25	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.101	15,150	649,228	95,243
26	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.092	13,800	591,376	86,756
27	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.084	12,600	539,952	79,212
28	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.076	11,400	488,528	71,668
29	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.069	10,350	443,532	65,067
30	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.063	9,450	404,964	59,409
31	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.057	8,550	366,396	53,751
32	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.052	7,800	334,256	49,036
33	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.047	7,050	302,116	44,321
Total	1,874,000	4,500,000	16,374,000	59,130,000	133,710,000	192,840,000	28,290,000		11,997,288	50,061,264	7,344,084

COST-EFFECTIVENESS ANALYSIS (TOMEGBE)

Discount rate: 10%

5. Hydro Capital Cost +50%

	Hydro Option			Diesel Option			CEB		Cost Comparison		
Year	Capital	O&M	Total	Capital O&M	Energy Cost	Total	Total	PW Factor	Hydro	Diesel	CEB
1	4,750,000	0	4,750,000	0	0	0	0	1.000	4,750,000	0	0
2	4,750,000	0	4,750,000	0	0	0	0	.909	4,317,750	0	0
3	4,750,000	0	4,750,000	0	0	0	0	.827	3,928,250	0	0
4	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.751	112,650	4,827,428	708,193
5	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.683	102,450	4,390,324	644,069
6	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.621	93,150	3,991,788	585,603
7	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.564	84,600	3,625,392	531,852
8	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.513	76,950	3,297,564	483,759
9	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.466	69,900	2,995,448	439,438
10	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.424	63,600	2,725,472	399,832
11	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.385	57,750	2,474,780	363,055
12	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.351	52,650	2,256,228	330,993
13	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.319	47,850	2,050,532	300,817
14	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.290	43,500	1,864,120	273,470
15	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.263	39,450	1,690,564	248,009
16	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.239	35,850	1,536,292	225,377
17	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.218	32,700	1,401,304	205,574
18	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.198	29,700	1,272,744	186,714
19	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.180	27,000	1,157,040	169,740
20	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.163	24,450	1,047,764	153,709
21	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.149	22,350	957,772	140,507
22	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.135	20,250	867,780	127,305
23	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.123	18,450	790,644	115,989
24	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.112	16,800	719,936	105,616
25	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.101	15,150	649,228	95,243
26	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.092	13,800	591,376	86,756
27	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.084	12,600	539,952	79,212
28	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.076	11,400	488,528	71,668
29	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.069	10,350	443,532	65,067
30	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.063	9,450	404,964	59,409
31	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.057	8,550	366,396	53,751
32	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.052	7,800	334,256	49,036
33	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.047	7,050	302,116	44,321
Total	4,250,000	4,500,000	18,750,000	59,130,000	133,710,000	192,840,000	28,290,000		14,164,200	50,061,264	7,344,084

COST-EFFECTIVENESS ANALYSIS (TOMEGBE)

Discount rate: 10%

6. Diesel Energy Cost +2%

	Hydro Option			Diesel Option			CEB		Cost Comparison		
Year	Capital	O&M	Total	Capital O&M	Energy Cost	Total	Total	PW Factor	Hydro	Diesel	CEB
1	3,167,000	0	3,167,000	0	0	0	0	1.000	3,167,000	0	0
2	3,167,000	0	3,167,000	0	0	0	0	.909	2,878,803	0	0
3	3,167,000	0	3,167,000	0	0	0	0	.827	2,619,109	0	0
4	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.751	112,650	4,827,428	708,193
5	0	150,000	150,000	1,971,000	4,546,000	6,517,000	943,000	.683	102,450	4,451,111	644,069
6	0	150,000	150,000	1,971,000	4,637,000	6,608,000	943,000	.621	93,150	4,103,568	585,603
7	0	150,000	150,000	1,971,000	4,730,000	6,701,000	943,000	.564	84,600	3,779,364	531,852
8	0	150,000	150,000	1,971,000	4,824,000	6,795,000	943,000	.513	76,950	3,485,835	483,759
9	0	150,000	150,000	1,971,000	4,921,000	6,892,000	943,000	.466	69,900	3,211,672	439,438
10	0	150,000	150,000	1,971,000	5,019,000	6,990,000	943,000	.424	63,600	2,963,760	399,832
11	0	150,000	150,000	1,971,000	5,120,000	7,091,000	943,000	.385	57,750	2,730,035	363,055
12	0	150,000	150,000	1,971,000	5,222,000	7,193,000	943,000	.351	52,650	2,524,743	330,993
13	0	150,000	150,000	1,971,000	5,327,000	7,298,000	943,000	.319	47,850	2,328,062	300,817
14	0	150,000	150,000	1,971,000	5,433,000	7,404,000	943,000	.290	43,500	2,147,160	273,470
15	0	150,000	150,000	1,971,000	5,542,000	7,513,000	943,000	.263	39,450	1,975,919	248,009
16	0	150,000	150,000	1,971,000	5,653,000	7,624,000	943,000	.239	35,850	1,822,136	225,377
17	0	150,000	150,000	1,971,000	5,766,000	7,737,000	943,000	.218	32,700	1,686,666	205,574
18	0	150,000	150,000	1,971,000	5,881,000	7,852,000	943,000	.198	29,700	1,554,696	186,714
19	0	150,000	150,000	1,971,000	5,999,000	7,970,000	943,000	.180	27,000	1,434,600	169,740
20	0	150,000	150,000	1,971,000	6,119,000	8,090,000	943,000	.163	24,450	1,318,670	153,709
21	0	150,000	150,000	1,971,000	6,241,000	8,212,000	943,000	.149	22,350	1,223,588	140,507
22	0	150,000	150,000	1,971,000	6,366,000	8,337,000	943,000	.135	20,250	1,125,495	127,305
23	0	150,000	150,000	1,971,000	6,493,000	8,464,000	943,000	.123	18,450	1,041,072	115,989
24	0	150,000	150,000	1,971,000	6,623,000	8,594,000	943,000	.112	16,800	962,528	105,616
25	0	150,000	150,000	1,971,000	6,755,000	8,726,000	943,000	.101	15,150	881,326	95,243
26	0	150,000	150,000	1,971,000	6,890,000	8,861,000	943,000	.092	13,800	815,212	86,756
27	0	150,000	150,000	1,971,000	7,028,000	8,999,000	943,000	.084	12,600	755,916	79,212
28	0	150,000	150,000	1,971,000	7,169,000	9,140,000	943,000	.076	11,400	694,640	71,668
29	0	150,000	150,000	1,971,000	7,312,000	9,283,000	943,000	.069	10,350	640,527	65,067
30	0	150,000	150,000	1,971,000	7,458,000	9,429,000	943,000	.063	9,450	594,027	59,409
31	0	150,000	150,000	1,971,000	7,608,000	9,579,000	943,000	.057	8,550	546,003	53,751
32	0	150,000	150,000	1,971,000	7,760,000	9,731,000	943,000	.052	7,800	506,012	49,036
33	0	150,000	150,000	1,971,000	7,915,000	9,886,000	943,000	.047	7,050	464,642	44,321
Total	9,501,000	4,500,000	14,001,000	59,130,000	180,814,000	239,944,000	28,290,000		9,833,112	56,596,413	7,344,084

COST-EFFECTIVENESS ANALYSIS (TOMEGBE)

Discount rate: 10%

7. Diesel Energy Cost +4%

	Hydro Option			Diesel Option			CEB		Cost Comparison		
Year	Capital	O&M	Total	Capital O&M	Energy Cost	Total	Total	PW Factor	Hydro	Diesel	CEB
1	3,167,000	0	3,167,000	0	0	0	0	1.000	3,167,000	0	0
2	3,167,000	0	3,167,000	0	0	0	0	.909	2,878,803	0	0
3	3,167,000	0	3,167,000	0	0	0	0	.827	2,619,109	0	0
4	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.751	112,650	4,827,428	708,193
5	0	150,000	150,000	1,971,000	4,635,000	6,606,000	943,000	.683	102,450	4,511,898	644,069
6	0	150,000	150,000	1,971,000	4,821,000	6,792,000	943,000	.621	93,150	4,217,832	585,603
7	0	150,000	150,000	1,971,000	5,014,000	6,985,000	943,000	.564	84,600	3,939,540	531,852
8	0	150,000	150,000	1,971,000	5,214,000	7,185,000	943,000	.513	76,950	3,685,905	483,759
9	0	150,000	150,000	1,971,000	5,423,000	7,394,000	943,000	.466	69,900	3,445,604	439,438
10	0	150,000	150,000	1,971,000	5,640,000	7,611,000	943,000	.424	63,600	3,227,064	399,832
11	0	150,000	150,000	1,971,000	5,865,000	7,836,000	943,000	.385	57,750	3,016,860	363,055
12	0	150,000	150,000	1,971,000	6,100,000	8,071,000	943,000	.351	52,650	2,832,921	330,993
13	0	150,000	150,000	1,971,000	6,344,000	8,315,000	943,000	.319	47,850	2,652,485	300,817
14	0	150,000	150,000	1,971,000	6,597,000	8,568,000	943,000	.290	43,500	2,484,720	273,470
15	0	150,000	150,000	1,971,000	6,861,000	8,832,000	943,000	.263	39,450	2,322,816	248,009
16	0	150,000	150,000	1,971,000	7,136,000	9,107,000	943,000	.239	35,850	2,176,573	225,377
17	0	150,000	150,000	1,971,000	7,421,000	9,392,000	943,000	.218	32,700	2,047,456	205,574
18	0	150,000	150,000	1,971,000	7,718,000	9,689,000	943,000	.198	29,700	1,918,422	186,714
19	0	150,000	150,000	1,971,000	8,027,000	9,998,000	943,000	.180	27,000	1,799,640	169,740
20	0	150,000	150,000	1,971,000	8,348,000	10,319,000	943,000	.163	24,450	1,681,997	153,709
21	0	150,000	150,000	1,971,000	8,682,000	10,653,000	943,000	.149	22,350	1,587,297	140,507
22	0	150,000	150,000	1,971,000	9,029,000	11,000,000	943,000	.135	20,250	1,485,000	127,305
23	0	150,000	150,000	1,971,000	9,390,000	11,361,000	943,000	.123	18,450	1,397,403	115,989
24	0	150,000	150,000	1,971,000	9,766,000	11,737,000	943,000	.112	16,800	1,314,544	105,616
25	0	150,000	150,000	1,971,000	10,156,000	12,127,000	943,000	.101	15,150	1,224,827	95,243
26	0	150,000	150,000	1,971,000	10,563,000	12,534,000	943,000	.092	13,800	1,153,128	86,756
27	0	150,000	150,000	1,971,000	10,985,000	12,956,000	943,000	.084	12,600	1,088,304	79,212
28	0	150,000	150,000	1,971,000	11,425,000	13,396,000	943,000	.076	11,400	1,018,096	71,668
29	0	150,000	150,000	1,971,000	11,882,000	13,853,000	943,000	.069	10,350	955,857	65,067
30	0	150,000	150,000	1,971,000	12,357,000	14,328,000	943,000	.063	9,450	902,664	59,409
31	0	150,000	150,000	1,971,000	12,851,000	14,822,000	943,000	.057	8,550	844,854	53,751
32	0	150,000	150,000	1,971,000	13,365,000	15,336,000	943,000	.052	7,800	797,472	49,036
33	0	150,000	150,000	1,971,000	13,900,000	15,871,000	943,000	.047	7,050	745,937	44,321
Total	9,501,000	4,500,000	14,001,000	59,130,000	249,972,000	309,102,000	28,290,000		9,833,112	65,304,544	7,344,084

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COST-EFFECTIVENESS ANALYSIS (TOMEGBE)

Discount rate: 10%

8. CEB Sales Rate +3%

	Hydro Option			Diesel Option			CEB		Cost Comparison		
Year	Capital	O&M	Total	Capital O&M	Energy Cost	Total	Total	PW Factor	Hydro	Diesel	CEB
1	3,167,000	0	3,167,000	0	0	0	0	1.000	3,167,000	0	0
2	3,167,000	0	3,167,000	0	0	0	0	.909	2,878,803	0	0
3	3,167,000	0	3,167,000	0	0	0	0	.827	2,619,109	0	0
4	0	150,000	150,000	1,971,000	4,457,000	6,428,000	943,000	.751	112,650	4,827,428	708,193
5	0	150,000	150,000	1,971,000	4,457,000	6,428,000	971,000	.683	102,450	4,390,324	663,193
6	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,000,000	.621	93,150	3,991,788	621,000
7	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,030,000	.564	84,600	3,625,392	580,920
8	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,061,000	.513	76,950	3,297,564	544,293
9	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,093,000	.466	69,900	2,995,448	509,338
10	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,126,000	.424	63,600	2,725,472	477,424
11	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,160,000	.385	57,750	2,474,780	446,600
12	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,195,000	.351	52,650	2,256,228	419,445
13	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,230,000	.319	47,850	2,050,532	392,370
14	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,267,000	.290	43,500	1,864,120	367,430
15	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,305,000	.263	39,450	1,690,564	343,215
16	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,344,000	.239	35,850	1,536,292	321,216
17	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,385,000	.218	32,700	1,401,304	301,930
18	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,426,000	.198	29,700	1,272,744	282,348
19	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,469,000	.180	27,000	1,157,040	264,420
20	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,513,000	.163	24,450	1,047,764	246,619
21	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,559,000	.149	22,350	957,772	232,291
22	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,605,000	.135	20,250	867,780	216,675
23	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,654,000	.123	18,450	790,644	203,442
24	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,703,000	.112	16,800	719,936	190,736
25	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,754,000	.101	15,150	649,228	177,154
26	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,807,000	.092	13,800	591,376	166,244
27	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,861,000	.084	12,600	539,952	156,324
28	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,917,000	.076	11,400	488,528	145,692
29	0	150,000	150,000	1,971,000	4,457,000	6,428,000	1,974,000	.069	10,350	443,532	136,206
30	0	150,000	150,000	1,971,000	4,457,000	6,428,000	2,034,000	.063	9,450	404,964	128,142
31	0	150,000	150,000	1,971,000	4,457,000	6,428,000	2,095,000	.057	8,550	366,396	119,415
32	0	150,000	150,000	1,971,000	4,457,000	6,428,000	2,158,000	.052	7,800	334,256	112,216
33	0	150,000	150,000	1,971,000	4,457,000	6,428,000	2,223,000	.047	7,050	302,116	104,481
Total	9,501,000	4,500,000	14,001,000	59,130,000	133,710,000	192,840,000	44,862,000		9,833,112	50,061,264	9,578,972

Appendix B. Chronology of communications between AID and NRECA

OPTIONAL FORM NO. 10
JULY 1973 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

MAY 25 1982

Memorandum

TO : Walter D. Lawrence, Paul H. Kirshen and Tobie E. Lanou

DATE: June 16, 1982

FROM : Clarence Koci, Energy Advisor, REDSO/WA, Abidjan

SUBJECT: Economic feasibility of small hydroelectric plants at Tomegbe and Wonougba, Togo.

I re-read your report "Togo Small Decentralized Hydropower Study" of July 1981 and extended the economic claculations on the Tomegbe and Wonougba sites. I used both a lower sales price for electricity (to compete with cheap power from Ghana) and higher (to compete with rural diesel-electric units). I also tried a 5% inflation rate on O & M operation and maintenance costs and electricity sale price.

There appears to be an error in your calculations in Tables 9 and 10 where you calculate the IRR (Internal Rate of Return) of the Wonougba and Tomegbe sites. I think you paid for the dam and power plant twice. I've recalculated the tables paying the capital costs only once and find a far better IRR.

My results are attached to this memo. It looks as if the two sites are quite promising. Let me know what you think.

.../...

5010-110

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

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I. Correction of apparent error in Table 9 (Wonougba and Table 10 (Tomegbe).

These tables show the computer runs that calculate the net present values of the project revenues, project costs, and total cash flows over the life of the project. The end result is the Internal Rate of Return (IRR). It appears that there is an error in the Project Cost Cash Flow columns of both tables.

For Wonougba the capital cost is $436,000 paid out at the rate of $218,000 in each o f the first two years. For Tomegbe it is $10,000,000 paid out at $3,333,330 in each of the first three years. Then starting at year three there is a pay out for Wonougba of $74,200 each year which consists of $20,000 for operation and maintenance and $54,000 for debt service and sinking fund. For Tomegbe, starting at year four, there is a payout each year of $1,693,000 which consists of $450,000 for operation and maintenance and $1,243,000 for debt service and sinking fund.

It looks to me like you've paid double on your capital costs. First you pay them out ($436,000 at Wonougba in the first two years and $10,000,000 at Tomegbe in the first three years during construction), then you pay them-off again as debt service and sinking fund.

In order to eliminate this double paying I've knocked out the debt service and sinking fund from the calculation and re-run it. For Wonougba the number $74,000 becomes $20,000

(O & M only) and for Tomegbe the number $1,693,000 becomes $450,000. Then I find that the IRR's are much better. They change as follows:

Wonougba : IRR changes from -3.3% to 13.7%.
Tomegbe : IRR changes from 17.6% to 26.3%.

This would make both Wonougba and Tomegbe economically viable.

II. Inflation:

It was assumed in I. that the price of electricity sold was 12.9 ¢/kWh and that this stayed the same for twenty years. To be more realistic we'll assume that both the selling price of electricity and of the O & M costs inflate at 5% per year. Then the IRR's are:

Wonougba : IRR (5% inflation) is 19.4%.
Tomegbe : IRR (5% inflation) is 32.7%.

Notice that the IRR goes up more than 5% when price and costs inflate at 5%.

III. Is 12.9 ¢/kWh a reasonable selling price?

The selling price chosen is the highest retail rate at which the electric company sells electricity. It is not likely to buy electricity at that rate. It is more likely to buy electricity at its off-peak industrial rate which was 19 CFA/kWh or (÷ 300) 6.3 ¢/kWh. Using 6.3 ¢/kWh and an inflation rate of 5% per year for costs and selling price one gets:

Wonougba : IRR (6.3 ¢/kWh and 5% inflation) is 5.7%.
Tomegbe : IRR (6.3 ¢/kWh and 5% inflation) is 17.0%

Even at this low selling price the IRR is positive. However, such low selling prices are due to the unrealistically low price of electricity from the dam in Ghana and most small hydro plants will probably compete against more costly diesel electric plants.

IV. Costs of producing diesel-electricity in rural areas

Diesel fuel can be bought before tax in bulk for about 40 ¢/l. After shipment to a site such as Wonougba and storage costs it may be about 50 ¢/l. Converting it to electrical energy at an overall efficiency of 23% by a diesel generator would give a production cost of 18 ¢/kWh. This is for fuel only and does not count capital (except for storage tanks) or O & M costs. It has been stated by the Electric Company in Senegal that it costs them 15.6 ¢/kWh to produce electricity at Matam with government subsidized fuel. Their cost of production at Dahra is 43 ¢/kWh.

Therefore we'll be very optimistic and say that we can sell electricity to the electric company for distribution at 18 ¢/kWh as long as we don't have to compete with cheap power from Ghana. Then assuming 5% inflation on everything we get

Wonougba : IRR (18 ¢/kWh, 5% inflation) is 27.2%.
Tomegbe : IRR (18 ¢/kWh, 5% inflation) is 42.2%.

V. Conclusion

The Tomegbe and Wonougba hydro plants would be economically attractive. They would be quite attractive if they compete against diesel electric power and one could sell the electricity at 18 ¢/kWh. They would be less attractive if they had to compete against Ghanaian electric power and had to sell for, say, 6.3 ¢/kWh. However, they would still have positive IRR's.

Walter D. Lawrence, Paul H. Kirshen
and Tobie E. Lanou
c/o National Rural Electric
Cooperative Association
Small Decentralized Hydropower Program
1800 Massachusetts Ave., N.W.
Washington, D.C. 20036

cc: USAID/Lomé
AID/W (ST & EY) (AFR/DR/SDP)
✓David Zoellner, NRECA

August 11, 1982

Dr. Clarence Kooi
Energy Advisor
REDSO/WA
U.S. Agency for International
Development
Department of State
Washington, D.C. 20523

Dear Clarence:

Thank you for your memo of June 16, 1982 concerning the economic feasibility of small hydroelectric plants at Tomegbe and Wonougba, Togo. I have distributed copies of your memo and have received comments from Walter Lawrence and Tobie Lanou. Attached is a copy of Tobie's response.

Apparently I, and the other reviewers, assumed the Internal Rate of Return calculations were correct because they were done on a computer. As you pointed out, the construction costs were included twice and I agree with your subsequent observations.

To further address your comments, I would like to review the purpose of the report and the value of the economic analysis performed. A "country survey" is conducted to determine the role small hydropower could play in a country's energy profile. The prefeasibility economics is done to compare and rank candidate sites. Accuracy of the cost figures are ± 100%. Hence, we feel it is not the purpose of a preliminary examination to address the more detailed issues of inflation, proper value of energy, etc., but rather to provide a consistent basis for comparison for all the candidate sites to reflect their relative merits and disadvantages. This provides sufficient general information upon which to base a decision for more detailed site analysis.

The Tomegbe site appears more attractive than the Wonougba in all cases and, hence, is recommended for detailed feasibility study. The feasibility study will tell us not only the economic feasibility, but also the technical, social, financial, and environmental soundness. A procedure for calculating the IRR in a small hydropower feasibility study is also attached. This procedure is taken from a paper entitled "Site Selection Methodology for Small Hydroelectric Power Plants", prepared by the NRECA SDH team for USAID/Santo Domingo, June 22, 1981.

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I appreciate your careful review of the Togo Report and if you would like a more detailed evaluation of the Tomegbe site, I think we could do so (with ST/EY's OK) from a desk in Washington.

Sincerely,

Bard Jackson
Principal Engineer
Small Decentralized Hydropower
Program

BJ:jc
cc: William Eilers
AFR/DR/SDP
USAID/Lome
Walter Lawrence
Tobie Lanou

JUL 27 1982

Tobie Lanou
6122 Woodmont Road
Alexandria, VA 22307

July 22, 1982

Bard Jackson
National Rural Electric Cooperative
Association
1800 Massachusetts Avenue NW
Washington, D.C. 20036

Dear Bard:

I have in hand Clarence Kooi's memo dated June 16, 1982, on the two hydro sites in Togo, Wonougba and Tomegbe. The memo is addressed to Walt Lawrence, Paul Kirshen and myself.

The memo picks up on our "Togo Small Decentralized Hydropower Study" prepared for NRECA in July 1981, and extends the financial analysis of the two sites and draws some revised conclusions.

Overall Evaluation of the Memo

On the whole, I think Kooi's remarks are useful and interesting. He points out some technical problems in our analysis which are well taken. He redoes our analysis in several particulars to produce somewhat more optimistic results about the two sites. I do not necessarily agree in all ways with his analysis, but it has merit.

My main conclusion after carefully reviewing his memo is that the direction of our earlier findings remains unchanged, even if the numbers vary. It still appears to me that Wonougba is a marginally promising site, having graduated from a negative project to a merely weak one. Tomegbe remains a superior project.

I would personally feel uncomfortable trying to infer too much from these kinds of prefeasibility calculations. At the same time I think it is worthwhile for Clarence to tinker with the numbers on a "what if" basis, since he is close to the situation in the field.

Some Particulars

For the record, let me talk to Clarence's memo, point by point. The roman numerals refer to sections in his memo.

I. Our IRR figures are in error, as he points out. There was a computer transcription problem. He has recomputed the IRR's. I have also re-run alternate figures, using a slightly different method from his. For Wonougba, I get a revised IRR of 10.5% (compared with his 13.7%.) This is based on calculations using my pocket calculator. I don't have access to the computerized program we used before.

As stated above, I do not believe the direction of our earlier conclusions has really changed.

II. Clarence inflates prices and costs as part of a new analysis. We didn't concern ourselves with this in our prefeasibility calculations. I don't believe it is always more "realistic" to deal in hard-to-impute inflation factors, especially in prefeasibility calculations.

III-IV. I followed Clarence's analysis here with some difficulty. I'm assuming that he is closer to such matters as electricity costs in Senegal than I am.

V. I have a problem with this section. The trouble with selling power to the electric company at 18¢/kwh is that the company has to sell it at 12¢/kwh, by law. Of course, production by diesel costs more than 12¢ also.

However, the investment justification for a diesel plant is much simpler than for a hydro project. As the main factor, it is much cheaper. There's no expensive, long term capital plant to justify.

Government subsidy of fuel costs is one thing, but investment subsidies of hydro projects are just not in the same category, in my opinion. When you consider that a second-stage Akossombo dam in Ghana is scheduled to add to cheap power sources for Togo, then it makes the subsidy of a hydro project even more unlikely.

* * *

In conclusion, let me say that Kooi's work is excellent in helping to keep an open mind about these projects.

Would you kindly share the information in this letter with him as appropriate. I welcome the opportunity to keep abreast of our Togo work.

Best regards.

cc: Lawrence

Sincerely,

Tobie Lanou

Tobie E. Lanou

VIA WUI KT
350 BB
0137 11/19

NRECA
USA
ATTN: DAVID ZOELLNER

CLARENCE KOOI WOULD LIKE US TO REVISE OUR ECONOMIC ANALYSIS IN THE TOGO REPORT AND SEND IT TO THE AAO LOME. PERHAPS JAMIE COULD DO THIS WITH A LITTLE GUIDANCE. USE A CAPITAL COST RATHER THAN DEBT SERVICE ANALYSIS AND ASSUME POWER PURCHASED FROM GHANA IS NOT AVAILABLE.

HAVE A NUMBER OF POTENTIAL SITES HERE BUT NO ONE WILLING TO COVER THE COST.

DID NOT CONTACT L. GRAHAM CONCERNING E.A. WORKSHOP.

WILL TRANSFER TO HOLIDAY INN THIS WEEKEND.

REGARDS

JACKSON