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Using Capital Projects to Promote Development and U.S. Commercial Interests

Economic and Financial Analyses of A.I.D. Capital Projects in Egypt

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FOREWORD

There is growing interest in some parts of Congress and the Executive Branch to use foreign assistance to advance U.S. commercial interests without jeopardizing the international development objectives of the foreign aid program. Congressional proposals have called for the establishment of a capital projects fund, a mixed credit program, and other trade-related programs.

Many ideas have been put forth as a rationale for capital projects. It is important to closely examine the empirical basis of the many ideas put forth in support of such projects. A first step is to analyze A.I.D.'s past experience. As part of that effort, the Center for Development Information and Evaluation (CDIE) has launched an assessment of A.I.D.'s experience with capital projects—experience that spans more than four decades.

The Capital Projects Assessment comprises two parts: First is an examination of the data on World Bank, other donor, and A.I.D. capital project experience. That analysis appears in a forthcoming CDIE Technical Report—"Using Capital Projects To Promote Development and U.S. Commercial Interests: Review of Literature." The second part examines capital projects in Egypt, which has the largest capital projects in the A.I.D. program portfolio.

A CDIE evaluation team of engineers, economists, and private sector analysts spent more than a month in Egypt analyzing nine A.I.D. capital projects. The team examined project-level impacts on Egypt's economic development and U.S. commercial interests. The evaluation team's findings are contained in the forthcoming CDIE technical report, "Using Capital Projects to Promote Development and U.S. Commercial Interests: Egypt Case Study." A separate study, "Using Capital Projects To Promote Development and U.S. Commercial Interests: U.S. Aid, Trade, and Capital Projects in Egypt," examines the relationships between U.S. aid and changes in U.S exports to Egypt over the past 15 years.

This paper examines nine A.I.D.-funded capital projects in Egypt over the 1977-1992 period. These projects helped create an infrastructure base that was essential to Egyptian economic development. The projects greatly increased electrical power generation, introduced a modern telephone system in Cairo and Alexandria, and rehabilitated a water and sewage system that served more than 23 million Egyptians. The projects were designed and built to high technical

standards, and they provided the basic infrastructure necessary for Egypt's continued economic growth.

Clearly, Egypt received important benefits from the A.I.D. projects. However, capital projects are an investment, and it is important to determine the return earned on such an investment. This study calculated the economic and financial rates of return on the nine A.I.D. capital projects. The methodology, assumptions, and data are carefully examined and described in the paper. It is probably one of A.I.D.'s most thorough and exhaustive financial and economic analyses of a broad range of capital projects.

Data from the analysis shows a mixed picture but generally low to medium financial and economic rates of return. The low rates are not due to technical problems—the projects were well designed, used appropriate technology, and were operated in a technically sound manner. In large measure, the poor performance was due to the Egyptian Government's poor economic policies, such as government price controls, regulations, subsidies, and employment and management structures that resulted in inefficient production and inefficient use of project outputs. A clear lesson is that in a bad policy environment even technically sound projects cannot generate a good rate of return.

In the last few years Egypt has initiated several policy reforms that have corrected a number of inappropriate prices and subsidies. These actions, it is hoped, will improve the economic rates of return on capital projects in future years.

SUMMARY

Purpose of the Analyses

This report examines one of the seven issues underlying the larger capital projects assessment: Under what circumstances have Agency for International Development (A.I.D.) capital investments generated a high economic rate of return? Specifically, the report looks at the economic rate of return for nine Egyptian infrastructure projects funded with U.S. assistance beginning in 1977.

Ex ante economic analysis is usually performed before a project begins to determine whether expected returns justify expected costs. This report in contrast presents ex post facto analyses of the economic and financial viability of A.I.D. capital projects that, in most cases, have been completed and operating for several years. The advantage of these analyses is that they can use actual construction and operating costs and estimates of benefit based on project experience. However, to fully account for future costs and benefits projections are required.

The analyses use internal rates of return as the principal measure of financial and economic impact. The financial internal rate of return (FIRR) is the private rate of return of an investment, based on market prices. The economic internal rate of return (EIRR) is the investment's rate of return to the whole economy, calculated using shadow or competitive market prices and valuing benefits not captured by the market, such as consumer surplus and external benefits. FIRR estimates the private profitability of the project to the business, whereas the more important EIRR estimates the return to the whole society.

Overview of Findings

Overall, the nine projects included in this report augmented and improved the quantity and quality of power, telecommunications, potable water, and sanitation services in Egypt. The projects provided new and rehabilitated plant, equipment, and machinery. They improved the *quality* of services for all consumers systemwide and provided new services for new consumers. All projects were judged technically sound.

Yet findings on the financial and economic soundness of the projects are mixed. Most of the projects have suffered from Government price controls that distort Egypt's markets. Particularly relevant to the utility projects is the Govern-

ment's control of utility output prices, which have been pegged at levels well below production costs, generating losses for the utilities that the Government must subsidize. Moreover, price policies have produced excessive and low-valued uses of utility outputs, which in turn have affected economic development adversely.

FIRR and EIRR for a base case and several sensitivity cases are summarized in Table 1 for power and telecommunications projects.

The *three power generation projects* examined are Helwan/Talkha, Shoubrah, and the Talkha combined-cycle addition. For the Helwan/Talkha and Shoubrah projects, FIRRs were 8.9 percent and 8.1 percent, respectively (see Table 1), assuming that reforms to increase energy prices continue as agreed under the terms of the World Bank structural adjustment loan. Sensitivity analyses revealed that if reforms do not continue, FIRR will decline significantly. Sensitivity analyses also demonstrated that under several plausible alternative assumptions, the projects are financially marginal investments; that is, they do not generate sufficient net profits to pay for capital at market rates. The projects remain financially weak, despite subsidized fuel prices, principally because power tariffs have been set well below the long-run marginal cost of power production.

When shadow prices (competitive free market prices) are used to value inputs and outputs, economic analyses of the Helwan/Talkha and Shoubrah projects also show they were unsound investments. The projects' low EIRR, (-5.2 percent for Helwan/Talkha and 6.8 percent for Shoubrah) indicate that although the projects are technically sound, their economic value is low. Again, the main problem has been electricity rates held well below the long-run marginal cost of power. Low electricity rates encourage overconsumption and inefficient uses, including uneconomic investments in energy- and capital-intensive industrial projects that generate further losses elsewhere in the Egyptian economy. The World Bank argues that in Egypt, "low energy prices gave wrong signals to the consumers and resulted in the (1) inefficient use of energy by end users; (2) high energy growth rates, rapid depletion of domestic energy resource reserves, and diminished energy export capacity; (3) establishment of energy intensive industries...; (4) lack of incentive for the adoption of energy conservation measures in industry; (5) inefficient resource allocation and suboptimal growth of [gross domestic product] GDP; and (6) an increase in environmental pollution" (World Bank 1992, 6).

Table 1. Internal Rates of Return
for A.I.D.-Financed Power and Telecommunications Projects in Egypt
(percent)

Cases	Financial Rate of Return/ Economic Rate of Return	Helwan & Talkha Project	Shoubrah Project	Talkha Project	Telecom- munications I, II, III Projects	Telecom-munications IV Project
Base case	F	8.9	8.1	13.1	1.0	1.0
	E	-5.2	6.8	17.0	11.0	18.0
No Further Price Reforms	F	7.4	4.1	9.1	1.0	1.0
	E	-11.8	0.3	12.6	11.0	18.0
Indirect Capital Cost 20% Higher	F	8.2	7.8	12.4	0.0	0.0
	E	-5.3	6.6	16.4	9.0	14.0
Indirect Capital Cost 20% Lower	F	9.7	8.4	13.8	1.0	3.0
	E	-5.1	7.0	17.1	15.3	24.0
Benefits 20% Higher	F	12.7	11.5	15.5	5.0	5.0
	E	-2.9	9.6	19.5	15.8	25.0
Benefits 20% Lower	F	4.5	4.4	10.5	-4.0	-6.0
	E	-8.1	3.5	14.2	6.8	11.0
O&M Costs 20% Higher (fuel)	F	7.2	7.2	--	-2.0	-3.0
	E	-7.4	5.4	--	10.0	16.0
O & M Costs 20% Lower (fuel)	F	10.2	9.0	--	2.0	4.0
	E	-2.8	8.3	--	12.6	20.0
Elasticity of Demand of -0.3	F	--	--	--	--	--
	E	-6.2	5.3	16.4	--	--
Elasticity of Demand of -0.1	F	--	--	--	--	--
	E	-2.5	10.9	18.8	--	--

Note: F = Financial, E = Economic, O&M = Operations and maintenance

The "need" for the electricity projects was based on excessive electrical demand driven by the Government of Egypt's policy of low electricity rates. If full long-range marginal-cost pricing of electricity had been implemented, low-valued demands for electricity would have been excluded and the added generating capacity of the projects would not have been needed. In effect, the projects became substitutes for needed policy reform. Furthermore, by increasing electricity supply, the projects inadvertently facilitated the Government's inexpensive-power policy and may have postponed the decision to raise power tariffs.

In contrast to the Helwan/Talkha and Shoubrah power projects, the Talkha combined-cycle addition project was both a financially and economically sound investment, with a 13.1 percent FIRR and a 17.0 percent EIRR. Sensitivity analyses suggested satisfactory rates under a range of alternative assumptions. The high financial and economic values of the project result from its unique technology, which increased the energy production of an existing generating plant without raising fuel and other operating and maintenance (O&M) expenses. The project also benefited from the electricity price reforms initiated as the project began commercial operation. Continued movement toward full-cost electricity pricing is essential to protect the project's economic soundness.

Basically the same covenants and policy issues were included in the Helwan/Talkha, Shoubrah, and Talkha combined cycle projects: reduction of the Egyptian Electrical Authority's (EEA) debt-to-equity ratio, improvement in the rate of return on EEA's fixed assets, and power tariffs set to cover full generation and distribution costs. The projects had limited success implementing the proposed reforms. However, sector policy performance has improved considerably since 1990, primarily because of structural adjustment reforms (including energy pricing) supported by the International Monetary Fund (IMF), the World Bank, and A.I.D. Recent power-sector projects have supported continued movement on the reform agenda agreed to by the Government of Egypt, IMF, the World Bank, and A.I.D.

A.I.D. began major support to Egypt's telecommunications sector with its first disbursements in 1983/1984 and has supported the sector every year since. This support has been delivered under four projects. Telecommunications Projects I, II, and III are combined here and analyzed as a single project. Telecommunications IV, which was only 29 percent disbursed at the time of this assessment (November 1, 1992), is analyzed separately.

Base-case FIRRs for all four telecommunications projects were 1 percent (see Table 1). However, Telecommunications I, II, and III have generated positive net cash flows since 1988/1989, about the time when real telecommunications price reforms began. Telecommunications IV has generated positive net cash flow since operations began. Sensitivity analysis demonstrated that plausible alternative assumptions concerning indirect capital costs, benefit levels, and O&M cost levels resulted in similarly low FIRRs. The telecommunications sector is particularly sensitive to price changes. Failure to maintain already implemented telecommunications tariff reforms would have an adverse effect on financial performance of the Arab Republic of Egypt National Telecommunications Organization (ARENTO).

The 1 percent FIRR for telecommunications is due primarily to the very low tariffs on local calls and subscriptions set by ARENTO, an organization that

practices cross subsidization, block pricing, and price discrimination. ARENTO sets long-distance-call tariffs at world prices, but local call and most installation charges are set well below levels in other Middle Eastern and North African countries. Revenues from international and domestic long-distance calls represent approximately 80 percent of total revenues and appear to be increasing through time as a proportion of total revenues.

Although the telecommunications projects have low financial returns, the economic returns are quite satisfactory. The base-case EIRR for Telecommunications I, II, and III was 11 percent and for Telecommunications IV, 18 percent. Most sensitivity scenarios showed similarly acceptable EIRRs. The economic cash flows are larger than the financial cash flows because of consumer surplus benefits that account for about 45 percent of total real economic benefits.

The telecommunications sector in Egypt generates about 80 percent of its benefits from international calls that are charged at international rates without price controls. In addition, beginning in the late 1980s, tariffs charged for installation of new telephone lines increased in real terms. The recent improvement in financial returns on these projects can therefore be attributed to the smaller influence of artificial price ceilings and the earlier start of tariff reforms. During the last 5 years the telecommunications sector has made real progress on tariff reform, institutional autonomy, training, financial controls, and the rest of the covenants and conditions precedent attached by A.I.D. and other donors to telecommunications sector projects.

Between 1978 and 1990, A.I.D. financed the rehabilitation and expansion of Rod-El-Farag, the largest of 16 sources of potable water in the Greater Cairo water supply system. Although detailed cost information was available for the Rod-El-Farag project, tariff benefits appeared to represent only a small portion of the total benefits from that project. The financial analysis proceeded in the same way for potable water projects as for power and telecommunications projects. Economic analysis of potable water projects used discounted cash flow and internal rate of return techniques but designed to answer a different set of questions than in the analyses of the power and telecommunications projects.

The Rod-El-Farag EIRR is highly negative because anticipated tariff revenues fell well below costs through the entire term of analysis (Table 2). Economically, most project benefits relate to improved health conditions, but these benefits were not estimated because of insufficient data and methodological problems in quantifying them. EIRR analysis was therefore not possible. Instead a different question was asked: How much would project beneficiaries have to benefit if the resources invested in the project were to return an EIRR of 10

Table 2. Internal Rates of Return for A.I.D.-Financed Potable Water and Sewerage Projects in Egypt

Cases	Type of Return	Cairo Water I	Cairo Sewerage II
Base Cases[a]	F	No positive real net financial cash flow.	No positive real net financial cash flow.
	E	10% Requires connected households WTP of $3.13 per month or $37.56 per year.	10% Requires connected households WTP of $11.60 per month or $139.20 per year.
No Further Price Reforms	F	No positive real net financial cash flow.	No positive real net financial cash flow.
WTP for IRR of zero	E	0% Requires connected households WTP of $1.90 per month or $22.80 per year.	0% Requires connected households WTP of $5.65 per month or $67.80 per year.
WTP-Nigeria[b]	E	10% Requires connected households WTP of $3.10 per month or $37.20 per year.	none
WTP-Ghana[b]	E	-6% Requires connected households WTP of $1.56 per month or $18.72 per year.	No positive real net financial cash flow. Requires connected households WTP of $1.43 per month or $17.16 per year.
O&M Costs 20% Higher	F	No positive real net financial cash flow.	No positive real net financial cash flow.
	E	9% Requires connected households WTP of $3.13 per month or $37.56 per year.	9% Requires connected households WTP of $11.60 per month or $139.20 per year.
O&M Costs 20% Lower	F	-7 Requires connected households WTP of $3.13 per month or $37.56 per year.	No positive real net financial cash flow.
	E	11% Requires connected households WTP of $3.13 per month or $37.56 per year.	11% Requires connected households WTP of $11.60 per month or $139.20 per year.

Note: E = Economic, F = Financial, nc = Not computed, O&M = operating and Maintenance, WTP = Willingness to pay

[a]Base cases assume that planned rate increases and policy reforms take place.
[b]Willingness to pay (WTP) studies of water and sewage projects in Nigeria and Ghana are used as a reference for the Egypt projects.

percent? For the water project, this amount is computed at $3.13 per month for connected households. A rate of 10 percent was used because this is the rate the Organization for Economic Cooperation and Development, Development Assistance Committee uses to define commercial rates of return. A.I.D. has also used 10 percent as a minimally acceptable rate of return for projects.

Under current pricing policies, and even anticipating promised tariff reforms, the General Organization for Greater Cairo Water Supply is not a financially viable organization. It will continue to require large and apparently increasing subsidies from public funds. However, it is plausible (using willingness-to-pay surveys from other countries) to suppose that customers for Rod-El-Farag water would be willing to pay $3.13 per month for water which is high enough for an EIRR of 10 percent from the project.

Cairo Sewerage II, one of the largest projects ever financed by A.I.D., provides modern methods of sewage collection, conveyance, treatment, and disposal for approximately 465,000 households (2 to 3 million persons), most of whom live on the west bank of the Nile River in Greater Cairo. The project, and others like it, has already resulted in significant abatement of sewage-related environmental hazards.

Detailed cost information was available for the project. Like potable water, tariff benefits represented only a small portion of total benefits from treatment. The major benefits related to improved health and living conditions but were not estimated for the same reasons that the health benefits of potable water were not estimated. Financial analysis of the project proceeded in the same way as for potable water, power, and telecommunications.

FIRR for Cairo Sewerage II was negative because anticipated tariff revenues remained below costs through the entire project life. The EIRR analysis answers the question: How much would project beneficiaries have to be willing to pay for the resources invested in Cairo Sewerage II for an EIRR of 10 percent? This amount is computed at $11.60 per month for connected households. Based on willingness-to-pay surveys from other countries, and Egypt's per capita income levels, the rate seems excessive.

The Cairo Wastewater Organization is not financially viable and, for the foreseeable future, will continue to require large annual appropriations of public funds. Consumer surplus and external benefits associated with sewage treatment are probably greater than in any other sector examined. But, in light of the enormous cost of the project, the question remains whether the project's economic benefits exceed its costs.

DEFINITIONS OF TECHNICAL TERMS

Consumer surplus	The incremental amount above revenue that consumers are willing to pay for a good or service consumed. Graphically, the triangular area above the price line and below the demand curve on a standard price-quantity diagram.
Externalities	The economic effect(s) present when an action of one economic agent affects the utility or production possibilities of another economic agent in a way that is not reflected in the marketplace.
Fiscal year	For the U.S. Government, October 1 to September 30. FY 1993 runs from October 1, 1992 to September 30, 1993. For the Government of Egypt, July 1 to June 30. FY 1993 runs from July 1, 1992 to June 30, 1993.
Net cash flow	All cash benefits minus all cash costs.
Obligation	A legal commitment of A.I.D. funds through a signed agreement between the U.S. Government and the host government.
Project benefits	Total of revenues, consumer surplus, and externalities generated by a project.
Public good	A good or service jointly consumed by several consumers when the nature of the good or service does not allow the exclusion of consumers for nonpayment (e.g., ambient quality, national defense, national parks, intergenerational rights).
Revenue	Quantity of a good or service times its price.
Tariff	A utility's price for a good or service sold to its customers.

GLOSSARY

A.I.D.	U.S. Agency for International Development
ARENTO	Arab Republic of Egypt National Telecommunications Organization (the Egyptian state telephone company)
CWO	Cairo Wastewater Organization
DCF	discounted cash flow
EEA	Egyptian Electrical Authority
EIRR	economic internal rate of return
FIRR	financial internal rate of return
GDP	gross domestic product
GOGCWS	General Organization for Greater Cairo Water Supply
IMF	International Monetary Fund
LE	Egyptian pound (currency)
OECD	Organization for Economic Cooperation and Development
O&M	operations and maintenance
PACD	project assistance completion date
USAID/Cairo	A.I.D. Mission in Cairo, Egypt

Map of Egypt

1. BACKGROUND

The Egypt capital projects study analyzed nine infrastructure projects selected from the following public utilities sectors: electrical power, telecommunications, potable water, and sanitation. This section provides an overview of conditions existing before and during the evolution of the nine projects.

Electrical Power

The Egyptian Electrical Authority (EEA) operates an electric power grid that covers much of Egypt. Between 1977 and 1992, brownouts and blackouts occurred at various points because of generation and distribution problems and deliberate load shedding.

The power system in Egypt has been characterized by excessive demands induced by a Government policy of extremely low electricity tariffs.[1] The Government kept power prices low as a deliberate policy to favor industrial development. Low prices were important for the viability of certain industries, particularly such energy-intensive industries as aluminum smelting and fertilizer manufacture. If electric power were priced to fully cover long-run marginal costs, some of these industries would not be economically viable. In addition, the Government's low electricity prices—provided as an indirect subsidy to consumers—have been primarily responsible for large EEA operating deficits.

Telecommunications

The Egyptian telephone company, ARENTO (Arab Republic of Egypt National Telecommunications Organization), administers a single telephone

[1]In 1991/1992 dollars, real electricity tariffs were between $0.005 and $0.025 per kilowatt hour between 1976/1977 and 1991/1992. These rates are substantially below typical international rates of $0.07 to $0.14 per kilowatt hour.

network covering all of Egypt. In the mid-1970s, Egypt's telecommunications system was small compared with the number of potential users; it was estimated that Egypt enjoyed fewer than 1 telephone line per 100 households. The system used mechanical switching equipment rather than modern electronic switches.

Communication between Cairo and other Egypt exchanges was unreliable. Only an estimated 30 percent of attempted calls were completed. On average, a call took 1 minute longer to complete than it does today. Because the telephone system was so unreliable, Cairo businesses used thousands of couriers to deliver messages. International callers experienced delays and difficulties in completing calls, and business executives sometimes traveled outside of Egypt to complete international calls.

ARENTO kept subscription fees and local-call tariffs low, and consequently, there were long waiting lists to obtain phone connections. Tariffs on international calls were priced according to international standards, but the volume of calls was much lower than it is today. ARENTO depended on the state treasury to finance recurring operating deficits.

Potable Water

The General Organization for Greater Cairo Water Supply (GOGCWS) produces potable water at 11 filtration plants and from 5 well fields. The system can produce 3.246 million cubic meters of potable water daily. The Rod-El-Farag Potable Water Treatment Plant, a recipient of A.I.D. project assistance, started operating in 1903. Between 1903 and 1964, the plant underwent several expansions, and, by 1977, capacity had reached 300,000 cubic meters daily and the plant was serving approximately 12 to 16 million persons in a 900 square kilometer area. Low water pressure and periodic lack of water were problems in the Rod-El-Farag service area and in the Greater Cairo system.

The Egyptian Government has traditionally considered that potable water is so essential to the public it should be provided free or nearly free of charge. The heavy subsidization of water is often justified by noting that clean water brings substantial social benefits—such as improved health—that are hard to capture with user charges.

Sewerage

In the mid 1970s, Cairo had two small wastewater treatment plants and five pumping stations dating to 1915. Sewage was discharged into pits, canals, open drains, and watercourses and at landfills and other waste sites throughout the city. More than 200 areas of the city were subject to flooding from sewage overflow. Wastewater collected in the sewer system was returned to the Nile

largely without treatment. Untreated sewage created serious health and quality-of-life problems, in Cairo and downstream, exacerbated by Egypt's rapid population growth, which continues today.

Until July 1, 1985, when water users were assessed a surcharge equal to 10 percent of the water tariff, there was no sewerage tariff in Egypt. As with the GOGCWS, the Cairo Wastewater Organization (CWO) operating costs represent a large drain on Egypt's public revenues. The financial analysis suggests that CWO may have annual operating deficits of about $14 million.

2. THE POLICY CONTEXT

A public utility may establish tariffs at rates intended to recover operating and maintenance (O&M) costs—this is sometimes called short-run marginal cost recovery. Alternatively, the utility may set tariffs at rates intended to cover both O&M and capital replacement costs; this is sometimes called long-run average cost recovery. If tariffs do not fully recover long-run average costs, the utility must obtain some financial resources from nontariff sources or eventually it will cease to operate. The Government of Egypt covers annual O&M operating deficits with treasury transfers and much of the capital costs with donor aid.

Government of Egypt policy over the last 15 years has generally been to provide substantial subsidies to utility consumers through price controls and overvalued exchange rates that have kept utility rates artificially low. Consequently none of the nine public utilities studied has ever experienced full long-run average cost recovery. Although cost recovery has improved in recent years, especially since 1990/1991, neither capital nor O&M costs have ever been recovered fully through service tariffs in the power, potable water, or sewerage sectors. ARENTO recently recovered full telecommunications O&M costs but not capital costs.

The Agency for International Development (A.I.D.) and other donors have continually expressed concern about the Government of Egypt's failure to fully recover public utility costs through tariffs. A 1983 USAID/Cairo memo states

> Both AID/W and this Mission have made the convergence of financial prices towards economic prices a major decision criterion in evaluating/selecting among competing programming options. The electricity and water/wastewater sectors are two cases.....

Similarly, a 1985 water and wastewater sector assessment recommended five specific tariff-reform proposals (USAID/Cairo, 1985).

A.I.D. has tried to promote cost recovery and other policy reforms in the public utilities by attaching policy conditions to its projects generally in three areas: (1) tariff reform, including increases in the level of service tariffs; (2) O&M expenditures provided by the utilities at levels adequate to protect project

investments; and (3) increased autonomy for the utilities, with the goal of utilities becoming self-sustaining. Establishing adequate levels of technically trained personnel and internal financial and other controls have been parts of all three areas.

Enforcing policy conditions for public-utility-cost recovery has been difficult for A.I.D. because of political pressures to maintain funding flows to Egypt.

More recently, A.I.D. has made stronger statements and has demonstrated a willingness to say no to new projects where improvements in cost recovery are not likely to occur. Policy reform conditionality is now included in project agreements as conditions precedent to disbursements. USAID/Cairo has financed a series of needs assessments, pricing studies, service-charge studies, and sector studies[2] to identify and resolve large policy and institutional impediments to the viable, long-run provision of power, telecommunications, potable water, and sewerage services. The Mission's 1992–1996 Country Program Strategy states, "...the amount of future assistance in the [Egypt public utility] sectors hinges on the Government of Egypt's willingness to reform policies, particularly those related to cost recovery and operations and maintenance." (USAID/Cairo 1992).

[2]Examples of studies include ASGG, Inc. 1992; Hagler, Bailey, Inc. 1992; and USAID/Cairo 1985.

3. METHODOLOGY: DISCOUNTED CASH FLOW ANALYSIS

Ex ante economic analyses are usually performed before projects begin to determine whether expected returns justify expected costs. According to Taddle (1990)

> An important principle underlying the economic analysis of projects is to determine whether the net benefits from the resources allocated to the projects would exceed, or at least equal, the net benefits to the economy that could be expected if these resources were made available for the next best alternative use.

The nine projects examined underwent limited ex ante economic analyses during their design. Cost-benefit analysis was carried out for only the power projects. Other projects were taken through a form of least-cost, or cost-effectiveness, analysis or none at all.

The methodology of the study evaluates the projects' ex post facto costs and benefits using discounted cash flow (DCF) analysis.[3] DCF analysis compares project costs and benefits through time. Costs include investment costs and the O&M costs that occur over many years. Costs are measured against a stream of benefits caused directly by the project.

DCF is used for both financial and economic analyses. The difference between these analyses is that where financial analysis uses market prices economic analysis uses shadow prices—prices that would prevail in the presence of competition and free markets. From the start of each of the nine projects, outputs and inputs have traded at prices distorted by price controls, overvalued exchange rates, and other market controls. Such distortions are most extreme in the prices of construction materials, foreign exchange, and energy. The adjust-

[3]Cairo Sewerage II and Telecommunications IV projects were not fully disbursed at the time of this assessment—November 1992. Therefore, estimates of total project investments were made.

ment of financial prices to correct for policy-induced distortions is the essence of the computational difference between the analyses.

Price distortions aside, important benefits, especially benefits associated with sewer and water development, do not trade in markets and so are difficult to quantify. Price controls and external benefits can render DCF analysis misleading if revenue benefits alone are used to justify the projects:

> This [DCF] approach, however, presupposes that the projects' costs and benefits can be identified, quantified, and valued in money terms. (Taddle 1990)

The following subsections discuss certain assumptions and parameters used in the DCF analysis.

Inflation

A standard approach to inflation in project analysis is provided by Gittinger (1972):

> ...Assume that all (future) prices on both the cost side and the benefit side will rise uniformly by the same proportion (with) no change in relative values. Then, value all future prices at today's levels.

Each of the projects analyzed started operating between 1977 and 1989. Between 1977 and 1992, the Egypt gross domestic product (GDP) deflator increased more than eightfold. Large changes in relative prices occurred as Egypt unified its foreign exchange markets. In these circumstances, the standard approach as described by Gittinger can be applied to future, but not to past, prices and costs.

In both the financial and economic analyses, Egyptian inflation between 1977 and 1992 is removed by converting nominal Egyptian pounds to U. S. dollars using historic exchange rates. The official rate is used in the financial analysis and the market rate is used in the economic analysis. Regression analysis revealed a high correspondence between the evolution of the Egypt GDP deflator and the foreign exchange rates; this permits the conversion of nominal pounds to dollars at the historic exchange rates to account for Egyptian inflation. Dollar figures are then deflated by the U.S. GDP deflator shown in Table 3, with the 1991/1992 deflation equal to 1.00. As Gittinger suggests, relative prices and costs in 1992 and beyond are assumed constant at 1992 levels, except when adjusted to account for anticipated policy changes.

Table 3. Egyptian Deflators, Exchange Rates, and Shadow Prices, 1977/1978 - 1991/1992

	1978-1979	1979-1980	1980-1981	1981-1982	1982-1983	1983-1984	1984-1985	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	1992-End
Deflator:															
U.S. GDP ($)	0.54	0.59	0.64	0.70	0.73	0.76	0.78	0.81	0.83	0.86	0.89	0.92	0.96	1.00	1.00
Exchange Rates:															
Official															
Pounds to Dollars	0.39	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	1.11	2.42	3.33	3.33
Dollars to Pounds	2.56	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	0.90	0.41	0.30	0.30
Market															
Pounds to Dollars	0.69	0.71	0.83	1.00	1.11	1.17	1.35	1.77	2.02	2.35	2.59	2.74	3.17	3.33	3.33
Dollars to Pounds	1.45	1.41	1.21	1.00	0.90	0.85	0.74	0.56	0.50	0.43	0.39	0.37	0.32	0.30	0.30

Shadow Price Coefficients — All Years:

Nontelecommunications construction materials: $1.667

Telecommunications building and construction materials: $1.669

Telecommunications O&M costs: $0.972

Exchange Rates

Before 1991/1992, the Government of Egypt controlled foreign exchange markets. The pound was greatly overvalued, a policy intended to make Egyptian-produced goods more competitive than imported goods in Egypt. Exchange-rate manipulation introduced serious price and cost distortions in the projects analyzed.

In the financial analysis, Egyptian pound costs and revenues were converted to U.S. dollars at the official rate of exchange applicable to the year and commodity in question. This mirrors actual project experience.

In the economic analysis, nominal Egyptian pound costs and revenues were converted to U.S. dollars at the free market rate of exchange. Table 3 shows yearly official and market rates of exchange, which were unified in 1991/1992.

Shadow Prices

Egypt operates several enterprises that supply inputs to the utilities benefiting from the A.I.D. projects under review. The Government's policy has been to set prices artificially low for critical utility inputs and services. As a result, significant price distortions exist in markets for construction materials and fuel used by the utilities. These items are subjected to shadow pricing in the economic analyses of the nine projects.

To remove the effects of price controls, shadow prices or shadow-price coefficients are applied to several inputs used by the utilities. Shadow-price coefficients developed by Page (1982) (see Table 1) are used for three items—non-telecommunications construction materials, telecommunications building and construction materials, and telecommunications O&M costs.

The shadow prices of domestic fuel oils used in the electric power plants are based on their border prices or export values. The shadow price of natural gas is determined by the energy equivalent of the export price of heavy fuel oil. This is what recent EEA and World Bank (World Bank 1992) economic analyses of power projects have used. The idea is that the opportunity cost of natural gas is the value of fuel oil exports that use of natural gas facilitates.

The issue of the economic price of natural gas burned in Egyptian power plants was analyzed extensively in a recent USAID/Cairo study of the long-run marginal costs in electricity pricing (Hagler, Bailey, Inc. 1992). The study, which provided baseline estimates of the long-run marginal costs against which tariff

increases will be made between now and 1995, considered an alternative approach of pricing natural gas using a depletion premium and the cost of exploitation. The approach was rejected, however, for one principle reason: Gas reserves and production in Egypt are not large compared with domestic demand. Gas production is not large enough to fully displace other fuels in appropriate uses in power plants and industry. In the future, as more gas is burned in power plants, more fuel oil will be available for export or less will have to be imported. The opportunity cost of natural gas is therefore determined by the border price of fuel oil. However, if natural gas production were to increase dramatically, the alternative method of shadow pricing natural gas may become appropriate. Sensitivity analyses included in the economic analysis of the power project allow fuel prices to fall 20 percent and provide some sense of the impact of the alternative natural gas shadow pricing approach.

Length of Analyses

The projects are analyzed for a term of years beginning when the first capital costs were disbursed and ending 25 years after the last capital costs were disbursed or are scheduled to be disbursed. For example, the Cairo Water I Project began in 1977 and ended in 1989. Its term of analysis begins in 1977 and ends in 2014, 25 years after the project's 1989 completion.

Project Costs and Cost Recovery

All projects had capital costs and O&M or recurrent costs. Capital costs include the initial costs of generators, transmission lines, new buildings, switching stations, satellite dishes, pumps, mains, filters, culverts, settling tanks, and other plant and equipment associated with installing new or rehabilitated services. Training, planning, financial controls, and other institutional-strengthening activities were also financed with project capital. The full recovery of project costs—long-run average cost recovery—involves generating sufficient revenue to finance the replacement of these capital items.

O&M costs are recurrent expenditures associated with providing services. Such costs include salaries and wages, fuel, electricity, supplies, communications, chemicals, routine maintenance (not the replacement of capital items), and other expenses incurred to ensure normal operations of the public utilities. Full O&M cost recovery—short-run marginal cost pricing—requires generating enough revenue to cover the normal recurrent costs. Total costs are the sum of capital and O&M costs. Section 4 describes the capital and recurrent costs associated with each project analyzed.

Project Benefits

Three kinds of benefits are central to the economic analysis of Egypt's capital projects: Revenue or tariff benefits, consumer surplus benefits, and external benefits. Table 4 describes tariff, consumer surplus, and external benefits as they pertain to the Egyptian public utilities.

Tariff or Revenue Benefits

Tariff benefits are the benefits utilities derive from selling services. The tariff revenues used in the analyses are derived from the additional output produced by the projects. Tariff revenues are calculated by multiplying the quantities of new services (kilowatts, phone lines, cubic meters of water) attributable to the projects by the prices of the services.

Tariff benefits are the only measure of benefit used in the financial analyses and provide the starting point for measuring economic benefits. For financial and economic analyses of projects before 1992/1993, actual year-by-year tariff rates charged by the Egyptian public utilities are used. For post 1992/1993 analyses, Government commitments on increased tariffs are used in all base-case scenarios: For example, if the utility has agreed to raise tariffs by a certain rate in a future year, the promised tariff is used in the base-case scenario. Sensitivity analysis projects the 1991/1992 service tariffs without incorporating promised tariff increases.

Revenue from the sale of project output is the main measure of economic benefits when the project's output is sold in competitive markets with no significant price controls or externalities. Market price is set by market supply and demand and serves to clear the market, eliminating excess demand or supply. In Egypt, however, markets are distorted by numerous subsidies and price controls. Excess demand for public-utility services and products has been widespread, with market-clearing prices generally well above controlled prices. Hence, revenue captures only part of the economic benefits of utility projects. Market benefits missed by revenue are included in consumer surplus benefits. (External benefits are not included in consumer surplus benefits.)

Table 4. Benefits Associated With Egyptian Capital Projects

Type of Benefit	Sewerage	Potable Water	Telecommunications	Power
Revenue	Connected households pay $0.3965 to $0.972 per household per year to process a total of 700,000 m^3 per day of sewage.	Connected households pay $0.042 per m^3 and consume a total of 450,000 m^3 of potable water per day.	Connected households pay $114 per new line per year plus $104 per new line installed. Together the four telecommunications projects added 263,000 new lines.	Connected households pay $0.0251 per kilowatt hour for newly generated power.
Consumer Surplus	Much excess demand as a result of low controlled price. Most connected households willing to pay more for ambient quality improvements, health benefits, and convenience.	Much excess demand as a result of low controlled prices. Most connected households willing to pay more for improvement in convenience, time, quality, health, and system pressure.	Considerable excess demand. Most connected households willing to pay more for increased call-completion rates, decreased call-completion time, and similar service improvements.	No significant excess demand. Some customers willing to pay more for stabilized voltage and reduced brownouts and blackouts.
External	Large external benefits. Less polluted water downstream. Reduced mortality and morbidity. Ambient quality improves for nonusers. Public Health care costs fall.	Significant external benefits. Water pressure increased throughout greater Cairo system. Public health care costs fall.	Limited but important external benefits. Essential for many businesses. Important for tourism.	Limited external benefits for industry and tourism.

Consumer Surplus Benefits

The economic analyses of the utility projects add quantified estimates of consumer surplus benefit to estimates of tariff benefit. Consumer surplus arises because at least some consumers would be willing to pay more than the prevailing market price for the good or service. On a standard, price-quantity demand diagram, consumer surplus is the triangular area below the demand curve and above the price line (Figure 1, area S).

In the economic analyses of the utility expansion projects, incremental not aggregate consumer surplus is added to tariff benefits to estimate total economic benefits. Incremental consumer surplus is measured by the increase in quantity supplied as a result of the project times the difference between the prevailing price and the average value consumers would be willing to pay for additional output. In Figure 2, the incremental consumer surplus is the area marked IS.

Public policies distort Egypt's public-utility markets. Prices are generally set well below market-clearing prices, resulting in considerable excess demand. This differential between the actual price and the market-clearing price creates more consumer-surplus benefits, which are included in the economic analyses.

Consumer surplus benefits are important to all the projects analyzed. They are directly assessed in the power and telecommunications economic analyses and indirectly included in the willingness-to-pay measures used in the water and sewerage economic analyses.

Willingness to Pay

Willingness to pay is a central idea in the quantification and valuation of benefits. A consumer's willingness to pay for a good or service is the maximum amount the consumer would be willing to give up in exchange for the good or service (Boadway and Bruce 1984; Mitchell and Carson 1989; Just et al. 1982). Willingness to pay equals the sum of revenue plus consumer surplus.

Aggregate willingness-to-pay is depicted in Figure 1. Demand for output of a public utility is a decreasing function of price. At price p_0, quantity q_0 is demanded. Revenue, R, equals price times quantity, p_0q_0. But consumers to the left of q_0 would actually be willing to pay more than p_0 for their consumption. Aggregate value, or maximum willingness to pay, R plus S, is the sum of revenue plus consumer surplus—the triangular area, S, above the price line p_0 and below the demand curve.

Where revenue and consumer surplus are difficult to measure directly, they can be replaced by willingness to pay measured by consumer surveys. Where direct demand estimates based on consumers' responses to alternative prices are not feasible, survey estimates may provide the best alternative measure. Direct demand estimates were not available for the Egyptian water and sewerage projects nor did the time and scope of the present study permit surveys. An alternative approach, analyzing the level of benefits required to earn an economic internal rate of return (EIRR) of 10 percent, is discussed in the sections on potable water and Cairo Sewerage II.

External Benefits and Other Nonquantified Benefits

A project may also generate external benefits for persons who are not direct utility consumers. Externalities exist when an action of one economic agent affects the utility or production possibilities of another in a way not reflected in the marketplace (Just et al. 1982). Externalities exist when a households or producer's preference ordering includes goods consumed by other consumers or producers (Boadway and Bruce 1984).

External benefits are perceived as very important in the water and sewerage projects. For example, potable water and sewage disposal create community public health benefits even for households not directly connected to the systems. And sewerage treatment creates significant external health and environmental benefits for the millions of Egyptians who live below the Greater Cairo sewage outfalls. Market prices capture most benefits in the power and telecommunications sectors, where external benefits are relatively less important. However, because of methodological problems and lack of data, these benefits are quantified in the report only for the sewerage project. Examples of other nonquantified benefits include the benefits of increased reliability of utility supplies, improved managerial efficiency translating into better and more efficient customer service, and indirect effects on industrial growth.

Discounted Net Cash Flow

Discounted-net-cash flow (DCF) is the difference between the discounted aggregate stream of benefits and the discounted aggregate stream of costs. These discounted benefits and costs were used to calculate three measures of financial and economic soundness for each of the nine projects: internal rate of return, benefit-cost ratio, and net present value. The internal rate of return is the DCF measure of choice and receives the most analysis because it can be compared with a "minimum" opportunity cost of capital, such as 10 percent.

Sensitivity Analyses

Several types of sensitivity analyses were carried out. These analyses estimate the impact on the financial rate of return (FIRR) and EIRR of alternative but plausible assumptions concerning costs and benefits. For the power projects, the impact of not continuing energy price reforms as promised, of alternately increasing or decreasing fuel costs, and of alternative demand elasticity assumptions are estimated. Other sensitivity analyses prepared for the projects include the impacts of alternative indirect capital costs, O&M costs, and direct benefit estimates. Alternative rate-of-return and willingness-to-pay assumptions are also incorporated into the sensitivity analyses for the water and sewerage projects.

4. PROJECT ANALYSES

For the financial and economic analyses of each project, DCF measures include internal rates of return. Internal rates of return for all projects are summarized in Tables 1 and 2 in the Summary of this report. Sensitivity analyses are carried out for the projects and discussed in the text.

Helwan and Talkha Gas Turbine Plants

The Helwan and Talkha Gas Turbine Plants Project began in 1977/1978. The project constructed a 120 megawatt gas turbine generator plant at Helwan and a 180 megawatt gas turbine generator plant near the city of Talkha. A.I.D. provided $67.4 million beginning in fiscal year (FY) 1976 and the Government of Egypt provided the pound equivalent of $14.9 million.

The gas turbines were designed to be prepackaged electric-power- generating plants with all required auxiliaries. These units were to operate continuously for 4,000 hours per year and for 30 starts per year while firing on natural gas with Solar oil (No. 2 fuel oil) as an alternative fuel. The gas turbines were to be capable of conversion for firing on Mazout oil (No. 6 fuel oil).

The Helwan plant is near an important iron and cement complex approximately 30 kilometers south of Cairo. Natural gas is obtained from the Abu Il Gharadig gas field located approximately 200 miles west of Cairo. The existing gas lines passed within 3 kilometer of the site and were extended to the site. The Helwan plant delivers power at 66 kilovolt, 50 hertz. The power plant is tied into the Cairo 220 kilovolt electric transmission grid.

The Talkha plant is located near Talkha in the compound of the 127 megawatt Talkha Thermal Electric Power Station. Natural gas, the primary fuel, is supplied from the Abu Madi gas field though existing pipelines. The plant delivers power at 220 kilovolts, 50 hertz and feeds power into the existing 220 kilovolt substation and transmission line.

The first engineering designs for both power plants were issued in June 1978. Construction began in November 1978. Delivery to the sites of gas

turbines, generators, and transformers was completed in June 1979. The Helwan units and the first six Talkha units were provisionally accepted and placed in commercial operation in December 1979, whereas the remaining two Talkha units were not completed until March 1980.

Training of operators and maintenance personnel consisted of formal classroom training with General Electric in the United States. A total of 40 personnel were trained.

The gas turbines met a critical need for electrical-energy supply for Egypt's Unified Power System. During the first full year of operation, both plants generated 56 percent of their rated output capacity, well above normal utility dependence on gas turbine capacity.

Covenants, Conditions Precedent, and Policy Reform

The turbine gas project aimed at improving the financial and economic soundness of EEA. The Project Paper included covenants that required a debt-to-equity ratio for EEA no greater than 1.5:1 within 3 years, targeted a rate of return on EEA fixed assets of 9 percent within 3 years, and required a tariff increase to achieve the proposed rate of return on assets. However, the project's overall effectiveness was limited in achieving sector policy reform during its implementation.

Project Costs

The Helwan and Talkha Gas Turbine Plants Project had a life-of-project A.I.D. obligation of $67.4 million and a Government of Egypt contribution of 11.7 million Egyptian pounds for direct capital costs. Indirect capital costs associated with increased transmission, distribution, and overhead investments added an estimated $13.1 million (A.I.D. obligation) and 25.6 million pounds. First project disbursements occurred in 1977/1978 and final disbursements were made in 1980/1981 (see project financial and economic analyses in Tables A-1 and A-2 in the Appendix).

O&M costs are expected to reach $23.2 million annually by 1995/1996. This level of costs includes routine and preventive maintenance, salaries and wages, benefits, fuel, and other regularly recurring costs, but it does not include funds to replace capital investment items. O&M costs are high because of the excessive number of people who work at the plants.

Costs are projected for 25 years after project completion assuming that energy price reforms continue as agreed under the terms of the World Bank structural adjustment loan requiring energy pricing at 100 percent of economic costs by mid-1995. All other costs beyond FY 1992 are projected assuming no change in relative prices.

Economic costs are the same as financial costs except that cost distortions caused by Government price controls are eliminated by pricing inputs at free market prices. The most important price distortions include construction and building costs, fuel costs, and the exchange rate. Local currency costs of construction and building investments were increased by approximately 67 percent to eliminate the effect of these subsidized costs, and fuel costs were increased by pricing fuel at its export value. Use of the free- market exchange rate—instead of the overvalued official exchange rate—to convert local currency to dollar equivalents reduced overall costs. After 1992 the two rates were unified.

Project Benefits

Tariff benefits (revenues). The main measure of the project's economic benefit is the revenue from the sale of electricity to end users and associated service connection and maintenance charges beginning in FY 1980. The price of electricity is subsidized and remains well below the long-run average cost. And, except for the intermittent peak-load service interruptions that occurred before the late 1980s, consumers have generally been able to obtain all the power they wanted at the subsidized prices. This has induced excessive power consumption, including low-valued and wasteful uses of electricity. Although such price controls have significantly distorted market demand throughout the Egyptian economy, the net effect of these distortions on the demand for electricity has not been large enough to preclude using market demand to determine economic benefits.[4] Hence, the administered supply price of electricity determines the per-unit economic value of electricity and market demand determines the quantity sold. However, the potential impact of market distortions generating alternative benefit levels is explored in the sensitivity analyses.

Base-case revenues are projected, assuming that electricity price reforms continue as agreed under the structural adjustment loan. The depreciated salvage value of the plant is included as a benefit in the final year.

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[4]Government controls on prices, interest rates, and the exchange rate have increased the capital and energy intensiveness of Egyptian industry, thereby raising the aggregate demand for electricity.

Consumer surplus benefits. Consumer surplus in the power market exists when at least some consumers are willing to pay higher power prices than the prices set by EEA. The primary consumer surplus benefit is represented by the traditional consumer surplus triangle that results from a downward sloping demand curve. Consumer surplus benefits also occur because of unserved excess demand. These benefits may be measured assuming the newly served beneficiaries are distributed randomly over the full demand curve (Webb and Pearce 1985). Hence, these per-unit benefits are much greater than the traditional measure of consumer surplus. In measuring consumer benefits in this analysis, it is estimated that at least 90 percent of the power generated was used to serve price-rationed customers and no more than 10 percent served excess demand. This is based on EEA data indicating that peak-load shedding represented less than 10 percent of total power generated before the project. In the economic analysis, consumer surplus benefits increased tariff benefits by more than 40 percent.

Consumer surplus may be derived by estimating the elasticity of demand for electricity. Market demand may be estimated indirectly through estimates of consumer willingness to pay for close substitutes. However, no reliable data are available on the extent of autogeneration of power in Egypt. An alternative method, used in this report, is to estimate demand-price elasticity directly. Econometric estimates from industrial countries have generated estimates that cluster in the -0.1 to -0.5 range. The estimate for India is -0.2. Direct estimates for Egypt have been restricted by the lack of price variation. Hagler and Bailly (1992) produced estimates in the range of -0.1 to -0.3. EEA is currently using similar elasticity estimates in developing their load forecasts. A.I.D. has repeatedly used estimates for Egypt of between-0.1 and -0.3 (in USAID/Cairo staff economic papers by Richter and Adler) and the World Bank has used an estimate of -0.5. Evidence from Egypt and elsewhere indicates that a range of -0.1 to -0.3 is likely to contain the true price elasticity for Egypt. Hence, the base-case economic analysis used an elasticity of -0.2. Sensitivity analysis tests the impact of alternative elasticity estimates of -0.1 and -0.3.

Nonquantified benefits. The Helwan and Talkha gas power plants helped stabilize voltage and reduce transmission losses for the entire EEA system. These benefits are not readily quantified, were probably not that large, and are therefore not included in the DCF analysis.

Financial and Economic Analyses

Base case. Tables A-1 and A-2 in the Appendix present the data used to carry out the financial and economic analyses of the Helwan and Talkha Gas Turbine Plants Project. Financial DCF measures rely only on tariff benefits. The

economic DCF measures include monetary estimates of tariff and consumer surplus benefits.

During the construction period through FY 1981, project costs were greater than project benefits even although revenues were generated early in the project when the first turbines came on line in FY 1980. Since FY 1981, *financial* benefits have been greater than costs.

The project's FIRR is 8.9 percent. The benefit-cost ratio of 0.95 indicates that discounted benefits are 5 percent less than discounted costs at a 10 percent opportunity cost of capital. At 10 percent, the net present value of the investments are minus $18 million.

The weak financial viability of the project is influenced primarily by tariffs set well below the long-run average cost of producing electrical power. However, because the Government has financed EEA at negative real interest rates and has subsidized fuel costs, the project has made a limited but positive contribution to the financial viability of the power sector.

Largely because of low tariffs and the high economic cost of fuel, real *economic* benefits were less than real economic costs through FY 1991— despite significant tariff increases that began in FY 1989. Net real benefits finally became positive in FY 1992 and are estimated, in the base case, to increase thereafter as real tariffs increase under the economic reform program. Continued movement toward full-cost pricing would significantly enhance the economic viability of the project.

The project's base case EIRR is minus 5.2 percent. The benefit-cost ratio of 0.32 indicates that discounted real benefits are 68 percent less than costs using 10 percent as the opportunity cost of capital. The net present value of the investment is minus $625 million.

Despite the project's technical soundness, its economic value is low. Its economic DCF measures are lower than its financial ones. This counter-intuitive result occurs because in the economic analysis inputs are valued at their real cost to society, whereas in the financial analysis input costs are subject to price controls. Shadow pricing of costs outweighs the value of consumer surplus in the economic analysis.

The project's weak economic performance is caused by low benefits resulting from tariffs set well below the cost of power supply during the 12 years of operation. A contributing cause is the Government's policy of setting low prices for state-supplied natural gas, fuel oil, and construction materials. By increasing the supply of electricity, the project inadvertently bolstered the Govern-

ment's inexpensive-power policy and may have postponed the decision to raise power tariffs.

Sensitivity Analyses

Several types of sensitivity analyses were carried out to determine the impact of alternative assumptions on FIRR and EIRR for the project: (1) The energy price reforms agreed to under the terms of the World Bank structural adjustment loan were assumed to be discontinued. (2) Indirect capital costs (such as the costs of the national power grid, the national telecommunications system, and other supporting infrastructure that provide benefits to the A.I.D. project) were assumed to increase or decrease by 20 percent. (3) The cost of fuel was assumed to increase or decrease by 20 percent. (4) Elasticity of demand for electricity was projected to increase from -0.2 to -0.3 or to decrease from -0.2 to -0.1. (5) Total benefits were assumed to increase or decrease 20 percent. The following results of the analyses suggest that under most plausible assumptions the financial viability of the project is marginal, and EIRR remains negative.[5] Nonquantified benefits mentioned previously are not likely to increase project benefits by more than 0.5 or 1.0 percent.

	FIRR (%)		EIRR (%)	
Base case, energy price reforms continue		8.9	-5.2	
No further energy price reforms		7.4	-11.8	
Indirect capital cost 20 percent higher		8.2	-5.3	
Indirect capital cost 20 percent lower		9.7	-5.1	
Fuel cost 20 percent higher	7.2	-7.4		
Fuel cost 20 percent lower		10.2		-2.8
Elasticity of demand -0.3		--		-6.2
Elasticity of demand -0.1		--		-2.5
Benefits 20 percent higher		12.7		-2.9
Benefits 20 percent lower		4.5	-8.1	

[5]The project's EIRR remains low unless extreme assumptions are used, for example, increasing project benefits by over 200 percent. The low EIRR is largely the result of the very high international fuel prices and very low electricity tariffs in the first half of the 1980s.

Shoubrah El Kheima Thermal Power Project

The Shoubrah El Kheima Thermal Power Project began in 1978/1979. A.I.D. funded $261.2 million of the project's costs, and other international donors, including the World Bank, the African Development Bank, the European Investment Bank, Japan, the European Economic Community, and Italy provided $482.8 million. The Government of Egypt provided the equivalent of $78.2 million in Egyptian pounds.

The project involved engineering and constructing a thermal power plant at Shoubrah El Kheima, a part of Greater Cairo. The plant initially included two steam-generating units, each capable of producing 315 megawatts net, together with the necessary auxiliary equipment, including fuel storage, transmission linkage to Egypt's Unified Power System, and communication and control equipment. The project was amended in 1981 to add a third 315 megawatt plant and again in 1985 to engineer and construct a fourth 315 megawatt generator and to provide transmission linkages and technical assistance. The four units together added 1,260 megawatts of total generating capacity to the Egypt power grid.

Construction began in FY 1982. The first three 315 megawatt units were completed in 1985 and the fourth unit was completed in 1988.

Initially, Mazout (No. 6, heavy fuel oil) was to be the primary fuel for the plant, supplied by pipeline by the Egyptian General Petroleum Corporation. Subsequently, natural gas became the preferred fuel and has since supplied over two-thirds of the plant's fuel needs.

The four generators added significantly to EEA's installed capacity and, in 1988, represented more than 12 percent of system generating capacity. Operation of the four units has been satisfactory since their commissioning. Reliability has been high and, since 1986, the first year units I, II, and III were in full commercial operation, forced outages have never exceeded 4 percent. When available, the units have been used at 75 to 85 percent of their rated capacities.

Covenants, Conditions Precedent, and Policy Reform

The Shoubrah project tried to improve EEA's financial and economic soundness. Project policy conditionality focused on reducing EEA's debt-to-equity ratio, improving the rate of return of EEA's fixed assets, and increasing electric power tariffs to cover all generation and distribution costs.

Overall, the Shoubrah power project had very limited success in achieving sector policy reform during its implementation. However, sector policy performance has improved considerably since 1990, primarily because of the Government of Egypt's structural-adjustment reforms (including energy pricing) supported by the IMF, World Bank, and A.I.D. Recent power sector projects have also played a supporting role, encouraging continued movement with the reform agenda agreed to by the Government of Egypt, IMF, the World Bank, and A.I.D.

Project Costs

The Shoubrah El Kheima Thermal Power Project includes capital costs and O&M costs, both of which have U.S. dollar and Egyptian pound elements. Life-of-project direct-capital-dollar costs were $744 million, of which A.I.D. contributed $261.2 million. The Government of Egypt provided an estimated 120 million pounds. Indirect capital costs associated with increased distribution and overhead investments added an estimated $76.1 million and 57.4 million pounds. First disbursements occurred in 1980/1981 and final disbursements occurred in 1988/1989.

O&M costs include project fuel costs, plant labor costs, and induced indirect O&M costs. They are projected to reach a level of $109 million annually by 1995/1996. Real costs are projected for 25 years after project completion assuming that energy price reforms continue.

Economic costs are the same as financial costs except that local currency cost distortions caused by price controls are eliminated by pricing inputs at free market prices. The most important price distortions are construction and building costs, fuel costs, and the exchange rate. Local currency costs of construction and building investments were increased by approximately 67 percent to eliminate the effect of these subsidized costs, and fuel costs were increased by pricing fuel at its export value. Using the free market exchange rate, rather than the overvalued official exchange rate, to convert local currency to dollar equivalents reduced overall dollar costs before FY 1992 when the rates were unified. Real costs beyond FY 1992 are projected, assuming no change in relative prices.

Project Benefits

Tariff benefits (revenues). The project's main financial benefit is the revenue gained from the sale of newly generated electricity to end users and associated service connection and maintenance charges that began in 1984/1985. Revenues are projected assuming real tariffs will increase and reach the 100

percent full-cost pricing target in 1995. The depreciated salvage value of the plant is included as a benefit in the final year.

Project revenue is also the primary measure of the economic benefit of the project. Although the price of electricity is subsidized and remains well below the long-run marginal cost, consumers have generally been able to obtain all the power desired (except for during intermittent peak-load service interruptions that occurred befor the late 1980s). This has induced excessive power consumption, including low-valued and wasteful uses of electricity. Market demand has been significantly distorted by price controls throughout the economy. The administered supply price of electricity determines the per-unit economic value of electricity, and market demand determines the quantity sold. The potential impact of market distortions generating alternative benefit levels is explored through the sensitivity analyses.

Consumer surplus benefits. Consumer surplus exists in the power market when some consumers would be willing to pay higher prices for power than the prices set by EEA. Consumer surplus benefits also occur when the project meets previously unserved, excess demand, manifested by peak-load brownouts and blackouts.

The primary consumer surplus benefit is represented by the traditional measure of the consumer-surplus triangle that results from a downward sloping demand curve. Consumer surplus benefits also occur because of unserved excess demand. Such benefits may be measured assuming newly served beneficiaries are randomly distributed over the full demand curve (Webb and Pearce 1985). Hence, these per-unit benefits are much greater than the traditional measure of consumer surplus. In measuring consumer benefits for this report, it was estimated that at least 95 percent of the power generated was used to serve price-rationed customers and no more than 5 percent served excess demand. The estimates were based on EEA data indicating that peak-load shedding represented less than 5 percent of total power generated before the project.

Market demand could be estimated indirectly through estimates of consumer willingness to pay for close substitutes. However, no reliable data are available on the extent of autogeneration of power in Egypt. An alternative is to estimate demand-price elasticity directly. Numerous econometric estimates from industrial countries have generated estimates that cluster in the -0.1 to -0.5 range. The estimate for India is -0.2. The work of Hagler and Bailly, as in the analysis of the Helwan and Talkha plants, produced estimates in the range of -0.1 to -0.3. EEA is currently using similar elasticity estimates to develop load forecasts. A.I.D. has repeatedly used estimates for Egypt of between -0.1 and -0.3 (in USAID/Cairo staff economic papers by Richter and Adler) and the World Bank (1990) has used an estimate of -0.5 for Egypt. Evidence from Egypt and else-

where indicates that the -0.1 to -0.3 range is likely to contain the true price elasticity for Egypt. Hence, the base-case economic analysis assumed an elasticity of -0.2. Sensitivity analyses explore the impact of alternately using elasticity estimates of -0.1 and -0.3.

Nonquantified benefits. The Shoubrah power plant helped improve supply quality and reduced transmission losses for the entire EEA system. These benefits are difficult to quantify but are probably not large and therefore are not included in the DCF analysis.

Financial and Economic Analyses

Discounted cash flow DCF measures—base case. Tables A-3 and A-4 in the Appendix present the data used to carry out the financial and economic analyses of the Shoubrah El Kheima Thermal Power Project. Financial DCF measures rely only on tariff benefits. The economic DCF measures include monetary estimates of tariff and consumer surplus benefits.

During the main construction period through FY 1988, project costs exceeded project benefits even though early project revenues were generated by the first turbines coming on line beginning in FY 1985. However, tariff increases that took effect in FY 1991 and are scheduled to continue through FY 1996 have generated and should continue to generate higher net benefits.

The project's FIRR is 8.1 percent. The benefit-cost ratio of 0.91 indicates that discounted benefits are 9 percent less than discounted costs using 10 percent as the opportunity cost of capital. The net present value of the investments at a 10 percent discount rate is minus $144 million.

The *weak financial viability* of the project is influenced primarily by tariffs set well below the long-run marginal cost of power supply. However, because the Government has financed EEA at negative real interest rates and has subsidized fuel costs, the project has made a limited but positive contribution to the financial viability of the power sector. Any delay in continuing energy price reforms would significantly reduce the financial viability of the project, as shown by the sensitivity analyses.

The project's base-case EIRR is 6.8 percent. The resulting benefit-cost ratio of 0.82 indicates that discounted real economic benefits are 18 percent less than economic costs using 10 percent as the opportunity cost of capital. The net present value of the investments is minus $316 million.

Despite the technical soundness of the project, its economic value is low. Economic DCF measures are lower than financial ones. This counterintuitive result occurs because in the economic analysis inputs are valued at their real cost to society, whereas in the financial analysis input costs are subject to low price ceilings. Shadow pricing of costs outweighs the value of adding consumer surplus in the economic analysis.

Revenue benefits were less than the economic cost of power supply during the initial years of operation because the Government of Egypt maintained electricity tariffs at an artificially low level. Low electricity rates encouraged overconsumption and inefficient uses, including poor investments in energy- and capital-intensive projects that generated economic losses elsewhere in the Egyptian economy. If full long-range-marginal-cost pricing of electricity had been implemented, low-valued demands for electricity would have been excluded and some of the project's generating capacity would probably have been redundant. Furthermore, by increasing the supply of electricity, the project inadvertently facilitated the Government of Egypt's power policy and may have postponed the decision to raise power tariffs. Continued movement toward full-cost pricing will significantly enhance efficiency in Egypt's power sector.

Sensitivity analyses. Several types of sensitivity analyses were carried out to determine the impact of alternative assumptions on FIRR and EIRR for this project. (1) The energy price reforms, as agreed under the terms of the World Bank structural adjustment loan, were assumed to be discontinued. (2) Indirect capital costs were assumed to alternately increase and decrease by 20 percent. (3) The cost of fuel was assumed to alternately increase and decrease 20 percent. (4) The elasticity of demand for electricity was assumed to increase from -0.2 to -0.3 and then decrease to -0.1. (5) Total benefits were assumed to increase and then decrease 20 percent. The following results suggest that under most plausible assumptions FIRR and EIRR remain below the assumed 10 percent opportunity cost of capital. Only by assuming that benefits increase 20 percent in the financial analysis or that demand is more inelastic, are rates of return above 10 percent generated.

	FIRR (%)	EIRR (%)
Base case, energy price reform continue	8.1	6.8
No further price reforms	4.1	0.3
Indirect capital cost 20 percent higher	7.8	6.6
Indirect capital cost 20 percent lower	8.4	7.0
Fuel cost 20 percent higher	7.2	5.4
Fuel cost 20 percent lower	9.0	8.3
Elasticity of demand -0.3	--	5.3
Elasticity of demand -0.1	--	10.9
Benefits 20 percent higher	11.5	9.6
Benefits 20 percent lower	4.4	3.5

Talkha Combined-Cycle Addition

The Talkha Combined-Cycle Addition Project began in 1986/1987. A.I.D. dollar obligations totaled $64.7 million. The Government of Egypt provided the equivalent of $11.5 million in Egyptian pounds.

The project involved engineering and constructing a nominal 110 megawatt thermal-cycle addition to the existing 192 megawatt gas turbine plant at Talkha and upgrading the eight existing gas turbines. The thermal-cycle addition included an individual heat recovery steam generator for each gas turbine, two steam turbine generators capable of producing 55 megawatt each under normal operating conditions, and auxiliary equipment and controls. The project sought to increase the efficiency of EEA's existing gas-turbine generating facility by recycling otherwise wasted heat energy.

The heat recovery steam generators were designed to use exhaust gases from the gas turbines as thermal energy. Hot exhaust gasses convert water into steam to drive the steam turbine generators, which produces an additional 106 megawatts of electrical energy when the eight gas turbines are operating at full output. Performance of the gas turbines was upgraded by replacing hot-gas path components with components designed to increase output 5 percent and improve the heat rate 3 percent.

The Talkha combined-cycle addition uses natural gas as its primary fuel and No. 2 fuel oil as secondary fuel. The plant began commercial operation in FY 1990. Energy generated from the new thermal-cycle addition and upgrades increased approximately 50 percent compared with previous years with no increase in fuel consumption. The rate of fuel consumption is 231 grams per kilowatt hours, well below the system's average of 263 grams per kilowatt hour.

Covenants, Conditions Precedent, and Policy Reform

The covenants and policy issues included in the Helwan, Talkha, and Shoubrah projects continued under the Talkha combined cycle project: reduction of EEA's debt-to-equity ratio, improvement in the rate of return on EEA's fixed assets, and power tariffs set to cover full generation and distribution costs.

While it was being implemented, the Talkha project provided virtually no support for achieving sector policy reform. In fact, the project clearly demonstrates the difficulty of using a project to promote policy reform after the project has begun. The Talkha project was obligated in FY 1986. By FY 1987, however, the A.I.D. Mission had adopted a policy of no new power projects until significant electric tariff reforms were made. Despite this policy, the Mission had to continue the contracted work on the project, because stopping a project once construction has started and contractors are in country is both legally and politically difficult.

Sector policy performance has improved considerably since 1990 primarily because of Government of Egypt structural adjustment reforms (including energy pricing reforms) supported by IMF, the World Bank, and A.I.D. Recent power sector projects have also supported continued movement on the reform agenda agreed to by the Government of Egypt, IMF, the World Bank, and A.I.D.

Project Costs

The Talkha combined-cycle addition includes capital costs and O&M costs, both of which have foreign- (U.S. dollars) and local-currency (Egyptian Pound) elements. Life-of-project direct-capital-dollar costs were $64.7 million, and the Government of Egypt provided an estimated 20.5 million pounds. Indirect capital costs associated with increased distribution and overhead investments added an estimated $13.6 million and 20.5 million pounds. First disbursements occurred in 1986/1987 and final disbursements in 1989/1990. The combined-cycle addition did not have an effect on the fuel or other O&M costs of the original Talkha generator. Hence, except for some transitory expenses associated with the additional startup, these costs were charged to the original generator. In sum, the project generated extra power through increased generator efficiency without incurring additional direct O&M costs.

Economic costs are the same as financial costs except that local currency cost distortions caused by the Government's price controls are eliminated by pricing inputs at free market prices. The most important price distortions include construction and building costs and the exchange rate. Local currency costs of construction and building investments were increased by approximately 67 percent

to eliminate the effect of these subsidized costs. Using the free market exchange rate rather than the overvalued official exchange rate to convert local currency to dollar equivalents reduced overall dollar costs before FY 1992 when the rates were unified. Real costs beyond FY 1992 are projected, assuming no change in real prices.

Project Benefits

Tariff benefits (revenues). The main financial benefit of the project is revenue from the sale of the additional power to end users and from service connection and maintenance charges. Revenue benefits are projected, assuming tariffs will continue to increase and reach the 100 percent full-cost pricing target for 1995 as agreed to under the World Bank structural adjustment program. The depreciated salvage value of the plant is included as a benefit in the final year.

The primary economic benefit is the same as the financial benefits—revenue from the sale of additional power plus the service connection and maintenance charges. The price of electricity has been subsidized and remains well below the long-run average cost. However, except for intermittent peak-load service interruptions that occurred before the late 1980s, consumers have generally been able to obtain the electric power they desire. This has induced excessive power consumption, including low-valued and wasteful uses of electricity. Although price controls have significantly distorted market demand throughout the economy, the net effect of these distortions on actual market demand for electricity has not been large enough to preclude using market demand to determine economic benefits. Hence, the administered supply price of electricity determines the per-unit economic value of electricity and market demand determines the quantity sold. However, the potential impact of market distortions generating alternative benefit levels is explored in the sensitivity analysis.

Consumer surplus benefits. The consumer surplus benefits calculated for the Talkha Combined-Cycle Addition Project are based on the same demand assumptions used for the Shoubrah El Kheima Thermal Power Projects. In the economic analysis, consumer surplus benefits increased Talkha combined-cycle tariff benefits by approximately 15 percent.

Nonquantified benefits. The Talkha combined-cycle addition improved supply quality and reduced transmission losses for the EEA system. These benefits could not be readily quantified and are not included in the DCF analysis.

Financial and Economic Analyses

Discounted cash-flow (DCF) measures—base case. Tables A-5 and A-6 in the Appendix present the data used to carry out the financial and economic analyses for the Talkha combined cycle addition. Financial DCF measures rely only on tariff benefits. The economic DCF measures include monetary estimates of tariff and consumer surplus benefits. DCF me

During the construction period project costs exceeded project benefits. Thereafter, as in the other two power projects, benefits were greater than costs. Real tariff benefits are projected to increase between FY 1992 and FY 1996.

The project's FIRR is 13.1 percent. The benefit-cost ratio of 1.30 indicates that discounted benefits are 30 percent greater than costs using 10 percent as the opportunity cost of capital. The net present value of the investment is $16.6 million.

The project is both technically and financially sound. The financial viability of the project was significantly enhanced by real increases in tariffs that began just as the project began commercial operation. It has also been favorably influenced by Government of Egypt financing of EEA at below market interest rates.

The project's EIRR is a robust 17 percent. The resulting economic benefit-cost ratio of 1.82 indicates that discounted real benefits are 82 percent greater than discounted costs using 10 percent as the opportunity cost of capital. The discounted economic net present value of the investment is $80 million.

The high economic value of the project results from the project's use of free waste heat for fuel—there are no cash outlays for fuel for this project. In addition, negligible O&M costs and the real tariff increases that began as the project started commercial operation have help. Continued movement toward full-cost electricity pricing is essential to protect the economic soundness of the project.

Sensitivity analyses. Several types of sensitivity analyses were carried out to determine the impact of alternative assumptions on the project's FIRR and EIRR: (1) The electricity price reforms, as agreed to under terms of the World Bank structural adjustment loan, were assumed discontinued. (2) Indirect capital costs were assumed to alternately increase and decrease by 20 percent. (3) The elasticity of demand for electricity was assumed to increase from -0.2 to -0.3 and then to decrease to -0.1. (4) Total benefits were assumed to increase and then decrease 20 percent. Analyses results suggest that under most plausible assumptions FIRR and EIRR remain well above the assumed 10 percent opportunity cost

of capital. However, if electricity pricing reforms were discontinued, FIRR would fall below 10 percent.

	FIRR (%)	EIRR (%)
Base case, energy price reform continue	13.1	17.0
No further energy price reforms	9.1	12.6
Indirect capital cost 20 percent higher	12.4	16.4
Indirect capital cost 20 percent lower	13.8	17.1
Elasticity of demand -0.3	—	16.4
Elasticity of demand -0.1	—	18.8
Benefits 20 percent higher	15.5	19.5
Benefits 20 percent lower	10.5	14.2

Telecommunications I, II, and III

Telecommunications Projects I, II, and III made a series of related improvements in the ARENTO telephone network. The goal was an efficient telecommunications system capable of supporting Egypt's economic and social growth. Under Telecommunications I, II, and III, A.I.D. dollar obligations eventually reached $240.902 million. The Government of Egypt contributed 49.58 million Egyptian pounds and $15.9 million dollars. First capital disbursements began in 1981/1982 under Telecommunications I. Final Telecommunications III disbursements occurred in 1991/1992.

These investments were aimed at improving all aspects of Egypt's telecommunications system. The state telephone company, ARENTO, benefited from major institutional strengthening in planning, management, accounting and financial controls, operations, and training. Program curricula were developed. Instructors, engineers, technicians, operators, clerks, and laborers were trained. Annual procurement plans were developed and implemented. Accounting, financial, and personnel systems were developed and implemented. A service improvement plan that covered maintenance, repair, logistics, traffic, and commercial operations was developed and implemented.

During Telecommunications I, a 20,000-line rotary exchange was replaced. Private automatic branch exchanges and microwave links were installed. Old equipment was replaced. Mobile exchanges were built.

During Telecommunications II, three rotary exchanges were replaced with electronic switching systems and new cable and other facilities were installed. Air conditioning, to cool switching installations, and standby power generators

were installed. The number of potential service lines was increased from 38,000 to 70,000. Technical advisors provided on-the-job training to planning, training, maintenance, procurement, accounting, finance, and other personnel.

Telecommunications III continued upgrading facilities and equipment focusing on exchanges, wiring, telephones, cables, conductors, air conditioners, and standby generators. More rotary exchanges were replaced with electronic switching equipment. Between 40,000 to 50,000 lines were installed. Institution building included procurement and oversight systems, planning and design studies, and surveyors and other personnel training.

The three projects eventually added 263,000 new lines to the system in addition to the training, financial controls, and other system improvements described. The rate of call completion increased from an estimated 30 percent of calls in 1977 to more than 90 percent by 1992.

The Egyptian telecommunications system also received $62.5 million in assistance from the A.I.D. commodity import program for a microwave system to connect all Alexandria and Cairo exchanges. Approximately 360,000 more lines and associated training and equipment for Cairo, Alexandria, and the Delta areas were financed through $750 million in subsidized credits from a European consortium. Japanese suppliers financed exchange systems in the Canal cities. With the ongoing Telecommunications IV project (analyzed later in this report), A.I.D. support is continuing in this capital sector. If new lines added by Telecommunications IV are considered in the calulation, Egypt today has approximately 2.5 telephone lines per 100 persons.

Covenants, Conditions Precedent, and Policy Reform

Covenants, conditions precedent, and policy reform in the A.I.D.-financed telecommunications projects have centered on ARENTO charter changes to permit autonomy, tariff reform, and institutional strengthening—especially training and improved financial controls. ARENTO has changed its basic charter to become an autonomous entity; is revising its personnel and accounting systems, and is implementing a schedule of increases in tariffs, rates, and fees. From a 1981/1982 level of 12 million pounds, revenues attributable to Telecommunications I, II, and III reached 130 million pounds by 1991/1992.

Project Costs

Cost information was obtained from ARENTO and classified into A.I.D. dollar disbursements and Government of Egypt expenditures as well as into

capital costs and O&M costs. Telecommunications I, II, and III had life-of-project disbursements totaling $256.80 million beginning in 1981/1982. The life-of-project Government of Egypt contribution was 49.58 million pounds, beginning in 1983/1984. Final capital costs were disbursed in 1991/-1992. Life-of-project cost streams are shown in Table 5.

In the economic analysis, local capital costs are adjusted by applying the telecommunications building and construction coefficient as calculated by Page (1982). The coefficient is 1.669, indicating that world prices are higher than local prices by nearly 70 percent.

Cost information suggests that indirect costs of A.I.D.-funded telecommunications improvements may not have been as extensive as the indirect costs of improvements financed by the European consortium or the Japanese suppliers. Therefore total capital costs—financial and economic—associated with the four A.I.D. projects are adjusted to reflect an average capital cost (including system overhead) for each new telephone line installed. This is accomplished by applying a cost-adjustment coefficient to the capital cost of each project. These cost adjustments increase project capital costs.[6] The overhead-cost-adjustment coefficients are: Telecommunications I, II, III, 1.382; Telecommunications IV, 2.885.

ARENTO data show that about 65 percent of total O&M costs are incurred for imported materials, which are priced at their dollar value. Remaining O&M costs—about 35 percent—are for local materials, which are adjusted in the economic analysis, using the 0.972 accounting ratio suggested by Page 1982.

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[6]Cost-adjustment coefficients are computed as follows:

1. Average capital cost per line—all projects

Project	*Capital Cost ($ million)*	*Lines Added (thousands)*
Telecommunications I, II, III	281.7	263
Microwave Station	62.5	0
EEC Consortium	750.0	360
Telecommunications IV	91.3	178
Totals	1,185.5	801

Note: Average capital cost per line, all projects: $1,480 = 1,185.5/0.801.

2. Average capital cost per line for Telecommunications I, II, III: $1,071 = $281.7/0.263

3. Average capital cost per line for telecommunications IV: $513 = $91.3/0.178

4. Indirect system capital cost adjustment coefficients for Telecommunications I, II, III: 1.382 = $1,480/$1,071; for Telecommunications IV: 2.885 = $1,480/$513

Labor costs are not shadow priced since they appear to reflect economic costs. O&M costs are therefore calculated in the economic analysis by using the following equation: [(O&M) (0.35)] 0.972 + O&M (0.65)].

Table 5. Cost Information for Telecommunications I, II, and III

	Capital Costs				Total Costs	
	US$ Million					
Year	USAID Contribution	Government of Egypt Contribution	Government of Egypt Million Egyptian Pounds	O&M Costs Million Egyptian Pounds	US$ Million	Million Egyptian Pounds
1981/1982	1.5	—	—	—	1.5	—
1982/1983	64.4	—	—	—	64.4	—
1983/1984	56.0	—	5.2	2.7	56.0	7.9
1984/1985	42.3	0.7	9.2	17.4	43.0	26.6
1985/1986	40.5	6.2	10.3	27.4	46.7	37.6
1986/1987	18.5	0.5	6.4	38.8	19.1	45.2
1987/1988	13.2	—	3.4	58.5	13.2	61.9
1988/1989	1.2	3.1	5.1	69.2	4.2	74.4
1989/1990	2.6	3.3	5.4	68.1	5.9	73.6
1990/1991	0.9	1.7	1.8	70.5	2.6	72.2
1991/1992	-0.2	0.4	2.8	78.4	0.2	81.2
1992/1993 & On				78.4	—	78.4

Project Benefits

Tariff benefits (revenues). Telecommunications tariff benefits come from three sources: telephone subscriptions, call charges, and installation charges. Telephone calls are local, national, and international. Revenues attributable to telephone calls on A.I.D.-financed lines was calculated as follows: First, total revenue was divided by the total number of lines in the system to produce average revenue per line systemwide. Average revenue was then multiplied by the number of lines introduced by the A.I.D.-financed projects. Revenues from telephone subscriptions, call charges, and installation charges attributable to Telecommunications I, II, and III are presented in Table 6. Table 7 shows the number of lines added by the project, Table 8 shows the evolution of the ARENTO tariff structure from 1983/1984 to 1991/1992, and Table 9 provides the average tariff per line and per call for the same years.

Table 6. Revenues Attributable to Telecommunications I, II, and III
(million current Egyptian pound)
1983/1984 - 1991/1992

		Telephone Calls				
Year	**Subscription**	**Local**	**National**	**International**	**Installation**	**Total**
1983/1984	1.9	0.9	0.6	4.2	4.4	12.0
1984/1985	9.1	3.5	2.0	15.9	17.0	47.4
1985/1986	13.7	4.1	3.5	21.6	3.7	46.5
1986/1987	14.6	7.4	5.4	28.9	2.7	59.1
1987/1988	14.6	7.4	8.5	14.8	0.0	45.3
1988/1989	14.7	8.0	15.6	63.2	2.0	103.5
1989/1990	14.7	8.0	17.2	68.7	—	108.6
1990/1991	14.7	8.0	20.3	71.4	—	114.5
1991/1992	15.0	8.0	23.2	84.2	—	130.4

Table 7. Incremental Telephone Lines Added by the Projects
1983/1984 - 1988/1989

Year	Number of Lines
1983/1984	40,000
1984/1985	153,000
1985/1986	35,000
1986/1987	20,000
1987/1988	—
1988/1989	15,000
Total	263,000

Table 8. Telephone Tariff Structure, 1983/1984 – 1991/1992
(weighted averages)

Year	Telephone Subscription Charges (LE/line)	Local Call Charges (LE/call)	Installation Charges (LE/line)
1983/1984	47	0.03	111
1984/1985	47	0.03	101
1985/1986	60	0.03	106
1986/1987	59	0.05	137
1987/1988	59	0.05	135
1988/1989	56	0.05	133
1989/1990	56	0.05	157
1990/1991	57	0.05	313
1991/1992	57	0.05	347

Note: LE = Egyptian pound. Starting in 1992 installation charges were adjusted as follows:

Beneficiary	*Standard LE/line*	*Immediate LE/line*
Household	750	2,400
Commercial	1,400	4,000
Governmental	600	—

Table 9. Average Tariff Per Call and Per Line
1983/1984 - 1991/1992

Year	International Tariff (LE/call)	International Charges (LE/line)
1983/1984	5.21	105.02
1984/1985	4.41	82.14
1985/1986	4.31	94.68
1986/1987	5.13	116.64
1987/1988	5.84	123.84
1988/1989	8.17	240.45
1989/1990	8.52	261.28
1990/1991	8.63	271.52
1991/1992	9.22	320.08

Note: LE = Egyptian pound

Consumer surplus benefits. Consumer surplus in the telecommunications market exists when at least some telephone users would be willing to pay more for services than they do. Even though the tariff structure information shows that rates have recently increased substantially, significant surplus continues to characterize the ARENTO network. Consumer surplus in the ARENTO system exists for two reasons. First, ARENTO has a system of cross subsidizing pricing of telecommunications services. International calls and installation charges are priced near prevailing international averages, but subscription and local-call charges are priced well below international averages. Second, tariff increases do not fully reflect the vast improvement in telephone service that has occurred in the ARENTO system over the last decade, much of which is attributable to the A.I.D.-financed projects. For example, the rate of call completion has tripled; the time it takes to complete a call has been reduced by about 1 minute; many fewer calls are aborted in midconversation; and call clarity has generally improved.

Neither demand nor elasticity estimates were available for Egyptian telecommunications services. Willingness to pay for Telecommunications I, II, and III services is estimated by comparing average tariffs for installation, subscription, and local calls in 21 countries in the Middle East and North Africa (International Telecommunications Union) with ARENTO tariffs. The differences between the average and ARENTO tariffs is the Egyptian telecommunications consumer surplus. To value surplus in the Egyptian system, ARENTO tariffs are adjusted in the economic analysis by applying the following shadow price coefficients to them: subscription charges, 5,000; installation charges, 1,339; local-call charges, 2,542.

Subscription, installation, and local-call charges (revenue benefits) are multiplied by these coefficients to quantify surplus associated with new lines created by Telecommunications I, II, and III. ARENTO tariffs for long-distance calls within Egypt and for international calls already reflect border prices.[7]

Nonquantified benefits. A quantitative value to external benefits is not assigned in the DCF analysis, but nevertheless such benefits are important to recognize. Benefits generated by Telecommunications I, II, and III extend to ARENTO network users who are not the beneficiaries of the 263,000 new lines financed by A.I.D. Benefits include improvements is system efficiency related to

[7]Surplus might also exists in the markets of the 20 other Middle Eastern and North African countries. However, at least some, if not a majority, of this surplus is extracted through block pricing (price discrimination) and cross subsidization by all 21 countries. In adjusting Egyptian rates to reflect area averages, the analysis probably captures most Egyptian telecommunications consumers' surplus.

satellite links between major service areas, and technical- and financial-institution building in ARENTO.

In addition, the general improvement in the quality of telecommunications services undoubtedly has had spillover effects on other sectors of the economy. Egypt's $3 billion per year tourist industry would probably be much smaller without a modern telecommunications system. Foreign investment would probably also be less. Moreover, improved telecommunications services is widely believed to increase efficiency in all productive sectors. Although ARENTO captures some of the benefits through revenues from increased tourism, investment, and efficiency, the value added to the Egyptian economy from these spillover effects is almost certainly greater than the tariff and consumer surplus benefits measured here.

Financial and Economic Analyses—Base Case

Discounted cash-flow (DCF) measures. Tables A-7 and A-8 in the Appendix present the data used to carry out the financial and economic analyses for the Telecommunications I, II, and III projects. The economic DCF measures include monetary estimates of tariff and consumer surplus benefits. The FIRR of investments in Telecommunications I, II, and III is 1 percent.

During the main construction period through 1987/1988, investment plus O&M costs exceeded project revenues. Beginning in 1988/1989, the projects generated positive net cash flow. Because project financial revenues have been greater than O&M costs in all years, the project has generated net benefits on operations since the first year of operations. O&M costs are about 60 percent of revenues. International calls are the most profitable source of income to ARENTO in general and to the projects in particular. Revenues from international and domestic long-distance calls represent approximately 80 percent of total revenues. ARENTO sets long-distance-call tariffs at world prices, but it sets local-call and installation charges well below levels prevailing in other Middle Eastern and North African countries.

The low FIRR of 1 percent results mainly from the very low tariffs on local calls and subscriptions. Failure to maintain already implemented telecommunications tariff reforms would have an adverse effect on ARENTO's financial performance.

Telecommunications I, II, and III show an EIRR of 11 percent and, at a 10 percent discount rate, an economic benefit-cost ratio of 1.06 and an economic net present value of $32.72 million.

The real net economic cash flow from Telecommunications I, II, and III turned positive in 1986/1987 and is projected to remain positive through the 25-year period of analysis. The economic cash flow is better than the financial cash flow because of consumer surplus benefits accounting for about 45 percent of total real economic benefits.

Although the three telecommunications projects have low financial returns, the economic returns are satisfactory. The telecommunications sector in Egypt generates about 80 percent of its benefits from long-distance calls charged at international rates without price controls. In addition, beginning in the mid-1980s, tariffs charged for the installation of new lines were significantly increased. The generally acceptable economic returns of these projects can therefore be attributed to the smaller influence of artificial price ceilings, the earlier start of tariff reforms, and the substantial consumer surplus benefits. External (nonquantified) benefits generated by these investments may also be significant.

Increases in telecommunications tariffs have been vital to recent, improved sector performance and may still not reflect the sector's real contribution to Egyptian society.

Sensitivity Analyses

Several types of sensitivity analyses were carried out to determine the impact of alternative assumptions on FIRR and EIRR for Telecommunications I, II, and III. (1) Indirect capital costs were assumed to alternately increase and decrease by 20 percent. (2) Total benefits were assumed to increase and then decrease 20 percent. (3) O&M costs were assumed to increase and decrease by 20 percent. The results are as follows:

	FIRR (%)	EIRR (%)
Base case, price reforms continue	1.0	11.0
Indirect capital cost 20 percent higher	0.0	9.0
Indirect capital cost 20 percent lower	1.0	15.3
Benefits 20 percent higher	5.0	15.8
Benefits 20 percent lower	-4.0	6.8
O&M costs 20 percent higher	-2.0	10.0
O&M costs 20 percent lower	2.0	12.6

The base-case revenue scenario reflects tariff reforms already instituted by ARENTO. These reforms took place in FY 1991/1992.

These results suggest that under most plausible assumptions the project is *not financially viable*. Although ARENTO no longer requires operating subsidies from the state treasury, no scenario shows FIRR close to 10 percent. Financial performance is most sensitive to changes in tariff revenues: The financial performance of ARENTO is significantly affected by the continuation of tariff reforms now in place.

The *economic viability* of the project exceeds a 10 percent threshold under most scenarios. Economic performance is less sensitive to movements in cost and more sensitive to movements in benefits. The nonquantified benefits, which may be significant, would enhance the economic viability results if they could be incorporated.

Telecommunications IV

Telecommunications IV continued enlarging and improving the Greater Cairo telephone exchanges and sponsored other ARENTO system improvements. Eventually, the project will add 178,000 new lines. Telecommunications IV was obligated in September 1989 and first disbursements occurred in January 1990. The current life-of-project obligation is $82 million, and the anticipated completion date is 1996. The Government of Egypt is expected to contribute 51.7 million pounds. As of 30 September 1992, $24,149 million, or 29.4 percent, of project funds had been disbursed.

Project Costs

Information on capital costs and O&M costs that have actually been incurred for Telecommunications IV since project startup were obtained from ARENTO. The disbursement schedule for undisbursed capital costs is based on the Project Paper, as adjusted by the actual disbursements that occurred from 1990 to 1992. Future O&M costs are also estimated on the basis of costs incurred from 1990 to 1992. Telecommunications IV cost information is presented in Table 10.

Table 10. Cost Information—Telecommunications IV

Year	Capital Costs ($ US million)	Capital Costs (Egyptian pounds million)	O&M Cost (Egyptian pound million)
1990/1991	7.6	—	—
1991/1992	11.7	—	25.9
1992/1993	15.7	10.0	34.8
1993/1994	26.0	11.0	43.5
1994/1995	15.0	5.0	62.2
1995/1996	6.0	5.0	77.5
1996/1997	—	—	77.5
Total	82.0	31.0	

The cost adjustments made for the economic analysis of Telecommunications I, II, and III were also made for Telecommunications IV.

Project Benefits

Tariff benefits (revenues). Telecommunications IV tariff benefits come from telephone subscriptions, call charges, and installation charges. The project is expected to add 178,000 lines to the ARENTO system; 43,000 of which were installed in 1991/1992. Installation of the remaining lines is projected to occur over 4 years according to the following time schedule: 1992/1993, 30,000 lines; 1993/1994, 25,000 lines; 1994/1995, 40,000 lines; 1995/1996, 40,000 lines.

Tariff revenues attributable to Telecommunications IV were calculated as follows: Average revenues from national and international calls throughout the ARENTO system were divided by the number of ARENTO lines, producing an average revenue per line. The average revenue per line was then multiplied by the number of lines introduced by the project. Benefits are estimated at 1991/1992 prices: Subscription charges, 57 Egyptian pounds per line; local call, 0.05 pounds per line; international calls, 320 pounds per line; hookup installation charge, 347 pounds per line.

Using this information, Telecommunications IV tariff benefits are estimated in Table 11 as follows:

Table 11. Tariff Benefits — Telecommunications IV
(million Egyptian pound)

Year	Subscription	Telephone Calls			Installation	Total
		Local	National	International		
1991/1992	2.4	2.7	8.0	13.8	14.9	41.8
1992/1993	4.2	4.5	13.6	23.4	10.4	56.1
1993/1994	5.6	6.1	18.3	31.4	8.7	70.1
1994/1995	7.9	8.6	25.8	44.2	13.9	108.4
1995/1996	10.1	11.0	33.0	57.0	13.9	125.0
1996/1997 & On	10.1	11.0	33.0	57.0	—	111.1

Consumer surplus benefits. The derivation of consumer surplus for Telecommunications IV is basically the same as for Telecommunications I, II, and III. Similarly, willingness to pay for Telecommunications IV services is estimated by computing average economic tariffs in the same manner as for Telecommunications I, II, and III.

Nonquantified benefits. Telecommunications IV benefits will extend to ARENTO network users who will not be beneficiaries of the system's 178,000 new lines. These benefits include system efficiency improvements related to satellite links among major service areas, and technical and financial institution building in ARENTO.

External benefits from Telecommunications IV are the same as for Telecommunications I, II, and III. External benefits are not assigned a quantitative value in the DCF analysis but, as discussed for Telecommunications I, II and II, are probably important.

Financial and Economic Analyses—Base Case

Discounted cash flow (DCF) Measures. Tables A-9 and A-10 in the Appendix present the data used for the financial and economic analyses of Telecommunications IV. The calculated economic DCF measures include monetary estimates of consumers' surplus but not external benefits. The DCF measures are summarized in Table 1 in the summary of this report.

The *financial discounted net present value* of the investments is minus $107.34 million, consistent with the estimated 1 percent FIRR. The financial discounted benefit-cost ratio is 0.70.

Financial revenues of the project are greater than O&M costs in all years, therefore the project generates net benefits on operations beginning in the first year of operations. During the main construction period through 1995/1996, total costs are projected to exceed revenues. Starting in 1996/1997, net financial cash flow from the project will be positive.

The low FIRR of 1 percent results primarily from the very low tariffs on local calls and subscriptions, which reflect the pricing policies of low block and incremental local call rates under cross subsidization. Telecommunications IV again illustrates that a failure to maintain telecommunications tariff reforms would adversely effect ARENTO's financial performance.

Telecommunications IV shows an EIRR of 18 percent and, at a 10 percent discount rate, the project's economic benefit-cost ratio is 1.32 and its economic net present value is $116.31 million.

The economic net-benefit stream is higher than the financial stream because tariffs for subscriptions, installations, and local calls, although increasing, are still lower than prevailing rates for comparable service in comparable countries. That is, Egyptian willingness to pay remains higher than prevailing tariffs. This results in more favorable economic DCF measures than financial measures. The difference in EIRRs between the first three telecommunications projects and the fourth project probably results from a continuing shift in the mix of revenues from local, national, and international calls: The proportion of total revenue generated from national and international calls appears to be increasing through time.

The economic efficiency of the telecommunications sector is clearly improving with time. The improvement reflects the investments and met conditionalities resulting from A.I.D. and other donor involvement.

Sensitivity Analyses

Several types of sensitivity analyses were carried out to determine the impact of alternative assumptions on the FIRR and EIRR for Telecommunications IV. (1) Indirect capital costs were assumed to alternately increase and decrease by 20 percent. (2) Total benefits were assumed to increase and then decrease 20 percent. (3) O&M costs were assumed to increase and decrease by 20 percent. The results are as follows:

	FIRR (%)	EIRR (%)
Base case, price reforms continue	1.0	18.0
Indirect capital cost 20 percent higher	0.0	14.0
Indirect capital cost 20 percent lower	3.0	24.0
Benefits 20 percent higher	5.0	25.0
Benefits 20 percent lower	-6.0	11.0
O&M costs 20 percent higher	-3.0	16.0
O&M costs 20 percent lower	4.0	20.0

These results suggest that under most plausible assumptions the project is *not financially viable.* Although ARENTO no longer requires operating subsidies from the state treasury, no scenario shows FIRR close to 10 percent. Financial performance is most sensitive to changes in tariff revenues: The financial performance of ARENTO is sensitive to the continuation of tariff reforms now in place.

The *economic viability* of the project exceeds a 10 percent threshold under all scenarios examined. Economic performance is less sensitive to movements in cost and more sensitive to movements in benefits. Increases in real tariffs began in earnest in 1988/1989. Without these increases, it is not likely that EIRRs would have approached 10 percent under any scenario.

Potable Water

Cairo Water Supply I began in 1977. The project rehabilitated, modernized, and expanded the Rod-El-Farag potable water plant, the largest of 16 water sources in the Greater Cairo water supply system. The project laid six kilometers of new main transmission line and provided training for the General Organization of Greater Cairo Water Supply (GOGCWS) personnel. It expanded the production capacity of the Rod-El-Farag plant by 450,000 cubic meters per day—from 300,000 to 750,000 cubic meters per day—with a peaking capacity of 850,000 cubic meters per day. The project succeeded in increasing water pressure, improving water distribution, and enabling more efficient use of reservoirs throughout the 35 square kilometer Rod-El-Farag service area. It also increased average system head—a measure of available system pressure—in the Greater Cairo water system by nearly 40 percent, from 43 to 60 meters.

New plant installations and modifications financed by the project included a raw-water intake, a raw-water pump station, 10 clarifiers, 14 filters, a backwash pump station, a filter control room, a finished water pump station with clearwell, a finished water storage reservoir, a chlorine building, a chemical building, a

10.5-kilovolt power substation, 4 380-volt substations, an administration building, and 5.5 kilometers of 1,000 to 1,400 millimeter transmission lines.

Rod-El-Farag produces about 23 percent of Greater Cairo's potable water. Based on Greater Cairo population estimates ranging between 12 and 16 million persons, this suggests that the number of persons receiving water from Rod-El-Farag is between 2.75 and 3.7 million persons (458,000 to 617,000 6-person households). The service area includes much of central Cairo, where many businesses, tourist hotels, and embassies are located. The increase in pressure caused by the plant, together with benefits from other project investments, such as the training and maintenance programs, have spillover benefits for the whole GOGCWS system.

Covenants, Conditions Precedent, and Policy Reform

Covenants, conditions precedent, and policy reform dealt with tariff reforms, including reforms in water rates and bill collection and to produce adequate levels of maintenance, proper plant operation, reduction of system wastage, better debt-to-equity ratios, and reasonable rates of return on fixed assets in operation.

Project Costs

Cairo Water I had a life-of-project A.I.D. obligation of $97.4 million and a life-of-project Government of Egypt contribution of $67.4 million. First project disbursements occurred in FY 1978. A.I.D.'s final disbursement was made in FY 1990; the Government of Egypt's was made 1 year later (see Tables A-11 and A-12 in the Appendix). No Cairo Water Supply I dollar funds were converted to Egyptian pounds.

O&M costs for Rod-El-Farag were obtained from GOGCWS and are projected at $8.647 million annually beginning in FY 1992. O&M costs include routine and preventive maintenance; salaries, wages, and benefits; and chemicals, power, and other process inputs, but they do not include funds to replace capital investments.

Project Benefits

Most experts believe the direct and external benefits of potable water supply are significant. Historically, GOGCWS has charged extremely low rates

for water, therefore, in Cairo, benefits not captured by tariffs are probably considerably larger than tariff benefits. It is possible to estimate surplus and total willingness to pay either from demand estimation or through surveys (Whittington and Choe). The scope and timeframe of this study precluded both techniques.

Tariff benefits (revenues). Tariff or revenue benefits attributable to Cairo Water I may be measured by multiplying the increased volume of water produced because of project installations, which is 450,000 cubic meters per day, by the price per cubic meter.

GOGCWS' general tariff (or rate) structure lists 18 water rates differentiated by kind of water and class of consumer. Water is not metered in most of Cairo. Residential charges depend on the number of rooms in the residence. According to GOGCWS, the average 1992 tariff for all water is 14 piasters ($0.0422) per cubic meter. If GOGCWS complies with promised tariff reforms, tariff benefits will reach $8.647 million by 1994/1995.

Water tariff reform began in 1985/1986. Since then, nominal water tariffs have increased from 3 to 20 piasters per cubic meter for residential customers and from 10 to 50 piasters per cubic meter for industrial customers. GOGCWS has agreed to raise average nominal tariffs to 50 piasters per cubic meter, or $0.1502, by 1994/1995.[8] Design and evaluation reports have estimated that consumers are billed for about 40 to 90 percent of produced water and that about one-half of all bills are collected. GOGCWS representatives said that over 90 percent of produced water is billed and almost all bills are collected.

Consumer surplus benefits. Consumer surplus exists in the potable water market when at least some individuals would be willing to pay more than they do for water. Because of very low rates charged by GOGCWS, surplus is evidently substantial in Cairo. This surplus is associated with consumer preferences related to water quality and health benefits and convenience associated with increased pressure and time savings.

A Cairo household of six persons using an average of 30 liters of potable water per person per day would pay $0.23 per month at the rate of $0.0422 per

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[8]To put the Egyptian rates in perspective, following are average rates for a cubic meter of water charged to consumers in selected industrialized countries:

Canada	$0.27
United States	$0.36
Great Britain	$0.81
Germany	$1.17

cubic meter and $0.81 per month under the $0.1502 rate. A 1992 literature review by Whittington and Choe reported average willingness to pay for a private tap from an improved water source by households in 12 cities located in 6 developing countries, including Nigeria and Ghana. The average willingness to pay for a private connection ranged from $0.68 per household per month in Banaga, the Philippines to $4.00 per household per month in Ceara, Brazil. Figures for Africa were $1.56 in Kumasi, Ghana; $1.95 in Nsukku District, Nigeria; and $3.10 per household per month in Onitsha, Nigeria. Therefore, even when the new GOGCWS rates go into effect they will be more than 10 times less than what Ghanaians are willing to pay and 20 times less than what Nigerians are willing to pay. These figures from other developing countries indicate that substantial consumer surplus probably exists for water consumers in Egypt.

Nonquantified benefits. As well as the direct value of water consumption, a number of social, economic, and health benefits are produced by the expanded availability of potable water that are easy to identify but difficult to measure. One of the most obvious is the health benefits.

Under its Water and Sanitation for Health (WASH) Project, A.I.D. reviewed 144 studies that sought to quantify the relation between improved water sanitation and health morbidity (Esrey et. al. 1990). The report concluded:

> In summary, broad, demonstrable health impacts affecting all age groups in most of the developing world can be expected from improvements in water supply and sanitation (page viii).
>
> ....improvements in one or more components of water supply and sanitation can substantially reduce rates of disease morbidity and severity for diarrhea, ascariasis, guinea worm, schistosomiasis, and trachoma (page 29).

Nonetheless, most researchers have been reluctant to assign a monetary estimate to the demonstrable and favorable impacts resulting from improved water quality. For this reason, the standard approach to the economic justification of water and sanitation projects is to cite the link between the projects and health, conclude that the link makes projects socially necessary, and then determine the least cost at which some desired level of service can be provided.

Financial and Economic Analyses—Base Case

Under any realistic set of either financial or economic tariffs, there is no scenario that produces an internal rate of return as high as zero. Therefore, the Cairo Water I financial analysis proceeded along the same lines as analyses for

power and telecommunications, but the economic analysis used a different approach.

Discounted cash flow (DCF) measures. The base-case financial analyses assume that GOGCWS continues to raise and effectively collect, as promised, water tariffs at an average rate of 50 piasters ($0.1502) per cubic meter for household and commercial use beginning in 1994/1995. A water tariff at this rate is designed to cover narrowly defined annual O&M costs.

The calculated financial DCF measures are shown in Table A-11 in the Appendix. FIRR cannot be calculated because there are no positive elements in the net financial cash flow. At a 10 percent discount rate, the benefit-cost ratio is 0.33 and the net present value is minus $114.1 million. Similar low DCF measures were obtained for a sensitivity scenario reflecting increased or decreased O&M expenses. These extremely unfavorable financial measures result from the extreme low water tariff and the reluctance of the Government of Egypt to increase tariffs.

Maintaining water tariffs at artificially low levels has required substantial annual transfers of public funds to cover GOGCWS's annual operating deficits. Deficits have increased in each of the last 4 years, from 12.809 million pounds in 1988/1989 to 43.568 million pounds ($13.123 million) in 1991/1992 (Table 12).[9] The Government of Egypt is not unique in having adopted a policy of subsidizing the production, distribution, and consumption of potable water. Many countries regard potable water as a commodity that should be provided to the population free or nearly free because it is essential to economic development and social well-being.

Table 12. Potable Water, Financial Deficit of GOGCWS
(thousand Egyptian pounds)

Fiscal Year	Deficit
1985/1986	4,290.00
1986/1987	16,973.00
1987/1988	20,691.80
1988/1989	12,809.00

[9]The deficits shown in Table 12 are the operating deficits of the entire GOGCWS not just Rod-El-Farag.

1989/1990	14,999.35
1990/1991	29,367.00
1991/1992	43,568.00

Sensitivity analysis—willingness to pay. Within the timeframe and budget of this study, it was not possible to quantify either consumer surplus or external benefits for Cairo Water I. However, it was possible to calculate how much Egyptians must be willing to pay for Cairo Water I to recover full capital and O&M costs.

The base and sensitivity economic analyses address two questions: (1) What level of benefits must exist for Cairo Water I to return an EIRR of 10 percent?[10] and (2) Is it plausible to suppose that the benefits are at least that high?

Table 2 summarizes the results. The base case finds an annual household willingness to pay that would result in EIRR of 10 percent. This figure is $3.13 per connected household per month ($37.56 per year) plus $0.313 per household per month ($3.76 per year) for households outside the Rod-El-Farag service area but with increased water pressure because of the project. That is, if 617,000 households are connected and willing to pay an average of $3.13 per month, and if 1.383 million households are willing to pay $0.313 per month for system benefits caused by Rod-El-Farag, then the project's EIRR would be 10 percent.

Willingness-to-pay estimates are available for potable water from 12 developing country sites (Whittington and Choe 1992). Two sites were at Kumasi, Ghana—$1.52 per household per month—and Onitsha, Nigeria—$3.10 per household per month. If these figures are applied to Rod-El-Farag, the resulting EIRR's are -6 percent ($1.52 per month) and 10 percent ($3.10 per month).

Many studies have measured health improvements from water supply and sanitation projects. The study by Esrey et. al. (1990), for example, found a median reduction of 26 percent in diarrhea morbidity and 29 percent in ascariasis morbidity and mortality from improved water supply and sanitation across 23 projects. Preproject rates of morbidity for these diseases in Cairo are not available, so the number of persons who benefited from reductions associated with the Rod-El-Farag plant cannot be calculated.

[10]Most donors take 10 percent as a minimum rate of return if project resources had been invested in an alternative use in a developing country.

Nevertheless, the information available suggests that surplus and external benefits associated with Rod-El-Farag are likely high. The Onitsha, Nigeria study showed a willingness to pay almost exactly the same as required in Cairo for the project to return an EIRR of 10 percent. Reductions in morbidity and mortality among a benefited population of 2 million households are certainly significant. Thus it seems plausible to suppose that willingness to pay among GOGCWS customers for Rod-El-Farag services is at least high enough for the project to return an EIRR of 10 percent.

Cairo Sewerage II

The Greater Cairo Wastewater Project began in 1977, with the preparation of a master plan. The plan provided for a total of 31 civil engineering projects consisting of treatment plants, pumping stations, collectors, culverts, tunnels, house connections, sewers, and sludge disposal facilities. According to the plan, Cairo Sewerage II focused on providing facilities for the Nile West Bank Area of Greater Cairo. These facilities included two large treatment plants, eight new pumping stations, many kilometers of collectors, tunnels, and culverts, and tens of thousands of house connections.

Cairo Sewerage II began in 1984. As of October 31, 1992, it had a life-of-project obligation of $715.659 million of which $550.321 million had been disbursed and $165.338 million remained in the pipeline.[11]

The project has renovated and enlarged the Zenin wastewater treatment plant, adding 330,000 cubic meters per day of new raw sewage processing capacity. The project also built the Abu Rawash wastewater treatment plant, which opened on October 25, 1992. The design capacity of Abu Rawash is 400,000 cubic meters per day of sewage. The project also sponsors extensive system improvements, including 8 new pumping stations, 48.5 kilometers of collection and conveyance culverts, and 62,000 house and apartment-block connections in Embaba, Boulac, Zenin, Giza, Kirdash, and other Cairo West Bank districts. The house connections are provided through a series of fixed- amount reimbursable contracts with Egyptian contractors.

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[11]In 1989, the project was amended to provide $14.0 million for training, technical and financial studies, engineering services and other activities aimed at supporting and strengthening the capacity of the Cairo Wastewater Organization (CWO). As of October 31, 1992, $1.043 million of amendment funds had been disbursed and $12,957,9000 remained in the pipeline. The costs and benefits of this amendment (Project 0173.01) are not analyzed here.

While the Zenin wastewater treatment plant is located on the West Bank, a large-diameter siphon under the Nile River conveys East Bank sewage to it. Consequently, an unknown volume of East Bank sewage is also processed by the A.I.D.-funded sewage infrastructure.

Amendments have extended the anticipated completion date of the project through September 1996, when the new West Bank connections will be serving approximately 465,500 households, or an estimated 2 million persons. Another 2 to 3 million persons living on the West Bank will benefit from reductions in wastewater discharged into trash collection areas, landfills, open sewers, drains, pits, ponds, and septic pools. Most sewer overflows caused by system overload and disrepair will have ceased. Some 730,000 cubic meters per day of sewage flow will have received primary or secondary treatment, benefiting the approximately 30 million Egyptians who live below Cairo in the Nile Delta. Because the Zenin plant also serves the Cairo East Bank through a siphon under the Nile, a large population on the other side of the river will also benefit from the project.

Covenants, Conditions Precedent, and Policy Reform

Covenants, conditions precedent, and policy reform dealt with proper operation and maintenance of the investments, with tariff (revenue) reforms, and with maintaining a policy dialogue. A covenant also established that the ability of households' to pay for sewer hookup would not be the sole criterion for selecting households for connection.

Project Costs

Capital costs of Cairo Sewerage II include a $715.659 million A.I.D. obligation, currently scheduled for disbursement between 1984/1985 and 1995/1996. During the same period, the Government of Egypt is expected to contribute 425.900 million pounds ($128.280 million), including some 187.4 million pounds ($57 million) of special account funds. As of November 1, 1992, approximately 171.762 million pounds ($51.881 million) were obligated to Egyptian contractors under fixed-amount reimbursable contracts. Capital costs fund the treatment plants, conveyance systems, and household connections described above. Before the project ends, more funds are expected to be added through amendments to the original $715.659 million obligation.

Operating and maintenance (O&M) costs for Cairo Sewerage II are projected to reach an annual level of $23,221,900 by 1997 according to a study by American-British Consultants (AMBRIC) (October 1992). O&M costs included in this study include routine and preventive maintenance; salaries, wages,

and benefits; and chemicals, power, and other process inputs, but they do not include funds to replace capital equipment.

Project Benefits

Most experts believe the direct and external benefits of sanitation services are significant. CWO first began charging for sanitation services in 1985. However, consumer surplus and external benefits not captured by sewerage tariff surcharges have been and continue to be considerably larger than the tariff benefits. It is possible to estimate surplus and total willingness to pay from demand estimation or through surveys (Whittington et. al. 1992). The scope and timeframe of this study precluded both techniques.

Tariff benefits (revenues). Tariff or revenue benefits accrue from the increase of 750,000 cubic meters per day of raw sewage now processed as a result of project investments. Base-case tariff revenues are projected to reach $9,167 million by 1997, under the assumption that the Government of Egypt adheres to a schedule of water surcharges promised under policy covenants. This level of revenues represents approximately 35 percent of narrowly defined O&M costs that do not include capital recovery.

To help the Government of Egypt meet these O&M costs, A.I.D. has focused policy dialogue and conditionality on O&M cost recovery. GOGCWS is responsible for billing sewerage charges as a surcharge on the water tariff. Subsequently, GOGCWS remits the sewerage portion to CWO, less a 10 percent administrative collection fee.

Until July 1, 1985, when a surcharge equal to 10 percent of the water tariff was imposed on all water users, no sewerage tariff was assessed. CWO raised the sewerage surcharge on July 1, 1991 to 20 percent of the water bill for residential customers and 50 percent for nonresidential customers. Based on an average potable water tariff of $0.0422 per cubic meter, CWO is currently collecting an average tariff of .008 of per cubic meter of sewage processed.

CWO expects to raise the residential tariff 10 percent per year until all water users are paying a flat 50 percent water bill surcharge by 1995. During FY 1992, the first year in which the increases became effective, CWO revenues tripled, reaching about $3 million.

Because of difficulty collecting water bills—estimates of the percentage of bills collected range from 40 to 90 percent—it may be some time before the goal of full O&M cost recovery is realized. AMBRIC's 1992 O&M cost-recovery study estimated that a surcharge on all water users of 50 percent of their water

bill would be adequate to achieve O&M cost recovery for the 1993-1997 period, providing that the percentage of all water bills collected reached 80 percent or more and that GOGCWS increased water tariffs as agreed. The current analysis suggests that even if promised tariff reforms occur, CWO will continue to experience large operating shortfalls as a result of large differences between annual tariffs remitted and annual recurrent costs.

Consumer surplus benefits. Given its extremely low tariff rates and the relatively recent imposition of any sewerage tariff, the Cairo Sewerage II Project (and the Greater Cairo Wastewater Project of which it is a part) must be characterized by significant consumer surplus. A household of six persons using 30 liters of water per capita per day would pay about 10.8 piasters per month ($.033) for a sewer connection under current rates and 27 piasters per month ($0.081), or $0.972 per year, under the proposed 50 percent rate. A May 1992 estimate of willingness to pay for sewer connections for the city of Kumasi, Ghana (Whittington et. al.) found that households with potable water connections and existing water closets (WCs) were willing to pay an average of $1.32 per month ($15.84 per year) for sewer connections. Households with potable water but no WC or sewer connections were willing to pay a mean of $1.43 per month ($17.16 per year) for both new WCs and new sewer connections. The Cairo sewerage tariff appears very low compared with these estimates.

Nonquantified benefits. Many of the health and aesthetic benefits of sewage disposal are received as a public service by groups and individuals who are not directly connected to, and therefore not paying for, services. Such groups include the 2 to 3 million individuals on the West Bank who are not directly connected to the project-financed CWO system and approximately 30 million individuals living downstream from Cairo who benefit because raw sewage is no longer dumped into the Nile.

The benefits to society from an expanded and more efficient sewage processing system are widely acknowledged but difficult to measure. The most obvious, as reported by Esrey et. al (1990), is that better sanitation reduces disease and improves public health. Improved health, in turn, reduces overall health costs, creates a more productive workforce, and generally improves the quality of life. The severe degradation of the Cairo urban environment that prevailed before Cairo Sewerage I has been described. Project-sponsored abatements are estimated to have effected at least 2 million persons directly and at least 30 million indirectly.

As was the case for water, however, researchers have found it difficult to assign a monetary estimate to the health and environmental quality benefits of sewage processing.

Financial and Economic Analyses—Base Case

Under any likely realistic set of financial or economic tariffs, there is no scenario that produces an internal rate of return as high as zero. Therefore, like Cairo Water I, the Cairo Sewerage II financial analysis proceeds along the same lines as analyses of the power and telecommunications projects, and the economic analysis employs a different approach.

Discounted cash flow (DCF) Measures. The base case represents a revenue scenario where CWO raises the wastewater surcharge to 50 percent of the water tariff by 1995. A discount rate of 10 percent is used for net present value and benefit-cost measures.

FIRR cannot be calculated because no positive elements exist in the net financial cash flow. At a 10 percent discount rate, the benefit-cost ratio is 0.06 and the net present value is minus $637.13 million. Sensitivity scenarios reflecting increased or decreased O&M costs also produced real net cash flows with no positive elements.

Evidently, for financial viability, CWO will require continued large transfers of donor and public funds. CWO's extremely unfavorable financial condition reflects the policy of the Government of Egypt not to recover all sewerage costs through tariffs. Public sanitation, like potable water, is viewed by most as necessary to social well-being and, especially in a large metropolitan area such as Cairo, a prerequisite for sustained economic growth.

Sensitivity analysis—willingness to pay. As was the case for Cairo Water I, for Cairo Sewerage II it was not possible to quantify either consumer surplus or external benefits within the timeframe and scope of the present study. However, it was possible to calculate how much Egyptians would have to pay for sewage processing if Cairo Sewerage II were to recover its total costs.

The base and sensitivity economic analyses address this questions: What level of benefits must exist for Cairo Sewerage II to return an EIRR of 10 percent?

The results are shown in Table A-14 in the Appendix and summarized in Table 2 in the Summary of this report. The base case finds an annual household willingness to pay that would result in an EIRR of 10 percent. This figure is $11.60 per connected household per month ($139.20 per year) plus $5.80 per month for each West Bank household not connected to the system ($69.60 per year) and $0.58 per household per month for Nile Delta households using water that no longer contains 730,000 cubic meters per day of unprocessed Greater

Cairo sewerage. That is, if these households are willing to pay the indicated amounts, then Cairo Sewerage II would have an EIRR of 10 percent.

One estimate of willingness to pay for improved sanitation services in a developing country is available from Kumasi, Ghana (Whittington et. al. 1992). If that estimate ($1.43 per connected household per month, or $17.16) per year is used for Cairo Sewerage II, it yields a net cash flow with no positive elements.

Most analysts are reluctant to assign monetary values to health benefits from improvements in sanitation, as in potable water, but many studies have measured health improvements from such projects. The 1990 Esrey et. al. review of 144 studies of the impact of improved water supply and sanitation facilities on 6 diseases found a median reduction of 26 percent in diarrhea morbidity and 29 percent in ascariasis morbidity and mortality from improved water supply and sanitation across 23 projects. Preproject rates of morbidity for these diseases in Cairo were not available, so the number of persons who benefited from reductions associated with the Rod-El-Farag plant could not be calculated. However, the number must be large.

Recent economic analysis of large sanitation projects suggests that conventional sewerage—such as that provided under Cairo Sewerage II—"is simply not affordable to the majority of [developing country] households without massive government subsidies" (Whittington et. al. 1992). Ambient pollution from sewerage has public-good characteristics, in that it is consumed jointly and many of the consumers cannot exclude themselves. These considerations justify public sector involvement. Even so in Cairo, *sewerage costs per benefited household seem very large* when compared with current service tariffs and limited willingness-to-pay estimates from elsewhere. In light of the enormous cost of the project, *the question remains whether the project's economic benefits are at least as large as its costs.* This question will not be resolved until detailed information is collected on Cairo households' willingness to pay for improved sanitation services.

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APPENDIX A

FINANCIAL AND ECONOMIC ANALYSES

Not Available

APPENDIX B

USAID/EGYPT COMMENTS ON THE ASSESSMENT FINDINGS

A Note From CDIE: CDIE Program and Operations Assessments are a unique type of evaluation in A.I.D. They are intended to provide an independent examination of development issues. Assessments are at their best when they critically and thoroughly examine and question all of the assumptions of a development issue. This is particularly important since development is an uncertain, high-risk business, where things can easily go awry.

In the case of the Capital Projects Assessment, the field work covered Egypt. When the evaluation team discussed its finding with the Mission, there were differences of opinion. The evaluation team took the Mission's views into account where it could, but in several cases, where there was still a difference of view, the team had to rely on its own judgment.

Often in A.I.D., documents go through a clearance process designed to build consensus on major issues. However, with CDIE Assessments, because of the need to ensure the objectivity of findings, they are not subjected to the same clearance process. A.I.D. places special emphasis on ensuring the integrity, objectivity, and independence of CDIE evaluation findings. To help ensure independence, CDIE selects skilled professionals for its evaluation teams who are not associated with either the USAID Mission or the program being evaluated. In addition, while Missions are always asked to review the draft evaluations and their comments are carefully considered, especially where issues pertain to the accuracy of facts, their concurrence is not a requirement for clearance.

In order to enable the USAID/Egypt Mission a chance to voice its dissenting views without compromising the evaluation team's own independent assessment and conclusions, CDIE has included this appendix which contains the Mission's views. CDIE welcomes such debate and differences of opinion as an important aspect of the learning process that will ultimately improve our understanding of development.

From the Mission's perspective, the final report represents an improvement over the earlier drafts. However, we continue to believe that the analysis is flawed as discussed in the following paragraphs.

As acknowledged in the CDIE study, the capital projects reviewed by CDIE have made important contributions to the development of Egypt's economic infrastructure. However, the study asserts that the economic rates of return for power and wastewater projects are low and implies that these types of projects should not be financed. We disagree with these conclusions. After careful review of the CDIE study, we believe that the economic analyses suffer from methodological deficiencies, incomplete information, and inappropriate hypotheses. As a result, the study draws conclusions which contain implications for capital project funding in Egypt and elsewhere which are inappropriate.

The CDIE analyses suffer from methodological flaws. The principal problem relates to measuring economic benefits for power and water/wastewater projects primarily in terms of tariff revenues generated by the projects at the time they were designed, rather than in terms of the value to the consumers of the outputs. This value is measured by increases in energy prices over the past several years. Consequently, the report greatly underestimates economic benefits in an environment—such as Egypt's—where tariffs have

historically been highly subsidized, but for which subsidies are being removed. In addition, CDIE's approach ignores a variety of external or secondary economic benefit—such as the downstream benefits of improved water quality or the gains to the economy resulting from reduced power outages—which are important for a number of the projects analyzed. These methodological weaknesses are, in USAID/Egypt's view, the principal explanation for CDIE finding low economic rates of return to the infrastructure projects examined in Egypt which, by its own admission, were well designed and made an important contribution to Egypt's economic development.

The analysis of the Shoubra power plant provides a useful example of the problems with measuring economic benefits primarily in terms of tariff revenues. As a general rule, the economic benefits of a project should be measured in terms of the economic value to consumers of project outputs—as measured by their willingness-to-pay for those outputs. At least three factors demonstrate that economic value was much greater than average tariffs in the case of Shoubra: 1) during the last few years, consumers have demonstrated—in the face of significant real tariff increases—that they value electricity much more than what was assumed in the early years of the Shoubra analysis; 2) the addition of Shoubra to the EEA grid effectively ended capacity-related outages—the costs of which are much higher than tariffs; and 3) most of Shoubra's output does not go to marginal consumption.

In this light, USAID/Cairo reworked the economic analysis of Shoubra using per kwh benefit measures consistent with consumers' demonstrated willingness-to-pay higher tariffs in recent years. The result was an economic return greater than 15 percent, instead of the CDIE assertion of an economic return of 6.8 percent.

Many of these same criticisms apply as well to the CDIE analyses of water/wastewater projects. That is, willingness-to-pay for connected consumers is clearly well above actual tariffs. In addition, there are many external benefits resulting from improvements in water/wastewater services which have been ignored, e.g., health and productivity gains for all urban households, whether connected to the system or not, and downstream benefits in form of improved health and increased agricultural productivity. In light of these problems and omissions, CDIE's estimated economic rates of return and "break even" willingness-to-pay levels are basically meaningless.

The series also utilizes information which should be either more accurate or more complete. An obvious example, the massive Cairo Sewerage Project, highlights serious discrepancies of information which exists. The CDIE study figures that $139 per household is necessary for payback while the more technical study, recently completed by Ernst and Young, concludes that $50 per family is necessary. Other technical discrepancies exist: on the water project, the CDIE study uses a per capita consumption of 30 liters per day while water specialists in Cairo estimate 100 to 300 liters per day, depending on the income group. Such discrepancies between CDIE figures and USAID/Cairo's should be resolved before an attempt is made to estimate project rates of return. The nonquantifiable benefits created by the projects, like improved health conditions for millions of people (Cairo Sewerage II) and increased productivity and employment (Shoubra Power Project) are variables which have to be measured before a definitive conclusion can be reached.

The CDIE study is an attempt to prove, or disprove, a set of hypotheses about the relationship of capital projects, development, and trade by retrofitting them onto ongoing or completed capital projects. (If the capital projects had been designed on the basis of these hypotheses, the Mission might have designed and implemented them differently.) The hypothesis of additionality, that a donor's assistance should generate follow-on donor

exports, has important variables which need further consideration. For instance, the study and its related piece on trade, assumes a level of spare part provisions for capital projects which is far too high. (For further clarification, the reader should see Mission comments on *Capital Projects: U.S. Aid and Trade in Egypt,* Technical Report No. 8.) Other hypotheses also need rethinking. The theory that capital projects should leverage other donor and private investor participation neither takes into account the numerous USAID and Congressional regulations which limit such cooperation, nor does it examine the regulations of other donor agencies.

It is important to emphasize that this CDIE study was primarily designed to test hypotheses about the secondary impacts of capital projects in generating additional trade. It was not, nor was it intended to be, a comprehensive ex post economic evaluation of the impacts of capital projects in Egypt. As a result, USAID/Egypt suggests that the CDIE series be viewed as a preliminary effort which accentuates the subject's complexity and underscores the necessity of more rigorous research on the intricate relationship of capital projects and development. The Mission plans further studies in this area which will employ a more rigorous methodology, and gather more complete information to analyze the economic impact of capital projects in Egypt. The Mission's most serious concern regarding the series is that CDIE has given such prominent and unequivocal interpretations to the results of these preliminary analyses.