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Abstract

In the past, most evaluations of the electric utility investments have been based on the assumptions that the suppliers of electricity would provide the quantity of energy demanded at an acceptable level of reliability. The question addressed in most of the investment appraisals has been: "is this investment the least cost way to supply the electricity demanded?"

In real life the situation is usually very different in most developing countries. Shortages, outages and deterred demand have been the rule, rather than the exception. Often the existing generation, transmission and distribution system are far from being the least cost method of supplying power. As a consequence, major investments are required to improve the existing capacity of electricity systems as well as to provide some expansion. In such a situation both the financial and economic analyses become more challenging. We need to isolate both benefits and costs of incremental investments that are part of an overall integrated system, where existing assets rather than new assets dominate the system's operations.

This study of a major rehabilitation program by Comision Federal de Electricidad (CFE) of Mexico (Mexico Public Electric Utility) presents a practical method of analysis for this type of projects along several fronts. First, the analysis is done in an integrated fashion where the financial, economic, distributive, and risk aspects of the project are examined together on a consistent basis. Second, the value of each of the components of the supply improvement, i.e reduction in shortages, outages, transmission losses, is considered separately and then combined in the overall appraisal. Third, the risks imposed on these investments from such macro-economic variables as changes in the real exchange rate and the rate of inflation are modeled, based on real world data, and combined with the risks inherent in the project inputs, such as fuel and investment costs to make an assessment of the overall risks associated with the undertaking of these investments.

Such an integrated analysis is much more than a set of procedures for estimating the expected net present values or rates of return of the project. An investment appraisal carried out in this fashion becomes an analytical tool for redesigning the project in ways that increase the likelihood of its sustainability and the probability of achieving its objectives.

Keywords: Mexico, electricity, rehabilitation, investment, generation, transmission, appraisal

JEL Codes: D61, H43, L94

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I. OVERVIEW

In the early 1980s, Mexico went through a period of economic recession characterized by high rates of inflation and a large external debt. Mexico responded by implementing macroeconomic reforms which were aimed at opening up the economy to foreign competition, limiting the role of the state in the productive sectors, fostering the development of non traditional exports and rescheduling the foreign debt.

In the mid-1980s the reforms were successful in stabilizing the economy. The stabilization program that started in December 1987 reduced substantially the level of inflation. Inflation rate dropped from a high 159.2%, in 1987, to 19.2% in 1989. That drop in inflation resulted from the reduction in the size of the government deficit, which was achieved by increasing the price of goods and services supplied by government enterprises, and by adopting a restrictive fiscal and monetary policy.

Along with macroeconomic reforms, several measures in different sectors of the economy were implemented to reduce the public deficit and to raise economic efficiency. In the energy sector for example, fuel prices were increased in real terms to correct the distortions in resource allocation, public sector procurements for the sector were opened to foreign competition, and rates-schedules were allowed to increase in line with inflation and the operating costs of the sector.

In the electricity sector, the government restricted the investments by Comission Federal de Electricidad (CFE) to a minimum. In the 1970’s CFE investment averaged 13% of total public investment. That share dropped in the 1980s to remain fairly constant at 10% from 1982 to 1989 while the annual amounts declined from year to year in terms of constant 1989 prices. From a figure of US$ 2 billion in 1982, total investment in the electricity sector was US$1.4 billion in 1983, 1984, and 1985. A further decline to US$ 1.15 billion occurred in 1986 and 1987.

The reduction of public investment in the sector forced CFE to postpone its least-cost investment program, which included the construction and maintenance of generating plants, and transmission and distribution equipment. Consequently, the electricity sector faced several technical problems; such as reduction of reserves in generating plants, increase in energy losses, and reduction in the supply and efficiency of thermal-electric generating plants.

With favorable economic conditions after mid-1980, public investment was resumed and CFE planned to expand its productive capabilities and achieve its objectives by implementing a long-term investment program which would take into account economic issues as well as financial restrictions. The total direct investment of this program, US$ 35 billion for the period 1989-1998.

The lending program of the World Bank, in accordance with the country assistance strategy, aimed at lending slightly more than US 2 billion per year to Mexico. Thus, the World Bank would serve as Mexico's "lead bank" and play a major catalytic role in securing external sources of financing for: (a) continued adjustment (agriculture, public enterprises, fiscal reform/deregulation, public sector enterprises); (b) increasing sector investment (time-slice lending for irrigation, power, transport, water); and (c) expanded lending in human resources, poverty alleviation and the environment[1]. It is in that context of country assistance strategy that the World Bank authorized a loan to assist in financing the construction of hydro generating plants in May 1989. In the same year, the bank prepared a lending operation to finance the 1991-92 time-slice investment program for CFE in transmission and distribution facilities, and in reconditioning thermal-electric plants.

The Electricity Sector in Mexico

Mexico has two public electric utilities that operate in the power sector. The first utility, CFE (Comission Federal de Electricidad) is in operation since 1937. It generates, transmits and distributes electricity to the whole country. The second company, CLFC (The Compania de Luz y Fuerza del Centro), a former private utility now wholly owned by CFE, is in charge of the distribution in the area of Mexico city and the vicinity.

The installed capacity of CFE at the end of 1988 included 23,921 MW in generation plants, 56,000 km of high voltage transmission lines (400 Kv, 230 Kv and 115 Kv), 255,000 km of distribution lines, and 16,500 MVA of distribution transformers. Although most of the country is interconnected through high voltage transmission lines, the full exchange of power plant reserves is not possible because of the limitations in the interconnection of different regions.

CFE estimated that, for the decade 1988-98, sales including export would grow at 6.6%. Should demand grow at a faster rate and the rate of investment in the power sector remain unchanged, the reliability of supply would deteriorate leading to a shortage situation. Consequently, as part of the ten-year investment program, CFE prepared four special subprograms that would be implemented over a five-year period to address specific problems in the areas of generation, transmission, distribution and rehabilitation of thermal plants.

CFE planned to add 17,626 MW in new power generation plants during the period 1989-98. Besides that generation program, CFE undertook three subprograms in generation, transmission, and distribution during the period 1990-94. The subprogram in generation would renovate the thermoelectric power plants to improve thermal efficiency and availability at CFE's main plants. The subprogram "Transmission" expanded and improved installations rated 400 kv to 115 kv. Finally, the subprogram "Distribution" aimed at connecting new customers, and at improving the reliability of the service of major activities in Distribution.

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[1] Mexico Country Strategy Paper, World Bank, 1993.

Transmission Project Objective and Benefits

The primary objective of the project under study was to expand and improve transmission installations rated 400 kv to 115 kv. The benefits come from increased consumption because of new customers, from transformer and lines loss reduction and from outages reduction.

In the financial analysis, the benefits from increased consumption are valued using the value of the transmission service, which is the share of the weighted average tariff less the fuel and operating costs attributed to transmission. The financial savings from loss reduction[2] are valued using fuel, operating, and generation capacity costs. The financial revenues from reduction of outages are simply valued as the product of the resulting increased consumption and the weighted average tariff.

The economic benefits from increased consumption are calculated using the willingness to pay approach. The economic benefits of loss reduction are calculated using the conversion factors for fuel, operating costs, and generation capacity costs. The economic benefits from the reduction of outages are valued at the costs of electricity to the end users. A survey on the costs of outages can be carried out for each group of customers to determine the average opportunity cost of the energy when outages occur.

Results of the Financial, Economic, Distributive, and Risk Analyses.

This study evaluates the Transmission Subprogram by using an integrated financial-economic-distributive approach. The economic analysis assesses the value to the economy of the project's output and inputs. It adjusts the financial values for any distortions such as taxes, subsidies, or foreign exchange premium, which cause financial prices to differ from true resource values.

The results of the base case indicate that if this project could be implemented successfully, the net present values from the total investment perspective and from the economic point of view would respectively be 1,619 and 3,894 billion pesos or US$ 527 and US$ 1,268 million (in 1990 prices).

The distributive analysis shows that consumers benefit most from this project. They gain 3,155 billion pesos or US$ 1,027 million (1990 prices). Labor benefits by 86 billion Pesos (US$ 28 million) while the government gains 652 billion Pesos (US $ 212 million).

The results of the risk analysis show that the net present values from the total investment perspective and from the economic point of view are 1,957 and 3,842 billion pesos respectively.

[2] An alternative would be to value loss reductions using the tariff since the energy saved because of the reduction of losses is now available for sale. This study makes an assumption that in the long run, savings in fuel, operating costs and capacity building are realized. Therefore, it is appropriate to use these savings rather than the tariff to calculate the benefits from loss reduction.

II. PROJECT DESCRIPTION

The transmission system at CFE covers most of the country's territory in Mexico. As of 1989, the system comprised approximately 24,000 km of high voltage lines (69 to 400 KV), and 66,000 MVA of capacity installed in substations. Seven regional divisions were in charge of the design, construction, maintenance and operation of the transmission system. Five of these regions were interconnected while the regions of Peninsular and Baja California were isolated from the national grid. All these regions are part of this project.

The reduction of public investment in the electricity sector in the 1980s forced CFE to postpone its least-cost investment. With better economic conditions at the end of that decade, public investment resumed and CFE, faced with many technical problems, planned to upgrade its productive capabilities in the three areas of the system.

The purpose of this special subprogram in the area of transmission is to connect new customers to the grid, to reduce transmission losses, and to improve the reliability of the system.

A. Project Components

This project includes the following components:

- Installation of new transformers with a capacity of 10,400 MVA in existing or new substations, and 1,020 circuit breakers.

- Construction of a total of 700 high voltage feeders and transmission lines with a total length of 7,500 km.

Transmission lines

The evaluation of a transmission project requires the analyst to identify the different types of transmission lines. There exist three types of transmission lines: (1) lines that link generation plants to the national grid; (2) lines that connect two isolated systems; and (3) lines that reinforce and expand the existing system. The objective of this project is to reinforce and expand the existing grid system. The current project does not include the connection of the two isolated systems, Peninsular and Baja California, to the national grid even though part of the investment will be made in those regions. This project deals only with the third type of the transmission lines described above. Table 1 summarizes the various transmission lines that are part of this project.

Table 1: Total Transmission Lines (in Km) by Level of Voltage

Area	400 KV	230 KV	138 KV	115 KV	69 KV	Total
Oriental	238	940		1674		2852
Occidental	360	782		372	28	1542
Nordeste		49		390		439
Norte		216		123		339
Noreste	887		86			973
Peninsular		380		372		752
Baja California		138		303	146	587
Total (Km)	1485	2505	86	3234	174	7484

Transformers

The objective of installing new transformers and circuit breakers is either to reduce the load of existing ones or to take on new demand. When the load of transformers exceeds the transformers' capacity, the losses increase substantially and the reliability of the electrical system decreases. In that situation, it is necessary to replace existing transformers by new ones with greater capacity or install new transformers to reduce the load of existing transformers.

As the project consists of replacing old transformers or installing new ones to supply the existing demand, the incremental benefits of this project would include the reduction of transformers losses and the improvement in reliability. The measurement of transformers losses is given by a chart provided by the manufacturer of the transformer. The losses in kilowatts are then converted into energy losses. The value of the incremental benefits from the reduction of transformer losses is the product of the energy losses (in kwh) and the cost savings per Kwh. This per unit savings per Kwh is measured by the marginal cost of generating and transmitting power to the substation where the transformers are installed.

The replacement of old transformers or the installation of new ones generates two types of revenues. The revenues from the sales of electricity to new customers and the savings due to the reduction of losses.

Table 2 shows the total capacity installed by the project by level of voltage for each region.

Table 2: Transformers' capacity installed with project (MVA)

Area	**400 Kv**	**230 Kv**	**161 Kv**	**115 Kv**	**69 Kv**	**Total** (MVA)
Oriental	1130	988		923.4		3041.4
Occidental	1375	1831	134	268.8	80	3688.8
Nordeste		430		320		750
Norte	500	594		270		1364
Noreste		363		86		363
Peninsular		400		248.8		648.8
B.California		312		170	60	542
Total	3005	4918	134	2201	140	10398

B. Alternatives Considered

This project is part of the least cost investment program of CFE in its transmission system. CFE has several planning models for optimization of the transmission system associated with schemes for expanding the generation. The other investment mixes, which are not described here, were analyzed by the models to come up with the investment program which has the lowest present value of costs and meets the capacity requirements overtime.

C. Project Cost and Financing

The estimated total cost of the project, including the costs of equipment, materials, labor, engineering, and supervision is $US 808 million in 1990 prices of which $US 545.86 million (67.6%) is in foreign currency and $US 262.14 million (32.4%) is in local currency. Total investment costs including equipment, labor cost, and contingencies for cost overruns are summarized in Table 3:

Table 3: Total Investment Costs (1990 Million $US)

Component	Description	Cost (1990 Million $US)
Power Transformers	Installation of new transformers with a capacity of 10,400 MVA.	89
Breakers	Installation of 1020.	71
Transmission lines	Construction of 7,500 km.	339
High Voltage Feeders	Construction of 700.	142
Labor Costs		87
Contingency		80
Total Cost		808

The financing of this project came from foreign and domestic sources. Foreign credit including multinational development agencies, export agencies and suppliers amounted to $US 545.86 million. Domestic sources included CFE, the Mexican government and the consumers. The sources and amounts of financing are summarized in Table 4.

Table 4: Financing (million 1990 Prices)

Source of Financing	Domestic (million US $)	Foreign (million US $)	Total(million US $)	Total(Million Pesos)*
CFE	208	0	208	638,768
IBRD Loan		171.5	171.5	526,677
IDB Loan		66	66	202,686
Eximbank Japan		22.5	22.5	69,098
IBRD (Hydro Project)		19.95	19.95	61,266
Contractors undertaking Turn Key Contract		84	84	257,964
Suppliers' Credits		181.91	181.91	558,646
Consumer Surcharges	23.16		23.16	71,124
Government Contributions	30.68		30.68	94,218
Total	261.84	545.86	808	2,480,447

*Exchange Rate in 1990: 3071 Pesos/ 1US $

The disbursements and loan schedules are summarized in Annex 5 and Annex 6.[3]

[3] All annexes for this paper are available from Glenn Jenkins' office (gjenkins@hiid.harvard.edu)

D. A Public Sector or Private Sector Project?

Even if the institutional framework in the area of electricity transmission were developed in Mexico to allow for the private provision of this service, a private enterprise would not have an incentive to undertake this investment, which is mainly an upgrade of the existing system. Also, private provision of the transmission of electricity alone is not sufficient for the project to be done in the private sector as the benefits of this project are mainly arising from the savings in generation of electricity. Indeed, 50 % of the financial benefits come from the savings in generation costs and these benefits accrue directly to CFE, the principal owner of the generating plants. To attract the private sector, part of these savings would have to be credited to the private owner of the transmission system.

The question remains whether a multilateral institution, such as the World Bank, should be financing this project or should CFE obtain its financing from private financial institutions? This question cannot be answered without further information on the costs and risks facing both CFE and the private financial institutions if the funds were obtained from such sources. Given the considerable real exchange rate risk associated with foreign borrowing to produce what is essentially a non-traded good, the sources of funds from a multilateral organization with the guarantee of the national government might be an efficient way to manage the associated risks of such a project. In this case, however, the question of the private sector undertaking this investment is not considered, as it is an enhancement of the existing CFE system, and CFE is a state-owned enterprise.

III. FINANCIAL ANALYSIS

The following incremental benefits accrue to the utility from the upgrading of the transmission system:

- Increased Sales due to new Customers
- Savings due to Reduction of Technical Losses
- Incremental Sales due to Reduction of Outages

The evaluation of financial benefits of a transmission project requires that the quantity of incremental consumption, the size of the reduction of losses, and the amount of the reduction of outages are identified and a financial value is placed on these items. To do so, specific data regarding the nature and the components of the project in the area of transmission are needed to measure these incremental benefits.

Service of a Transmission Line

The service of a transmission line depends on the net energy delivered by the line to the distribution system or to the customers directly connected to that transmission line. That net energy is the difference between the energy received from generation and the sum of the line and transformer losses.

Tariff Share of the Transmission Service

The challenge in valuing the service of a transmission line for a regulated integrated electrical utility arises from the absence of a tariff for the services of transmission alone.

For a utility that generates, transmits, and distributes to final consumers, there is no price for the transmission service independent of the distribution service. The absence of such prices makes the financial valuation of service in either component of the electric system difficult. It is therefore convenient in valuing the service of generation, transmission, or distribution to set an internal service price for each component of the electric system. One way to set this internal price for transmission is to multiply the weighted average tariff less the variable fuel, and operating costs[4] by the share of the transmission costs in total marginal capital costs of the system. This internal price of transmission service represents the contribution of transmission towards the total financial benefits from the sale of electricity to customers. The following formula is used in the case of the transmission project:

Financial Value of Transmission Service per Kwh=(Weighted average tariff-Fuel cost-Operating cost)*[MCT/(MCG +MCT+MCD)] (1)

where MCG: Marginal Capital Cost of Generation ($/Kwh)
MCT: Marginal Capital Cost of Transmission ($/Kwh)
MCD: Marginal Capital Cost of Distribution ($/Kwh)

The tariff and the long run marginal costs adjust to changes in the real exchange rate. Long run marginal costs vary with changes in the exchange rate because the costs of fuel and other tradable components are linked to the exchange rate. The tariff adjusts to the changes in the real exchange rate through the changes in the long run marginal costs.

Table 5 shows the estimates of marginal cost at CFE for the three components of the utility in 1990. Given these estimates, the value of the transmission service for one kilowatt hour delivered to the distribution is about 28.8% of the weighted average of tariff less the fuel and operating costs.

[4] All operating costs of the system excluding the fuel cost for generation.

Table 5: Marginal Supply Costs[5] (1990 prices)

System Costs	*US$/Mwh*
Marginal cost generation	51.8
a. Fuel	39.2
b. Capacity	12.6
Marginal capacity cost transmission	9.9
Marginal capacity cost distribution	11.8
Operating	0.7
Long Run Marginal Cost(LRMC)	74.2

A. Financial Benefits of the Transmission Project

1. Increased Sales due to New Customers

The total capacity installed as shown in Table 2 differs from total demand because of new customers. Indeed, part of the new transformers installed will replace old ones with or without increased consumption, while the rest will meet a share of the incremental demand. CFE estimated that total incremental demand due to new customers would be 295, 273, 202 and 602 MW respectively during the period 1990-1993. No further adjustment in incremental demand is made after 1993 because capacity made available by the project is maximized in 1993. Demand remains constant, while the incremental energy varies according to the load factor of the system. Table 6 summarizes net incremental consumption due to new customers for the period 1990-1993. The consumption for the entire project period is given in Annex 3.

[5] For the capacity cost for transmission and distribution : See Economic Analysis of a Power Investment Program by Luis Gutierrez, January 1991, p5. The levelized capacity cost for generation and the fuel come from the October 25, 1989 report of CFE : "Proyecto Especial Para Rehabilitacion Y Modernizacion de Unidades Generadoras del Area de Generacion Thermoelectrica de CFE". The levelized cost of a 350 MW steam plant was Ps 33.71/Kwh, and the fuel cost was Ps 86.58/ Kwh. The exchange rate in 1988 was Ps 2473/ $ 1 US.

Table 6: Incremental Consumption For The Period 1990-1993

	1990	**1991**	**1992**	**1993**
Net Incremental Demand (MW)	295	273	202	602
Cumulative net demand (MW)	295	568	770	1372
Load Factor[6]	54.61%	52.96%	51.28%	49.37%
Net energy sold[7] (Gwh)	1411	2635	3459	5933

Using the value of service defined in equation (1) above, Table 7 shows the calculation of the sales revenues for the period 1990-1993. The present value of sales revenues from incremental consumption due to new customers amounts to 2,230 billion pesos or US$ 726 million (1990 prices) from the whole project. This represents 46% of the project's financial revenues.

[6] The load factor is derived from the projections of both energy and system capacity of the whole electric system. Load Factor= Projected Energy Demanded/(8760*Projected System Capacity)

[7] Energy Sold(Gwh)= 8.76* Incremental Demand (Mw)*Load Factor

Table 7: Measurement of Revenues from Incremental Electricity Sales to New Customers for Period 1990-1993 (Nominal Prices)

	1990	1991	1992	1993
Net energy sold[8] (Gwh)	1411	2635	3459	5933
Nominal tariff [9] (million pesos/ Mwh) (a)	0.114	0.153	0.205	0.276
Fuel Cost[10] (million Pesos/ Mwh) (b)	0.1203	0.1384	0.1591	0.1830
Operating Cost[11] (Million Pesos/Mwh) (c)	0.0021	0.0024	0.0028	0.0032
Value of Transmission Service[12] (million pesos/ Mwh) (d)	(0.0086)	(0.0037)	0.0043	0.0165
Revenues (million Pesos)	(12,119)	(9,634.2)	14,727.7	97,609.8
Revenues[13] (million US $)	(3.95)	(2.82)	3.88	23.17

To obtain the transmission sales revenues of 97,609 million pesos or US$ 23.17 million for the year 1993 as shown in table 7, we make the following calculations. In 1993, the total sales to new customers amounted to 5933 Gwh. The nominal price of electricity was 0.276 million pesos per Mwh while the fuel cost was 0.183 million pesos per Mwh. Hence, the difference

[8] Energy Sold(Gwh)= 8.76* Incremental Demand (Mw)*Load Factor.
[9] Nominal tariff= Weighted Average Nominal Gross of Tax Tariff.
[10] The fuel cost in 1990 was US$ 39.2/Mwh. To obtain the value in nominal pesos, the fuel cost is expressed in real pesos and then multiplied by the price index in subsequent years.
[11] The operating cost in 1990 was US$ 0.7 /Mwh. The method used for the fuel is also applicable here.
[12] Value of transmission service= [a-(b+c)/(1-0.15)]*0.2877. The sum (b+c) is divided by (1-0.15) to take into account the additional fuel and operating costs induced by 15 % of system losses.
[13] The projected nominal exchange rates from 1990 to 1993 are 3071, 3412, 3791,and 4213 pesos/1 US$ respectively.

between the electricity price and the sum of fuel and operating costs adjusted for energy losses[14] is 0.0572 million pesos per Mwh. This difference multiplied by the share of the transmission capital cost to the total system capital cost, which is 28.77%, gives the value of the transmission service as 0.0165 million pesos per Mwh. This value of the transmission service is multiplied by the quantity of electricity sold to new customers, 5933 Gwh, to obtain the financial sales revenues of 97,609 million pesos derived from new customers.

2. Reduction of Technical losses

Technical losses in the area of transmission refer essentially to losses in transmission lines and transformers, and losses due to failure of transmission equipment. The incremental energy saved is the difference of total losses in two situations: "with" and "without" project. The calculation of these losses can be simple or complex depending upon the nature of the project. When the project involves the integration of transmission lines and transformers into an interconnected network, the assessment of incremental benefits is more difficult.[15]

Transmission losses

There are three types of transmission losses: line losses, transformer losses and losses of synchronous condensers. Each of these losses can be evaluated easily for a single component such as one transmission line, or one transformer. The difficulty arises when that single component is part of a dynamic network. In this case, all components of the system interact and the calculation of transmission losses becomes complex.

The transmission-line losses vary with the loads at both ends of the line, the length of the line, the power factor, and the level of voltage[16]. A transmission network, however, consists of many lines, transformers, condensers and the power flows through the system following the routes of least resistance. The operating conditions affect all parts of equipment of an electric system. When electric equipment such as transformers and transmission lines are overloaded, the losses increase.

In the case of a network, the valuation of losses is not straightforward. A system flow model is usually constructed to simulate the power flow and losses of the system. In this project, the results from two scenarios of a load flow model "with project" and "without project" are used

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[14] The energy losses amount to 15% of generation.

[15] Max J. Steinberg and Theodore H. Smith, Economy Loading of Power Plants and Electric Systems.

[16] For a three-phase transmission line that links two stations, the line losses in KW are given by

$$T_L = \frac{R\ (kw)^2}{1000\ (kv)^2} + \frac{R\ (kvar)^2}{1000\ (kv)^2}$$

where,
R= line resistance per wire in ohms
kvar = total three-phase transmitted reactive kilovolt-amperes.
kw = total three-phase transmitted energy.
kv = line voltage, in kilovolts.
T_L = total three-phase line losses, in kilowatts

to calculate the reduction of losses due to the project. The output of the model of load flows includes both incremental consumption and loss reduction. The following data in Table 8 shows only the loss reduction estimated by CFE's system flow model in the "with" and "without" project scenario for the period 1990-93. After 1993, the losses[17] expressed in megawatts in a given year are the product of losses in the previous year and the ratio of total demand in that given year and total demand in the previous year.

Table 8: Technical losses for the period 1990-93

Technical losses	**1990**	**1991**	**1992**	**1993**
With Project (MW)	276	280	303	349
Without Project (MW)	445	471	546	658
Reduction of Losses (MW)	169	191	243	309
Load Factor	54.61%	52.96%	51.28%	49.37%
With Project (GWH)	841	810	831	898
Without Project (GWH)	1356	1361	1497	1692
Reduction of losses (GWH)	515	551	666	794

[17] To convert the losses expressed in megawatts into gigawatt-hours the following equation is used:

Losses (Gwh) = L*8.76*[0.8*Lf^2+0.2*Lf]

where L: Losses in MW

Lf: Load factor

Table 9 shows the calculation of the benefits from loss reduction for the period 1990-1993.

Table 9: Measurement of Savings from Loss Reduction for Period 1990-1993 (Nominal Million Pesos)

	1990	**1991**	**1992**	**1993**
Reduction in losses[18] (Gwh) (a)	515	551	666	794
Fuel Cost[19] per Mwh (b)	0.1203	0.1384	0.1591	0.1830
Operating Cost[20] per Mwh (c)	0.0021	0.0024	0.0028	0.0032
Marginal Generation Capacity Cost[21] per Mwh (d)	0.039	0.044	0.051	0.059
Savings per Mwh of loss reduction[22] (e)	0.1614	0.1848	0.2129	0.2452
Total Savings due to Loss reduction[23]	83,121	101,825	141,791	194,689

The financial benefits from savings in transmission losses are created because a reduction in these losses allows the system to generate a smaller quantity of electricity and still deliver the same amount of energy to its customers. Hence, the savings are estimated here by multiplying the sum of the fuel, and marginal generation capacity costs, and operating costs by the quantity of the reduced losses.

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[18] The reduction in losses are calculated in Table 8.
[19] See footnote 10.
[20] See footnote 11.
[21] The generation capacity cost in 1990 was US$ 12.6/Mwh. To obtain the value in nominal pesos, the capacity cost is expressed in real pesos and then multiplied by the domestic price index in subsequent years.
[22] Savings per unit of loss reduction = (b)+(c)+(d)
[23] Total savings = (a)*(e) *1000

In the short run, the savings in generation capacity costs may not be realized. However, in the long run, the approach used to evaluate the savings due to loss reduction takes into account the degree to which generation capacity costs are saved through a reduction in transmission losses. For this project, the present value of the savings in variable generation costs due to loss reduction in substations and transmission lines amounts to 2,413 billion pesos (1990 prices), which is about 50% of the total financial benefits of the project.

3. Increased Sales due to Reduction of Outages

Table 10 provides the estimated decline in the total duration of the interruptions and outages. CFE has estimated, based on computer models, a total annual reduction of 102 minutes in outages duration by the year 1993 due to the implementation of this project. In 1992, the reduction in outages duration is the product of the time in 1993, which is 102 minutes, and the ratio of the incremental demand in 1992 and 1993 respectively. The same procedure is used to calculate the reduction in outages time for the years 1991 and 1990. After 1993, the reduction in total outages time remains at 102 minutes.

The incremental consumption due to outage reduction is distinct from the incremental demand calculated earlier. The incremental consumption due to outage reduction relates to existing customers who suffer from outages. Since the duration of outages in this case affects the whole electric system, the value of reduced outages is therefore the product of the incremental energy sold because of outage reduction and the weighted average tariffs of different groups of consumers.

Table 10: Reduction of Outage Duration and Energy Provided.

	1990	1991	1992	1993
Total system demand for energy[24] (Gwh)	89,743	92,411	94,618	96,823
Reduction outage time[25] (minutes)	22	42	57	102
Net Energy for sale due to outage reduction[26](Gwh)	6.86	14.02	20.11	38.06

Using the weighted average tariff, Table 11 shows the calculation of the benefits from outages reduction for the period 1990-1991.

[24] Projected system demand for electricity.
[25] CFE estimates of annual reduction in outages time.
[26] The difference in energy provided because of outages with and without the project is given by the following formula: $\frac{R_t}{60} * \frac{E_t}{8760 * Lf_t}$ where
E_t: Total Energy demanded in year t
R_t: Number of Minutes in Reduction of outage time in year t. To express R_t in hours, divide it by 60.
Lf_t: Load factor in year t.
The ratio $E_t/(8760*Lf_t)$ is the system demand. The system demand multiplied by the reduction in time of outages equals the energy provided as a result of that reduction in outages time.

Table 11: Revenues from Outages Reduction For Period 1990-1993 (Nominal Prices)

	1990	1991	1992	1993
Sales from outages reduction[27] (Gwh)	6.86	14.02	20.11	38.06
Nominal tariff[28] (million pesos/ Mwh)	0.114	0.153	0.205	0.276
Revenues from outages reduction[29] (million Pesos)	782	2,145	4,123	10,504

The present value of revenues due to reduction of total outages time for the entire project amounts to 216 billion pesos[30] or US$ 70 million (1990 prices) for the whole project, or four percent of the project's financial benefits.

B. Methodology of Financial Analysis

The first step in financial analysis consists of making assumptions about variables such as tariff, inflation, interest during construction, income tax and sales taxes, project economic life, and working capital. The second step consists of carrying out the analysis in both nominal and real prices from the total investment and equity owner's perspectives. The analysis in both nominal and real prices sheds light on the impact of inflation on the project. Inflation has both direct and indirect effects on the results of the analysis. The indirect impacts, also known as the tax impacts, are relevant when the equity owner is subject to corporate income tax. The direct effects of inflation take place through changes in accounts receivable, changes in accounts payable and changes in cash balances.

1. Assumptions

A. Tariff Policy

Although the level of tariff is very important for the financial sustainability of a regulated electric utility, this project illustrates how measurement of financial savings from loss reduction is as important as the end user tariff. Because the fuel cost alone is about 53% of the long run marginal cost of the system, the reduction of losses due to the transmission project will have a

[27] See footnote 18.
[28] Weighted Average Nominal Gross of Tax Tariff.
[29] Calculated as the product of sales due to outages reduction and the nominal weighted average gross of tax tariff.
[30] Stream of revenues from outage reduction for entire life of project discounted at financial discount rate of 7.17%.

significant effect on the financial results of this project. Indeed, the results of the financial analysis confirm that 50% of total benefits come from loss reduction. The importance of the fuel cost savings of generation created by this project does not mean that the analysis of tariff should be neglected.

The tariff used in this study is consistent with the new tariff policy agreement signed in 1989 between CFE and the government. There are two major issues confronting electricity tariff in Mexico. First, electricity rates have been subsidized by the government since the 1970s, and second, the tariff structure does not reflect the costs of supplying electricity to each customer class. Electricity rates fell in real terms by about 37% between 1980 and 1983 because of the high rate of inflation and a lag in the adjustment of nominal tariff. Despite the sharp increases in nominal terms from 1984 to 1988, the rates did not reach the 1980 level.

Facing both issues of subsidies and high inflation, the government and CFE signed a new Financial Rehabilitation Agreement (FRA) on August 31, 1989. One measure adopted in the FRA was for CFE to update the tariff study in order to establish a program of rate increases in real terms in accordance with macroeconomic conditions. Under that scheme, most government subsidies except those to low-income residential and rural users would be eliminated by 1991, and average electricity rate would reach the Long Run Marginal Cost (LRMC) level by 1996. In this study, we assume that all customers tariff reach their LRMC level by the year 1996.

After eliminating the government subsidies, another condition has to be met to achieve the LRMC target by the year 1996: nominal electricity rates have to fully adjust to inflation. Thus, this study considers that nominal electricity rates will be adjusted to inflation with a lag period of three months to account for institutional and other constraints in setting electricity prices.

B. Inflation

Inflation in Mexico in the 1960s and up until 1972 remained low within the range of 1.5% to 5%. The OPEC oil price hike led to a double-digit inflation in 1973 and the following years. Between 1973 and 1982, inflation fluctuated between 12% and 28% range. Between 1983 and 1988 inflation rates were high and unstable reaching a high of 114% in 1988. Given such instability, it is difficult to predict long-term inflation rates. However, since the government aims at reducing the level of inflation to that of Mexico’s main trading partners, a 15% inflation rate was assumed in the base case analysis of this study. The possible fluctuations in the rate of inflation are considered in the sensitivity and risk analysis.

C. Interest During Construction and Capital Cost

There are different ways to consider interest during construction (IDC) in a financial analysis. First, if interest has been paid during the period of construction then it enters the analysis as a cash outflow when the project is examined from the equity owner’s point of view. Second, if no interest on the loan has been paid out during the construction period, which is the case in this project, then interest during construction is accrued and added to the total investment after completion of the project for depreciation purposes.

D. Income Tax and VAT on Electricity.

CFE as a state-owned electric utility is not subject to corporate income tax. The value added tax on electricity is 15%.

E. Project's Economic Life

The project was to be completed in four years starting in 1990. CFE estimated an economic life of 30 years for the main equipment of the transmission subprogram.

F. Accounts Receivable, Accounts Payable, Cash Balances

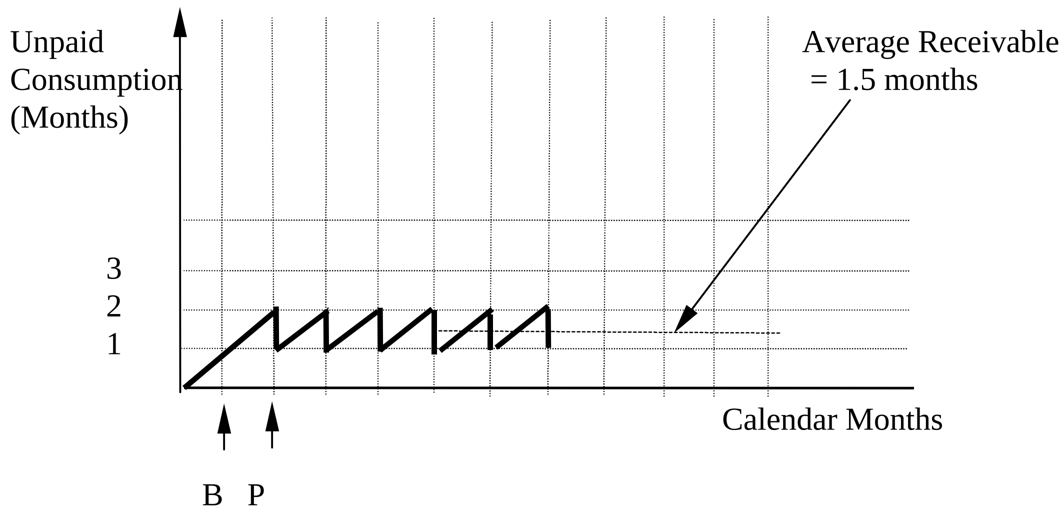
Accounts payable are set at one and a half months of fuel and operating expenses. Also, cash balances that are held as working capital are assumed to be three months of these expenses.

The level of accounts receivable is a function of the billing and collection cycles, and the uncollectibles receivable (bad debt). For a utility that sells essential services to customers and bills them on a regular basis, the nature of its billing and collection cycles can have substantial impact on the firm's revenues. For instance, a power company may bill the customer every month after reading the meter, and allow the customer to pay within one month after the bill is sent. This will result in a billing cycle of one month, and a collection cycle of 1 month. The relationship between the length of billing cycle, the collection period and the level of accounts receivable expressed in months of sales can be written as[31]:

Accounts Receivable (in months of sales)= Billing cycle + Average Collection Cycle/2

[31] In this study, accounts receivable is equal to the unpaid sales rather than unpaid bills. Unpaid consumption is always greater than the unpaid bills.

Figure 1: Billing, Collection Cycles and Accounts Receivable



Where

B: Bill sent out to customers
P: Payment Date

In this study, the billing cycle is one month. A customer has one month to pay after the bill is sent. In this case, the accounts receivable equal 1.5 months.

Accounts Receivable = 1+ 1/2 = 1.5 months.

The amount of bad debts written off each year will mean a net reduction of the potential cash flow for the year, hence bad debts written off during the period are reflected through a negative adjustment to the cash inflows for the period. It is also assumed that the bad debts written off each year will be equal to 0.1 month of sales.

G. Exchange Rate

This project has about US$ 546 million of foreign loans out of a total investment cost of US$ 808 million. Because the foreign component of the loan is significant, a devaluation will negatively affect the net present value of the project from the equity point of view. The nominal exchange rate is a function of the growth and the change of the real exchange rate as well as the rates of inflation at home and abroad. The expression for the nominal exchange rate is given by

$$E^t_N = (1+g)^t * (E^o_R) * (I^t_D / I^t_F) * (1+k)$$

Where

E^t_N = Nominal Exchange rate at period t.
g = Rate of real devaluation
E^o_R = Real Exchange rate as of Period 0.
I^t_D = Domestic price Index at Period t.
I^t_F = Foreign Price Index at Period t.
k = Deviation of the Rate of real devaluation from the trend in the movement of the real exchange rate.

The rate of real devaluation assumed over time in the base case is zero.

C. Points of View and Discount Rates

The financial analysis in both nominal and real prices were conducted from the equity and the total investment points of view. From the total investment point of view, the viability of the project is analyzed irrespective of financing while from the equity's viewpoint the debt and its repayments are included in the cash flows.

The real return on equity recommended in the Financial Rehabilitation Agreement is 7%. The Agreement has also suggested a funding mix of 47.4 % from external borrowing, 5.4% from government and 47.2% from internal sources. The real returns on these sources of financing were respectively 7.17 %, 8.6% and 7%. The funding mix and the real rates of returns yield a real weighted average cost of capital (WACC) of 7.17%, which is used as real discount rate in the total investment perspective.

The financial net present value from both equity and total investment viewpoints are estimated by discounting the annual projected stream of cash flows by their respective discount rate. Annexes 2 to 9 show the tables used to construct the net cash flow statement. These tables include the loans schedule, electricity tariff, investment cost, operating and maintenance expenses and working capital. After conducting the analysis in current pesos, the nominal cash flows are deflated by the price index to obtain the real (1990 pesos) cash flows.

D. Results of Financial Analysis

The financial benefits of this project come from increased consumption due to new customers, loss reduction, and increased consumption due to outages time reduction. Increased consumption due to new customers represents 46% of total financial benefits, while loss reduction and outages time reduction amount respectively to 50% and 4% of total financial benefits. The 50% share of total benefits from loss reduction signals that special care should be taken in the estimation of these losses. The sensitivity analysis will show the net impact of the losses on the net present value of this project. Table 12 summarizes the present values of each type of benefit.

Table 12: Present Value of Benefits and Cost Savings for Entire Life of the Project

	Present Value (Million of 1990 Pesos)	Present Value (Million of 1990 US$)	% Total Benefits
Benefits from Increased sales due to new customers	2,229,760	726	46%
Benefits from loss Reduction	2,413,118	786	50%
Benefits from outages reduction	216,502	70	4%
Total	4,859,380		100%

Table 13 shows the results of the financial analysis. The net present values from the total investment point of view and from the equity point of view are respectively 1,619 and 2,003 billion of pesos or US$ 527 million and US$ 652 million.

Table 13: Summary of Financial Cash Flow Analysis

	Real Discount Rate	**Real NPV (Million Pesos)**	**Real NPV (Million US $)**	**IRR**
Total Investment Point of View	7.17%	1,619,513	527	12%
Equity Point Of View (CFE)	7%	2,003,064	652	21%
Equity Point Of View (without gov. grants)	7%	1,853,251	603	18%

Tables 14a,14b, and 14c show the results of the projected real cash flow statement from the total investment, the equity owner's, and the equity owner's excluding government grants[32] perspectives respectively.

[32] The government will grant US$ 30.68 million to finance this project. This grant is included in the Total Investment perspective as a cash inflow. The NPV from the equity owner's perspective remains positive even if this amount of US$ 30.68 million is not accounted for as a cash inflow.

TABLE 14A: CASH FLOW STATEMENT -Total Investment Point of View (Real Prices)
(million Pesos)

		1990	1991	1992	1993	1994	1995	1996	1997	1998	2024
RECEIPTS											
REVENUE											
Sales to new customers		-12119	-8378	11136	64180	117704	179251	251416	248754	245867	186391
Lines and Transformers Losses reductions		82975	88799	107334	127932	128219	129093	130465	135535	141484	460085
Sales due to Reduction of Outages		783	1864	3121	6913	8430	10327	12701	13273	13946	51988
Change in accounts receivable		-7494	-9798	-10846	-28559	-13859	-16338	-19442	-9371	-9224	-5167
Government contributions		23555	23555	23555	23555						
Consumers contributions		17781	17781	17781	17781						
Total Net Revenue		105481	113824	152081	211802	240494	302332	375140	388192	392073	693296
Cash Inflow		105481	113824	152081	211802	240494	302332	375140	388192	392073	693296
EXPENDITURES											
Investment Costs											
Equipment and Materials											
Transformers		27295	136205	68102	41888						
Breakers		21890	109450	54860	32970						
Transmission lines		104045	510769	257006	167824						
High Voltage Feeders		43510	217820	109450	64049						
Labor Costs											
Skilled		15649	77492	38929	24398						
Unskilled		11179	55359	27810	17429						
Sub-Total		223569	1107096	556158	348559						
Contingency as costs overruns		24593	121781	61177	38341						
Total Subprogram Investment		248161	1228876	617335	386900						
Operating costs											
Maintenance Expenses due to sales from		17	35	50	94	97	100	103	107	113	427
Fuel costs due to outages reduction		971	1985	2846	5388	5534	5694	5862	6128	6442	24369
Total operating costs due to outage reduct		988	2019	2896	5482	5631	5794	5965	6236	6555	24796
Bad Debt		500	1088	1669	3355	3841	4430	5148	5101	5051	4224
Working capital											
Change in accounts payable		-18907	-18900	-15725	-39419	-7578	-7613	-7696	-8831	-8698	-4929
Change in cash balance		-18907	-18900	-15725	-39419	-7578	-7613	-7696	-8831	-8698	-4929
Total change in working capital		0	0	0	0	0	0	0	0	0	0
Taxes											
VAT		7820	17024	26121	52515	60127	69333	80576	79844	79055	66110
Income Taxes		0	0	0	0	0	0	0	0	0	0
Total tax expenditures		7820	17024	26121	52515	60127	69333	80576	79844	79055	66110
Cash Outflow		257468	1249007	648022	448252	69599	79556	91689	91181	90660	95129
NET CASH FLOW		-151988	-1135183	-495941	-236451	170894	222776	283451	297011	301413	598167
NPV fin @ fin. d.r.	**7.17%**	**1,619,513**									
IRR		**12%**									

TABLE 14B: CASH FLOW STATEMENT -EQUITY POINT OF VIEW (Real Prices)
(in million Pesos)

		1990	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*2024*	*2025*
Net cashflow from total investment		-151988	-1135183	-495941	-236451	170894	222776	283451	297011	301413	598167	55092
Debt, Consumer & Goverr												
IBRD proposed loan			158743	237945	96945	0	0	0	0	0	0	
IDB proposed loan			50442	140474	0	0	0	0	0	0	0	
Eximbank Japan			22254	21501	20774	0	0	0	0	0	0	0
Loan 3083-ME(hydro projects)			19732	19064	18420	0	0	0	0	0	0	0
Turn-key Contracts			83080	80271	77556	0	0	0	0	0	0	0
Suppliers Credits			179918	126894	129897	-30858	-29814	-28806	-27832	-26891	0	0
Total cash flow			514167	626149	343592	-30858	-29814	-28806	-27832	-26891	0	
Net Cash flow after financing		-151988	-621016	130208	107142	140037	192962	254645	269179	274522	598167	55092
NPV (Million Pesos)	7.00%	**2,003,064**										
NPV (Billion Pesos)		**2,003**										
IRR		**21%**										

TABLE 14C: CASH FLOW STATEMENT -Equity Point of View-no Govt. Subsidies (Real Prices)

Net cashflow from total investment		-193324	-1176519	-537277	-277786	170894	222776	283451	297011	301413	598167	55092
Debt, Consumer & Government Financing												
IBRD proposed loan			158743	237945	96945	0	0	0	0	0	0	0
IDB proposed loan			50442	140474	0	0	0	0	0	0	0	0
Eximbank Japan			22254	21501	20774	0	0	0	0	0	0	0
Loan 3083-ME(hydro projects)			19732	19064	18420	0	0	0	0	0	0	0
Turn-key Contracts			83080	80271	77556	0	0	0	0	0	0	0
Suppliers Credits			179918	126894	129897	-30858	-29814	-28806	-27832	-26891	0	0
Total cash flow			514167	626149	343592	-30858	-29814	-28806	-27832	-26891	0	0
Net Cash flow after financing		-193324	-662351	88872	65806	140037	192962	254645	269179	274522	598167	55092
NPV @	7.00%	**1,853,251**										
IRR		**18.2%**										

E. Sensitivity Analysis

A sensitivity analysis was carried out to identify the impact of key variables on the financial net present value. These variables are: the rate of domestic inflation, the percentage of cost overruns, the real fuel cost, the rate of demand growth for electricity for each group of customers, the tariff, the accounts receivable, the technical loss reduction, the length of the lag in adjustment of tariff for inflation, and changes in the real exchange rate.

1. Sensitivity of Financial NPV to Electricity Prices

Electricity prices for residential and rural customers are highly subsidized. In 1988, residential customers paid 39% of the long run marginal cost while rural users paid only 16%. In the same period industrial and commercial rates were respectively equal to 82% and 93% of their marginal cost. To bring these prices in line with marginal costs, prices have to grow annually in real terms by 26.2%, 14.9%, 13%, 38.3% , and 18.1% respectively for residential, industrial, commercial, rural and other customers during the period 1989-1996.

It is assumed in this sensitivity analysis that the tariff is adjusted continuously for the rate of inflation but with a three months lag time. There is a time lag of three months between the time the inflation occurs and when the statistics are published and used to set tariffs. The weighted average price of electricity is based on the demand and the tariff of each group of customers. Tables 15 to 18 summarize the results of the sensitivity analysis for each type of customers. The first column of each table shows the 1996 real tariff as a percentage of the long run marginal cost for a group of customers.

The financial NPVs are sensitive at various degrees to all four classes of tariff according to the starting ratio of the tariff and the LRMC, and the share of demand of each group of customers. The lower the ratio of tariff and LRMC as of 1988, the greater the net impact on NPV. Also the greater the share of the demand of a group of customers, the greater the net impact on NPV.

1.1 Residential Tariff

As mentioned above, the lower the ratio of the tariff to the LRMC, the greater the impact on NPV of raising the tariff to the level LRMC. Residential tariffs in 1988 were about 39% of LRMC. By raising that share to 100% in 1996, one would expect a positive change in NPV. Indeed the results of the sensitivity analysis in Table 15 show a net impact on Total Investment perspective NPV of about 544 billion pesos or about US$ 177 million when the residential tariff is raised to its LRMC level.

Table 15: Effect of Residential Tariff on NPV
(Million 1990 Pesos)

1996 Real Tariff as % of LRMC	Total Investment (Real NPV)	Equity (Real NPV)
40%	1,075,167	1,447,865
50%	1,139,054	1,512,966
60%	1,212,408	1,587,745
65%	1,252,918	1,629,051
70%	1,296,139	1,673,129
75%	1,342,194	1,720,103
80%	1,391,208	1,770,103
85%	1,443,313	1,823,261
90%	1,498,640	1,879,714
95%	1,557,326	1,939,600
100%	1,619,513	2,003,064

1.2 Industrial Tariff

Industrial demand amounts to 57.8% of total demand in 1990. Hence, the impact of a percentage change in the real tariff is larger. At the same time, as the industrial tariff is already 82 percent of the long run marginal cost, the financial impact of raising it to 100 percent of long run marginal cost is smaller. The net impact on Total Investment NPV of raising industrial tariff from 80 to 100 percent of the LRMC by the year 1996 is about 264 billion pesos or US$ 86 million (1990 prices). Table 16 shows the effect of changes in industrial tariff on NPV.

Table 16: Effect of Industrial Tariff on NPV
(Million 1990 Pesos)

1996 Real Tariff as % of LRMC	Total Investment (Real NPV)	Equity (Real NPV)
50%	1,031,207	1,403,472
55%	1,079,615	1,452,772
60%	1,130,190	1,504,289
65%	1,182,987	1,558,078
70%	1,238,061	1,614,196
75%	1,295,468	1,672,699
80%	1,355,264	1,733,646
85%	1,417,507	1,797,095
90%	1,482,256	1,863,107
95%	1,549,571	1,931,743
100%	1,619,513	2,003,064

1.3 Commercial Tariff

The net impact on Total Investment NPV of raising the commercial tariff from 90 to 100 percent of LRMC is about 37 billion pesos or about US$ 12 million. This small amount compared with the results of the remaining groups of customers is mainly explained by the fact that commercial tariff was very closed to LRMC to start with, and by the fact that demand of commercial customers represented only 8.7% of total demand in 1990. The results of the sensitivity analysis of commercial tariff are summarized in Table 17.

Table 17: Effect of Commercial Tariff on NPV
(Million 1990 Pesos)

1996 Real Tariff as % of LRMC	Total Investment (Real NPV)	Equity (Real NPV)
50%	1,459,490	1,839,791
55%	1,472,892	1,853,462
60%	1,486,822	1,867,672
65%	1,501,298	1,882,441
70%	1,516,338	1,897,786
75%	1,531,962	1,913,726
80%	1,548,187	1,930,281
85%	1,565,035	1,947,472
90%	1,582,524	1,965,318
95%	1,600,676	1,983,842
100%	1,619,513	2,003,064

1.4 Rural Tariff

One would expect as in the case of residential customers, a significant impact on the NPV when rural tariff increases to their LRMC level because the initial ratio of tariff and LRMC was low. Although this is the case and the raising of rural tariff to their LRMC level adds about 297 billion of pesos or about US$ 97 million to Total Investment NPV, the impact here is lower because rural demand amounts to only 7.9% of total demand in 1990. Consequently, the impact on NPV is smaller even though the initial ratio of tariff and LRMC was 18% for rural customers while the same ratio for residential users was 39%.

Table 18 summarizes the results of the sensitivity analysis of the rural tariff.

Table 18: Effect of Rural Tariff on NPV
(Million 1990 Pesos)

1996 Real Tariff as % of LRMC	Total Investment (Real NPV)	Equity (Real NPV)
18%	1,321,879	1,698,948
25%	1,331,955	1,709,232
30%	1,340,224	1,717,673
40%	1,359,856	1,737,719
50%	1,384,324	1,762,709
60%	1,414,608	1,793,647
70%	1,451,847	1,831,696
80%	1,497,360	1,878,207
90%	1,552,667	1,934,734
100%	1,619,513	2,003,064

1.5 Summary

This analysis shows that the largest financial gain received by the utility from increasing the tariffs to LRMC is from the residential sector. Over 48 percent[33] of the revenue gain will come from the higher electricity bills of residential customers.

2. Sensitivity of Financial NPV to Inflation

Inflation has a significant impact on the financial results of this project. If inflation rate rises from its base case level of 15%, the net present values drop for both total investment and equity owner's point of view. Increasing inflation has both positive and negative impact on the cash flow. Since CFE is not subject to income tax payment, the impact of inflation on the cash flow takes place through the working capital items and the loan repayment schedule. In addition to the impact through the working capital items, the change in inflation rate affects the real value of the revenues derived from new customers. The revenues from sales to new customers is a function of the difference between the tariff and the sum of the fuel, and operating costs per kilowatt-hour. In this study, the fuel and operating costs fully adjust to changes in the rate of inflation whereas the tariff adjusts to the changes in the rate of inflation with a three-month lag time. As a result, the impact of inflation on the net present values goes through more channels than the working capital items. Table 19 details the net impact of inflation on the financial results of this project. The net present value from the Total Investment Perspective drops by 88 billion pesos or about US$ 29 million when inflation rises from 15% to 30%.

[33] When all tariffs reach their LRMC level in 1996, residential, industrial, commercial, and rural customers will add 544, 264, 37, and 297 billion pesos respectively to the NPV. The contribution of residential customers alone, represents 48% of the total.

Table 19: Effect of Inflation on NPVs
(Million 1990 Pesos)

Rate of Inflation	Total Investment (Real NPV)	Equity (Real NPV)
5%	1,686,871	2,071,564
10%	1,652,246	2,036,353
12%	1,638,936	2,022,817
15%	1,619,513	2,003,064
20%	1,588,501	1,971,527
25%	1,559,062	1,941,590
30%	1,531,063	1,913,116
40%	1,478,928	1,860,097
50%	1,431,297	1,811,659
75%	1,328,009	1,706,619

3. Sensitivity of Financial NPV to Lag in Adjustment of Tariff for Inflation

Because of institutional constraints in setting prices and gathering data on inflation, this study considers that electricity tariff will be adjusted to inflation with a three-month lag period. To make that adjustment, we first set a path of real tariff to reach the long run marginal cost in 1996. We then adjust the implicit nominal tariff because there is a lag time in adjustment of tariff for inflation. If the tariff fully adjusts to inflation, the lag time is zero and the nominal tariff in any period is given by the product of the real tariff and the domestic price index in that period. Should the lag time be twelve months, the nominal tariff for a given year becomes simply the tariff of the year adjusted for the price level of the previous year. To estimate the nominal tariff as a function of the number of months in adjustment lag for inflation we use equation (2).

$$\text{Nominal Tariff}_T = \text{Real Tariff}_T * (1+\text{inflation rate})^{T-to-1} * (1+\text{Inflation Rate}_T * (12-\text{Lag})/12) \qquad (2)$$

where

$\text{Real Tariff}_T = \text{Real Tariff}_{to} * (1+\text{Tariff Growth})^{T-to}$
Real Tariff_{to} = Real Tariff at the beginning of the project.
Tariff Growth= Real tariff growth required to reach LRMC level in 1996.
Inflation Rate_T: Rate of Inflation in Period T
Lag: Lag time in months
t_o: initial period

Table 20 shows the results of the sensitivity analysis for different lag periods. The NPV from Total Investment perspective drops by 312 billion pesos or US $ 102 million when the lag period is increased from 3 to 12 months.

Table 20: Effect of Lag in Adjustment of Tariff for Inflation

(Million 1990 Pesos)

Months	Total Investment (Real NPV)	Equity (Real NPV)
0	1,730,053	2,115,771
1	1,692,843	2,077,831
2	1,655,997	2,040,264
3	1,619,513	2,003,064
6	1,512,195	1,893,648
8	1,442,401	1,822,491
10	1,373,982	1,752,737
12	1,306,914	1,684,362
24	931,647	1,301,819

4. Sensitivity of Financial NPV to Investment Cost Overruns

The investment costs for the base case already includes a contingency cost item. Since cost overruns is the difference between the investment costs upon realization of the project and the initial investment cost, the value of cost overruns may be higher or lower than the contingency cost.

In the base case, the contingency cost represents 11% of total investment. In Table 21 below, we vary the percentage of total investment from -10% to 50%. That range includes the 11% of the contingency cost. As shown in Table 21, the real cost overrun has a significant impact on the financial result. The financial NPV from Total Investment perspective drops about 182 billion pesos or US$ 59 million when costs overruns increase to 20% from the base level of 11%. At the same time this project is quite robust with respect to investment costs. Even if the investment cost rise to 50 percent above the original estimates, the financial net present value from the Total Investment perspective would still be positive. The following table shows the summary of the effect of cost overruns on NPV.

Table 21: Effect of Cost Overrun on NPV

(Million 1990 Pesos)

Costs Overruns as % of total investment	Total Investment (Real NPV)	Equity (Real NPV)
-10%	2,044,572	2,429,057
-5%	1,943,368	2,327,630
0%	1,842,163	2,226,203
11%	1,619,513	2,003,064
15%	1,538,549	1,921,923
20%	1,437,344	1,820,496
25%	1,336,139	1,719,070
30%	1,234,935	1,617,643
40%	1,032,525	1,414,789
50%	830,116	1,211,936

5. Sensitivity of Financial NPV to Amount of Accounts Receivable

Table 22 indicates that the financial NPV is affected by the size of the accounts receivable. The Total Investment NPV drops by 200 billion pesos or US$ 65 million when the accounts receivable are increased from 1.5 months to 3.5 months of annual sales.

Table 22: Effect of Accounts Receivable on NPV (million pesos)

Accounts Receivable (Months)	Total Investment	Equity
1	1,669,541	2,053,740
1.5	1,619,513	2,003,064
2.0	1,569,484	1,952,389
2.5	1,519,455	1,901,714
3	1,469,426	1,851,039
3.5	1,419,397	1,800,364
4	1,369,368	1,749,689
5	1,269,310	1,648,338
6	1,169,253	1,546,988

6. Sensitivity of Financial NPV to Fuel Cost

From 1962 to 1988, the growth in real fuel oil price[34] averaged 3.6% with peak rate of 40% and 60% respectively in 1974, and 1983. Although there were fuel oil price hikes in some years, the growth in real fuel oil price tends to be negative in many years. The following sensitivity analysis considers a range from -5% to 7% change in the level of real fuel oil price for the life of the project. Changes in the real fuel cost have two effects on the revenues of this project. The first effect takes place through the adjustment of long-run marginal costs to changes in real fuel costs. When real fuel cost increases, the long run marginal costs increase and this also increases the savings due to reduction of losses. Moreover, the revenues from the sales to new customers and sales due to reduction of outages also increase because the real tariff adjusts to changes in the long-run marginal cost. The second effect is the impact of the changes in the real fuel cost on the revenues from new customers and from reduction of outages. When real fuel cost increases, the revenues fall because the production cost increases.

In this study, the overall net impact on the NPV of a rise in real fuel cost is positive because the first effect dominates the second one. When the real cost of fuel increases by 7%, the NPV from the Total Investment perspective increases by 54 billion pesos or US$ 17.6 million pesos. Table 23 summarizes the impacts of the level of change in real fuel cost on the net present values in both cases.

[34] World Bank, Sectoral Electricity Demand in Mexico, Table A-5, p.38

Table 23: Effect Of Fuel Cost On NPV (Million 1990 Pesos)

Change in Level of Real Fuel Oil Cost for Entire Project	Total Investment (Real NPV)	Equity (Real NPV)
-5%	1,580,411	1,962,559
-3%	1,596,101	1,978,811
-1%	1,611,725	1,994,997
0%	1,619,513	2,003,064
1%	1,627,284	2,011,116
2%	1,635,040	2,019,151
3%	1,642,780	2,027,169
4%	1,650,504	2,035,172
5%	1,658,212	2,043,158
6%	1,665,905	2,051,129
7%	1,673,583	2,059,083

7. Sensitivity of Financial NPV to Real Exchange Rate

his analysis considers a percentage change in real exchange rate in the year 1990. After this one time change, real exchange rate remains constant throughout the life of the project. With that assumption, the burden of the loan repayment in later years is offset by the inflow of the loan in early years so that the resulting impact on the net present value of the project from the equity perspective is reduced.

Long run marginal costs, tariffs, and fuel cost are adjusted to changes in the real exchange rate. Exchange rate is linked to fuel, and marginal costs because of their tradable content. Since tariffs adjust to marginal cost, changes in real exchange rate also affect the tariff.

Given the volatile history of real exchange rate and the substantial share of foreign loans in this project, movements in the real exchange rate are expected to have an impact on the project net present value. A real devaluation of the domestic currency has two opposing effects on the net present value. The first effect lowers the net present value because the fuel cost and the debt burden increase. The second effect leads to greater revenues because the level of real tariff, and the savings resulting from loss reduction increase. In this study, the net impact of a real devaluation of the domestic currency is a moderate change in net present values. In increasing the real exchange rate by 3% in 1990, the net present value from the Total Investment perspective decreases by 3.4 Billion pesos. Table 24 summarizes the sensitivity analysis of changes in real exchange rate on net present values from both Total Investment and Equity Owner's perspectives.

Table 24: Effect of Real Exchange Rate on NPV
(million of Pesos)

Change in Real Exchange Rate in Year 0 (g)	Total investment (Real NPV)	Equity (Real NPV)
-3.0%	1,622,474	1,995,600
-2.0%	1,621,529	1,998,132
-1.0%	1,620,542	2,000,620
0%	1,619,513	2,003,064
1.0%	1,618,441	2,005,466
2.0%	1,617,329	2,007,826
3.0%	1,616,176	2,010,144
4.0%	1,614,982	2,012,420

8. Sensitivity of Financial NPV to Technical Losses

The reduction of technical losses translates into savings for CFE. In the base case analysis these savings represent 50% of the financial benefits. If the actual value of the level of technical losses is 10% below the losses estimated in the base case , the financial NPV from the Total Investment Perspective drops by 241 billion pesos or US$ 78 million. On the other hand, if the base case underestimates the reduction of losses by 10%, the results in Table 25 show that the NPV from the Total Investment Perspective increases by the same amount.

Table 25: Effect Of Reduction Technical Losses On NPV (million of Pesos)

Changes as percent of Base case losses	Total investment (Real NPV)	Equity (Real NPV)
-30%	895,577	1,262,094
-20%	1,136,889	1,509,084
-10%	1,378,201	1,756,074
0%	1,619,513	2,003,064
5%	1,740,168	2,126,560
10%	1,860,824	2,250,055
15%	1,981,480	2,373,550
20%	2,102,136	2,497,045
25%	2,222,792	2,620,540
30%	2,343,448	2,744,035

9. Sensitivity of Financial NPV to Demand For Electricity

The demand growth has three effects on the net present value of this project which offset each other. These effects can be analyzed through the three benefits of the project.

First, an increasing demand growth would have no impact on the revenues from new consumption because the new capacity installed by the project would be utilized completely when the project is implemented. When the new capacity due to the project is just enough to supply the new customers, an increase in the demand for electricity will have no impact on the benefits from increased consumption by new customers. If however, the project provides capacity in excess of existing demand, an increase in future demand met by the project would generate more revenues and hence increase the financial benefits. It is assumed in this study that upon completion of this project, the new capacity will be completely utilized to reduce part of the existing shortage and, therefore, any further increase in demand will not be met by the capacity installed because of this project.

Second, the effect of demand growth on the revenues from outages reduction is relatively small. The revenues from outages reduction are a function of total demand and reduction of outages time. We expect that when demand increases the benefits from the reduction of outages also increase. To measure the effect of demand growth on the revenues, we need to separate the growth of demand in two components. The first component measures the growth due to existing customers who are currently affected by outages. The second component measures the growth due to new customers. Only the first component is used in this study to assess the impact of demand on the benefits from the reduction of outages. With the assumption that electricity prices and income are constant in the "with" and "without" project situations, one can infer that the growth in demand due to existing customers is relatively small compared to the growth due to new customers. Hence, the additional benefits due to demand growth in the case of outage reduction is relatively small.

Third, when the demand increases for a given capacity of transmission network the losses also increase. These losses will increase with the demand to a level of reliability admissible by the utility. Beyond that level of reliability, the utility will not operate its transmission equipment. When demand increases the benefits from reduction of losses will be smaller since an increasing demand will also increase the losses. Hence, increasing demand has a negative impact on the benefits derived from reduction of losses. The constraints on the reliability of the transmission system are not incorporated in this study. However, it is assumed that when the project achieves its target level of reliability of the transmission system, the utility will maintain that level throughout the life of the project so that any further increase in demand will be met by new equipment. As a consequence, the benefits from the reduction of losses because of this project will not be affected by any further growth in demand.

In conclusion, the net of the two opposing effects of the growth in demand on the net present value of this project is small.

F. Conclusion of Sensitivity Analysis

As a result of the sensitivity analysis, five variables are identified as risk variables because of their appreciable impact on the financial net present value, while four variables are found to have moderate impact on the financial results and therefore will not be included in the risk analysis. The risk variables are: rate of inflation, cost overruns, real fuel cost, real exchange rate, and the loss reduction level. The demand for electricity, the size of the accounts receivable are not included in the risk analysis because of their moderate impact on the financial NPV of this project. The tariff of electricity, and the lag in adjustment of tariff for inflation are policy variables and therefore excluded from the risk analysis.

Sensitivity analysis measures only the net impact of changes in one variable at a time while others remain constant. Since in reality many variables move together a more complete risk analysis needs to be undertaken to assess the overall risk associated with the project.

IV. ECONOMIC ANALYSIS[35]

The appraisal is conducted using the domestic price level of 1990 as the numeraire. The first step in the economic analysis is to determine the economic benefits of additional electricity consumption of electricity, the economic benefits of loss reduction and outages reduction, and finally the economic conversion factors for all inputs used in the project.

A. Economic Benefits

1. Economic Benefits from Increased Consumption due to New Customers.

The transmission project will connect new customers to the grid for whom the service of the utility would not be available without the project. For these customers, the alternative would be to generate their own electricity by a gasoline or diesel electricity generator. The cost of self-generation with the same quality as the service of the electric utility represents the maximum willingness to pay for electricity. The benefits of electricity delivered to new customers are valued at what they would be willing to pay for the incremental energy supplied by this project.

Energy shortage arises because the demand for electricity at the price charged exceeds the supply of electricity. The current project will increase the capacity to reduce that shortage. The maximum demand net of losses which will be met by the project in 1993 is 1372 MW.

The economic valuation of electricity, as depicted in figure 2, takes into account the shortage of energy, the rise of electricity prices to their marginal cost level in 1996, and the increase in capacity due to the project.

The rise in prices does not result from the implementation of this project. The adjustment of electricity prices to their LRMC level in 1996 is part of the financial rehabilitation agreement signed between CFE and the government.

The demand for electricity is represented by the curve DD' in figure 2. If there were an adequate supply of electricity at the price of P_0 the quantity of electricity consumed would be Q_3. The lack of system capacity to meet total demand forces CFE to ration the supply of electricity.

[35] For further discussion of methodology, see Harberger, Arnold and Glenn Jenkins, Manual, "Program on Investment Appraisal and Management," Harvard Institute for International Development, 1997.

Hence, if we assume that the available supply is rationed over the potential consumers in a way unrelated to their willingness to pay, the demand curve with rationing becomes DD_0. With the given supply of electricity and the regulated price of P_0, the quantity of electricity consumed is Q_0.

Upon completion of the transmission project, the supply of electricity will increase to Q_2 and the electricity price will be P_1. We calculate the economic value by analyzing first the price effect and thereafter the incremental demand effect. When the tariff increases to P_1, the quantity of electricity demanded is reduced to Q_1 by the present consumers. The quantity of electricity released, Q_0-Q_1, can now be made available to other consumers who are willing to buy electricity at prices from P_1 to P_{max}. As a result, the effective demand curve rotates to the right and the new demand curve becomes DD_1 while the supply remains at Q_0.

If now, additional capacity from the project that is equal to Q_2-Q_0 is added to the system, the rationing of electricity can be relaxed further. The demand curve with new level of rationing for the new capacity after the project is implemented is shown as DD_2. At a price of P_1, the effective quantity demanded becomes Q_2. The economic benefits as a result of additional capacity is shown by the area Q_0BDCQ_2.

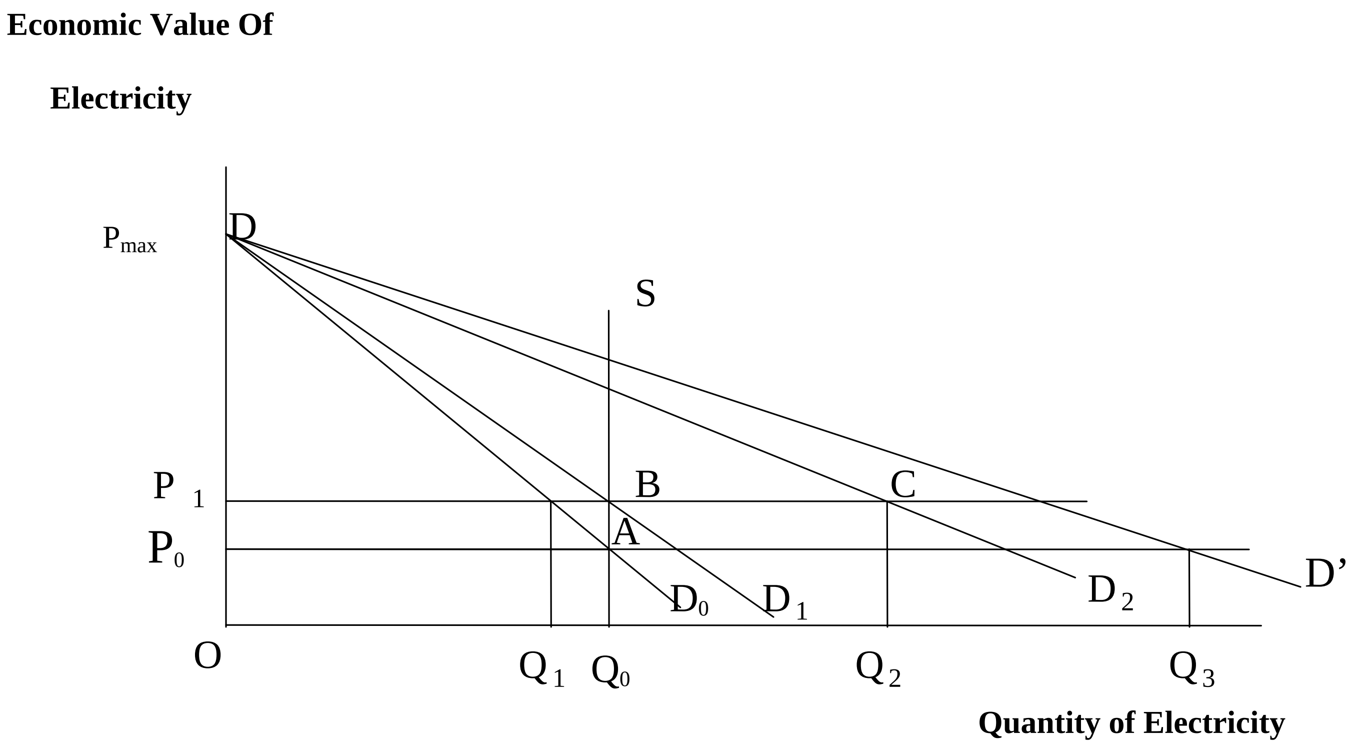
$$\text{Area } Q_0BDCQ_2 = (P_{max} + P_1)/2 * (Q_2 - Q_0)$$

The economic benefits per unit of electricity consumed in a situation of shortage, when rationing is done proportionally, that is now being supplied as a consequence of the project is therefore the average of P_{max} and P_1 or,

$$\text{Economic Benefits per kwh} = (P_{max} + P_1)/2 \qquad (3)$$

In this study, we assumed a linear demand curve with a constant price intercept, which is the maximum willingness to pay (P_{max}). With that assumption, the economic benefits per kilowatt-hour may change only with the real tariff. If however, we allow a change in the price intercept, the economic value would also change with the maximum willingness to pay. The first approach, a linear demand curve with constant price intercept or a semi-log curve yields lower estimates of the benefits. The second approach, a linear demand curve with a price intercept that increases overtime or a constant elasticity curve will give higher estimates of the benefits. Since we choose in this study a linear demand curve with a constant price intercept, the economic value per unit of energy shortage calculated may be lower than the actual economic benefit. It is assumed in this study that the price of electricity will gradually increase in real terms to reach the long run marginal cost level in 1996. Because of that change in prices, the economic value per unit of electricity consumed in a situation of shortage will also increase.

Figure 2: Economic Value Of Electricity due to increased consumption by new customers.



The maximum willingness to pay for electricity (Pmax) with the same quality of power as provided by a power company with adequate reserves can be measured by the cost of own-generation plus backup generation. To calculate the cost of self-generation, which is about 903.5 pesos or US$ 0.294 per Kwh, the following procedure has been used.

The capital cost of a 10HP gasoline power generator in Mexico in 1996 was US$19,174 or US$ 15,598 when expressed in 1990 prices. The capacity cost per Kilowatt[36], $2,091.7 per Kilowatt, is determined as the ratio of the cost and the capacity of the generator. The annualized capital cost[37], $370.2, is calculated with an economic life of 12 years, and a discount rate of 12%. The capital cost per Kilowatt-hour[38] is found to be US$0.0845.The backup factor, the ratio of the capital cost and total generation cost, is US$ 0.403. The generator consumes 1.17 gallon per hour[39]. At a price of 80 cents per gallon, it costs $0.125[40] to produce one Kilowatt-hour. The total own-generation cost, $0.210/kwh, is the sum of the fuel and capacity cost per Kilowatt-hour.

[36] Capacity cost per Kw = cost of generator/capacity of generator = 15,598/(10*0.7457) =$2091.7/Kw. 1HP=0.7457 Kw.
[37] Annualized cost = PMT(12%,10,-2091.7). PMT is an Excel function for calculating the payment of a loan based on constant payments and a constant interest rate.
[38] Capital cost per Kwh = Annualized capital cost/(8760*Load Factor). The load factor is taken as 50%.
[39] Fuel consumption of the generator is 7 gallon for 6 hours.
[40] Fuel cost per Kwh= Fuel cost/Gallon* Fuel consumption/capacity of generator =0.8*1.1667/(10*0.7457)

The maximum willingness to pay[41] is $0.294 per Kilowatt-hour. Table 26 summarizes the results of total own-generation and the maximum willingness to pay.

Table 26: Own-Generations: Average tariff and Willingness To Pay in Mexico
(1990 Prices)[42]

Capital cost of a 10 HP gasoline power generator in Mexico in 1990 (US$)*	15,598
Generating Capacity (kW)	7.5
Capacity Cost ($/kW)	2091.7
Annualized Capacity Cost ($/kW, 10 years life, 12%)	370.2
Load Factor	50%
Capital Cost per kWh	0.0845
Fuel Consumption (gallon per hour, note: 7 gallon per 6 hours)	1.1667
Fuel Cost ($/gallon)	0.8
Fuel Cost ($/kWh)	0.125
Total Own-generation Cost ($/kWh)	0.210
Maximum Willingness To Pay (1990 $/kWh)	0.294
Maximum WTP (1990, m. Ps/MWH)	0.9035

Based on 1997 cost in Mexico.

The economic benefits to new customers are calculated as the product of new consumption and the benefit per unit of shortage as defined in equation (3). The economic costs of providing the incremental demand to new customers, include fuel and operating costs. The difference between the benefits and costs is multiplied by the share, 28.77%, of the capital cost of transmission to the total capital cost of the electricity system to estimate the final benefits that accrue due to the transmission project.

Calculation of the economic value of electricity from increased consumption due to new customers[43] from 1990 to 1993 is shown in Table 27.

[41] Maximum willingness to pay = (1+backup power factor)*Total generation cost=(1+0.403)*0.210=0.294
[42] See Annex 17.
[43] For the entire life of the project, refer to Annex 16B.

Table 27: Economic Value of Electricity from Increased Consumption due to New Customers. (million of 1990 Pesos per Mwh)

	1990	**1991**	**1992**	**1993**
Maximum willingness to pay (Pmax)	0.903	0.903	0.903	0.903
Average electric tariff P_1	0.114	0.133	0.155	0.182
Economic value per unit of shortage[44] (a)	0.509	0.518	0.529	0.543
Economic value of fuel per Mwh[45] (b)	0.151	0.151	0.151	0.151
Economic Value of operating cost per Mwh[46] (c)	0.0017	0.0017	0.0017	0.0017
Share of transmission to overall value of economic benefits [47] (d)	0.287	0.287	0.287	0.287
Economic value of electricity due to transmission project (million Pesos)[48]	133,730	256,786	348,169	619,765
Economic value of electricity due to transmission project[49] (US$ million)	43.55	83.6	113.37	201.8

The present value of economic benefits from increased consumption due to new customers is 4,497 billion pesos or US$ 1,464 million.

2. Economic Benefits due to Reduction of Losses

In addition to the benefits from increased consumption, the Mexican economy also gains from the resources saved because the project lowers the technical losses. The resources saved include fuel, operating and generation capacity costs. The conversion factors for these items are 1.253, 0.809, 0.999 respectively.

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[44] Economic Value per unit of shortage = (Pmax+P1)/2 or the average of the maximum willingness to pay and the electric tariff.

[45] Economic value of fuel per Mwh= Financial value per Mwh * Conversion factor for fuel.
The financial value of fuel per Mwh estimated by CFE equals 86.6 pesos per kwh. The conversion factor for fuel calculated in Annex 15D of this study is 1.253.

[46] Economic value for operating costs per Mwh= Financial value per Mwh* Conversion factor for operating items. This conversion factor 0.809, is calculated in Annex 16A.

[47] This share is calculated using equation 4.

[48] Economic value from consumption by new customers = [a-(b+c)/(1-losses)]* d *energy sold to new customers. Losses equal 15% of total generation.

[49] The benefits expressed in pesos are converted in dollars using the real exchange 3,071 pesos/ 1US$ in 1990.

The present value of the economic benefits from loss reduction is estimated to be 1,558 billion pesos or US$ 507 million. Most of these benefits come from the savings in fuel consumption. The fuel saved from the reduction of losses is now available for export and the economy gains the foreign exchange and the foreign exchange premium for exporting that amount of fuel.

3. Economic Benefits From Reduction of Outages.

The economic benefits from reduction of outages are estimated by multiplying the difference in energy provided in the "without" and "with" project by the cost of power outages. The opportunity cost of power outages is estimated from data given in Table 28. The cost per kwh remains constant throughout the life of this project.

Table 28: Outage Costs by User[50] Categories.

Users	**US$/Kwh**
Residential	0.70
Industrial	1.20
Commercial	0.75
Rural	0.75
Other	0.50
Weighted Total	1.00

CFE has estimated, based on computer models, a total annual reduction of 102 minutes in duration of outages as a result of the implementation of the transmission project by the year 1993. From 1990 to 1992, outage time reduction is estimated prorata of the total demand in each year since the losses are a function of the total demand of the system. From 1993 to the end of the project, it is assumed that the project will result in a reduction in outage time of 102 minutes. The present value of the benefits from reduction of outage time is 267 billion pesos or US$ 87 millions.

4. Summary of Present Values of Gross Financial and Economic Benefits

As shown in Table 29, the economic benefits from increased consumption due to new customers are 4,497 billion while the financial benefits are 2,230 billions pesos. The economic benefits due to loss reductions amount to 1,558 billion pesos while the financial benefits amount to 2,413 billion pesos. The economic benefits from outage reduction amount to 314 billion while the financial benefits are only 216 billion pesos.

[50] Luis Gutierrez, Economic Analysis of a Power Investment Program, p8.

Table 29: Present Values of Gross Financial and Economic Benefits (billion of Pesos)

	Financial Benefits	Economic Benefits
Benefits from Increased Consumption due to new customers	2,230	4,497
Benefits from Reduction of Technical losses	2,413	1,558
Benefits from reduction of outages	216	314

The economic benefits from reduction of technical losses are lower than the financial benefits because the impact of a higher economic discount rate outweighs the gains from foreign exchange premium and the gains from the reduction of fuel subsidies for electricity generation. A low financial discount rate accounts for about 1,100 billion[51] pesos that contributes to a greater financial net present value. Therefore, at the same economic discount rate, the economic net present value would be higher by 245 billion Pesos[52]. The amount of 245 billion pesos comes mainly from the net gain from foreign exchange premium and from the reduction in fuel subsidies.

[51] The present value of the financial benefits due to reduction of losses using the economic discount rate is 1313 billion. The present value of the financial benefits due to reduction of losses using the financial discount rate is 2413 billion The difference of the present values at the financial and at the economic discount rate is 1100 billion pesos.

[52] The present value of the economic benefits due to loss reduction using the economic discount rate is 1558 billion. At the same economic discount rate, the present value of the economic benefits due to loss reduction would be greater than the present value at financial discount rate by 245 billion, which equals 1558-1313 billion pesos.

B. Economic Costs of Foreign Exchange and Capital

1. Economic Cost of Foreign Exchange

The economic cost of foreign exchange is calculated in Annex 15B. The economic cost of foreign exchange is found to be 10.6% higher than the official exchange rate. This premium is due partly to the impact of net import tariffs and indirect taxes (VAT and excises).

2. Economic Cost of Capital

The economic cost of capital for Mexico is estimated to be 12.4%. This cost is determined as a weighted average of the different domestic net-of-tax saving rates, the gross-of-tax returns on investment for the different sectors, and the marginal costs of foreign borrowing. Annex 15C gives the assumptions and the computation of the economic cost of capital.

C. Estimates of Economic Costs of Inputs

1. Basic Conversion Factors

The investment and operating costs of the project consist of the costs of individual items such as freight, insurance, non- tradable and tradable materials and equipment, and tradable fuel. Before calculating the conversion factors for the investment and operating items, we determine the basic conversion factors for the above individual items.

The following assumptions were made for labor, import tariff, local freight and insurance, and non-tradable materials.

Economic Cost of Labor

From a previous study[53] done by the World Bank we derived the composition of skilled and unskilled labor involved in the transmission project. Skilled labor represents about 58% of the total labor. No further information regarding the prevailing market wage, the existence of a protected labor market, the distortions in the labor market or the chance that skilled labor migrated to the project area, was readily available. As an alternative, we used the conversion factors obtained from a study[54] done by the Inter-American Development Bank in 1988. The conversion factors for skilled and unskilled labor were respectively 0.734 and 0.482.

[53] Luis Gutierrez ,Economic Analysis of a Power Investment Program, January 1991.
[54] National Finananciera, Los precios de cuenta en Mexico 1988, 2nd ed., p77.

Import Tariff

The actual import tariff for different categories of the tradable components were not available. The average import tariff calculated in Annex 15B for 1990 is 10%. This rate is appropriate given the prevailing rates applicable after the March 1989 Trade Tariff Regime[55].

Local Freight and Insurance

The local freight and insurance costs were also estimated to be 10% of the CIF value. The supply and demand weights for freight and insurance were assumed to be 80% and 20% respectively. We also considered that freight and insurance were made of 50% tradable components. The weights are the proportions of the quantity of the local freight and insurance purchased by the project that are accommodated by increased supply and decreased demand respectively.

Non-tradable materials

We used equal weights of 50% each for the supply and demand, and 20% as the proportion of tradable components used in the supply of these items. The weights are the proportions of the quantity of non-tradable purchased by the project that are accommodated by increased supply and decreased demand respectively.

The low weight for demand in local freight is attributable to the weak response of demanders of these items. In other words, most of the freight, insurance and non-tradable demanded by the project is accommodated by an increase in the supply of local freight by suppliers.

With the above assumptions, we calculated the basic conversion factors, making appropriate adjustments for the foreign exchange premium, freight and insurance, tradable materials and equipment, non-tradable materials, and tradable fuel. The calculations and results of the basic conversion factors are summarized in Annex 15D.

The next step is to calculate the conversion factors for investment and operating items.

2. Conversion Factors for Investment Cost Items

Investment costs comprise transformers, breakers, transmission lines, and high voltage feeders. Each investment item is made of a share of tradable and non-tradable materials, and a share of skilled and non-skilled labor. Given the shares and the basic conversion factors, we estimated the conversion factor for each investment line as the weighted average of the conversion factors of its components.

[55] World Bank, Mexico Tax Reform for Efficient Growth, Report No 8097-ME, p.78.

3. Conversion Factors for Operating Cost Items

Operating Expenses

The conversion factor for operating and maintenance is the weighted average of the conversion factors for labor, tradable and non tradable materials.

Fuel Costs

Fuel is an input in this project that is currently being heavily subsidized when used in electricity generation. Fuel used in the project reduces the quantity available for export and, hence, results in a loss of foreign exchange. Therefore, the economic cost of fuel is measured as the foregone benefits due to the reduction of fuel exports. The conversion factor for fuel, calculated in Annex 15 D, is 1.253.

4. Conversion Factors for Working Capital Items

Accounts Payable

As this item constitutes a percentage of operating expenses, the conversion factor is the same as that for the operating expenses.

Accounts Receivable and Cash Balances

Accounts receivable result from the sales to new customers and the sales due to outages reduction. Therefore, the economic value of per unit of receivable is the weighted average of the economic benefits per unit of increased sales to new customers and per unit of sales induced by outages reduction.

The conversion factor for changes in cash balances is taken simply as 1.0.

D. Environmental Impact of the Project

The potential environmental impacts for a transmission project include electromagnetic radiation, noise, erosion and land use[56]. While a few studies have attempted to relate electromagnetic radiation from transmission lines to cancer in humans, there is no reliable evidence to substantiate this conclusion. The erosion from temporary or permanent earthworks reduce soil levels and affect agriculture and terrestrial ecosystems. The right-of-way land for the transmission line could displace households or limit land use for agriculture and other productive uses. Although these environmental stressors affect the results of the project, no attempt was made in this appraisal to account for these stressors because of the lack of quantitative data of these stressors and because of their small effect on environment. However, we provide in Annex A the taxonomy for evaluating potential impacts of the environmental stressors in a transmission project.

[56] Economic Evaluation of Environmental Impacts, Asian Development Bank, p.62

E. Results of Economic Analysis

The economic value per unit of shortage, adjusted for fuel cost and the marginal capital cost of the transmission, is used to calculate the economic benefits due to additional consumption. The economic benefits from outages reduction are valued at the cost of outages. For other items, the conversion factors are applied to the real cash flow from the total investment point of view to obtain the economic cash flow statement presented in Table 30. The economic net present value of the transmission project is 3,894 billions of pesos or US$ 1,268 million, indicating that the project adds substantial net wealth to the Mexican economy.

TABLE 30: STATEMENT OF ECONOMIC BENEFITS AND COSTS (1990 prices)
(Million of Pesos)

			1990	1991	1992	1993	1994	1995	1996	1997	1998	2024	2025
RECEIPTS													
REVENUE													
Sales to new customers			133730	256786	348169	619765	625028	637306	657868	651318	644180	499505	
Lines and Transformers Losses reductions			98464	105375	127370	151812	152153	153190	154818	160835	167895	545968	
Change in accounts receivable			-7662	-6661	-4505	-13520	1148	984	822	255	276	1377	24493
Sales due to Reduction of O			5613	11477	16460	31157	32004	32927	33899	35440	37252	140919	0
Total Benefits			230144	366978	487495	789213	810332	824408	847408	847848	849603	1187768	24493
EXPENDITURES													
Investment Costs													
Equipment and Materials													
Transformers	0.997		27205	135756	67878	41750							
Breakers	0.933		20426	102132	51192	30766							
Transmission lines	0.991		103125	506252	254733	166340							
High Voltage Feeders	0.991		43125	215894	108483	63482							
Labor Costs													
Skilled	0.734		11486	56879	28574	17908							
Unskilled	0.482		5388	26683	13404	8401							
Sub-Total			210757	1043597	524264	328647							
Contingency as costs overru	0.943		23180	114786	57663	36139							
Total Subprogram Investment			233937	1158383	581928	364787							
Operating costs													
Maintenance Expenses due	0.809		14	28	40	76	78	81	83	87	91	346	
Fuel costs due to outages re	1.253		1217	2488	3568	6753	6937	7137	7348	7682	8075	30546	0
Total System Costs			1230	2516	3608	6830	7016	7218	7431	7769	8166	30891	0
Bad Debt	0		0	0	0	0	0	0	0	0	0	0	0
Working capital													
Change in accounts payable	0.809		-15304	-15299	-12728	-31908	-6134	-6162	-6229	-7148	-7040	-3990	42538
Change in cash balance	1.000		-18907	-18900	-15725	-39419	-7578	-7613	-7696	-8831	-8698	-4929	52552
Total change in working capital			3603	3602	2996	7512	1444	1451	1466	1683	1657	939	-10014
VAT													
Income Taxes													
Environmental impact of Land Use			42537	42537	42537	42537	42537	42537	42537	42537	42537	42537	42537
Total Costs			281307	1207037	631070	421665	50997	51206	51435	51989	52361	74367	32523
NET ECONOMIC BENEFITS			-51163	-840059	-143575	367548	759336	773202	795973	795859	797242	1113401	-8030
NPV (in Million Pesos)		**12%**	**3,893,828**										
NPV (in Billion Pesos)			**3,894**										
NPV (in US$ Million)			**1,268**										

F. Sensitivity Analysis- Economic Variables

The results of the economic analysis are sensitive to a number of variables used in the analysis. To measure the impact of each variable on the economic net present value, we carried out a sensitivity analysis. In addition to the variables used in the sensitivity of the financial analysis, the economic net present value is sensitive to key variables such as the maximum willingness to pay for electricity and the cost of power outages.

1. Sensitivity of Economic NPV to Inflation

If the rate of inflation is raised from 15% to 20%, the value of economic benefits increases by 32 billion pesos or about US $ 10 million. An increase of inflation reduces the real tariff, which leads to more demand for electricity. The impact of an increase of electricity demand outweighs the fall in the economic value per unit of energy consumed, so that the net present value increases.

Table 31: Effect of Inflation Rate on Economic NPV

Inflation Rate	Economic NPV
5%	3,820,731
10%	3,858,888
12%	3,873,227
15%	3,893,828
20%	3,925,940
25%	3,955,552
30%	3,982,942
40%	4,031,985
50%	4,074,618
75%	4,160,229

2. Sensitivity of Economic NPV to Electricity Prices

We illustrate the sensitivity of the economic NPV to electricity prices by using only the residential tariff since the residential tariff has the greatest impact on the net present value**.**

As the electricity price is increased, the quantity of consumption by each consumer is reduced. The energy released is made now available to those who can afford it at higher prices. Hence, since the effect of a rise in electricity price is to transfer a quantity of electricity from "low value" to " high value" use, we would expect that the economic net present value will slightly increase. This is confirmed by the results of the sensitivity analysis in Table 32 where the economic net present value increases when the residential tariff is raised.

The values shown in the first column of Table 32 reflect the 1996 real tariff expressed as a percentage of the long run marginal cost. In 1988, that value was 39% for residential tariff. This project considers that between 1988 and 1996, the real tariff for residential consumers will grow at a rate of 26.2% so that the ratio of residential tariff to LRMC will become 100%. If the rate is lower than 26.2%, the ratio will be lower than 100%.

In raising the residential tariff to the LRMC level, the whole economy gains 56 billion pesos or US$ 18 million.

Table 32: Effect of Residential Tariff on Economic NPV
(Million 1990 Pesos)

1996 Real Tariff as % of LRMC	Economic NPV
40%	3,838,100
55%	3,837,259
60%	3,840,071
65%	3,842,935
70%	3,846,821
75%	3,851,767
80%	3,857,813
85%	3,865,000
90%	3,873,369
95%	3,882,963
100%	**3,893,828**

3. Sensitivity of Economic NPV to Lag in Adjustment of Tariff for Inflation

The economic benefits of additional electricity demand is a function of the real annual price of electricity. When the lag in adjustment of tariff for inflation increases, the real price of electricity falls and consumption increases. The average economic benefits per unit of shortage supplied by the project will also fall as the existing consumers now have an incentive to consume more units that have a lower marginal value. The impact of the lag in adjustment of tariff for inflation is shown in Table 33. If the lag is increased from 3 months, its base case value, to 12 months the economic net present value drops by 36 billion pesos or US$ 11.7 million.

Table 33: Effect of Lag in Adjustment of Tariff for Inflation (Million Pesos)

Lag in Adjustment of Tariff for Inflation (in months)	Economic NPV
0	3,907,604
1	3,902,906
2	3,898,314
3	3,893,828
6	3,880,997
8	3,872,955
10	3,865,313
12	3,858,064

4. Sensitivity of Economic NPV to Investment Cost Overruns

The economic net present value drops by 250 million pesos or US$ 81.4 million when investment cost overruns increase from 11% to 25% of total investment. The economic net present value, however, remains still highly positive even if investment cost overrun is as high as 50% of total investment. Table 34 summarizes the impact of cost overruns on economic net present value.

Table 34: Effect of Cost Overrun on Economic NPV
(Million Pesos)

Investment Cost Overrun as % Total Investment	Economic NPV
-10%	4,268,545
-5%	4,179,327
0%	4,090,109
11%	3,893,828
15%	3,822,454
20%	3,733,235
25%	3,644,017
30%	3,554,799
40%	3,376,362
50%	3,197,925

5. Sensitivity of Economic NPV to Fuel Cost

The change in real fuel cost has three impacts on the economic net present value. First, an increase in fuel price has a positive impact on the value of savings due to loss reduction. With the reduction of technical losses, the amount of fuel used to generate the same quantity of electricity delivered to customers drops. When the world price of fuel oil increases, the quantity of fuel saved because of the reduction of losses can be now exported and the economy gains the foreign exchange savings from the export of the fuel. Second, an increase in fuel price reduces the net economic benefits derived from new customers as the cost of generation increases. Third, an increase in fuel price also raises the long run marginal costs and because of that the tariff also increase because the tariff adjusts to the long run marginal costs. This third impact has a positive effect on the net present value because the revenues from new consumers increase. The net effect of the changes in the real fuel price is uncertain. In this study, the net effect is negative as shown in Table 35. The economic net present value decreases when the level of real fuel cost increases. The net present value decreases by 18 billion pesos when the level of fuel cost rises to 3%. Table 35 summarizes the effect of fuel oil prices on the economic net present value.

Table 35: Effect of Fuel Cost on Economic NPV
(Million Pesos)

Change In Average Real Fuel Oil Cost as percent of Base Case Fuel Cost	Economic NPV
-5%	3,924,400
-3%	3,912,136
-1%	3,899,920
0%	3,893,828
1%	3,887,748
2%	3,881,679
3%	3,875,622
4%	3,869,575
5%	3,863,539
6%	3,857,513
7%	3,851,498

6. Sensitivity of Economic NPV to Real Exchange Rate

An increase in the real exchange rate has three effects on the net present value of the project. The first effect is to increase the net present value because the savings due to loss reduction are higher. These savings comprise the fuel, the operating, and the capacity costs of generation. The second effect on the net present value is also positive. Long run marginal costs adjust upward with an increase of the real exchange rate. Real tariff also go up with an increase of long run marginal costs. A rise of 1% of the real exchange rate leads to an increase of 0.7%[57] of the real tariff. High real tariff translates into high economic value per unit of electricity consumed by new customers because the average willingness to pay is a function of the real price. The third effect of an increase of the real exchange rate on the net present value is negative. When the real exchange rate rises, the cost of the fuel expressed in domestic currency increases. Such an increase of the cost of fuel leads to an increase of the generation cost and reduces the net present value.

In this study, a real devaluation has a moderate negative impact on the economic NPV. As illustrated in Table 36, the economic net present value decreases when the real exchange rates rise. When the real exchange rate rises by 1% a year, the economic net present value decreases by 20 billion pesos or US$ 6.5 million.

[57] It is assumed in this study that 70% of the investments items of this project are tradable, and hence only that portion is affected by changes in real exchange rate.

Table 36: Effect of Annual Changes in the Real Exchange Rate on Economic NPV
(Million Pesos)

Annual Changes in Real Exchange Rate (#Ps/$)	Economic NPV
-3.0%	3,954,828
-2.0%	3,934,482
-1.0%	3,914,149
0%	3,893,828
1.0%	3,873,519
2.0%	3,853,223
3.0%	3,832,937
4.0%	3,812,663

7. Sensitivity of Economic NPV to Technical Losses

As shown in Table 37, the economic net present value increases with the reduction of losses. If the reduction of technical losses is 5% higher than the losses in the base case, the economic net present value increases by 77 billion pesos or US$ 25 million. Again these benefits come mainly from the foreign exchange savings and foreign exchange premium because the fuel oil saved can be exported.

Table 37: Effect of Technical Losses Reduction on Economic NPV
(Million Pesos)

Changes as percent of Base case losses	Economic NPV
-30%	3,426,457
-20%	3,582,247
-10%	3,738,038
0%	3,893,828
5%	3,971,724
10%	4,049,619
15%	4,127,514
20%	4,205,409
25%	4,283,305
30%	4,361,200
35%	4,439,095

8. Sensitivity of Economic NPV to Maximum Willingness to Pay

The economic value of increased consumption due to new customers increases with the estimate of the maximum willingness to pay. The higher the maximum willingness to pay, the higher the economic value from increased consumption due to new customers. The results in Table 38, show that the net present value of the economic benefits increases by 299 billion pesos when the value of the maximum willingness to pay increases from 850 pesos per Kwh to 903 pesos per Kwh.

Table 38: Effect of Maximum Willingness to Pay on Economic NPV

Maximum Willingness to Pay		Economic NPV
US $ /Kwh	Pesos/Kwh	
0.081	**250**	242,613
0.098	**300**	521,971
0.130	**400**	1,080,685
0.212	**650**	2,483,337
0.244	**750**	3,036,184
0.277	**850**	3,594,898
0.294	**903**	3,893,828
0.391	**1200**	5,550,398
0.488	**1500**	7,226,541

9. Sensitivity of Economic NPV to Opportunity Cost of Power Outages

The economic benefits increase with the estimates of the outage cost. The base case considers an outage cost of 3,025 pesos per kwh. If that cost increases to 4000 pesos per kwh, the economic benefits increase by 101 billion of pesos or US$ 35 million. Table 39 summarizes the sensitivity of the economic benefits to outage cost estimates.

Table 39: Effect of Cost of Outage on Economic NPV

Cost of Power Outages		Economic NPV (Million Pesos)
US $ / Kwh	Pesos/Kwh	
0.326	**1000**	3,671,057
0.651	**2000**	3,781,057
0.814	**2500**	3,836,057
0.977	**3000**	3,891,057
0.985	**3025**	3,893,828
1.140	**3500**	3,946,057
1.303	**4000**	4,001,057
1.465	**4500**	4,056,057
1.628	**5000**	4,111,057

G. Conclusion from Economic Analysis

The main conclusion from the economic analysis and the sensitivity tests done on it is that this project is highly attractive. Although each of the key input variables have been changed across a wide range of values, the economic net present value never becomes negative. It is clear that certain variables are more important in determining the final outcome than others. The ability of this project to actually cut technical losses, the willingness to pay for electricity, the cost of power outages, the cost overruns, the real exchange rate, and the rate of inflation in Mexico all cause large changes in the economic net present value of the project. The impact of the other variables is less significant.

V. DISTRIBUTIVE ANALYSIS

A distributive analysis was conducted to determine the externalities generated by the project and to identify who benefits and who loses from these externalities. The statement of externalities results from the difference between the economic and financial cash flow statements.

The NPV of externalities is calculated as follows.
NPV of externalities = NPV of economic cash flows - NPV of financial cash flows;

all NPVs estimated at the same discount rate, that is, the economic or social cost of capital..

Applying the above formula, we have

NPV of externalities = 3,893,828- 910 = 3,892,918 (million 1990 pesos).

The total benefits of the project are equal to the financial NPV of the project plus the externalities. Table 40 summarizes the allocation of these externalities to the government, the consumers, and the labor.

A. Distribution of Project Net Benefits

Column 1 of Table 40 shows that the net benefits to the government is positive . The net gains accruing to the government are of the order of 652 billion pesos or US$ 212 million. The benefits to the government come from 523 billion pesos from taxes and additional value added taxes on increased consumption of electricity, and 245 billion pesos from the foreign exchange savings and foreign exchange premium made available because the fuel saved by the reduction of losses can now be exported. The loss to the government includes 80 billion of grants, 13 billion of forgone foreign exchange premium because of the incremental consumption of fuel due to reduction of outages, and 23 billion in change in account payable.

Table 40: Distribution of Project Net Benefits (Million of 1990 pesos)

	Government (1)	Consumers (2)	Labor (3)	Total (4)
Benefits				
Sales to New Customers		3,271,414		3,271,414
Losses reduction	245,065			245,065
Sales due to Reduction of outages		209,451		209,451
Accounts receivable		82,184		82,184
Government Grants	-79,696			-79,696
Consumers contributions		-60,162		-60,162
Costs				
Transformers	764			764
Breakers	12,424			12,424
Transmission lines	7,777			7,777
High voltage feeders	3,261			3,261
Skilled labor			35,248	35,248
Unskilled Labor			49,035	49,035
Contingency as overruns	10,526		1,435	11961
Maintenance cost due to outages reduction	181			181
Fuel cost due to reduction of outages	-13,768			-13,768
Bad debt		31,192		31,192
Change in accounts payable	-22,994			-22,994
VAT	488,222			488,222
Environment cost		-378,638		-378,638
Net Benefits	651,762	3,155,441	85,718	3,892,921

Reconciliation of Economic, Financial and Distributive Analysis.

The economic net present value equals the financial net present value determined at the economic discount rate plus the sum of the distribution impacts induced by the project.

Economic NPV at economic discount rate	=	Financial NPV at economic discount rate	+	PV Externalities at economic discount rate
3,893,828	=	910		3,892,929

B. Conclusion of Distributive Analysis

Consumers gain most from this project, approximately 3,155 billion pesos or US$ 1,027 million, mainly due to the electricity consumption of the newly connected consumers and the avoidance of outages. New consumers get a large amount of the economic benefits because the average willingness to pay for electricity is high. In addition to these benefits, all consumers gain from the reduction of the frequency and duration of outages.

The government gains about 652 billion pesos or US$ 212 million which come primarily from foreign exchange savings, foreign exchange premium, and taxes.

The labor, especially the workers at CFE, gains 86 billion Pesos or US$ 28 million.

The present value of the net benefits to consumers is very substantial at 3,155,441 million pesos (US$ 1,027 million). In principle it would be a reasonably easy task to allocate these benefits amongst the various income groups. Unfortunately, the requisite information is presently not available for this project.

VI. RISK ANALYSIS OF FINANCIAL AND ECONOMIC RETURNS

The base case gives a single value for the forecast of either the financial or economic NPV. Sensitivity analysis helps to identify variables that may have a major impact on the financial and economic results. Although a sensitivity analysis provides useful insights about the financial and economic returns of a project, a risk analysis will allow us to evaluate the spread of the returns when the effect of the individual variables are combined. To do so, we construct the probability distribution of each variable identified in the sensitivity analysis as having a significant impact on the financial or economic net present value. The expected value of each distribution corresponds to the value used in the base case analysis.

In addition to the five risk variables identified in the financial analysis, two more variables identified in the economic analysis are included in the risk analysis. These two variables are: estimate of the maximum willingness to pay, and estimate of cost of outage. The risk variables in this project are: rate of inflation, investment cost overrun , real fuel costs, real exchange rate, technical loss factor, estimate of maximum willingness to pay, and estimate of cost of outages.

A. Risk Variables

1. Inflation

Graph 1: Inflation in Mexico, 1949-1996

Graph 1 shows how the rate of inflation evolved through the period 1949 to 1996. Starting from low levels, the rate of inflation increased significantly during the period 1973 to 1993. The average rate of inflation excluding the rates of hyperinflation period is about 12%. In the base case analysis we assumed a mean rate of inflation at 15%. This rate can be achieved and even brought down since the Mexican government is willing to carry out sound macroeconomic policies to reduce the level of inflation rates to that of Mexico's main trade partners. To account for the disturbances around the mean of 15%, Table 41 shows the distribution of the percentage disturbances used in the risk analysis.

Table 41: Distribution Used for Inflation in the Risk Analysis

Percentage Disturbances of Inflation	Probability
0% to 5%	5%
5% to 10%	15%
10% to 15%	40%
15% to 20%	20%
20% to 25%	10%
25% to 30%	5%
30% to 35%	5%

2. Investment Cost Overrun

In the base case, a contingency cost of 11% of total investment has already been taken into account. In spite of this cost contingency provision, it is likely that the actual level of cost overruns exceeds the amount of that provision. To account for the dispersion of the cost overruns, we use a step distribution in the model of the risk analysis. That distribution ranges from 0% to 30% of total investment cost with the expected value equal to the contingency cost of 11%. Table 42 shows the distribution used for cost overruns in the risk analysis.

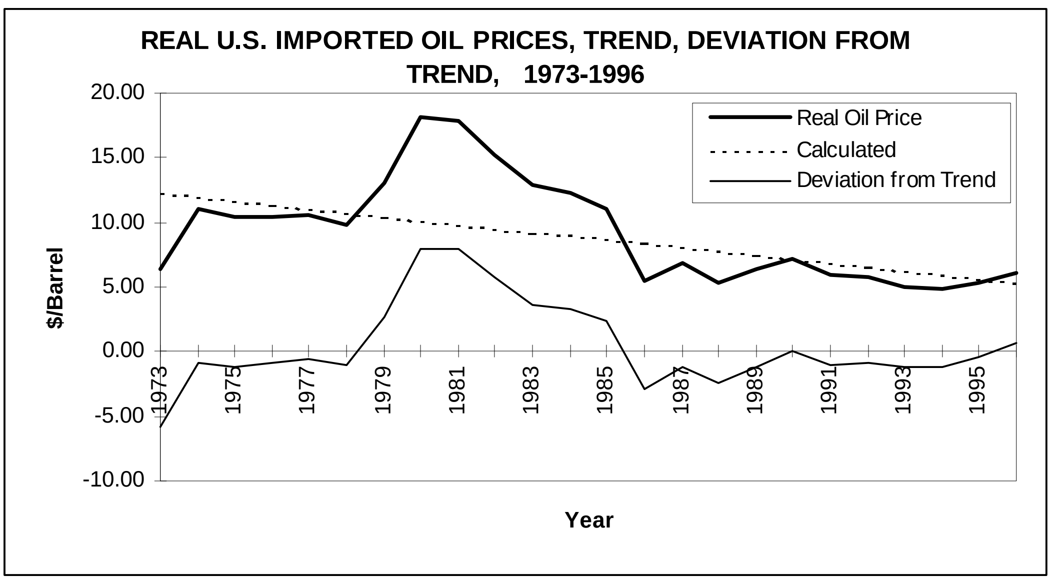
Table 42: Distribution Used for Cost Overruns in the Risk Analysis

Percentage of Total Investment	Probability
0%-10%	50%
10%-20%	40%
20%-30%	10%

3. Real Fuel Cost

The sensitivity analysis shows that changes in real fuel cost impact both financial and economic results. The real oil prices show very little long term trend. The short run real prices fluctuate around that trend. In the base case analysis, we assume that the cost of fuel used for electricity generation is affected by the world price of oil. Graph 2 shows the real U.S imported oil price, the trend and the deviation from the trend for the period 1976-1996.

Graph 2: Real U.S Imported Oil Price, Trend, and Deviation from Trend, 1976-1996



The probability distribution of the percentage deviations between the trend values and the actual values, is given in Table 43. In the risk analysis, we use that distribution to account for the annual disturbances of the real fuel prices.

Table 43: Percentage Disturbances of Real Oil Price

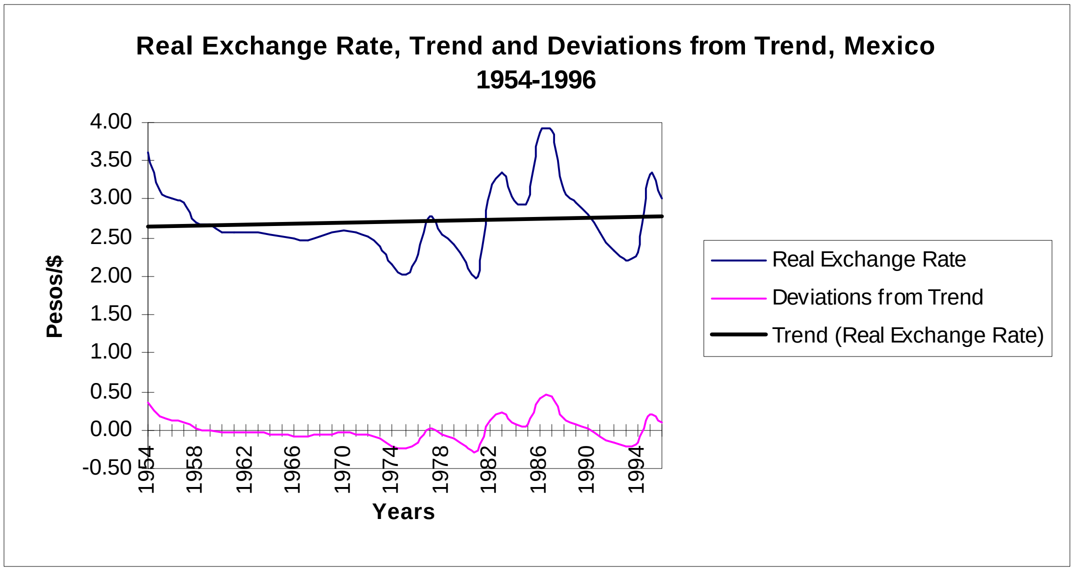
Percentage Disturbances of Real Oil Price	Probability
-40% to -30%	4%
-30% to -20%	13%
-20% to -10%	25%
-10% to 0%	17%
0% to 10%	8%
10% to 20%	8%
20% to 30%	13%
30% to 40%	13%

4. Real Exchange Rate

From 1954 to 1996, the real exchange rate expressed in 1990 new pesos averages 2.72 pesos per dollar. The average growth of the real exchange rate in the same period is 0.4%, which is illustrated by the trend line of Graph 3. In the base case we assume a growth of 0% for the real exchange rate.

In addition to the growth rate, the real exchange rate moves up and down in the short term. In the case of Mexico these movements have been frequent and large since 1974. Such movements will have an impact on this project due to its reliance on oil as a major input. These movements are illustrated by the error terms in Graph 3 below. The average of these error terms is zero.

Graph 3: Real Exchange Rate, Trend, and Deviations from Trend, Mexico 1954-1996



To capture the variation of the real exchange rate, we construct a distribution of the annual disturbances of the real exchange rate. The errors have a mean of 0% and a standard deviation of 35.5%.

For the purposes of the risk analysis it is the level of the average real exchange rate that the project experiences over its life that has the most significant impact on the project outcome. Given the high volatility of the year to year change in the real exchange rate, most of these annual changes cancel each other out. If the annual changes in the real exchange rate have a mean of zero and a standard deviation of 35.5% then the movement of the mean real exchange rate averaged over the life of the project will have a mean of zero and a standard deviation of 7.75%. It is this normal distribution that is used in the risk analysis of this project

5. Technical loss Reduction

The benefits from loss reduction account for 50% of total financial benefits. This important share requires good estimates of the level of loss reduction. To account for the variability of these estimates, we use a normal distribution with a range from -15% to 15% of the base case level in the model of the risk analysis.

6. Changes in Estimate of Maximum Willingness to Pay

In the base case, the changes in the estimate of the maximum willingness to pay is 0%. We used a normal distribution to account for the uncertainty about the actual value of the maximum willingness to pay with a range of –15% to 15%.

7. Changes in Estimate of Cost of Outage

In the base case, the changes in the estimate of the cost of outage is 0% . We used a normal distribution with a range of –15% to 15% to account for the uncertainty about the actual value of this cost. The probability distributions of all variables used in the risk analysis are summarized in Table 44.

Table 44: Table of Risk variables.

Risk Variable	**Base Case Mean Value**	**Probability Distribution**	**Range Value**	**Probability**
1. Inflation Rate	15%	Step	0% to 5% 5% to 10% 10% to 15% 15% to 20% 20% to 25% 25% to 30% 30% to 35%	5% 15% 40% 20% 10% 5% 5%
2. Investment Cost overrun factor	11%	Step	0% - 10% 10%-20% 20%-30%	50% 40% 10%
3. Annual Percentage Change in Real Oil Price	0%	Step	-40% to -30% -30% to –20% -20% to –10% -10% to 0% 0% to 10% 10% to 20% 20% to 30% 30% to 40%	4% 13% 25% 17% 8% 8% 13% 13%
4. Percentage Change in Average Real Exchange Rate	0%	Normal	-23% to 23%	Mean =0 Standard Deviation=7.75%
5. Technical Loss Factor	0%	Normal	(-15) to (15%)	Mean =0% Standard Deviation= 5%
6. Percentage Changes in Estimate of Maximum Willingness to pay	0%	Normal	-15% to 15%	Mean =0% Standard Deviation= 5%
7. Changes in Estimates of Cost of Outage	0%	Normal	-15% to 15%	Mean =0% Standard Deviation= 5%

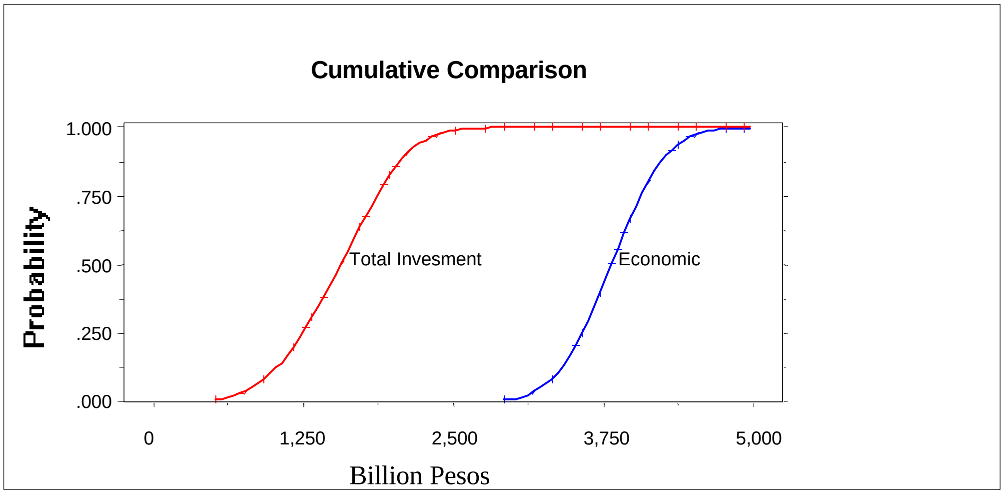
B. Risk Analysis Results

Table 45 summarizes the results of the risk analysis. Consumers gain the most, about 3,114 billion pesos, from this project followed by the government, 648 billion pesos, and labor, 86 billion pesos. The economic, total investment, and the equity net present values are 3,842, 1,576, and 1,957 billion pesos respectively with almost zero probability of any loss.

Table 45: Risk analysis results (Billion of Pesos)

	NPV Equity	NPV Total Investment	NPV Economic	Government	Labor	Consumers
Expected Value	1,957	1,576	3,842	648	86	3,114
Probability of negative value	0.21%	0.06%	0.18%	0.14%	0.17%	0.29%

The following graph illustrates the cumulative distribution for the equity and economic NPVs of the project.



VII. CONCLUSION

The results of the risk analysis show that all present values calculated have almost zero probability of negative return pointing to a highly attractive project. The results obtained in the risk analysis are close to the values calculated in the base case analysis. In the risk analysis, the economic, total investment, and the equity net present values are 1.3%, 2.6%, and 2.3% lower than their corresponding values of the base case analysis.

The transmission component of the CFE rehabilitation and expansion program appears to be a highly attractive project from both financial and economic perspectives. If the project is implemented successfully, it is expected to add net wealth of at least 3,894 billion pesos to the Mexican economy.

ANNEX A: ENVIRONMENTAL IMPACTS OF THE TRANSMISSION PROJECT

The potential environmental impacts for a transmission project include electromagnetic radiation, noise, erosion and change in land use. A few studies have related electromagnetic radiation from transmission lines to cancer in humans, but there is still very little evidence to substantiate this conclusion. The erosion from temporary or permanent earthworks reduces soil levels and affects agriculture and terrestrial ecosystems. The right-of-way land for the transmission line could displace households or limit land use for agriculture and other productive uses.[58]

The assessment of the environmental impacts include broadly two steps. The first step consists of identifying and screening the impacts, and the second step deals with the quantification and valuation of the impacts.

1. Impact Identification and Screening

This first step consists of identifying all relevant environmental stressors and then selecting the most important ones for economic evaluation. In general, four environmental stressors can be identified in a transmission project. These are: electromagnetic radiation, Noise, Erosion, and Land Use. The first two put a burden on air while the erosion and land use put a burden on land.

The following table summarizes the taxonomy for evaluating potential impacts of the environmental stressors in the transmission project.

Table 46: Taxonomy for Evaluating Potential Impacts of the Environmental Stressors in the Transmission Project

Stressor	Human Health	Human Welfare				Environmental Resources		Global System
	Morbidity	Materials	Aesth-etics	Resource Use	Social/ Cultural	Biodiversity/ Endangered Species	Terrestrial Ecosystem	
Potential Emission/ Burden to Air								
Gases								
Electromagnetic Radiation	✓							
Noise	✓		✓		✓	✓		
Potential Emission/ Burden to Land								
Hazardous Chemicals								
Erosion				✓			✓	
Land Use	✓	✓	✓	✓	✓	✓	✓	✓

[58] Economic Evaluation of Environmental Impacts, Asian Development Bank, p.62

2. Impacts Quantification and Valuation

The impacts of the stressors have to be quantified in physical and monetary units. Whenever market prices of the impacts are not available, the analyst has to use data from primary or secondary valuation methods.

A. Electromagnetic Radiation

Since there is no evidence to substantiate the conclusion that relates diseases such as cancer in humans to electromagnetic radiation, we did not evaluate the economic impact of this stressor in this project. Should evidence relating human cancer to electromagnetic radiation emerge, the following table provides partial data to evaluate the environmental impact of that stressor. The data will have to be adjusted to reflect costs of cancer effects in Mexico.

Summary Of Selected Monetary Values for Cancer Effects[59] (1990 $)

	Dollars per Nonfatal Cancer Case	Dollars per Fatal Cancer Case	Average Dollars for All Cancer Case[a]
Low	$102,000	$1.7 million	$0.9 million
Central	$204,000	$3.3 million	$1.7 million
High	$408,000	$6.6 million	$3.4 million

[a] Based on the average 5-year cancer survival rate of 51% in the United States

B. Noise

This stressor affects human health and welfare, and the environmental resources. The impacts of noise on health and human welfare can be minimized or internalized whereas the impact on Biodiversity and endangered species can be high. No valuation of the impact of noise was made in this appraisal because of the lack of relevant data.

C. Erosion

The impacts of the soil erosion are unknown in this project because data are insufficient to assess the erosion rate or the nutrient loss due to the transmission project.

D. Land Use

The land use has impacts on human health, human welfare, and environmental resources. There are little impacts on human health due to the land used in a transmission project. The impacts on human welfare, especially the changes in visual aesthetic can be substantial although their effects can be mitigated by landscaping the corridor of the transmission lines. The social impacts such as the displacement of residential dwellings are more difficult to mitigate.

[59] Economic Evaluation of Environmental Impacts, Asian Development Bank, p 200-- Source: Rowe et Al. (1994)

In the present study we restricted the evaluation of the impacts of the land use to the social burden and we used difference between the willingness to pay (WTP) for the land in the vicinity of the transmission lines and the WTP for other lands away from the project area to proxy the environmental costs. However, since no data collected through surveys or other studies were readily available, we estimated the environmental costs to be 20% of the average willingness to pay for agricultural, industrial, recreational and residential lands in Mexico.

In conclusion, the damages of the land use could be large, but some impacts are mitigated rendering the remaining effects over the life of the transmission project uncertain or small.

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