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PHOTOVOLTAIC SYSTEM COSTS USING LOCAL LABOR AND MATERIALS IN DEVELOPING COUNTRIES

Final Report

Prepared for

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SECTION I

INTRODUCTION

To enjoy sustained development, a nation must find sources of energy that are dependable, renewable, and feasible. Solar energy, including all solar-driven renewable sources, is politically attractive and economically feasible under certain conditions. Solar energy is feasible because once it is installed, balance of payments deficits for energy are reduced and because a great portion of the solar energy industry may be available within a country's existing agricultural and industrial infrastructure. Solar energy system components are typically not high technology and could apply the comparative advantages enjoyed by many nations in small manufactures, agriculture, and labor.

Photovoltaics (PV) is an emerging solar technology that has shown its cost effectiveness in the United States and elsewhere in increasing numbers of applications. Flat plate photovoltaic energy conversion systems have the capability of providing electrical energy in remote locations or in any location where solar cells can be arrayed to collect solar energy. The PV electric generator has no moving parts, has few parts that require servicing and is composed of components which, with the exception of the solar cells themselves, are recognized, well-known, relatively low-technology industrial products. The system can be prefabricated to permit installation by individuals with little formal training in electricity or electronics. Typically, the appliances or devices powered by the photovoltaic system are likely to be more complex, requiring more maintenance, than the electricity supply itself.

Photovoltaic energy conversion systems comprise solar cells and other components that support those cells in providing usable electricity. Those supporting components are refered to as the balance of the system (BOS). The BOS is subdivided into five categories: array and structure, electrical, storage, installation and checkout, and other. The major part of costs in stand-alone PV installations is in BOS components. As the U. S. Department of Energy realizes its goal to reduce the cost of PV modules by 1986, those BOS costs will be even more significant.

This study addresses the use of photovoltaic technology in countries that do not presently have high technology industrial capacity. The project determines the relative cost of integrating indigenous labor (and manufacturing where available) into the BOS industry of seven countries: Egypt, Haiti, the Ivory Coast, Kenya, Mexico, Nepal, and the Phillipines. Some of the results may be generalized to other countries, at most levels of development.

Following this introduction, Section II presents conclusions and recommendations. Section III describes the methodology used in carrying out the research project. Included in that section are discussions of the research design and the tools used, including data collection and computational assumptions. Section IV deals with the results of the study. In synopsis form, the collected data and the system costs for all seven countries are given. For comparison, the analogous data and calculations are made for the United States and presented in the synopsis. Appendix A provides the data collected and the system costs in detail, presented in tabular form for each country. Appendix B provides a reproduction of the questionnaires used to collect data, and the names of individuals who supplied information for the study. Appendix C presents the full Fortran coding of the calculation program.

The relative costs of solar technologies depend on existing energy infrastructure, including national priorities and the supply and distribution system. In general, however, development at almost any level implies an increased demand for energy; traditional fuels are practically infeasible to apply in increasing proportion; thus, renewable fuels appear very attractive. Economic development progresses directly as energy availability. Energy drives industry, agriculture and investment in human capital as well. In addition, as energy demand increases, investment in energy industries is likely to increase, and economic development is stimulated.

Much information used in this research was available at embassies of the seven countries in Washington, DC. The remainder was collected by mail as described in Section II, "Methodology."

SECTION II

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The results of the study imply several conclusions:

1. The cost of installing and maintaining comparable photovoltaic systems in developing countries is less than that in the United States. Those countries with the lowest wage rates show the lowest system costs.
2. Skills and some materials are available in the seven subject countries that may be applied to constructing and maintaining PV systems.
3. There is an interest in foreign countries in photovoltaics. There is not yet a strong bias against PV in favor of other solar technologies, but in some countries and some bureaucratic echelons there exists a misunderstanding of the technology and its attendant costs and benefits.
4. Conversations with foreign nationals suggest that photovoltaics must be introduced in foreign markets as an appropriate technology with high technology components rather than as a high technology system.
5. Socio-economic institutions, such as barter, significantly complicate the determination of feasibility. That is not to imply that they will hinder the introduction of photovoltaic technology.
6. For those countries that supplied minimum-wage data, the labor is often not available at those rates, but at higher rates.

Recommendations

Based on the experience of performing this study, there are several implications for further research into this area.

1. Life-cycle system costs for other alternative energy sources should be determined for the countries under study. At a minimum, electric rates are essential to make wise investment decisions concerning energy source infrastructure.

2. Socio-cultural or economic behavioral considerations ought to be included in the specification of the system trade-offs. For example, there is a trade-off between maintenance-free components and man power. Such trade-offs are made differently within different socio economic contexts.

3. Demonstration experiments should be initiated that would make maximum use of local labor and capital inputs, perhaps in one of the included countries, to install a photovoltaic system. For examples, contacts in the Philippines, have expressed a degree of local willingness to cooperate and even to contribute to such an experiment.

4. Data must include unemployment within labor classification, minimum wages, and market wage rates. All data are necessary to determine realistic system costs. Workers are hired at prevailing market rates, not necessarily at minimum wage. It is recognized that many data are not available.

5. Continually changing energy markets in the world economy require periodic evaluation of relative feasibility of energy alternatives.

6. U.S. Department of Commerce generic Industry Profiles may be used to characterize potential BOS manufacturing. In order to make use of the profiles, the costs of all the inputs to each industry must be avail-

able so that a total cost may be calculated for the production process and an average unit cost derived.

7. Relative prices among countries do not determine the feasibility of photovoltaics. The acceptance of the technology depends primarily on the relative prices of alternative energy sources within a national economy.

SECTION III

METHODOLOGY

The methodology addresses the problem of calculating system costs for a standardized photovoltaic system, using local inputs. The methodology has the following five aspects:

1) definition of a standard photovoltaic system
2) determination of the labor and materials input requirements per unit of each BOS component.
3) collection of price data in the foreign markets for labor and materials that are available in the BOS areas
4) construction of cost calculation assumptions and algorithms
5) calculation of system cost based on the generic system configuration and collected data.

Standard System

There is no standard PV system, but for comparison purposes, a 1000 peak watt system with the attendant BOS requirements was defined for this study. In addition, there is no functional relationship between the peak power of a system and the magnitude of the BOS components. A system would have components that fall into each of the five BOS categories mentioned in Section I. In specifying the system, a compromise was struck between a high enough level of detail to calculate a meaningful, comparative system cost, and low enough level to permit the collection of useful data.

The configuration of the standard 1000 W_p system was specified as follows:

- 1000 W_p photovoltaic modules

- 2500 watt-hours of battery storage
- 10 square meters of shelter structure
- 20 meters of fencing
- 200 meters of wire
- miscellaneous (constant)

These figures are based on experience with existing systems; they are abstractions or simplifications, since there are neither load nor insolation paramaters specified. The miscellaneous input was included for accounting reasons.

<u>Input Requirements</u>

Based on previous work, each BOS component was broken into the materials and labor that compose it. This determination was done in the first days of the study, so that data could be collected in a timely fashion from foreign sources. The labor categories that were determined to contribute to BOS components either at the construction phase or in the manufacture of components, are:

- Laborer
- Electrician
- Carpenter
- Pipefitter/Plumber
- Foreman
- Machinist
- Welder
- Mason
- Heavy Equipment Operator

The composition of the components were specified as shown in Table III-1. Most of the inputs were available in the economies of foreign countries. The collection of data was simplified by expressing the information sought in terms understandable to people that may have no exposure to solar energy systems.

TABLE III-1

COMPOSITION OF COMPONENTS

1. Array and Structure

    a. structural steel

    b. fencing (wood, steel, blocks, locks)

    c. construction materials (wood and blocks)

    d. ventilation equipment (louvers, fan)

    e. labor

2. Electrical

    a. wire

    b. voltage regulator

    c. inverter

    d. boxes

    e. insulation plastic

    f. labor

3. Storage

    a. batteries

    b. labor

4. Installation and Checkout

    a. labor

5. Other

    a. labor

There has been no work reported to date in disaggregating labor and other inputs in PV systems costs. Typical labor requirements for system construction were subjectively synthesized, based on previous experience and knowledge of the construction requirements for other systems. The labor input requirements assumed for system installation are presented in Table III-2.

Operating and maintenance extends throught the system lifetime, but because of the peculiar nature of photovoltaic experience and the variety of economic contexts being studied, some simplifying assumptions were made. Checkout is considered as O&M during the first year, and is assumed to be the only significant such cost over the system life. In particular, O&M is expressed entirely as labor costs, outlined in Table III-3. First year requirements are given, the second year is assumed to be the year requiring minimum O&M. The minimum amount as well as the requirement during the last year of the life cycle are also given.

Price Data

Foreign wage and price data were collected by sending data worksheets to individuals identified as likely sources. The embassies of the countries in question were visited for the suggestions of their staffs, and local contacts were approached directly. Many data were available from previous work done in the subject countries by Georgia Tech personnel, from United Nations documents, from the appropriate ministries of the national governments, from embassies, and from other contacts made previously, but some data were collected or clarified by telephone contacts. Very little information was collected from the initial mailing. Follow-up cables, telexes, telephone calls, and visits were required to assemble sufficient information to make meaningful system cost calculations. Some sources

TABLE III-2
LABOR INPUT REQUIREMENTS
(In man-hours per unit)

	System Component					
Labor Classification	Array	Battery	Structure	Fencing	Wiring	Misc. (Constant)
Common Labor	0.04/Wp	0.001/WH	$5.0/m^2$	0.2/m	0.001/m	20.0
Machinist	0	0	0	0	0	0
Electrician	0.03/Wp	0.01/WH	0	0	0.001/m	10.0
Welder	0	0	0	0	0	0
Carpenter	0	0	$4.0/m^2$	0.05/m	0	5.0
Mason	0	0	$7.0/m^2$	0	0	5.0
Pipefitter	0	0	0	0	0	0
Heavy Equipment Operator	0	0	$0.25/m^2$	0	0	4.0
Foreman	0.005/Wp	0	0	0	0	40.0

TABLE III-3

OPERATING AND MAINTENANCE REQUIREMENTS
FOR STANDARD PV SYSTEM

Labor Category	Hours Required First Year	Hours Required Second Year	Hours Required Final Year
Common Labor	100	80	100
Electrician	80	0	10
Carpenter	40	0	5
Foreman	40	1	2

were hesitant to provide data, because of price uncertainty due to high rates of inflation. The ultimate sources of information are found in Appendix B.

There are deficiencies in the data worksheets that did not show up until it was attempted to make use of the data. It is recommended that the following improvements be made in future data collection efforts of this type:

- o inquire concerning length of standard work week and work day.
- o inquire as to average worker productivity
- o specify type of wage: minimum, average, union/non-union/urban/rural/etc.
- o include labor classification of foreman or supervisor
- o specify thoroughly the products (e.g. copper or aluminum wire, exact metric gauges, etc)
- o indicate what to enter in data sheet if question is not applicable
- o choose units, items, etc. so that non-comparability is minimized

Even when these suggestions are taken into account, the collected data may be inadequate to permit detailed cost calculations.

Since some countries produced no goods in some industries, methodology was developed to determine the likely cost of such commodities if the industries were to be established. The methodology is based on using the U.S. Department of Commerce generic Industry Profiles. Such profiles exist for several industries that make products that are included or products that are similar to those in the balance of systems, such as plywood, creosoted wood products, concrete blocks, steel bars and shapes, flexible steel conduit, copper wire, chain link fencing, electric outlet switch and fuse boxes, and automobile batteries. The profiles identify and quantify the input requirements for each industry. It was impractical to incorporate that information into the calculation of costs of those components in foreign countries due to data limitations, and default values were provided.

The system configuration in this study is illustrative. Based on previous BOS experience, a per-unit cost was determined that would provide sufficient accuracy in comparative calculations. Specifically, the following unit prices were used:

Photovoltaic Modules	$10 per peak watt
Batteries	$0.25 per watt-hour
Shelter Structure	$215 per square meter
Fencing	$6.52 per lineal meter
Wire	$0.46 per lineal meter.

These prices are useful only for system installations within the United States. Outside the United States, the prices are not applicable, but where no data are available, these prices are used as default values. Price data were assumed to be f.o.b. the manufacturer or his designated delivery point. Freight and tariffs are significant in the cost calculations, but they are not expressly included here.

Assumptions

Cost calculations were based upon the state of the art system design methodology, with a provision for permitting the substitution among components according to the desires of the operator. The cost calculation uses, as inputs, the set of price data, the system configuration, the labor input requirements, inflation, discount, and interest rates, and operating and maintenance requirements. It is assumed that the installation is financed, and that the loan is repayed in equal annual installments. In the absence of data supplied for the subject countries, default values were provided.

Calculations were done by using a number of equations specified with the goal in mind to keep the calculation methodology as general as possible. The procedure is broken down into several parts:

1) Construction Cost
2) Operating and Maintenance Cost
3) Finance Costs
4) Total Life Cycle Costs and Cash Flow
5) Net Present Value of Life Cycle Costs
6) Correction for Inflation
7) Conversion to Equivalent U.S. Currency

Parameters may be specified by the individual performing the calculations. However, default values in our calculations are as follow:

interest rate	=	10%
inflation rate	=	10%
discount rate	=	6%
life cycle	=	20 years
term of loan	=	20 years
down payment	=	0

Calculations

The calculations may be done by hand, but computer tools were used to simplify and streamline the operation. The full computer coding is given as Appendix C, but the definitional equations are presented here. The list of variables appears as Table III-4.

TABLE III-4

LIST OF VARIABLES

a_i	=	construction/installation labor requirement for labor category i per peak watt
⋮		
e_i	=	construction/installation labor requirement for labor category i per meter of wiring
f_i	=	constant for labor category i
CF_j	=	cash flow in year j
COST	=	system construction cost
D	=	discount rate
ER	=	the exchange rate in U.S. dollars per unit of foreign currency.
F	=	fencing length in meters
I	=	interest rate
$LABOR_i$	=	requirement for labor classification in installation
LCC	=	life-cycle costs
LW_i	=	wage rate for labor classification i
M	=	year in which O & M labor requirement is minimum
$MATERIAL_j$	=	requirement for material type j in construction
MC_j	=	material cost per unit for material type j
N	=	length of useful life of system
$OMLABOR_{j,i}$	=	operating and maintenance labor requirement for labor category i during year j of system life
$O\&M_j$	=	operating and maintenance costs during year j
P	=	original financed principal amount (construction cost minus down payment)

TABLE III-4 (Continued)

PMT	=	annual payment on loan (debt service)
R_j	=	inflation rate in year j
$REALX_k$	=	the inflation adjusted value of X_k
S	=	shelter structure size in square meters
T	=	term of loan
USZ	=	the equivalent of Z in U.S. dollars
W	=	wiring length in meters
WH	=	storage capacity in watt hours
Wp	=	peak wattage of system
X_k	=	any money variable in year k
Z	=	any money variable in foreign currency

1) Construction costs are the total of all component costs and the labor to install them. The materials requirements are discussed under "Standard System," while labor requirements are detailed under "Input Requirements."

(1.0) $$COST = \sum_i (LABOR_i \times LW_i) + \sum_j (MATERIALS_j \times MC_j)$$

(1.1) $$LABOR_i = a_i Wp + b_i WH + c_i S + d_i F + e_i W + f_i$$

2) Operating and maintenance costs are born throughout the lifetime of the system. It is assumed in this calculation that operating and maintenance can be approximated with a two parabolas sharing a minimum point.

(2.0) $$O\&M_j = \sum_i (OMLABOR_{j,i} \times LW_i)$$

(2.1) $$OMLABOR_{j,i} = \frac{(OMLABOR_{1,i} - OMLABOR_{M,i}) \times (j - M)^2}{(M-1)^2} + OMLABOR_{M,i}$$

when $j - 1 \leq M$

(2.2) $$OMLABOR_{j,i} = \frac{(OMLABOR_{N,i} - OMLABOR_{M,i}) \times (j - M)^2}{(N - M)^2} + OMLABOR_{M,i}$$

when $j - 1 > M$

3) There are three options available for paying for the system:

- o cash at the beginning
- o financing with equal payments over the term of financing
- o financing with equal payments to a point and a payoff at the end of the term (equal payments may be zero)

The calculation was done assuming the second option.

(3.0) $$PMT = \frac{(1 + I)^T \times P}{\sum_{j=1}^{T} (1 + I)^{j-1}}$$

4) Cash flow is the sum of all costs every year for the life of the system.

(4.0) $$LCC = \sum_j CF_j$$

(4.1) $$CF_j = PMT_j + O\&M_j$$

5) Net present value is the value today of a stream of life-cycle costs based on the relative value of money at some future time compared to the present--the so-called discount rate.

(5.0) $$NPV = \sum_{j=1}^{N} \frac{CF_j}{(1 + D)^j}$$

6) The value of these figures is affected by inflation. In order to reflect the buying power of the cash flow involved, the figures are corrected for inflation, by expressing them in terms of currency of the construction year.

(6.0) $$REALX_k = \frac{X_k}{\prod_{j=1}^{k} (1 + R_j)}$$

7) The value of international exchange is determined from day to day on the foreign exchange markets.

(7.0) $$USZ = Z \times ER$$

The costing program is written to permit specification of inputs or to rely on default values. The program was constructed based on the assumption that system configurations are variable, conditions of insolation and geography diverse, and socio-cultural trade-offs numerous. Therefore, it is useful to leave the options open to apply any relevant set of hypotheses. The program is capable of taking into account economic conditions, wages and prices, exchange rates, operating and maintenance requirements, system configuration, labor input requirements, and capital (components) input requirements. The calculations were performed for each country, based on the useful information obtained from that country. Other values were defaulted.

The output is in the form of system costs, as described in Section IV, integrating indigenous labor into BOS production. The construction cost, life-cycle cash flow, present value of life cycle cash flow, and both cash flows corrected for inflation are given in both local currency and U.S. dollars. Examples output are Tables A-1 through A-8 in Appendix A.

SECTION IV

RESULTS AND OBSERVATIONS

This section reports the numerical results of the research, from which the conclusions of Section II are drawn. In addition, further relevant observations are made, on which the recommendations of Section II are based.

Results

The results of this study belong to two groups: 1) data collection results and 2) system cost calculations. Both the data and the cost calculation results are presented in country-specific form in Appendix A, but summarized in this section.

The data collection included wage and product information. The wage data are nearly complete, but product data were seldom available, and when they were provided, they did not always fit well into the standard system configuration that was postulated. The country specific labor data, summarized in Table IV-1, are expanded in tables A-1 through A-8 in Appendix A.

The design phase of the data collection did not take into account that there is a large variety of talents and skill levels for each category. (e.g., finish/rough carpentry, house/water-main plumber, bulldozer/tractor/crane operators, etc.) There was also a large regional differential in wage rates among urban and rural areas. Thus, for each data set, the appropriate wage rate or an average was used for calculations. In addition, some of the data were collected with the intention that they would be used in costing out component manufacturing processes. However,

TABLE IV-1
SUMMARY OF LABOR RATES
(In U.S. Dollars per Month)

Labor Category	Egypt[1]	Haiti[1]	Ivory Coast[2]	Kenya[1,3]	Mexico[1]	Nepal[1]	Philippines	United States[2,4]
Laborer	[illegible]11.35	57.25	1[illegible]9.65	72.89	173.20	16.65	44.90	1927.70
Machinist	1113.45	156.20	218.30	102.15	433.00	24.20	60.40	n/a
Welder	1855.70	182.20	328.90	110.55	433.00	26.70	64.20	n/a
Electrician	371.15	130.15	349.50	102.15	433.00	24.20	61.80	2459.45
Carpenter	1484.60	130.15	349.50	102.15	433.00	32.50	56.60	2459.45
Mason	556.70	182.20	349.50	102.15	346.40	32.50	53.60	2459.45
Pipefitter	927.85	130.15	275.95	102.15	461.86	32.50	57.70	2667.30
Heavy Equipment Operator	927.85	174.95	436.60	109.15	433.00	37.50	74.00	2424.80
Forman	---[5]	200.20	---[5]	164.30	---[5]	---[5]	---[5]	2580.00

1. Based on six 8-hour days per week or 48-hour week.

2. Based on five 8-hour days per week.

3. Includes $10.12 housing allowance

4. Includes benefits.

5. When no data were available, a default value was used, equal to 1.66 times the average of the first seven categories.

more information would be required to do that. Thus, not all the data were used.

Price data were collected for a large variety of commodities, but the following were useful, where they were available: batteries, wire, building construction, and fencing. Again there is a degree of ambiguity that made the data difficult to use. (e.g., commercial/industrial/domestic construction, etc.) In each case a judgment was made to be able to make use of the data. Table IV-2 summarizes the component price data that were used in calculations.

The cost calculation results are given in tables A-9 through A-16 in Appendix A. They are presented in synopsis form in Table IV-3. A system cost is calculated for the United States data for comparison purposes. The differences among system costs are generally due to labor input costs at two levels -- in the installation of the system and in the manufacture of the system components. The cost impact from installation is calculated, while the cost impact of using components manufactured with local labor is factored in by using local prices for domestically produced commodities when available. The life-cycle costs of the systems augment the construction costs by debt service and by operating and maintenance costs. O & M is largely labor, and in our calculations it is assumed to be entirely so.

Observations

Photovoltaic design procedures range in complexity from computer programs to slide rules. Most published work to date assumes U. S. prices of the late 1970's, a developed economy, a clear cost effectiveness with (or in the absence of) competing electric grid supplied power, and an implicit level of risk aversion. Load profiles are also assumed to be established. In fact, few of those characteristics exist outside the United States. To

TABLE IV-2
SUMMARY OF MATERIALS COSTS
(In U.S. Dollars per unit)

Component	Unit	Egypt	Haiti	Ivory Coast	Kenya	Mexico	Nepal	Philippines	United States
Batteries	Watt hours	n/a	n/a	n/a	n/a	.28	n/a	.23	.25
Shelter Structure	Square meter	n/a	n/a	200.	n/a	n/a	100	75.	215.00
Fence	lineal meter	n/a	n/a	n/a	n/a	12.	n/a	3.75	6.52
Wire	lineal meter	n/a	n/a	.36	n/a	n/a	n/a	.49	0.46

TABLE IV-3
SUMMARY OF SYSTEM COSTS[1,2]
(In U.S. Dollars)

	Egypt	Haiti	Ivory Coast	Kenya	Mexico	Nepal	Philippines	United States
1. Construction Costs	16,014	15,164	15,344	15,122	15,697	13,672	13,247	19,728
materials	14,947	14,947	14,752	14,947	15,092	13,625	13,147	14,947
labor	1,067	217	592	175	605	48	100	4,781
2. Total Life Cycle Cash Flow (constant dollars)	17,210	15,493	16,201	15,485	16,719	13,760	13,466	30,505
a. Debt Service[3] (P&I)	16,014	15,164	15,344	15,122	15,697	13,672	13,247	19,727
b. Total O & M								
year 1	705	129	379	118	414	30	68	3,186
years 2-20[3]	491	200	479	245	608	57	150	7,591
3. Net Present Value of Life-Cycle Costs	11,765	10478	11,005	10,468	11,358	9,290	9,097	21,056

1. Figures occasionally do not total due to rounding errors.

2. Parameters governing these calculations are found in chapter III, and full calculations are in Appendix A.

3. Total.

design systems in a universal fashion, these factors must be taken into account on an individual basis. There must be interface between the pricing and the sizing portions of the design procedure. And there must be explicit recognition of the many facets of energy demand, including variable load profiles and willingness to take risks.

There are cost and technology trade-offs among the various components of PV systems. Within reason, for one example, battery capacity may be replaced with PV generation capacity. More cells will generate electricity on cloudy days, obviating the need for battery storage during periods of cloudiness. In another example applicable to relatively inexpensive labor, we observe that batteries are made with or without maintenance requirements. Maintenance requires man-hours of labor, but maintenance-free batteries cost more. As a third example, if reliability requirements are reduced, other components may be reduced. If the user is willing to take the chance that demand will coincide with sunshine, or that battery discharge will be of one description and not another, then designers may be able to include fewer or less expensive batteries in the system.

Demand for energy is a culturally defined phenomenon. Demand will slowly change as sources of energy change and are accepted, but initially the existing energy-related behavior will define the load on new sources. If PV replaces oil lamps, then people will want to use PV-powered lights in the same way as they used oil. If PV replaces horses, then the machinery powered by PV will be used according to the same schedule as similar machinery driven by horses. If machinery is placed where there was nothing previously, then there is no characteristic demand profile, and it can be molded.

In societies where electricity and electrical appliances are used and maintained, then the technical expertise to deal with them is likely to be available. Since the technical level for much BOS installation or operation and maintenance is no higher than for such appliances, then PV system construction and support are feasible. On the other hand, in some societies, there is presently no electricity. Thus, it is much more difficult to locate skills adequate to participate in the installation of PV systems.

The recognition of PV cost effectiveness will increase demand for systems. That will imply increased demand for components that can be produced locally. Thus, industrial development will be stimulated.

APPENDIX A

DETAILED DATA AND COST CALCULATIONS

TABLE A-1
LABOR DATA FOR EGYPT

Labor Category	Wages in Pounds/day[1]	Wages in U.S.$/day[2]
Laborer	3	4.30
Machinist	30	42.85
Welder	50	71.40
Electrician	10	14.30
Carpenter	40	57.15
Cement Mason	15	21.45
Pipe Fitter	25	35.70
Heavy Equipment Operator	25	35.70

1. Source: A. Alaa El-Din Nazmy, Third Secretary, Embassy of the Arab Republic of Egypt.

2. Exchange Rate: 0.70 L.E./U.S. dollar. Effective November 15, 1979 (Source: First National Bank of Atlanta)

TABLE A-2
LABOR DATA FOR HAITI

Labor Category	Wages in Gourdes/day[2]	Wages in U.S.$/day[1]
Laborers	11.00	2.20
Machinist	30.00	6.00[3]
Welder	35.00	7.00
Electrician	25.00	5.00
Carpenter	25.00	5.00
Mason	35.00	7.00
Pipefitter	25.00	5.00
Heavy Equipment Operator	873.00/month	175/month
Foreman	38.72	7.75

1. Data was collected in U.S. dollars during a trip to Haiti in October, 1979 and then converted to gourdes.

2. Exchange Rate: 4.99 Gourdes/U.S. Dollar, effective November 15, 1979 (First National Bank of Atlanta)

3. Estimated by relative wages for similar categories

TABLE A-3
LABOR DATA FOR IVORY COAST

Labor Category	Wages in Francs/mo.[1]	Wages in U.S.$/month[2]
Laborer	27,408	109.65
Machinist	54,576	218.30
Welder	82,224	328.90
Electrician	87,357	349.50
Carpenter	87,357	349.50
Mason	87,357	349.50
Pipe Fitter	68,986	275.95
Heavy Equipment Operator	109,152	436.60

1. Source: Ivory Coast Chamber of Commerce

2. Exchange Rate: 250 FCFA/U.S. dollar. Effective November 15, 1979 (Source: First National Bank of Atlanta)

TABLE A-4
LABOR DATA FOR KENYA

Labor Category	Wages in Shillings/hour[1,2]			Wages in U.S.$/hour[3]
	Nairobi area	other urban	rural	
Laborers	2.30	2.25	2.15	.30
Machinists[4]	3.40	3.30	3.10	.44
Welders	3.75	3.60	3.30	.48
Electricians[4]	3.40	3.30	3.10	.44
Carpenters[4]	3.40	3.30	3.10	.44
Masons[4]	3.40	3.30	3.10	.44
Pipefitters[4]	3.40	3.30	3.10	.44
Heavy Equipment Operators	3.70	3.55	3.25	.48
Foreman		5.89		.80
Housing Allowance	90.00/mo.	75.00/mo.	60.00/mo.	8.10/mo.

1. Minimum wages effective October 30th 1979, housing allowances must be added. Source: Kenya Ministry of Labor.

2. The data for skilled tradesmen in Kenya was subdivided into three levels, any of which appear to be qualified to do unsupervised work. Some of the data in this table are the middle of the three categories.

3. Exchange Rate: 7.4 shillings/U.S. Dollar, effective November 15th, 1979. Values are converted from the column marked "other urban." (First National Bank of Atlanta)

4. These labor categories fall under the label "general tradesmen"

TABLE A-5
LABOR DATA FOR MEXICO

Labor Category	Wages in Pesos/day[1]	Wages in U.S. $/day[2]
Laborer	150	6.65
Machinist	375	16.65
Welder	375	16.65
Electrician	375	16.65
Carpenter	375	16.65
Mason	300	13.35
Pipefitter	400	17.51
Bulldozer Operator	375	16.65

1. Effective 1980. Source: Ricardo Alvarez

2. Exchange Rate: 22.50 pesos/U.S. dollar, effective February 12, 1980 (First National Bank of Atlanta)

TABLE A-6
LABOR DATA FOR NEPAL

Labor Category	Wages in Rupees/month[1]	Wages in U.S.$/month[2]
Laborers	200	16.70
Mechinists	290	24.20
Electricians	320[3]	26.70
Welders	290[3]	24.20
Carpenters	390[4]	32.50
Masons	390[4]	32.50
Pipefitters	390[4]	32.50
Heavy Equipment Operators	450[4]	37.50

1. Effective October 30, 1979. Source: Nepal Ministry of Industry and Commerce, Department of Labour

2. Exchange Rate: 12.00 Rupees/U.S. Dollar, effective November 15, 1979 (First National Bank of Atlanta)

3. May be as high as 390 Rupees

4. May be higher

TABLE A-7
LABOR DATA FOR THE PHILIPPINES

Labor Category	Wages in pesos/month[1]	Wages in U.S.$/month[2]
Laborer	330	44.90
Machinist	444	60.40
Welder	472	64.20
Electrician	454	61.80
Carpenter	416	56.60
Cement Mason	394	53.60
Pipe Fitter	424	57.70
Heavy Equipment Operator	544	74.00

1. Mean wages for Manila effective March 1979 assuming a 48-hr. work week. Source: Philippine Ministry of Labor

2. Exchange Rate: 7.35 Pesos/U.S. dollar. Effective November 15, 1979 (Source: First National Bank of Atlanta)

TABLE A-8
LABOR DATA FOR THE UNITED STATES

Labor Category	Wages in U.S. $/hour[1,2]
Laborer	11.13
Electrician	15.30
Carpenter	14.20
Mason	14.20
Pipefitter	15.40
Heavy Equipment Operator	14.00
Supervisor	(percentage)

1. Prevailing union wages effective July 1979. Source: National Construction Estimator, Craftsman Book Co. (1979)

2. Including benefits

TABLE A-9a
SYSTEM COSTS FOR EGYPT
(in Egyptian Pounds)

EGYPT: FIGURES IN EGYPTIAN POUNDS

TOTAL LABOR COST: 746.97
TOTAL MATERIALS COST: 10462.91
TOTAL CONSTRUCTION COST: 11209.88

	CASH FLOW			CASH FLOW CORRECTED FOR INFLATION		
YR	PAYMENT	MAINT.	COST/YR	PAYMENT	MAINT.	COST/YR
	DOWNPAYMENT:		0.00	DOWNPAYMENT:		0.00
1	1316.71	542.53	1859.24	1197.01	493.30	1690.31
2	1316.71	34.33	1351.04	1088.19	29.02	1117.22
3	1316.71	35.28	1351.99	989.26	26.51	1015.77
4	1316.71	35.75	1352.46	899.33	24.42	923.74
5	1316.71	36.52	1353.23	817.57	22.68	840.25
6	1316.71	37.60	1354.31	743.25	21.23	764.47
7	1316.71	38.99	1355.70	675.68	20.01	695.69
8	1316.71	40.70	1357.41	614.25	18.99	633.24
9	1316.71	42.71	1359.42	558.41	18.11	576.53
10	1316.71	45.03	1361.74	507.65	17.36	525.01
11	1316.71	47.66	1364.37	461.50	16.70	478.20
12	1316.71	50.60	1367.31	419.55	16.12	435.67
13	1316.71	53.85	1370.56	381.40	15.60	397.00
14	1316.71	57.41	1374.12	346.73	15.12	361.85
15	1316.71	61.27	1377.98	315.21	14.67	329.88
16	1316.71	65.45	1382.16	286.56	14.24	300.80
17	1316.71	69.94	1386.65	260.50	13.84	274.34
18	1316.71	74.74	1391.44	236.82	13.44	250.26
19	1316.71	79.84	1396.55	215.29	13.05	228.35
20	1316.71	85.26	1401.96	195.72	12.67	208.39
TOT	26334.16	1536.36		11209.88	837.09	

CASH FLOW: 27870.52 ADJUSTED CASH FLOW: 12046.97
NPV OF CASH FLOW: 16116.70 ADJUSTED NPV: 8235.36

TABLE A-9b
SYSTEM COSTS FOR EGYPT
(in U.S. Dollars)

EGYPT: FIGURES IN U.S. DOLLARS

TOTAL LABOR COST: 1067.10
TOTAL MATERIALS COST: 14947.01
TOTAL CONSTRUCTION COST: 16014.11

	CASH FLOW			CASH FLOW CORRECTED FOR INFLATION		
YR	PAYMENT	MAINT.	COST/YR	PAYMENT	MAINT.	COST/YR
	DOWNPAYMENT:		0.00	DOWNPAYMENT:		0.00
1	1881.01	775.18	2656.19	1710.01	704.71	2414.72
2	1881.01	50.18	1931.19	1554.55	41.47	1596.03
3	1881.01	50.41	1931.42	1413.23	37.87	1451.10
4	1881.01	51.07	1932.08	1284.76	34.88	1319.64
5	1881.01	52.17	1933.18	1167.96	32.39	1200.35
6	1881.01	53.72	1934.73	1061.78	30.32	1092.11
7	1881.01	55.71	1936.72	965.26	28.58	993.84
8	1881.01	58.14	1939.15	877.51	27.12	904.63
9	1881.01	61.01	1942.02	797.73	25.88	823.61
10	1881.01	64.33	1945.34	725.21	24.80	750.01
11	1881.01	68.09	1949.10	659.29	23.86	683.15
12	1881.01	72.29	1953.30	599.35	23.03	622.38
13	1881.01	76.93	1957.94	544.86	22.28	567.14
14	1881.01	82.01	1963.02	495.33	21.60	516.93
15	1881.01	87.54	1968.55	450.30	20.95	471.25
16	1881.01	93.51	1974.52	409.36	20.35	429.71
17	1881.01	99.91	1980.92	372.15	19.77	391.92
18	1881.01	106.77	1987.78	338.32	19.20	357.52
19	1881.01	114.06	1995.07	307.56	18.65	326.21
20	1881.01	121.79	2002.81	279.60	18.10	297.70
TOT	37620.23	2194.80		16014.11	1195.84	

CASH FLOW: 39815.03 ADJUSTED CASH FLOW: 17209.95
NPV OF CASH FLOW: 22023.85 ADJUSTED NPV: 11764.79

TABLE A-10a
SYSTEM COST FOR HAITI
(in Haitian Gourdes)

HAITI: FIGURES IN HAITIAN GOURDES

TOTAL LABOR COST: 1082.90
TOTAL MATERIALS COST: 74585.58
TOTAL CONSTRUCTION COST: 75668.48

	CASH FLOW			CASH FLOW CORRECTED FOR INFLATION		
YR	PAYMENT	MAINT.	COST/YR	PAYMENT	MAINT.	COST/YR
	DOWNPAYMENT:		0.00	DOWNPAYMENT:		0.00
1	8887.99	707.20	9595.19	8079.99	642.91	8722.90
2	8887.99	115.24	9003.23	7345.45	95.24	7440.69
3	8887.99	115.49	9003.48	6677.68	86.77	6764.44
4	8887.99	116.22	9004.21	6070.62	79.38	6150.00
5	8887.99	117.45	9005.44	5518.74	72.92	5591.67
6	8887.99	119.16	9007.15	5017.04	67.26	5084.30
7	8887.99	121.37	9009.36	4560.94	62.28	4623.22
8	8887.99	124.06	9012.05	4146.31	57.88	4204.19
9	8887.99	127.25	9015.24	3769.38	53.96	3823.34
10	8887.99	130.92	9018.91	3426.71	50.48	3477.18
11	8887.99	135.09	9023.08	3115.19	47.35	3162.53
12	8887.99	139.74	9027.73	2831.99	44.53	2876.51
13	8887.99	144.85	9032.84	2574.53	41.97	2616.50
14	8887.99	150.53	9038.52	2340.49	39.64	2380.12
15	8887.99	156.65	9044.64	2127.71	37.50	2165.22
16	8887.99	163.27	9051.26	1934.29	35.53	1969.82
17	8887.99	170.37	9058.36	1758.44	33.71	1792.15
18	8887.99	177.97	9065.96	1598.58	32.01	1630.59
19	8887.99	186.05	9074.04	1453.26	30.42	1483.68
20	8887.99	194.63	9082.62	1321.14	28.93	1350.07
TOT	177759.82	3413.53		75668.48	1640.66	

CASH FLOW:	181173.35	ADJUSTED CASH FLOW:	77309.14
NPV OF CASH FLOW:	104024.60	ADJUSTED NPV:	52204.09

TABLE A-10b
SYSTEM COSTS FOR HAITI
(in U.S. Dollars)

HAITI: FIGURES IN U.S. DOLLARS

TOTAL LABOR COST: 217.01
TOTAL MATERIALS COST: 14947.01
TOTAL CONSTRUCTION COST: 15164.02

	CASH FLOW			CASH FLOW CORRECTED FOR INFLATION		
YR	PAYMENT	MAINT.	COST/YR	PAYMENT	MAINT.	COST/YR
	DOWNPAYMENT:		0.00	DOWNPAYMENT:		0.00
1	1781.16	141.72	1922.88	1619.24	128.84	1748.08
2	1781.16	23.09	1804.25	1472.03	19.09	1491.12
3	1781.16	23.14	1804.30	1338.21	17.39	1355.60
4	1781.16	23.29	1804.45	1216.56	15.91	1232.46
5	1781.16	23.54	1804.70	1105.96	14.61	1120.57
6	1781.16	23.88	1805.04	1005.42	13.48	1018.90
7	1781.16	24.32	1805.48	914.02	12.48	926.50
8	1781.16	24.86	1806.02	830.92	11.60	842.52
9	1781.16	25.50	1806.66	755.39	10.81	766.20
10	1781.16	26.24	1807.40	686.71	10.12	696.83
11	1781.16	27.07	1808.22	624.29	9.48	633.77
12	1781.16	28.00	1809.17	567.53	8.92	576.46
13	1781.16	29.04	1810.20	515.94	8.41	524.35
14	1781.16	30.17	1811.33	469.04	7.94	476.98
15	1781.16	31.39	1812.55	426.40	7.52	433.91
16	1781.16	32.72	1813.88	387.63	7.12	394.75
17	1781.16	34.14	1815.30	352.39	6.75	359.15
18	1781.16	35.66	1816.82	320.36	6.41	326.77
19	1781.16	37.29	1818.45	291.23	6.10	297.33
20	1781.16	39.00	1820.16	264.76	5.80	270.56
TOT	35623.21	684.07		15164.02	328.79	

CASH FLOW:	36307.28	ADJUSTED CASH FLOW:	15492.81
NPV OF CASH FLOW:	20840.62	ADJUSTED NPV:	10477.77

TABLE A-11a
SYSTEM COSTS FOR IVORY COAST
(in Ivory Coast Francs)

IVORY COAST: FIGURES IN HUNDREDS OF IVORY COAST FRANCS

TOTAL LABOR COST: 1480.14
TOTAL MATERIALS COST: 36878.78
TOTAL CONSTRUCTION COST: 38358.92

	CASH FLOW			CASH FLOW CORRECTED FOR INFLATION		
YR	PAYMENT	MAINT.	COST/YR	PAYMENT	MAINT.	COST/YR
	DOWNPAYMENT:		0.00	DOWNPAYMENT:		0.00
1	4505.62	1041.93	5547.55	4096.02	947.21	5043.23
2	4505.62	134.30	4639.92	3723.66	110.99	3834.65
3	4505.62	134.65	4640.26	3385.14	101.17	3486.31
4	4505.62	135.72	4641.34	3077.40	92.70	3170.10
5	4505.62	137.49	4643.12	2797.64	85.37	2883.01
6	4505.62	139.97	4645.60	2543.31	79.01	2622.32
7	4505.62	143.16	4648.79	2312.10	73.47	2385.56
8	4505.62	147.06	4652.69	2101.91	68.61	2170.51
9	4505.62	151.67	4657.30	1910.82	64.32	1975.15
10	4505.[illegible]	156.99	4662.62	1737.11	60.53	1797.64
11	4505.62	163.02	4668.64	1579.19	57.14	1636.33
12	4505.62	169.76	4675.36	1435.63	54.09	1489.72
13	4505.62	177.20	4682.83	1305.12	51.33	1356.45
14	4505.62	185.36	4690.98	1186.47	48.81	1235.28
15	4505.62	194.22	4699.85	1078.61	46.50	1125.11
16	4505.62	203.79	4709.42	980.56	44.35	1024.91
17	4505.62	214.08	4719.70	891.41	42.35	933.77
18	4505.62	225.07	4730.69	810.38	40.48	850.86
19	4505.62	236.77	4742.39	736.71	38.71	775.42
20	4505.62	249.18	4754.80	669.73	37.04	706.77
TOT	90112.43	4341.41		38358.92	2144.17	

CASH FLOW: 94453.89 ADJUSTED CASH FLOW: 40503.09
NPV OF CASH FLOW: 54379.40 ADJUSTED NPV: 27512.09

TABLE A-11b
SYSTEM COSTS FOR IVORY COST
(in U.S. Dollars)

IVORY COAST: FIGURES IN U.S. DOLLARS

TOTAL LABOR COST: 592.06
TOTAL MATERIALS COST: 14751.51
TOTAL CONSTRUCTION COST: 15343.57

	CASH FLOW			CASH FLOW CORRECTED FOR INFLATION		
YR	PAYMENT	MAINT.	COST/YR	PAYMENT	MAINT.	COST/YR
	DOWNPAYMENT:		0.00	DOWNPAYMENT:		0.00
1	1802.25	416.77	2219.02	1638.41	378.88	2017.29
2	1802.25	53.72	1855.97	1489.46	44.40	1533.86
3	1802.25	53.86	1856.11	1354.06	40.47	1394.52
4	1802.25	54.29	1856.54	1230.96	37.08	1268.04
5	1802.25	55.00	1857.25	1119.06	34.15	1153.20
6	1802.25	55.99	1858.24	1017.32	31.60	1048.93
7	1802.25	57.27	1859.52	924.84	29.39	954.23
8	1802.25	58.83	1861.08	840.76	27.44	868.21
9	1802.25	60.67	1862.92	764.33	25.73	790.06
10	1802.25	62.80	1865.05	694.85	24.21	719.06
11	1802.25	65.21	1867.46	631.68	22.85	654.53
12	1802.25	67.90	1870.15	574.25	21.64	595.89
13	1802.25	70.88	1873.13	522.05	20.53	542.58
14	1802.25	74.14	1876.39	474.59	19.52	494.11
15	1802.25	77.69	1879.94	431.44	18.60	450.04
16	1802.25	81.52	1883.77	392.22	17.74	409.96
17	1802.25	85.63	1887.88	356.57	16.94	373.51
18	1802.25	90.03	1892.28	324.15	16.19	340.34
19	1802.25	94.71	1896.96	294.68	15.49	310.17
20	1802.25	99.67	1901.92	267.89	14.82	282.71
TOT	36044.99	1736.56		15343.57	857.67	

CASH FLOW: 37781.56 ADJUSTED CASH FLOW: 16201.24
NPV OF CASH FLOW: 21751.76 ADJUSTED NPV: 11004.84

TABLE A-12a
SYSTEM COSTS FOR KENYA
(in Kenyan Shillings)

KENYA: FIGURES IN KENYAN SHILLINGS

TOTAL LABOR COST: 1296.10
TOTAL MATERIALS COST: 110607.87
TOTAL CONSTRUCTION COST: 111903.98

YR	CASH FLOW PAYMENT	CASH FLOW MAINT.	CASH FLOW COST/YR	CASH FLOW CORRECTED FOR INFLATION PAYMENT	CASH FLOW CORRECTED FOR INFLATION MAINT.	CASH FLOW CORRECTED FOR INFLATION COST/YR
	DOWNPAYMENT:		0.00	DOWNPAYMENT:		0.00
1	13144.20	959.80	14104.00	11949.27	872.55	12821.82
2	13144.20	214.69	13358.89	10862.97	177.43	11040.40
3	13144.20	215.05	13359.25	9875.43	161.57	10037.00
4	13144.20	216.12	13360.32	8977.66	147.61	9125.28
5	13144.20	217.91	13362.11	8161.51	135.31	8296.82
6	13144.20	220.42	13364.62	7419.56	124.42	7543.98
7	13144.20	223.64	13367.84	6745.05	114.76	6859.82
8	13144.20	227.58	13371.78	6131.87	106.17	6238.03
9	13144.20	232.23	13376.43	5574.42	98.49	5672.91
10	13144.20	237.60	13381.80	5067.66	91.61	5159.26
11	13144.20	243.69	13387.89	4606.96	85.41	4692.37
12	13144.20	250.49	13394.69	4188.15	79.81	4267.96
13	13144.20	258.01	13402.21	3807.41	74.74	3882.14
14	13144.20	266.24	13410.44	3461.28	70.11	3531.39
15	13144.20	275.19	13419.39	3146.62	65.88	3212.50
16	13144.20	284.86	13429.06	2860.56	61.99	2922.55
17	13144.20	295.24	13439.44	2600.51	56.41	2656.92
18	13144.20	306.34	13450.54	2364.10	55.10	2419.20
19	13144.20	318.15	13462.35	2149.18	52.02	2201.20
20	13144.20	330.68	13474.88	1953.80	49.15	2002.95
TOT	262883.99	5793.92		111903.98	2682.53	

CASH FLOW: 268677.90 ADJUSTED CASH FLOW: 114586.51
NPV OF CASH FLOW: 154234.86 ADJUSTED NPV: 77462.98

TABLE A-12b
SYSTEM COSTS FOR KENYA
(in U.S. Dollars)

KENYA: FIGURES IN U.S. DOLLARS

TOTAL LABOR COST: 175.15
TOTAL MATERIALS COST: 14947.01
TOTAL CONSTRUCTION COST: 15122.16

YR	CASH FLOW PAYMENT	CASH FLOW MAINT.	CASH FLOW COST/YR	CASH FLOW CORRECTED FOR INFLATION PAYMENT	CASH FLOW CORRECTED FOR INFLATION MAINT.	CASH FLOW CORRECTED FOR INFLATION COST/YR
	DOWNPAYMENT:		0.00	DOWNPAYMENT:		0.00
1	1776.24	129.70	1905.95	1614.77	117.91	1732.68
2	1776.24	29.01	1805.26	1467.97	23.98	1491.95
3	1776.24	29.06	1805.30	1334.52	21.83	1356.35
4	1776.24	29.21	1805.45	1213.20	19.95	1233.15
5	1776.24	29.45	1805.69	1102.91	18.28	1121.19
6	1776.24	29.79	1806.03	1002.64	16.81	1019.46
7	1776.24	30.22	1806.46	911.49	15.51	927.00
8	1776.24	30.75	1807.00	828.63	14.35	842.98
9	1776.24	31.38	1807.63	753.30	13.31	766.61
10	1776.24	32.11	1808.35	684.82	12.38	697.20
11	1776.24	32.93	1809.17	622.56	11.54	634.10
12	1776.24	33.85	1810.09	565.97	10.79	576.75
13	1776.24	34.87	1811.11	514.51	10.10	524.61
14	1776.24	35.98	1812.22	467.74	9.47	477.21
15	1776.24	37.19	1813.43	425.22	8.90	434.12
16	1776.24	38.49	1814.74	386.56	8.38	394.94
17	1776.24	39.90	1816.14	351.42	7.89	359.31
18	1776.24	41.40	1817.64	319.47	7.45	326.92
19	1776.24	42.99	1819.24	290.43	7.03	297.46
20	1776.24	44.69	1820.93	264.03	6.64	270.67
TOT	35524.86	782.96		15122.16	362.50	

CASH FLOW: 36307.82 ADJUSTED CASH FLOW: 15484.66
NPV OF CASH FLOW: 20842.55 ADJUSTED NPV: 10467.97

TABLE A-13a
SYSTEM COSTS FOR MEXICO
(in Mexican Pesos)

MEXICO: FIGURES IN MEXICAN PESOS

TOTAL LABOR COST: 13615.41
TOTAL MATERIALS COST: 339572.00
TOTAL CONSTRUCTION COST: 353187.41

	CASH FLOW			CASH FLOW CORRECTED FOR INFLATION		
YR	PAYMENT	MAINT.	COST/YR	PAYMENT	MAINT.	COST/YR
	DOWNPAYMENT:		0.00	DOWNPAYMENT:		0.00
1	41485.26	10242.48	51727.74	37713.87	9311.34	47025.21
2	41485.26	1569.55	43054.81	34285.34	1297.15	35582.49
3	41485.26	1573.07	43058.33	31168.49	1181.87	32350.36
4	41485.26	1583.65	43068.93	28334.99	1081.66	29416.65
5	41485.26	1601.29	43086.55	25759.08	994.28	26753.36
6	41485.26	1625.98	43111.24	23417.35	917.82	24335.17
7	41485.26	1657.72	43142.98	21288.50	850.67	22139.17
8	41485.26	1696.52	43181.78	19353.18	791.44	20144.62
9	41485.26	1742.37	43227.63	17593.80	738.93	18332.74
10	41485.26	1795.27	43280.54	15994.36	692.16	16686.52
11	41485.26	1855.23	43340.49	14540.33	650.25	15190.58
12	41485.26	1922.25	43407.51	13218.48	612.49	13830.97
13	41485.26	1996.31	43481.57	12016.80	578.26	12595.06
14	41485.26	2077.43	43562.70	10924.37	547.05	11471.42
15	41485.26	2165.61	43650.87	9931.24	518.43	10449.67
16	41485.26	2260.84	43746.10	9028.40	492.02	9520.43
17	41485.26	2363.12	43848.38	8207.64	467.53	8675.17
18	41485.26	2472.46	43957.72	7461.49	444.69	7906.18
19	41485.26	2588.85	44074.11	6783.17	423.30	7206.47
20	41485.26	2712.29	44197.55	6166.52	403.17	6569.68
TOT	829705.22	47502.30		353187.41	22994.51	

CASH FLOW:	877207.52	ADJUSTED CASH FLOW:	376181.92
NPV OF CASH FLOW:	505037.12	ADJUSTED NPV:	255557.44

TABLE A-13b
SYSTEM COSTS FOR MEXICO
(in U.S. Dollars)

MEXICO: FIGURES IN U.S. DOLLARS

TOTAL LABOR COST: 605.13
TOTAL MATERIALS COST: 15092.09
TOTAL CONSTRUCTION COST: 15697.22

	CASH FLOW			CASH FLOW CORRECTED FOR INFLATION		
YR	PAYMENT	MAINT.	COST/YR	PAYMENT	MAINT.	COST/YR
	DOWNPAYMENT:		0.00	DOWNPAYMENT:		0.00
1	1843.79	455.22	2299.01	1676.17	413.84	2090.01
2	1843.79	69.76	1913.55	1523.79	57.65	1581.44
3	1843.79	69.91	1913.70	1385.27	52.53	1437.79
4	1843.79	70.36	1914.17	1259.33	48.07	1307.41
5	1843.79	71.17	1914.96	1144.85	44.19	1189.04
6	1843.79	72.27	1916.06	1040.77	40.79	1081.56
7	1843.79	73.68	1917.47	946.16	37.81	983.96
8	1843.79	75.40	1919.19	860.14	35.18	895.32
9	1843.79	77.44	1921.23	781.95	32.84	814.79
10	1843.79	79.79	1923.58	710.86	30.76	741.62
11	1843.79	82.45	1926.24	646.24	28.90	675.14
12	1843.79	85.43	1929.22	587.49	27.22	614.71
13	1843.79	88.73	1932.51	534.08	25.70	559.78
14	1843.79	92.33	1936.12	485.53	24.31	509.84
15	1843.79	96.25	1940.04	441.39	23.04	464.43
16	1843.79	100.48	1944.27	401.26	21.87	423.13
17	1843.79	105.03	1948.82	364.78	20.78	385.56
18	1843.79	109.89	1953.68	331.62	19.76	351.39
19	1843.79	115.06	1958.85	301.47	18.81	320.29
20	1843.79	120.55	1964.34	274.07	17.92	291.99
TOT	36875.79	2111.21		15697.22	1021.96	

CASH FLOW:	38987.00	ADJUSTED CASH FLOW:	16719.20
NPV OF CASH FLOW:	22446.05	ADJUSTED NPV:	11356.11

TABLE A-14a
SYSTEM COSTS FOR NEPAL
(in Nepalese Rupees)

NEPAL: FIGURES IN NEPAL RUPEES

TOTAL LABOR COST: 574.61
TOTAL MATERIALS COST: 163494.12
TOTAL CONSTRUCTION COST: 164068.73

YR	CASH FLOW PAYMENT	CASH FLOW MAINT.	CASH FLOW COST/YR	CASH FLOW CORRECTED FOR INFLATION PAYMENT	CASH FLOW CORRECTED FOR INFLATION MAINT.	CASH FLOW CORRECTED FOR INFLATION COST/YR
	DOWNPAYMENT:		0.00	DOWNPAYMENT:		0.00
1	19271.45	401.04	19672.49	17519.50	364.58	17884.08
2	19271.45	80.21	19351.66	15926.82	66.29	15993.11
3	19271.45	80.36	19351.81	14476.93	60.37	14539.30
4	19271.45	80.79	19352.24	13162.66	55.18	13217.84
5	19271.45	81.52	19352.97	11966.06	50.61	12016.67
6	19271.45	82.53	19353.98	10878.23	46.59	10924.82
7	19271.45	83.83	19355.29	9889.30	43.02	9932.32
8	19271.45	85.43	19356.88	8990.27	39.85	9030.13
9	19271.45	87.31	19358.76	8172.98	37.03	8210.01
10	19271.45	89.49	19360.94	7429.98	34.50	7464.48
11	19271.45	91.95	19363.40	6754.53	32.23	6786.75
12	19271.45	94.71	19366.16	6140.40	30.16	6170.65
13	19271.45	97.75	19369.20	[illegible]	28.31	5610.57
14	19271.45	101.08	19372.53	[illegible]	26.62	5101.39
15	19271.45	104.71	19376.16	4613.43	25.07	4638.50
16	19271.45	108.62	19380.07	4194.03	23.64	4217.67
17	19271.45	112.82	19384.27	3812.[illegible]	22.32	3835.08
18	19271.45	117.32	19388.77	3466.14	21.10	3487.24
19	19271.45	122.10	19393.55	3151.04	19.96	3171.00
20	19271.45	127.17	19398.62	2864.58	18.90	2883.48
TOT	385429.03	2230.73		164066.73	1046.36	

CASH FLOW: 387659.76 ADJUSTED CASH FLOW: 165115.09
NPV OF CASH FLOW: 222388.31 ADJUSTED NPV: 111480.19

TABLE A-14b
SYSTEM COSTS FOR NEPAL
(in U.S. Dollars)

NEPAL: FIGURES IN U.S. DOLLARS

TOTAL LABOR COST: 47.88
TOTAL MATERIALS COST: 13624.51
TOTAL CONSTRUCTION COST: 13672.39

YR	CASH FLOW PAYMENT	CASH FLOW MAINT.	CASH FLOW COST/YR	CASH FLOW CORRECTED FOR INFLATION PAYMENT	CASH FLOW CORRECTED FOR INFLATION MAINT.	CASH FLOW CORRECTED FOR INFLATION COST/YR
	DOWNPAYMENT:		0.00	DOWNPAYMENT:		0.00
1	1605.95	33.42	1639.37	1459.96	30.38	1490.34
2	1605.95	6.68	1612.64	1327.23	5.52	1332.76
3	1605.95	6.70	1612.65	1206.58	5.03	1211.61
4	1605.95	6.73	1612.69	1096.89	4.60	1101.49
5	1605.95	6.79	1612.75	997.17	4.22	1001.39
6	1605.95	6.88	1612.83	906.52	3.88	910.40
7	1605.95	6.99	1612.94	824.11	3.55	827.69
8	1605.95	7.12	1613.07	749.19	3.32	752.51
9	1605.95	7.28	1613.23	681.08	3.09	684.17
10	1605.95	7.46	1613.41	619.16	2.88	622.04
11	1605.95	7.66	1613.62	562.88	2.69	565.56
12	1605.95	7.89	1613.85	511.71	2.51	514.22
13	1605.95	8.15	1614.10	465.19	2.36	467.55
14	1605.95	8.42	1614.38	422.90	2.22	425.12
15	1605.95	8.73	1614.68	384.45	2.09	386.54
16	1605.95	9.05	1615.01	349.50	1.97	351.47
17	1605.95	9.40	1615.36	317.73	1.86	319.59
18	1605.95	9.78	1615.73	288.84	1.76	290.60
19	1605.95	10.17	1616.13	262.59	1.66	264.25
20	1605.95	10.60	1616.55	238.71	1.58	240.29
TOT	32119.09	185.89		13672.39	87.20	

CASH FLOW: 32304.98 ADJUSTED CASH FLOW: 13759.59
NPV OF CASH FLOW: 18532.40 ADJUSTED NPV: 9290.02

TABLE A-15a
SYSTEM COST FOR PHILIPPINES
(in Philippine Pesos)

PHILIPPINES: FIGURES IN PHILIPPINE PESOS

TOTAL LABOR COST: 735.17
TOTAL MATERIALS COST: 96633.58
TOTAL CONSTRUCTION COST: 97368.75

YR	CASH FLOW PAYMENT	CASH FLOW MAINT.	CASH FLOW COST/YR	CASH FLOW CORRECTED FOR INFLATION PAYMENT	CASH FLOW CORRECTED FOR INFLATION MAINT.	CASH FLOW CORRECTED FOR INFLATION COST/YR
	DOWNPAYMENT:		0.00	DOWNPAYMENT:		0.00
1	11436.90	551.69	11988.59	10397.18	501.53	10898.71
2	11436.90	131.37	11568.27	9451.98	108.57	9560.55
3	11436.90	131.58	11568.48	8592.71	98.86	8691.57
4	11436.90	132.21	11569.10	7811.55	90.30	7901.85
5	11436.90	133.25	11570.14	7101.41	82.74	7184.15
6	11436.90	134.70	11571.60	6455.83	76.04	6531.87
7	11436.90	136.59	11573.48	5868.94	70.09	5939.02
8	11436.90	138.87	11575.77	5335.40	64.78	5400.18
9	11436.90	141.58	11578.47	4850.36	60.04	4910.40
10	11436.90	144.70	11581.60	4409.42	55.79	4465.21
11	11436.90	148.24	11585.14	4008.56	51.96	4060.52
12	11436.90	152.20	11589.09	3644.15	48.49	3692.64
13	11436.90	156.57	11593.47	3312.86	45.35	3358.21
14	11436.90	161.36	11598.26	3011.69	42.49	3054.18
15	11436.90	166.57	11603.46	2737.90	39.87	2777.78
16	11436.90	172.19	11609.09	2489.00	37.47	2526.48
17	11436.90	178.23	11615.13	2262.73	35.26	2297.99
18	11436.90	184.66	11621.56	2057.03	33.22	2090.24
19	11436.90	191.56	11628.45	1870.02	31.32	1901.34
20	11436.90	198.84	11635.74	1700.02	29.56	1729.58
TOT	228737.94	3486.95		97368.75	1603.73	

CASH FLOW: 232224.90 ADJUSTED CASH FLOW: 98972.49
NPV OF CASH FLOW: 132261.97 ADJUSTED NPV: 66864.64

TABLE A-15b
SYSTEM COST FOR PHILIPPINES
(in U.S. Dollars)

PHILIPPINES: FIGURES IN U.S. DOLLARS

TOTAL LABOR COST: 100.02
TOTAL MATERIALS COST: 13147.43
TOTAL CONSTRUCTION COST: 13247.45

YR	CASH FLOW PAYMENT	CASH FLOW MAINT.	CASH FLOW COST/YR	CASH FLOW CORRECTED FOR INFLATION PAYMENT	CASH FLOW CORRECTED FOR INFLATION MAINT.	CASH FLOW CORRECTED FOR INFLATION COST/YR
	DOWNPAYMENT:		0.00	DOWNPAYMENT:		0.00
1	1556.04	75.06	1631.10	1414.58	68.24	1482.82
2	1556.04	17.87	1573.91	1285.98	14.77	1300.76
3	1556.04	17.90	1573.94	1169.08	13.45	1182.53
4	1556.04	17.99	1574.03	1062.80	12.29	1075.08
5	1556.04	18.13	1574.17	966.18	11.26	977.44
6	1556.04	18.33	1574.37	878.34	10.35	888.69
7	1556.04	18.58	1574.62	798.49	9.54	808.03
8	1556.04	18.89	1574.93	725.90	8.81	734.72
9	1556.04	19.26	1575.30	659.91	8.17	668.08
10	1556.04	19.69	1575.73	599.92	7.59	607.51
11	1556.04	20.17	1576.21	545.38	7.07	552.45
12	1556.04	20.71	1576.75	495.80	6.60	502.40
13	1556.04	21.30	1577.34	450.73	6.17	456.90
14	1556.04	21.95	1577.99	409.75	5.78	415.54
15	1556.04	22.66	1578.70	372.50	5.43	377.93
16	1556.04	23.43	1579.47	338.64	5.10	343.74
17	1556.04	24.25	1580.29	307.85	4.80	312.65
18	1556.04	25.13	1581.17	279.87	4.52	284.39
19	1556.04	26.06	1582.10	254.43	4.26	258.69
20	1556.04	27.05	1583.09	231.30	4.02	235.32
TOT	31120.81	474.42		13247.45	218.20	

CASH FLOW: 31595.22 ADJUSTED CASH FLOW: 13465.64
NPV OF CASH FLOW: 18120.88 ADJUSTED NPV: 9097.23

TABLE A-16
SYSTEM COSTS FOR UNITED STATES
(in U.S. Dollars)

U.S. FIGURES IN U.S. DOLLARS

TOTAL LABOR COST: 4780.63
TOTAL MATERIALS COST: 14947.01
TOTAL CONSTRUCTION COST: 19727.64

	CASH FLOW			CASH FLOW CORRECTED FOR INFLATION		
YR	PAYMENT	MAINT.	COST/YR	PAYMENT	MAINT.	COST/YR
	DOWNPAYMENT:		0.00	DOWNPAYMENT:		0.00
1	2317.20	3505.00	5822.20	2106.55	3186.36	5292.91
2	2317.20	905.40	3222.60	1915.04	749.26	2663.31
3	2317.20	906.82	3224.03	1740.95	681.31	2422.26
4	2317.20	911.10	3226.30	1582.68	622.29	2204.97
5	2317.20	918.22	3235.42	1438.80	570.14	2008.94
6	2317.20	926.20	3245.40	1308.00	523.94	1831.94
7	2317.20	941.02	3258.22	1189.09	482.89	1671.98
8	2317.20	956.69	3273.89	1080.99	446.30	1527.29
9	2317.20	975.21	3292.41	982.72	413.58	1396.30
10	2317.20	996.58	3313.78	893.38	384.22	1277.61
11	2317.20	1020.80	3338.00	812.16	357.78	1169.95
12	2317.20	1047.87	3365.07	738.33	333.88	1072.22
13	2317.20	1077.79	3394.99	671.21	312.20	983.41
14	2317.20	1110.56	3427.76	610.19	292.44	902.64
15	2317.20	1146.17	3463.37	554.72	274.38	829.10
16	2317.20	1184.64	3501.84	504.29	257.81	762.10
17	2317.20	1225.96	3543.16	456.45	242.55	700.99
18	2317.20	1270.12	3587.32	416.77	228.44	645.21
19	2317.20	1317.14	3634.34	378.88	215.36	594.24
20	2317.20	1367.00	3684.20	344.44	203.20	547.63
TOT	46344.03	23712.27		19727.64	18777.37	

CASH FLOW:	70056.30	ADJUSTED CASH FLOW:	30505.01
NPV OF CASH FLOW:	40635.28	ADJUSTED NPV:	21055.65

APPENDIX B

DATA SOURCES

FIGURE B-1
WAGE RATE WORKSHEET

PHOTOVOLTAIC ENERGY CONVERSION SYSTEM

(Average Labor Costs)

Country: ____________

Currency: ____________

Skill	Wage
Laborer	_____ per (hour) (day) (month)
Machinist	_____ per (hour) (day) (month)
Welder	_____ per (hour) (day) (month)
Electrician	_____ per (hour) (day) (month)
Carpenter	_____ per (hour) (day) (month)
Mason	_____ per (hour) (day) (month)
Pipe fitter (plumber)	_____ per (hour) (day) (month)
Bulldozer Operator	_____ per (hour) (day) (month)

Airmail to:

Mr. Ed Jacobson
Baker Building
Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332
U.S.A.

FIGURE B-2
MATERIALS COST WORKSHEET

PHOTOVOLTAIC ENERGY CONVERSION SYSTEM

(Typical Component Costs)

Country: __________

Currency: __________

		Cost per Unit
Array		
Galvanized Steel	1¼" angle iron or channel	______ per (ft.)(meter)
	1¼" x 3/16" flat iron	______ per (ft.)(meter)
Security		
Fencing (2 m high)	wood	______ per (ft.)(meter)
	steel	______ per (ft.)(meter)
	concrete blocks	______ per (ft.)(meter)
	lock for gate	______ each
Electrical		
600v Insulated Wire	#10 AWG	______ per (ft.)(meter)
	#12 AWG	______ per (ft.)(meter)
	#18 AWG	______ per (ft.)(meter)
	#20 AWG	______ per (ft.)(meter)
Voltage Regulator		______ each
Voltage Inverter	DC to AC (35A. maximum AC output)	______ each
Equipment Boxes, Steel	(2 ft. x 2 ft. x 1 ft. approximately)	______ each
Batteries 12v or 24v, (10 amp-hour minimum, 8 hr. life) type - (lead calcium) (lead) (antimony)		______ each
Steel	- 1 7/8" channel (48 mm x 48 mm)	______ per (ft.)(meter)
Plastic	- 1/16" thick plastic insulation (for batteries on rack)	______ per (ft.)(meter)
Structures		
Materials	- wood	______ per ($ft.^2$)($meter^2$)
	- block	______ per ($ft.^2$)($meter^2$)
Miscellaneous		
- Ventilator louvers (for building)		______ each
- 10" fan (for building ventilation)		______ each

Airmail to: Mr. Ed Jacobson
Baker Building
Engineering Experiment Station
Georgia Institute of Technology
Atlanta, GA 30332
U.S.A.

TABLE B-1
LIST OF DATA SOURCES

Egypt

A. Alaa El-Din Nazmy
Third Secretary
Embassy of the Arab Republic of Egypt
Commercial and Economic Office
2715 Connecticut Avenue, N.W.
Washington, DC 20008

Haiti

Ernest Paultre
Engineer, U.S.A.I.D.
J.C. Duvalier & Christophe
Porte au Prince, Haiti, W.I.

Ivory Coast

M. Delafosse
Secretaire General
Chambre de Commerce de la Cote d'Ivoire
01 - B.P. 1399
Abidjan, Ivory Coast

Kenya

J.B.C. Chegge
Permanent Secretary
Ministry of Labour
P.O. Box 40326
Nairobi, Kenya

Mexico

Ricardo Alvarez
Avenida Morelos 25
Parque Industrial Naucalpan
Estado de Mexico, Mexico

Nepal

P. Wagle
Section Officer
Ministry of Industry & Commerce
Department of Labour
Puspa Aashram
Ram Shaha Path
Kathmandu, Nepal

Khilendra N. Rana
United Consultants Engineering
P.O. Box 253
Kathmandu, Nepal

TABLE B-1
(continued)

Philippines

Ross Hammond
Director, Asia Office
Georgia Institute of Technology
Enrique T. Virata Hall
UP Campus, Diliman
Quezon City, Philippines

Eugene Construction Supply
25 Roosevelt Avenue
Quezon City, Philippines

University of the Philippines
Physical Plant,
School of Architecture,
Administration Department,
Center for Non-Conventional Energy Development,
Engineering Department
Quezon City, Philippines

Rufino Lopez & Sons
Manila, Philippines

United States

National Construction Estimator
Craftsman Book Co.

APPENDIX C

FORTRAN CODING
of
CALCULATION PROGRAM

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      PROGRAM COSTEST(INPUT,OUTPUT,COST,DATA,PRINT,TAPE5=INPUT,
     *TAPE6=OUTPUT,TAPE7=COST,TAPE11=DATA,TAPE9=PRINT)
C     ************************************************************
C            SUBROUTINES
C
C 1   MAIN     READS INPUT AND SUMS THE COSTS EACH YEAR
C 2   BATTERY CALCULATES THE CONSTRUCTION COST
C 3   MAT      CALCULATES THE MATERIALS COST OF CONSTRUCTION
C 4   CAP      CALCULATES THE YEARLY LOAN PAYMENTS
C 5   MAINT    CALCULATES THE YEARLY MAINTENANCE COSTS
C 6   EXCHNG   EXCHANGES VALUES IN U.S. DOLLARS FOR THOSE IN LOCAL CURRENCY
C 7   CHART    FIGURES TOTALS AND PRINTS ALL OUTPUT
C 8   REAL     CALCULATES FIGURES ADJUSTED FOR INFLATION
C 9   NPV      CALCULATES THE NET PRESENT VALUE OF TOTALS
C
C  VARIABLES                                                  IN SUBROUTINES:
C
C BAL      BALANCE OF LOAN STILL UNPAID                          4
C CAPCOST TOTAL CONSTRUCTION COST                                1,2,4,7
C CAPMK    TOTAL CONSTRUCTION COST                               7
C CCOUN    ALPHANUMERIC NAME OF CURRENCY                         1,7
C CLAB     MAN-HOURS OF LABOR CATEGORY I NEEDED TO BUILD
C                      ONE PART J                                1,2
C CNPV     NET PRESENT VALUE OF THE TOTAL COST                   7,9
C COSTL    SALARY OF LABOR CATEGORY I NEEDED TO BUILD ONE
C                      PART J                                    1,2,5
C COSTMAT TOTAL COST OF MATERIALS                                2,3,7
C COSTNET NET COST FOR A GIVEN YEAR                              7
C COUN     ALPHANUMERIC NAME OF COUNTRY                          1,7
C CS       COST OF ONE PART J IN COUNTRY I                       1,3
C CSD      COST OF ONE PART I  (DEFAULT)                         1,3
C CST      COST OF ONE PART I                                    3
C DISRT    DISCOUNT RATE USED TO CALCULATE NPV                   9
C DMLAB    PARAMETERS GOVERNING HOURS OF MAINTENANCE             1,5
C DOWN     DOWNPAYMENT ON LOAN                                   1,7
C EXC      EXCHANGE RATES FOR INCLUDED COUNTRIES                 1
C EXCH     EXCHANGE RATE FOR COUNTRY I                           1,3,6
C FIXIT    MAINTENANCE COSTS                                     1,5,7
C GOTO     DUMMY VARIABLE CONTROLLING RUN-AGAIN OPTION           1
C HRSLAB   HOURS OF LABOR CATEGORY I NEEDED FOR MAINTENANCE
C                      DURING YEAR J                             5
C ICOUN    NO. COUNTRIES INCLUDED IN DATA SETS                   1
C LOCAM    INDEX GOVERNING OUTPUT CURRENCY                       1,7
C NCOUN    INDEX FOR COUNTRY PROGRAM IS RUN FOR                  1,2,3,5,7
C NPAY     NO. YEARS TO PAY BACK LOAN                            1,4
C NPP      PAYMENT PLAN INDEX                                    1,4
C NYR      YEAR NUMBER INDEX                                     1,4,5,7,8,9
C NYRS     NO. YEARS OF USEFUL LIFE                              1,7
C PAYMENT YEARLY PAYMENTS, IF KNOWN                              1,4
C PAYR     BANK PAYMENT FOR YEAR I                               1,4
C RATINT   INTEREST RATE ON LOAN                                 1,4
C RCNPV    NET PRESENT VALUE OF THE ADJUSTED TOTAL COST          7,9
C RCOSTNT NET COST PER YEAR ADJUSTED FOR INFLATION               7
C RFIX     MAINT COST PER YEAR ADJUSTED FOR INFLATION            7,8
C RPAYR    YEARLY LOAN PAYMENT ADJUSTED FOR INFLATION            7,8
C RTCOST   TOTAL COST ADJUSTED FOR INFLATION                     7
C SN       AMOUNT OF PART I NEEDED FOR CONSTRUCTION              1,2,3
C SND      AMOUNT OF PART I NEEDED FOR CONSTRUCTION (DEFAULT)    1,2
C TCAT     NO. HOURS OF LABOR CATEGORY I NEEDED FOR CON-
C                      STRUCTION                                 2
C TCLAB    NO. HOURS OF LABOR CATEGORY I NEEDED TO BUILD
C                      ALL OF PART I                             2
C TLC      COST OF LABOR IN CONSTRUCTION                         1,2,7
C TMAINT   TOTAL MAINTENANCE COST                                1,7
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C TOTCOST  TOTAL CASH FLOW                                          7
C TPAYR    TOTAL OF PAYMENTS                                        1,7
C TRMAINT  TOTAL MAINTENANCE COST ADJUSTED FOR INFLATION            1,7
C TRPAY    TOTAL OF PAYMENTS ADJUSTED FOR INFLATION                 1,7
C XINF     INFLATION RATE                                           8
C      **********************************************************
       DIMENSION SN(6),XINF(30),PAYR(100),FIXIT(100),COSTNET(100),
      *RPAYR(100),RFIX(100),RCOSTNT(100),EXC(8),SND(6),CSD(5),CS(8,5),
      *DMLAB(9,4),COUN(8,2),CCOUN(8,4),COSTL(9,8),CLAB(9,6)
       COMMON NCOUN,NPP,RATINT,NPAY,PAYMENT,NYRS,EXCH,ICOUN,TPAYR,TMAINT,
      *TRPAY,TRMAINT,SN(6),SND(6),XINF(30),CSD(5),CS(8,5),COSTL(9,8),
      *DMLAB(9,4),COUN(8,2),CCOUN(8,4),CLAB(9,6),TLC,COSTMAT
       GOTO=0.
C          WRITE IN DATA:
 1234  DO 16 I=1,4
 16    SN(I)=-2.
       NPP=2
       RATINT=.10
       NPAY=20
       PAYMENT=1000.
       DOWN=0.
       NYRS=20
       ICOUN=8
       WRITE(6,26)
       WRITE(6,6)
  6    FORMAT("COUNTRY,IF 1-NEPAL 2-PHILLIPPINES 3-MEXICO 4-HAITI 5-KENYA
      * 6-IVORY COAST:")
       WRITE(6,17)
  17   FORMAT(11X,"7-EGYPT 8-U.S.:")
       READ(5,*)NCOUN
       WRITE(6,200)
 200   FORMAT("WRITE '2' TO OBTAIN DEFAULT VALUES FOR ALL FURTHER INPUT")
       WRITE(6,201)
 201   FORMAT("          <OTHERWISE, ENTER 0>")
       READ(5,*)Z
       IF(Z .EQ. 2.) GO TO 2
       WRITE(6,26)
  26   FORMAT("  ")
       WRITE(6,14)
  14   FORMAT("WRITE IN DATA.")
       WRITE(6,15)
  15   FORMAT("IF YOU WISH TO USE THE DEFAULT VALUE FOR QUESTIONS NOTED <
      *DEF=-2>, ENTER -2")
       WRITE(6,26)
       WRITE(6,13)
   13  FORMAT("HOW MANY YEARS OF USEFUL LIFE:")
       READ(5,*)NYRS
       WRITE(6,1)
  1    FORMAT("PEAK WATTAGE IN WATTS:  <DEF=-2>")
       READ(5,*) SN(1)
       WRITE(6,3)
  3    FORMAT("BATTERY CAPACITY IN WATT-HOURS:  <DEF=-2>")
       READ(5,*) SN(2)
       WRITE(6,4)
  4    FORMAT("METERS OF FENCING:  <DEF=-2>")
       READ(5,*) SN(3)
       WRITE(6,5)
  5    FORMAT("SQ. METERS OF STRUCTURE:  <DEF=-2>")
       READ(5,*) SN(4)
       WRITE(6,7)
  7    FORMAT("PAYMENT PLAN,IF 1-KNOWN PAYMENTS 2-CALCULATED PAYMENTS 3-D
      *EFERRED PAYMENT:")
       READ(5,*) NPP
       WRITE(6,8)
```

```
  8    FORMAT("INTEREST RATE IN PERCENT:")
       READ(5,*) RATINT
       RATINT=RATINT/100.
       WRITE(6,10)
 10    FORMAT("NUMBER OF YEARS TO PAY BACK LOAN:")
       READ(5,*) NPAY
       WRITE(6,11)
 11    FORMAT("IF PLAN #1 IS USED, ENTER PAYMENT <IF NOT, ENTER 0>:")
       READ(5,*) PAYMENT
       WRITE(6,12)
 12    FORMAT("IF A DOWNPAYMENT IS MADE, LIST IT <IF NOT, ENTER 0>:")
       READ(5,*) DOWN
C*****************************************************************
C        IN THIS SECTION, COSTEST SUMS THE TOTAL COST OF
C      THE PROJECT FOR EACH YEAR FOR BOTH LOCAL AND U.S. CURRENCY
  2    IF(GOTO .EQ. 1.) GO TO 4321
C      READ IN ALL DATA FROM DATA SETS
       READ(11,*)(EXC(I),I=1,ICOUN)
       READ(11,*)(SND(I),I=1,6)
       READ(11,*)((COSTL(I,J),J=1,ICOUN),I=1,9)
       READ(11,*)((CLAB(I,J),J=1,6),I=1,9)
       READ(11,*)(CSD(I),I=1,5)
       READ(11,*)((CS(K,I),I=1,5),K=1,ICOUN)
       READ(7,*)((DMLAB(I,J),J=1,4),I=1,9)
       DO 18 IX=1,ICOUN
 18    READ(7,19)(COUN(IX,J),J=1,2),(CCOUN(IX,J),J=1,4)
 19    FORMAT(2A8,4A6)
4321   EXCH=EXC(NCOUN)
       DOWN=DOWN*EXCH
       PAYMENT=PAYMENT*EXCH
       CALL BATTERY(CAPCOST)
       CAPCOST=CAPCOST-DOWN
       DO 101 LOCAM=1,2
       IF(NCOUN .EQ. 8 .AND. LOCAM .EQ. 2) GO TO 101
       TPAYR=0.
       TMAINT=0.
       TRPAY=0.
       TRMAINT=0.
       DO 100 NYR=1,NYRS
       IF (LOCAM .EQ. 2) GO TO 50
       CALL CAP(NYR,PAYR(NYR),CAPCOST)
       CALL MAINT(NYR,FIXIT(NYR))
       GO TO 100
 50    CALL EXCHNG(DOWN,CAPCOST,PAYR(NYR),FIXIT(NYR))
       TLC=TLC/EXCH
       COSTMAT=COSTMAT/EXCH
100    CALL CHART(NYR,DOWN,CAPCOST,PAYR(NYR),FIXIT(NYR),LOCAM)
101    CONTINUE
       WRITE(6,26)
       WRITE(6,21)
 21    FORMAT("-PROGRAM STOP-  IF YOU WANT TO RUN IT AGAIN, ENTER 1")
       WRITE(6,201)
       READ(5,*) GOTO
       IF(GOTO .EQ. 1.) GO TO 1234
       STOP
       END
C
C
       SUBROUTINE CHART(NYR,DOWN,CAPCOST,PAYR,FIXIT,LOCAM)
C      PRINTS ALL OUTPUT ONTO DATA SET 'PRINT'
       DIMENSION COSTNET(100),RPAYR(100),
      *RFIX(100),RCOSTNT(100),COUN(8,2),CCOUN(8,4)
       COMMON NCOUN,NPP,RATINT,NPAY,PAYMENT,NYRS,EXCH,ICOUN,TPAYR,TMAINT,
      *TRPAY,TRMAINT,SN(6),SND(6),XINF(30),CSD(5),CS(8,5),COSTL(9,8),
```

```
     *DMLAB(9,4),COUN(8,2),CCOUN(6,4),CLAB(9,6),TLC,COSTMAT
C     SET UP CHARTS
      IF (NYR .NE. 1) GO TO 100
      TOTCCST=DOWN
      RTCOST=DOWN
      WRITE(9,26)
 26   FORMAT("  ")
      IF (LOCAM .EQ. 1) GO TO 75
      WRITE(9,2) (COUN(NCOUN,JX),JX=1,2)
  2   FORMAT(2A6,"FIGURES IN U.S. DOLLARS")
      GO TO 1
  75  DO 74 I=1,5
  74  WRITE(9,26)
      WRITE(9,6)(COUN(NCOUN,JX),JX=1,2),(CCOUN(NCOUN,JX),JX=1,4)
   6  FORMAT(2A8,"FIGURES IN ",4A8)
  1   CAPWK=CAPCOST+DOWN
      WRITE(9,26)
      WRITE(9,4) TLC
   4  FORMAT(7X,"TOTAL LABOR COST:",F10.2)
      WRITE(9,5) COSTMAT
   5  FORMAT(3X,"TOTAL MATERIALS COST:",F10.2)
      WRITE(9,3)CAPWK
   3  FORMAT("TOTAL CONSTRUCTION COST:",F10.2)
      WRITE(9,12)
  12  FORMAT(51X,"CASH FLOW")
      WRITE(9,27)
27    FORMAT(16X,"CASH FLOW",16X,"CORRECTED FOR INFLATION")
      WRITE(9,26)
      WRITE(9,50)
   50 FORMAT(1X,"YR",2X,"PAYMENT",4X,"MAINT.",5X,"COST/YR",6X,
     *"PAYMENT",4X,"MAINT.",5X,"COST/YR")
      WRITE(9,26)
      WRITE(9,25) DOWN,DOWN
25    FORMAT(5X,"DOWNPAYMENT:",10X,F9.2,4X,"DOWNPAYMENT:",10X,F9.2)
 100  CALL REAL(NYR,PAYR,FIXIT,RPAYR(NYR),RFIX(NYR))
      COSTNET(NYR)=PAYR+FIXIT
      RCOSTNT(NYR)=RPAYR(NYR)+RFIX(NYR)
      CALL NPV(NYR,COSTNET(NYR),RCOSTNT(NYR),CNPV,RCNPV)
      RTCOST=RTCOST+RCOSTNT(NYR)
      TOTCOST=TOTCOST+COSTNET(NYR)
      TPAYR=TPAYR+PAYR
      TMAINT=TMAINT+FIXIT
      TRPAY=TRPAY+RPAYR(NYR)
      TRMAINT=TRMAINT+RFIX(NYR)
      WRITE(9,101)NYR,PAYR,FIXIT,COSTNET(NYR),RPAYR(NYR),
     *RFIX(NYR),RCOSTNT(NYR)
101   FORMAT(I3,2X,F9.2,2X,F9.2,2X,F9.2,4X,F9.2,2X,F9.2,2X,F9.2)
      IF (NYR .NE. NYRS) GO TO 99
      WRITE(9,200)TPAYR,TMAINT,TRPAY,TRMAINT
 200  FORMAT("TOT",F11.2,F11.2,13X,F11.2,F11.2)
      WRITE(9,26)
      WRITE(9,102) TOTCOST,RTCOST
 102  FORMAT("CASH FLOW:",15X,F11.2,2X,"ADJUSTED CASH FLOW:",3X,F11.2)
      WRITE(9,103) CNPV,RCNPV
 103  FORMAT("NPV OF CASH FLOW:",6X,F11.2,2X,"ADJUSTED NPV:",9X,F11.2)
 99   RETURN
      END
C
C
      SUBROUTINE EXCHNG(AA,BB,CC,DD)
C     EXCHANGES VALUES IN U.S. DOLLARS FOR VALUES IN LOCAL CURRENCY
      COMMON NCOUN,NPP,RATINT,NPAY,PAYMENT,NYRS,EXCH,ICOUN,TPAYR,TMAINT,
     *TRPAY,TRMAINT,SN(6),SND(6),XINF(30),CSD(5),CS(8,5),COSTL(9,8),
     *DMLAB(9,4),COUN(8,2),CCOUN(8,4),CLAB(9,6),TLC,COSTMAT
```

```
      AA=AA/EXCH
      BB=BB/EXCH
      CC=CC/EXCH
      DD=DD/EXCH
      RETURN
      END
C
C
      SUBROUTINE CAP(NYR,PAYR,CAPCOST)
C         CALCULATES THE LOAN PAYMENT FOR A GIVEN YEAR
      COMMON NCOUN,NPP,RATINT,NPAY,PAYMENT,NYRS,EXCH,ICOUN,TPAYR,TMAINT,
     *TRPAY,TRMAINT,SN(6),SND(6),XINF(30),CSD(5),CS(8,5),COSTL(9,8),
     *DMLAB(9,4),COLN(8,2),CCOLN(8,4),CLAB(9,6),TLC,COSTMAT
C     CHOOSE THE PAYMENT PLAN
      IF (NPP .EQ. 3) GO TO 3
      IF (NPP .EQ. 2) GO TO 2
C             PLAN #1
      PAYR=PAYMENT
      IF (NYR .EQ. NPAY) PAYR=BAL*(1.+RATINT)
      IF (NYR .GT. NPAY) PAYR=0.
      IF (NYR .EQ. 1) BAL=CAPCOST
      BAL=BAL*(1.+RATINT)-PAYR
      IF(BAL .GT. 0.) GO TO 5
      PAYR=BAL+PAYR
      BAL=0.
      GO TO 5
C             PLAN #2
    2 IF(NYR .NE.1) GO TO 1
      C=CAPCOST*(1.+RATINT)**NPAY
      S=0.
      DO 10 I=1,NPAY
   10 S=S+(1.+RATINT)**(NPAY-I)
    1 PAYR=C/S
      IF (NYR .GT. NPAY) PAYR=0.
      GO TO 5
C             PLAN #3
    3 PAYR=0.
      IF (NYR .EQ.NPAY) PAYR=CAPCOST*(1.+RATINT)**NPAY
    5 RETURN
      END
C
C
      SUBROUTINE REAL(NYR,PAYR,FIXIT,RPAYR,RFIX)
C     CALCULATES THE INFLATED VALUE OF THE PAYMENTS
C     AND MAINTENANCE COSTS
      DIMENSION XINF(30)
      COMMON NCOUN,NPP,RATINT,NPAY,PAYMENT,NYRS,EXCH,ICOUN,TPAYR,TMAINT,
     *TRPAY,TRMAINT,SN(6),SND(6),XINF(30),CSD(5),CS(8,5),COSTL(9,8),
     *DMLAB(9,4),COUN(8,2),CCOLN(8,4),CLAB(9,6),TLC,COSTMAT
      DO 1 I=1,30
    1 XINF(I)=.10
      IF (NYR .EQ. 1) D=1.
      D=D*(1.+XINF(NYR))
      RPAYR=PAYR/D
      RFIX=FIXIT/D
   99 RETURN
      END
C
C
      SUBROUTINE NPV(NYR,COSTNET,RCOSTNT,CNPV,RCNPV)
C     CALCULATES THE NET PRESENT VALUE OF THE COST PER YEAR
C         IN BOTH CASH FLOW AND IN INFLATED VALUE TERMS
      COMMON NCOUN,NPP,RATINT,NPAY,PAYMENT,NYRS,EXCH,ICOUN,TPAYR,TMAINT,
     *TRPAY,TRMAINT,SN(6),SND(6),XINF(30),CSD(5),CS(8,5),COSTL(9,8),
```

```
     *DMLAB(9,4),COUN(8,2),CCOUN(8,4),CLAB(9,6),TLC,COSTMAT
      DISRT=.06
      IF(NYR .EQ.1) CNPV=0.
      IF(NYR .EQ.1) RCNPV=0.
      CNPV=CCSTNET/(1.+DISRT)**NYR +CNPV
      RCNPV=RCOSTNT/(1.+DISRT)**NYR +RCNPV
   99 RETURN
      END
C
C
      SUBROUTINE BATTERY(CAPCCST)
C        CALCULATES THE TOTAL CONSTRUCTION COST FOR THE PROJECT
      DIMENSION SN(6),SND(6),CLAB(9,6),COSTL(9,8),TCLAB(9,6)
      COMMON NCOUN,NPP,RATINT,NPAY,PAYMENT,NYRS,EXCH,ICOUN,TPAYR,TMAINT,
     *TRPAY,TRMAINT,SN(6),SND(6),XINF(30),CSD(5),CS(8,5),COSTL(9,8),
     *DMLAB(9,4),COUN(8,2),CCOUN(8,4),CLAB(9,6),TLC,COSTMAT
C     INSTALL THE MATERIAL DEFAULT VALUES WHERE NEEDED
      DO 2 I=1,4
    2 IF (SN(I) .LT. 0.) SN(I)=SND(I)
      SN(5)=SND(5)
      SN(6)=SND(6)
C     INSTALL THE LABOR COST DEFAULT VALUES WHERE NEEDED
      W=0.
      DO 4 I=1,7
    4 W=COSTL(I,NCOUN)+W
      AV=W/7
      DO 5 I=1,7
    5 IF (COSTL(I,NCOUN) .EQ. 0.) COSTL(I,NCOUN)=AV
      IF (COSTL(8,NCOUN) .EQ. 0.) COSTL(8,NCOUN)=1.36*AV
      IF (COSTL(9,NCOUN) .EQ. 0.) COSTL(9,NCOUN)=1.66*AV
C      THIS SECTION OF BATTERY CALCULATES THE TOTAL LABOR
C      COST OF CONSTRUCTION
      DO 7 J=1,6
      DO 7 I=1,9
    7 TCLAB(I,J)=CLAB(I,J)*SN(J)
      TLC=0.
      DO 9 I=1,9
      TCAT=0.
      DO 8 J=1,6
    8 TCAT=TCAT+TCLAB(I,J)
    9 TLC=TLC+TCAT*COSTL(I,NCOUN)
      CALL MAT
C     SUM UP THE LABOR AND MATERIALS COSTS
      CAPCOST=TLC+COSTMAT
      RETURN
      END
C
C
      SUBROUTINE MAT
C      SUMS THE TOTAL MATERIALS COST OF CONSTRUCTION
      DIMENSION CSD(5),SN(6),CS(8,5),CST(5)
      COMMON NCOUN,NPP,RATINT,NPAY,PAYMENT,NYRS,EXCH,ICOUN,TPAYR,TMAINT,
     *TRPAY,TRMAINT,SN(6),SND(6),XINF(30),CSD(5),CS(8,5),COSTL(9,8),
     *DMLAB(9,4),COUN(8,2),CCOUN(8,4),CLAB(9,6),TLC,COSTMAT
C     PUT ALL FIGURES IN LOCAL CURRENCY
      DO 2 I=1,5
    2 CST(I)=CSD(I)*EXCH
      COSTMAT=0.
      DO 5 I=1,5
      IF(CS(NCOUN,I) .NE. 0.) CST(I)=CS(NCOUN,I)
    5 COSTMAT=COSTMAT+CST(I)*SN(I)
      COSTMAT=COSTMAT+.15*COSTMAT
      RETURN
      END
```

```
C
C
      SUBROUTINE MAINT(NYR,FIXIT)
C        CALCULATES THE MAINTENANCE COSTS EACH YEAR
      DIMENSION DMLAB(9,4),HRSLAB(9),COSTL(9,6)
      COMMON NCOUN,NPP,FATINT,NPAY,PAYMENT,NYRS,EXCH,ICOUN,TPAYR,TMAINT,
     *TRPAY,TRMAINT,SN(6),SND(6),XINF(30),CSD(5),CS(6,5),COSTL(9,6),
     *DMLAB(9,4),COUN(6,2),CCOUN(8,4),CLAB(9,6),TLC,COSTMAT
      FIXIT=0.
      DO 50 I=1,9
      IF (NYR .LE. DMLAB(I,2))CM=(DMLAB(I,1)-DMLAB(I,4))/
     *(DMLAB(I,2)-1.)**2.
      IF (NYR .GT. DMLAB(I,2))CM=(DMLAB(I,3)-DMLAB(I,4))/
     *(NYRS-DMLAB(I,2))**2.
      HRSLAB(I)=DMLAB(I,4)+CM*(NYR-DMLAB(I,2))**2.
 50   FIXIT=FIXIT+HRSLAB(I)*COSTL(I,NCOUN)
      RETURN
      END
```