PN-AAY-416
ISN 52610

REGIONAL INDUSTRIAL ENERGY EFFICIENCY PROJECT BASELINE DATA SURVEY STUDY

Conducted By

ELIAS C HILL

Under

ROCAP/AID CONTRACT

NO. 596-0000-C-00-2004-00

Guatemala City, Guatemala

March, 1982

CONTENTS

Chapter	Page No.
Summary	i
Introduction	1
Procedure	2
Information	6
Macro Universe	11
Target Group	14
Energy Utilization and Efficiency	23
Problem Areas and Recommendations	41
Survey Generalities	53

TABLES

No.	Title	Page No.
1	Questionnaire Sample Coverage	8
2	Central American Total Energy Utilization by Country and Sector	12
3	Central America - Yearly Average % Increase by Country	13
4	Central America - Industry Total Units by Country	18
5	Central America - Productive Units by Type and Country	19
6	Central America - Population and Employment by Country	20
7	Central America - GNP and Industrial Added Value by Country	21
8	Central America - Industrial Energy Compared to Total by Type and Country	24
9	Central America - Energy Utilization Percentage by Type	25
10	Central America - Potential and Installed Electric Energy by Country	27
11	Central America - Electricity Consumed by Sector	28
12	Central America- Average Energy Prices Paid by Target Group	29
13	Central America - Energy Savings Yearly Estimates	39
14	Central America - Comparative Estimates Between Petroleum Imports and Real Consumption	40

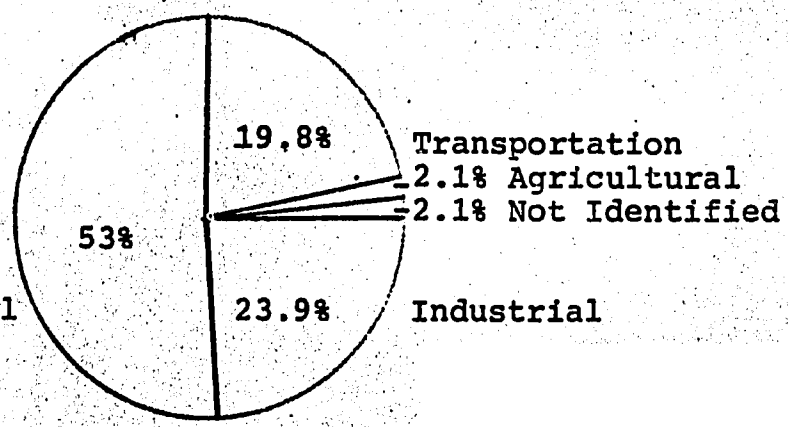
SUMMARY

This study followed the marketing investigating approach under which a macro-related universe was established.

MACRO UNIVERSE = 12,566,000 TEP[1/] yearly
ENERGY CONSUMPTION WITHIN THE
CENTRAL AMERICAN ISTHMUS

The macro universe was then broken down into component parts.

MACRO UNIVERSE
SECTOR COMPOSITION



Detailed analysis were made of the various parts composing the macro universe to establish a target area or group.

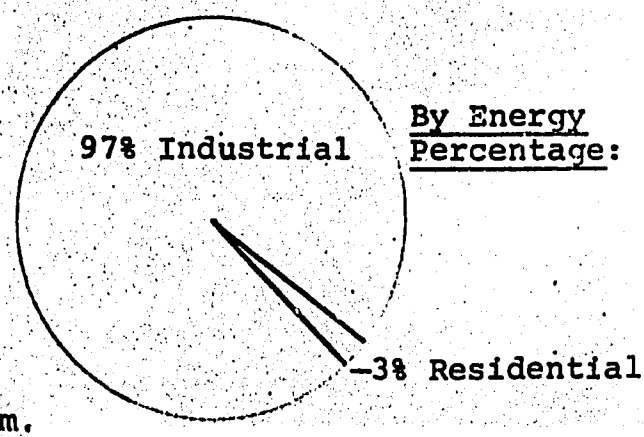
TARGET GROUP = 3,240,231 TEP yearly

The target group was broken down for detailed study.

Target Composition:

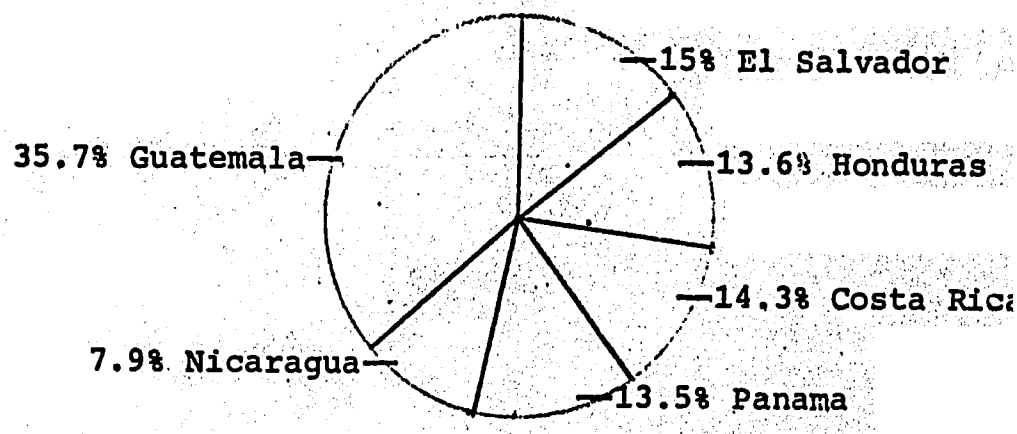
By Sector:

100% Industrial
1.45% Residential



1/ Tons equivalent of petroleum.

By Country's Energy:



The industrial sector is composed of the various productive units including manufacturing, construction, mining and energy producers. This productive sector is composed of:

TOTAL UNITS	128,097
Units with 5 or more employees	8,849
Units with less than 5 employees	119,249
These units employ all together:	846,300 people

A detailed analysis of the target group permited establishing the importance of this group.

Target Group Importance

- Accounts for 14.1% of total employment;
- Contributes $2,094.4 million in production added value, which represents 24.9% of the Region's GNP;
- Is responsible for 42.8% of total exports. lots of ag exports

?!

With the assurance of the target group's importance, further target group analyses were made, focusing on the areas to determine the program's activities.

ENERGY TYPE UTILIZATION
BY TARGET GROUP

Electricity	9.2%
Crude Oil	1.0%
Fuel Oil	26.9%
Diesel	16.9%
Kerosene	1.3%
Gasoline	0.6%
LPG	0.7%
Wood	20.7%
Other Vegetable and Animal	23.0% ~ bagasse
TOTAL	100 %

Based on detailed analysis of the target group's forms and methods of energy utilization, an estimate of the percentage per type of energy was determined. See following page for estimates on savings.

SAVINGS ESTIMATES

(In Millions of $)

Energy Type	%	% Paid By Industry	$ in Oil Imports
Electricity	10	24.5	5.9
Crude Oil	30	1.9	
Fuel Oil	28	48.8	
Diesel	21	36.9	
Kerosene	30	4.1	75.5
Gasoline	5	0.5	
LPG	8	0.5	
Wood	16	-	
Other Vegetable and Animal	20	-	
TOTALS		117.3	81.4

further substitution

Based on savings, comparative significant-impact analyses were made:

IMPACT

$81.4 million in import savings per year represents 6.6% savings in total oil imports.

$117.3 million in industrial savings per year represents 5.6% of the total added value. Theoretically, this could benefit the total area population of 22 million people through a reduced cost of local industrial products.

INTRODUCTION

The rapid increase of oil prices has further limited the less developed countries in their attempts to reach the needed economical and social growth. This condition has probably become the most crucial problem nowadays that requires massive consideration to attenuate the increasing economical gap among the various countries in the world.

The AID Regional Office for Central American Programs (ROCAP) has proposed a regional industrial energy efficiency program to assist the six countries of the Central American isthmus. This program is intended to improve the energy utilization within the industrial sector, thereby reducing production costs.

Also, as a direct consecuence, this project will increase productivity and reduce oil imports, and so lower the balance of payments deficit.

To properly design the referred program, directed at attaining the maximum rate of real economic growth in Central America and Panama, while keeping the growth rate of energy consumption as low as possible, it was mandatory to have realistic, up-to-date data. This information would permit and insure a response to the real needs of each industry in direct concurance with actual energy utilization volumes and usage characteristics. This report is the result of this study.

PROCEDURE

This study has followed the marketing investigating approach, under which a macro-related universe is first established. This universe is then broken down into its various components in order to select the specific ones that are to be included in the program (target population).

These components are then further divided into micro-elements in order to study each group's specific characteristics in more detail. This more specific knowledge is used to project back from the micro to the actual macro that realistically could be expected to be covered and/or achieved by the program. Also, this knowledge permits determining realistic targets and ways through which the program goals may be accomplished.

To expedite study results, a three-way information gathering approach was selected:

Existing Information

Efforts were made in each of the six countries and within the region in general to locate as much as possible of the existing information related to energy or to the target population in relevant matters. This information was used within the scope of this study and is now available for future project utilization.

The information also would permit learning from others' experiences in the field and most of all, eliminating duplication of efforts.

Mail Survey

A small mail survey was conducted within a readily accessable target population. For this purpose, a two-page questionnaire was prepared and distributed.

To insure private enterprise involvement from the start, cooperation was obtained from the Central American Federation of Industrial Chambers and Associations, and the direct participation of at least one chamber of industry or association in each country.

For an adequate design and distribution of the questionnaire, the following points were covered:

1. General requirements of information for project design were determined. In order to do so, technical personnel from ROCAP and other related institutions was consulted.
2. A draft was designed and discussed with ROCAP, ICAITI and SIECA personnel on several occasions until an acceptable final draft was produced.
3. The questionnaire was tested in ten different local industries.
4. Based on test results, a final questionnaire was prepared and printed.
5. Questionnaires were mailed out in each country by a national chamber of industry or association in a package consisting of: the questionnaire, including a motivating introductory letter from FECAICA, a supportive letter from the

local chamber of industry or association; and a self-addressed, stamped envelope.

6. Follow-up telephone calls were made to further motivate industrialists to complete and return the questionnaire.

A computer program was prepared for processing the data contained in the questionnaires. This computer program not only provided immediate, organized information in order to prepare the necessary study tables, but also provided bases for future evaluation comparisons, as it can be easily rerun with up-dated information.

Observation Visits

To obtain more detailed information as to the actual manner in which industry utilizes energy and to obtain general pertinent data from related institutions, observation visits were conducted to industry and related organizations.

Strong emphasis was placed on noting the efficiency levels on which each industry utilizes energy. This information served as a basis to estimate the savings percentages that could be achieved through this program.

These visits also served to detect specific weaknesses within industry that affect the implementation of energy-saving programs. Based on these notations, specific needs related to technical know-how were determined.

In general, these visits served to provide more accurate inside knowledge of industry in relation to energy and to the

idiosyncracies of industrial personnel that lead to many of the recommendations included in this report.

INFORMATION

This study provides three information categories, which served as a basis for making this study and which no doubt will serve others for project design, implementation and evaluation.

General Information

A sizable amount of existing pertinent information was located and made part of this study. This information appears in Annexes 1 - 7. The first six annexes correspond to country information in the following order: 1.- Costa Rica, 2.- El Salvador, 3.- Guatemala, 4.- Honduras, 5.- Nicaragua and 6.- Panama.

Annex 7 groups all the information that refers to two or more countries or that covers more general aspects. Since the countries of the region have long made moves towards integration, it was easier to locate information related to the whole area. This strengthened the approach used of utilizing information developed regionally whenever possible.

Since the latest information on an individual issue in a particular country was often not available, this approach was sometimes inconvenient, but it provided many other advantages. Some of these advantages were; having similar information for all countries from a single document, utilizing information gathered under one methodology with a single interpretation of terms, eliminating the burden of having to select one source of information per country when two or more existed that often reflected different figures, etc.

There is only one copy of the information contained in Annexes 1 - 7. It was considered unnecessary and costly to reproduce such a large quanitity of documents, as these documents are considered working data only. In addition, this study essentially reflects the most important aspects used to reach the conclusions presented in it.

Nevertheless, it is highly recommended that this material be kept securely for reference purposes only. It will no doubt provide useful information for the other phases of this project.

Specific Information

A total of 2,440 questionnaires was sent out. Nevertheless, it was estimated that only 1,601 should be considered. This difference responds to the fact that within the regular mailing lists utilized, there is a number of commercial companies that do not fall within the scope of the study. These companies automatically disregard the questionnaire as not applicable.

A total of 257 questionnaires was returned, which accounts for a 16.1% return, within the relatively short time allowed in this specific case.

According to the experience of the industrial associations involved, this percentage is considered excellent, demonstrating a reasonably high interest in this program. The industrial associations involved claim that with mail questionnaires, even when related to important current issues, the percentage return

is seldom above ten percent and hardly ever over fifteen. They also indicated that to reach those percentages, they allow considerably more time than this study did.

TABLE 1

QUESTIONNAIRE SAMPLE COVERAGE

Country	Mailed Out	Estimated N. A. %	Equivalent	Received Back	% Return
Costa Rica	625	25	469	71	15.1
El Salvador	275	20	220	27	12.3
Guatemala	630	35	410	96	23.4
Honduras	600	50	300	18	6.0
Nicaragua	0	-	-	-	-
Panama	310	35	202	45	22.3
TOTALS	2,440	34.4	1,601	257	16.1

The referred sample of 257 questionnaires returned represents 2.9% of the total industrial regional universe of 8,848. This provides a sufficient sample size to have a confidence factor over 90% with less than 5% error for overall figures. Based on this, it was considered safe to project figures, including for Nicaragua, even though questionnaires were not received for that country. This was due to a specific Nicaraguan bureaucratic requirement that made impossible mailing out questionnaires within sufficient time to include the returns

in this study.

It is important to point out that overall projections are valid. But extreme care should be excersized when working with specific points. In each micro-individual case, the percentage confidence factor and margin for error change. This is due to the fact that in this case a very heterogeneous universe and finely broken-down information are being dealt with. In some individual cases, the sample practically covers the whole micro-universe, but in others, the sample is too small or nonexistant for valid projections.

The questionnaire consisted of 25 questions divided into five sections:

1. General Information. To properly classify the corresponding industry by name, type, size, interest in program, etc.
2. Electric Energy. To provide information to determine volumes used, prices paid, quantity of own electricity generated, etc. This section also included questions to determine the efficiency level of the electricity utilized.
3. Uses and Applications. This section provided information to determine how energy is utilized, providing bases to determine main areas of impact and needed technical know-how to be contracted for the program.
4. Wastes. The information from this section provided bases for establishing estimating figures for volume savings

by a more rational utilization of existing potentials within industry that are not yet utilized.

5. Other Types of Energy. This information provided the overall usage of energy, its cost and the specific differences that exist among industrial groups and countries. Also provided were comparative guidelines for industry and basis for quota determinations. See sample of questionnaire in Attachment A., Exhibit 1.

Qualitative Information

A total of 56 visits were made to key industries and institutions within the Central American region. Twenty-three corresponded to industries and 33, to institutions.

Besides allowing for physical observations of industrial facilities, these visits also permited in-depth interviews with experienced industrialists and other people knowledgeable of the energy issue.

The 23 observations correspond to approximately 0.3% of the total target group. Considering that general industry behaviour is quite similar within the region, it becomes a sample sufficiently adequate for pinning down corrective measures and general recommendations to be included in the program.

In all, it can be safely stated that the information presented within this study is enough to establish a base line data to properly and realistically design the proposed program and establish solid bases for program implementation and evaluation guidelines to achieve the desired objectives.

MACRO UNIVERSE

The total estimated 1981 energy consumption for the six Central American countries was 12,566,000 TEP[1/]. This total was estimated by a simple 5% yearly average projection from the 1978 total of 10,927,200 TEP reported by OLADE. This was the most recent year for which a single source of information was found for the six countries.

The 1978 referred data is presented in Table 2, divided into four groups for the main socio-economic activities: 1) industrial; 2) residential, commercial and public; 3) transportation; and 4) agricultural.

The 5% yearly average rate of increase was determined based on 1970-78 historical data. Table 3 presents yearly average percentage increases by country and region. Information from OLADE's publication was used in most instances to determine these percentages, but when not available, national energy balance information from each country was used. This on some occasions required altering some total regional quantities reported by OLADE. The changes were made after analyzing both figures, leaving the one that demonstrated to be more logical. The 5% yearly average was derived from a single source and found very reasonable after the analysis.

The referred Table 3 presents the yearly average increase in increments of two-year periods and the total for 1970-78. This information provides an adequate picture of general energy consumption trends.

1/ TEP = Tons Equivalent of Petroleum

TABLE 2

CENTRAL AMERICA - TOTAL ENERGY UTILIZATION BY COUNTRY AND SECTOR

(IN 1000 TEP)

	INDUSTRIAL		RESIDENTIAL, COMMERICAL, PUBLIC		TRANSPORATATION		AGRICULTURAL		NOT IDENTIFIED		TOTAL	
	TEP	%	TEP	%	TEP	%	TEP	%	TEP	%	TEP	%
CENTRAL AMERICA	2612.8	23.9	5884.8	53.9	21663	19.8	235	2.1	28.3	0.3	10927.2	100
COSTA RICA	372	26.9	556	40.2	450	32.6	-	-	4	0.3	1382	100
EL SALVADOR	397	17.6	1446	64.1	371	16.4	27	1.2	15	0.7	2256	100
GUATEMALA	895	28.0	1730	54.2	560	17.5	-	-	8	0.3	3193	100
HONDURAS	338	20.4	1093	65.9	203	12.3	24	1.4	-	-	1658	100
NICARAGUA	251	19.1	630	48.0	248	18.9	184	14.0	-	-	1313	100
PANAMA	359.8	32.0	429.8	38.2	334.3	29.7	-	-	1.3	0.1	1125.2	100

SOURCE: OLADE Energy Balances 1978 - and % Calculations

TABLE 3

CENTRAL AMERICA - YEARLY AVERAGE % INCREASE BY COUNTRY

(ENERGY UTILIZED IN 1000 TEP)

	1970 TEP	1972 TEP	% 1970-1972	1974 TEP	% 1972-1974	1976 TEP	% 1974-1976	1978 TEP	% 1976-1978	% 1970 1978
CENTRAL AMERICA	7818.3	8561	5.5	9195.3	2.5	10019.8	5.0	10927.2	4.5	5.0
COSTA RICA	962	1063	5.3	1115	2.4	1221	4.8	1382	6.6	5.5
EL SALVADOR	1552	1719	5.4	1865	4.3	2026	4.3	2256	5.7	5.7
GUATEMALA	2335	2645	6.6	2645	0	2911	5.0	3193	4.8	5.0
HONDURAS	1308	1351	1.6	1419	2.5	1514	3.3	1658	4.8	3.3
NICARAGUA	989	1052	3.2	1202	7.1	1324	5.1	1313	0	4.1
PANAMA	6752.3	731	4.4	949.3	14.9	1023.8	3.9	1125.2	5.0	8.4

SOURCE: OLADE Energy Balances Complemented and Changed when Considered Logical, Based on National Energy Balance Figures - and Study % Calculations

TARGET GROUP

The proposed program is directed to impact on the industrial community. There are several good reasons why this economical sector is attractive for this type of programs.

- This group is a high energy user, consuming approximately 25% of the total energy utilized in the region.
- It is the smallest group in number compared to the other sectors.
- It is a more accessible group to influence on energy-improvement activities.
- It has an excellent potential for influencing other sectors in order to extend achievement to other areas.

Based on these reasons, the target group could be estimated in two fashions:

1. In the strict sense of the word, it would consider the energy used by industry alone. In this case, it would simply be 24% of the macro universe, in which case consumption would amount to 3,241,500 TEP.
2. More realistically, in respect to the real impact of the program on the total community, it should include a greater part of the micro-universe, in spite of the fact that all program activities will be directed to benefit the industrial community.

In the latter case, in addition to the 3,241,500 TEP established previously, a portion of the Residential sector

should be considered. This is based on the fact that some program interventions, especially training, directly involve people that belong not only to the industrial sector, but also to the residential group.

where who hrs.?

It has been observed by industry in general that improving behaviour patterns, especially those related to good practices in energy utilization, is far more effective if the personnel is trained in regards to home-habit rather than to work ones. People are more receptive and more cooperative since the benefits are for themselves. Once they develop good habits at home, it is very simple to have them apply them at work.

To determine the portion of the residential group to be considered part of the target group, the following considerations and estimates were made:

A. The residential-commercial-public sector consumes approximately 54% of the total energy utilized in the region. This sector consequently used in 1981 a total of 6,785,640 TEP.

B. The referred residential-commercial-public sector is composed of three well defined groups. This project will directly impact on the residential portion and only in an indirect way on the other two. Therefore, only the residential portion should be considered to form part of the target.

The residential portion accounts for approximately 97% of the energy consumed by this sector. That leaves a total of 6,528,071 TEP.

C. This program is not intended to improve on wood fuel utilization efficiency outside of the industrial sector. For this, ROCAP already is sponsoring a project. Therefore, the 98.5% of wood energy utilized by this group should be disregarded for this purpose. This leaves a difference of 98,731 TEP, equivalent to approximately 1.45% of the residential-commercial-public sector.

Therefore, the target group in this case would be composed of the total industrial sector and 1.5% of the residential group, which amounts to a total of:

Industrial	3,141,500
Residential	98,731
TOTAL	3,240,231 TEP

Composition

The target group may be classified in several ways, according to its composition or in relation to whom or what its actions are directed. Following are three of them:

1. Energy. This classification was already established, as this is probably the most logical one. What could be more significant than energy parameters for an energy program? Detailed analysis of this point will be made later on.

2. Industry. The actions of this program will be directed at benefitting 128,097 productive units. Included are manufacturing, construction, mining and energy producing units. There are 8,849 productive units with five or more employees per unit and 119,249 small units with less than five employees per unit. (See Tables 4 and 5).

3. People. The target group is composed of 846,300 people employed by the target productive units. This amount represents 14.1% of the total working force of the area. (See Table 6).

Approximately 346,000 people work in the 119,249 productive units with less than five employees, averaging 2.9 persons per unit. The remaining 500,300 people work in the 8,849 units with five or more employees, averaging 56.5 persons per unit. In other words, 41% of the total target working force is employed by 119,249 units and the remaining 59% is employed by 8,849 units.

Importance

The target group no doubt is a very important socio-economic sector. It accounts for 14.1% of the area's total employment. This group also participates with $2,094.4 million of production added value, which represents 24.9% of the region's GNP. (See Table 7).

With respect to exports, this group is responsible for 42.8% of total exportation, although it imports over 50%

TABLE 4

CENTRAL AMERICA - INDUSTRY TOTAL UNITS BY COUNTRY

EMPLOYEES PER UNIT	COSTA RICA [1]	EL SALVADOR [2]	GUATEMALA [3]	HONDURAS [4]	NICARAGUA [5]	PANAMA [6]	CENTRAL AMERICA
LESS THAN 5	4403	20223	51844	38303	2217	2259	119,249
5 AND MORE	2870	1128	2107	849	932	962	8,849
TOTAL	7273	21,351	53,951	39,152	3149	3221	128,097

SOURCE: 1. OSPI Basic Industrial Data 1979; 2. Statistics and Census 1979; 3. CDI Industrial Survey; 4. Ministry of Industry and Central Bak 1979; 5. Industrial Census and CDSS 1980; 6. Statistics and Census 1976.

TABLE 5

CENTRAL AMERICA - POPULATION AND EMPLOYMENT BY COUNTRY

	COSTA RICA	EL SALVADOR	GUATEMALA	HONDURAS	NICARAGUA	PANAMA	CENTRAL AMERICA
POPULATION 1980 (in millions)	2.2	4.8	7.3	3.7	2.7	1.9	22.6
TOTAL EMPLOYMENT (IN 1000)	686.9	1504.1	1914.12	826.9	529.0	527.0	5988.1
% EMPLOYMENT OF TOTAL POPULATION	31.7	33.9	28.1	23.2	21.5	28.0	26.5
INDUSTRIAL EMPLOYMENT (IN 1000)	107.8	315.1	231.6	90.2	48.2	53.4	846.3
% INDUSTRIAL EMPLOYMENT OF TOTAL EMPLOYMENT	15.7	20.9	12.1	10.9	9.1	10.1	14.1

SOURCES: Various country and regional study's calculation.

TABLE 6

CENTRAL AMERICA - GNP AND INDUSTRIAL ADDED VALUE BY COUNTRY

(IN $ MILLION)

	COSTA RICA	EL SALVADOR	GUATEMALA	HONDURAS	NICARAGUA	PANAMA	CENTRAL AMERICA
GROSS NATURAL PRODUCT	1721.1	1381.6	3291.7	1098.7	930.4	1120.2	8423.5
INDUSTRIAL ADDED VALUE	522.4	320.2	739.9	271.9	240.0	267.9	2094.4
% INDUSTRIAL PARTICIPATION	30.4	23.2	22.5	24.8	25.8	23.9	24.9

SOURCE: SIECA July 1981 Publication; Panama Statistic and Census. 1976 and Estimate for 1980 (in 1970 Constant value).

TABLE 7

CENTRAL AMERICA - INDUSTRIAL ENERGY COMPARED TO TOTAL BY TYPE & COUNTRY

(IN 1000 TEP)

		ENERGY TYPE										
		Electricity	Crude Oil	Fuel Oil	Diesel	Kerosene	Gasoline	L.P.G.	Wood	Other Vegetable & Animal	Charcoal	
CENTRAL AMERICA	TOTAL	643	27	771	1511	295	1174	169	5711	618	16	10935
	IND.	246	27	721	454	36	15	20	548	618	0	2685
	%	38.3	100	93.5	30.1	12.2	1.3	11.8	9.6	100	0	24.6
COSTA RICA	TOTAL	154	-	124	325	47	154	23	435	136	9	1407
	IND.	60	-	124	39	5	-	2	19	136	-	385
	%	39.0	-	100	12.0	10.6	-	8.7	4.4	100	-	27.4
EL SALVADOR	TOTAL	116	-	149	227	54	166	34	1398	162	1	2307
	IND.	53	-	139	11	4	-	3	30	162	-	402
	%	45.7	-	93.3	4.8	7.4	-	8.8	2.2	100	-	17.4
GUATEMALA	TOTAL	119	27	255	360	116	317	40	1926	152	-	3312
	IND.	59	27	237	123	21	-	9	331	152	-	959
	%	49.6	100	92.9	34.2	18.1	-	22.5	17.2	100	-	29.0
HONDURAS	TOTAL	63	-	92	233	64	111	10	1088	65	5	1731
	IND.	30	-	75	80	3	8	1	104	65	-	366
	%	47.6	-	81.5	34.3	4.7	7.2	10.0	9.6	100	-	21.1
NICARAGUA	TOTAL	80	-	60	154	4	168	17	570	-	-	1053
	IND.	27	-	55	62	2	7	2	57	-	-	212
	%	33.8	-	91.7	40.3	50.0	4.2	11.7	10.0	-	-	20.1
PANAMA	TOTAL	111	-	91	212	16	258	45	294	103	1	1125
	IND.	17	-	91	139	1	-	3	7	103	-	361
	%	15.3	-	100	65.6	10.0	-	6.7	2.4	100	-	32.1

SOURCE: OLADE Energy Balances 1979 and Calculations

of the total in equipment and raw material. Day by day, this group incorporates for manufacturing more import substitution products, contributing to the reduction of the balance of payments deficit.

This sector, which had been experiencing a positive growth rate for the last two decades, has come to a virtual standstill in the last few years. There are several reasons for this, some of which are:

- Escalation of energy costs,
- Regional political instability,
- Increasing restrictions for foreign exchange acquisition,
- General inflation causing price increases of many imported raw materials,
- Increased capital flight.

The situation, of course, is not equal in each country; as some, even though decreasingly, are still productive, others are not at all, and still others are negative.

In spite of its temporary lack of growth, great hope has been placed on this sector in order to remedy the present and future economic situation of the area. An energy program will no doubt be an excellent contribution to this sector's improvement.

ENERGY UTILIZATION AND EFFICIENCY

The target group utilizes practically every type of energy. The percentage of each energy type used in realtion to the total varies, ranging from 1.3% for gasoline to 100% for crude oil. See Table 8 for detailed energy percentage utilizations.

Grouping all energy types in three specific categories: electricity, petroleum-origin and renewable energy, it is found that petroleum-origin sources are used the most, 47.4%; renewable, 43.4%; and electricity the least, 9.2%. See Table 9.

Electricity

In spite of the fact that electricity could be used for most energy consuming activities with considerable advantages, it is used in a limited manner by the target group. For instance, approximately 90% of the electricity is used for producing mechanical power through motors. Sometimes this mechanical power is further converted to other types of energy, as in the case of refrigeration. In most cases, however, it is used as mechanical power.

The remaining 10% of electricity is used mainly for illumination and heat.

The tendency to utilize other types of energy rather than electricity originates in several factors: a) productive equipment frequently responds to conditions in which electricity is not found in sufficient quantities, as is the case in many places; b) the initial investment is higher; c) the cost of electricity is higher than other types of energy, that is, by com-

TABLE 8

Country	TEP	Percentage
Target Group	12,566,000	100
Costa Rica	1,796,938	14.3
El Salvador	1,884,900	15.0
Guatemala	4,486,062	35.7
Honduras	1,708,976	13.6
Nicaragua	992,714	7.9
Panama	1,696,410	13.5

Source: Based on Table 7

TABLE 9

CENTRAL AMERICA - ENERGY UTILIZATION PERCENTAGES BY TYPE

	ELECTRI-CITY	CRUDE OIL	FUEL OIL	DIESEL	KEROSENE	GASOLINE	L.P.G.	WOOD	OTHER VEGETABLE & ANIMAL	CHARCOAL	TOTAL
ALL SECTORS	5.9	0.3	7.1	13.8	2.7	10.7	1.5	52.2	5.7	0.1	100
PRODUCTIVE SECTOR	9.2	1.0	26.9	16.9	1.3	0.6	0.7	20.4	23.0	0	100
	9.2	PETROLEUM ORIGEN 47.4						43.4			100
1000 TEP	298.2	1536.2						1406.8			3241.5

SOURCE: Calculations Based on Table 8

paring the cost of BTU per BTU and disregarding efficiency; d) higher levels of technical know-how are required, etc.

Considering the current high cost of imported oil and the fact that within the region, 40,207 MW of hydraulic/geothermal energy exist, with a potential to be used for generating electricity, which amounts to fifteen times the total 2,679.3 MW presently installed electric generating power. It is logical to expect an accelerated transition from other types of energy to electricity. See Table 10 and 11.

Nevertheless, this transition will not take place in an accelerated manner until the governments develop more generating power units and make electricity available at reasonable prices. The average price of $0.08 per KWH paid by industry today is not attractive at all. See Table 12. Also, considerable training and motivation for such transitions are required.

It was found among industrialists that a lack of knowledge as to the various energy usage alternatives for industry was pervasive.

Electricity efficiency utilization is low throughout the region. In most cases, the power factor is below 80. Only four places out of 32 visited had sufficient capacitor panels to correct the power factor level. In many places, managers didn't even know that the power factor could be improved by a relatively low-cost investment with a pay-back return of two years or less.

TABLE 10

CENTRAL AMERICA - POTENTIAL AND INSTALLED ELECTRIC ENERGY BY COUNTRY

(IN MW)

	POTENTIAL			INSTALLAED			% INSTALLED VS. POTENTIAL
	Hydraulic	Geothermic	TOTAL	Hydraulic	Geothermic	TOTAL	
CENTRAL AMERICA	30967	9240	40207	1387.8	1291.5	2679.3	6.7
COSTA RICA	9000	720	9720	444.5	154.4	598.9	6.2
EL SALVADOR	1351	720	2071	337.9	137.1	475.0	22.9
GUATEMALA	10900	1800	12700	99.0	281.3	380.3	3.0
HONDURAS	2800	-	2800	108.7	111.4	220.1	7.9
NICARAGUA	4416	6000	10416	100.0	201.2	301.2	2.9
PANAMA	2500	-	2500	297.7	406.1	703.8	28.2

SOURCE: MITRE Study and United Nations Electric Energy Statistics 1980.

TABLE NO. 11

CENTRAL AMERICA INSTALLED CAPACITY FOR ELECTRICAL ENERGY, DEMAND SERVICED AND NUMBER OF CONSUMERS FOR 1965, 1970 AND 1978

CONCEPT AND YEAR	GUATEMALA	EL SALVADOR	HONDURAS	NICARAGUA	COSTA RICA	PANAMA
Installed Capacity (MW)						
1965	70	82	58	131	144	111
1970	176	166	76	122	216	163
1978	436	491	189	302	506	495
Demand Serviced (MW)						
1965	84	73	24	51	134	---
1970	129	121	57	110	214	---
1978	302	321*	123	220	355	---
Number of Consumers (Thousands)						
1965	93	119	40	73	125	107
1970	144	166	53	104	173	133
1977	257	274	103	174	282	183+

Source: Selected Statistical Series for Central America and Panama, SIECA, November 1980
* = 1977, + = 1976

TABLE 12

CENTRAL AMERICAN AVERAGE ENERGY PRICES PAID BY TARGET GROUP

BY COUNTRY

(IN US$)

Energy Type	Costa Rica	El Salvador	Guatemala	Honduras	Panama	Average For Central America
Electricity	0.03	0.06	0.14	0.08	0.08	0.078
Fuel Oil	0.44	0.82	0.94	0.65	0.89	0.748
Diesel	0.95	1.70	1.08	1.04	1.34	1.222
Gasoline	1.50	2.56	1.98	1.60	2.22	1.972
Kerosene	0.86	1.55	1.10	1.04	1.35	1.180
LPG	0.18	0.22	0.20	0.34	0.26	0.240
Wood	8.00	14.00	12.00	6.00	10.00	10.000

Note: All prices per gallon; except wood, per "pante" and LPG, per pound.

Source: Study

All the places visited had a high maximum demand in relation to normal energy consumption. At no place was it found that a strict and well-designed turn-on sequence existed for equipment.

A disregard of good practices in the utilization of electrical equipment and lights was typical. It was common to find equipment running while not in use, lights and air-conditioning units turned on where people were not present for considerable lengths of time, etc.

Based on the findings, it is estimated that through a well orchestrated energy program, at least 20% electricity efficiency utilization improvement could be achieved in no less than 50% of the target population. This would mean a savings of (246,000 x .2 x .5 =) 24,600 TEP per year, which in turn is equivalent to 40.3% of the total 61,092[1/] TEP petroleum used by the region for generating electricity.

Petroleum-Origin Energy

This category of energy is the one most used by the target group in spite of the fact that it places a heavy burden on the Central American countries' balance of payments.

The old tendency to utilize this type of energy comes from the fact that this energy was originally very low in price and dependable. In addition it is easy to store and to handle;

1/ Source: Mitre Study for 1977.

and compared to biomass, it is cleaner.

There are some typical uses for each type of energy within the petroleum-origin category:

Crude Oil: Within the target group, this fuel is used only in Guatemala by two productive units: a cement manufacturer and an electric generating plant. Exmibal, an unrefined nickel producer, was the third unit that utilized crude oil, but the firm has stopped operating since last year.

The cement plant utilizes it to burn directly in their clinker kiln. The electric plant uses it as fuel in their boilers to produce steam to operate their generator. Efficiency in this type of operation is very low, it is always safe to expect a high percentage of savings in most operations of this type, following the implementation of a few corrective measures. In this particular case, an average of 30% savings could be expected within 100% of the population that utilizes this energy type. This would mean a savings of (27,000 x .3 x 1 =) 8,100 TEP per year.

Fuel Oil: This is the energy type most commonly used within the target group. It alone corresponds to 26.9% of the total energy consumed by this group. It is also interesting to note that this type of energy is practically utilized only by the target group as the group alone consumes 93.5% of the total.

This energy is used for two operations, mainly: a) to be burned directly in furnaces, kilns, ovens, cookers, etc., or

b) to be burned in boilers to produce steam or hot water. These two operations are similar in nature and will be further described and evaluated. Nevertheless, it can be stated that at least a 40% efficiency improvement can be achieved among a large portion of the target group that utilizes this type of energy. The group that has boilers and/or furnaces, kilns, etc. is relatively small in number and very accessable. Also, this group has demonstrated to be willing to incorporate changes of this type relatively easily. Consequently, at least 70% of this group could be affected positively by the program. This would imply a (721,000 x .4 x .7 =) 201,880 TEP yearly savings.

Diesel: This type of energy is used by the target group also mainly for burning directly in furnaces, kilns, etc., or in boilers. Volume-wise, it is the fourth most used energy source. With respect to the total of this energy type, the target group utilizes 30.1% of it. The efficiency pattern follows basically the same as that of fuel oil, which will be further described later on. Nevertheless, it was observed that in most cases where diesel was used, the efficiency utilization was much higher. A 30% savings could be expected here with at least 70% of the users. This higher percentage of efficiency no doubt could be accounted for by the fact that this energy type's price is higher. A savings of (454,000 x .3 x .7 =) 95,340 TEP per year could be expected in this case.

Kerosene: This type of energy is utilized in different

forms, but mainly burned directly in cookers and ovens by the target group, especially within smaller-sized food industries.

The utilization efficiency of this type of fuel in most instances is very low. In the great majority of cases, the burners are locally manufactured, copying similar designs which are not too efficient to start with. They follow the standard principle of pre-heating the fuel to convert it into gas, then allowing it to come through a regulated orifice to mix with air to obtain the proper amount of oxygen for combustion. As indicated, most of these units lack precision; consequently, they either expell too much or too little fuel for proper combustion. This is in addition to the very inefficient way in which the heat (flame) is utilized after it is produced. Estimates indicate that in most places, with a small investment, a 50% or greater savings is obtainable.

Due to the existing tradition, in this guild, of copying the neighbor's method, it is expected that after a few successful cases, the majority of places would incorporate the necessary changes. This could mean a percentage coverage between 60 and 70 of the total target population. Based on this, the total savings for this type of fuel could reach (36,000 x .5 x .6 =) 10,800 TEP per year in a relatively short time of a few years.

Gasoline: This is the energy type least utilized by the target group and the most diversified in its utilization. Among

its uses are: as fuel for transportation, cleaning purposes, raw material, primer to start combustion with other fuels, etc. There is no doubt that utilization efficiency of this energy type could by highly improved. But, due to its micro highly diversified utilization and the comparable little usage within the target group, it would be a minor priority item. Nevertheless, it would be expected that within the project activities, this area would be covered in general terms and specifically, only when technical personnel visit and advise productive units. Based on this, a general 5% improvement of the energy type could be easily expected. This would amount to (15,000 x .05 =) 750 TEP per year.

Liquid Petroleum Gas (LPG): This energy type is utilized very extensively within the target group, but in very small quantities. This is the reason why volume-wise it is comparatively very low. It is used for many purposes, but in most instances, it is used for precise operations, such as pilot lights, primers, etc., where volume-wise it has very little utilization. The highest percentage of it is used as regular combustible fuel for heating purposes. The utilization efficiency may be categorized in two ways:

a. as far as its usage is concerned, in precision uses its efficiency is high and very little improvement could be achieved; in addition, possible improvements would not amount to much.

b. in relation to its usage as regular fuel, there are minor flaws, but in most cases, the combustion part of it to produce a flame is adequate, as this energy type contains its own oxygen. Regarding the usage of the heat produced by combustion, there is room for improvement. Misusage of the open flame where most of the fuel is wasted is also typical of this energy type. In all, an estimated 20% improvement, in no less than 40% of the target population could be achieved. This would mean a savings of (20,000 x .2 x .4 =) 1,600 TEP per year.

Renewable

There are basically two types of energy that are included in this category; one is wood and the other is composed of a series of waste materials or subproducts.

Wood: This type of energy is highly utilized volume-wise by the target group. It alone represents 20.4% of the total energy used by this group. This type of energy is probably the one used most inefficiently. In most cases, the efficiency utilization does not reach even 40%. This energy type is used mainly in direct burning in kilns in a wide variety of activities in the food industry and to make products such as bricks, pottery, lime (calcium oxide), salt, etc. Also, it is used to burn in boilers to produce hot water or steam for various uses.

The low efficiency in its utilization starts with the humidity content, and continues throughout all stages of its use to the extremes in which it is allowed to burn without any use. That is, there is no control over the quantity that is necessary. The great majority of the target population that principally uses this energy type is widly spead out and normally is not in physical, cultural or technical contact. There is no doubt that a good impact could be made in energy savings with this group, but it will require special program activities to do so. Based on the above points, an impact on more than 40% of this target group would not be likely. This would mean a savings of (548,000 x .4 x .4 =) 87,680 TEP per year.

Other Vegetable and Animal Sources: This energy type is the second most utilized by the target group. This alone represents 23% of the total energy consumed by this group. This energy source is composed of a large variety of types. The following are some of the most important: sugar cane bagasse, coffee wastes, rice hulks, sawdust, animal faeces, etc. This energy type is used very inefficiently, but not as poorly as wood is. The reason for this is that those that utilize this type of energy are mainly larger producers of some other product and frequently have more technical know-how available. On the other hand, this group has not concentrated too much on developing an efficient utilization of these fuels as they are substances that in the past had to be paid for to be eliminated,

as is still the case in many places. The efficiency utilization of this energy type could be estimated at 60%. The target population that uses this energy is more accessable than the ones utilizing wood, so an impact of 50% could be expected. This would imply a savings of (618,000 x .4 x .5 =) 123,600 TEP per year.

In relation to this energy type, it was found that a problem greater than the inefficiency of its usage was its lack of usage. It is estimated that approximately 60% is wasted every year. There is a high potential for improvement in this area and no doubt the proposed program can make it happen. The proper utilization of this is an ace in the hole to insure that the percentage of savings estimated may be achieved.

Savings Summary

The previously estimated yearly savings for each energy type in each category were based on 1979 figures. To bring them up to 1981 relations, and assuming no change in energy composition, requires only a 10% straight addition, which reflects the established 5% average annual increase.

This amount of energy cost-wise could be expressed in two ways: a) the actual cost to the industrialist, based on average regional market prices, and b) the cost of the petroleum that the region would have to import. Only petroleum-origin fuels and electricity are considered for these figures.

Electricity is considered within the figures due to the fact that oil-generated electricity is used only when hydraulic electricity is not enough to meet the demands. Therefore, the electricity savings would be part of the oil generated portion. These energy savings volumes and costs are reflected in Table 13.

The import savings of $81,413,000 represents 6.6% of the total oil imported in 1981, as shown in Table 14. This same energy savings at average prices to the industrialist amounts to $117,275,200. This is the real savings to the target group.

TABLE 13

CENTRAL AMERICA - ENERGY SAVINGS

YEARLY ESTIMATES

Energy Type	1979 Estimates (TEP)	1981 Estimates (TEP)	Industrial[1] Savings (US$1,000)	Import[2] Savings (US$1,000)
Electricity	24,600	27,060	24,547.2	5,872
Petroleum-Origin	(316,470)	(348,117)	(92,728.0)	75,541
Crude Oil	8,100	8,910	1,933.5	-
Fuel Oil	201,880	222,068	48,835.4	-
Diesel	93,340	102,674	36,887.5	-
Kerosene	10,800	11,880	4,121.4	-
Gasoline	750	825	478.3	-
LPG	1,600	1,760	471.9	-
Renewable				
Wood	(211,280)	(232,408)	-	-
Vegetable/Animal	123,600	135,960	-	-
TOTALS	552,350	607,585	117,275.2	81,413

Source: Study Estimates

1. Renewable in most places is considered marginal. Energy average prices used from Table 12.

2. Conversion formula used: $\$Imports = TEP \times \frac{7 \text{ Barrels}}{TEP} \times \frac{\$31}{\text{Barrel}}$

   This formula does not take into consideration 30% offered as loans at low interest rates.

TABLE 14

CENTRAL AMERICA: COMPARATIVE TABLE BETWEEN ESTIMATE PETROLEUM & DERIVED PRODUCTS IMPORTS DURING 1981 AND REAL CONSUMPTION DURING 1980 1/

	TOTAL		GUATEMALA		EL SALVADOR		HONDURAS		NICARAGUA		COSTA RICA	
	1980	1981	1980	1981	1980	1981	1980	1981	1980	1981	1980	1981
VOLUME (000 TPE)2/	3876	4125	1290	1540	699	695	607	580	580	600	700	710
Millions of Barrels3/	27.9	29.2	9.3	11.1	5.0	5.0	4.4	4.2	4.2	4.3	5.0	5.1
CIF Value Millions of CA$	928	1240	409	480	167	200	145	170	139	170	168	220

1/ 1980 Preliminary Data
1981 Based on worldwide prices, January 1981.

2/ TPE - Thousands of tons of equivalent petroleum

3/ B - Barrels of 42 gallons = 158.9 liters

SOURCE: SIECA

PROBLEM AREAS AND RECOMMENDATIONS

A detailed analysis of various productive units revealed that most problems in energy utilization may be reduced to a few specific points. To better present this concept, it was found convenient to group the problems and recommendations into four areas: electricity; liquid and gas fuels; solid fuels, and unconventional energy.

It is true that each type of industry utilizes diverse energy types for different particular processes in apparently different ways. Nevertheless, boiled down, it is the same specific, well-defined problem. This provides for establishing priorities and strategies for pinpointing realistic and effective program interventions. Following are descriptions and recommendations for each problem group.

Electricity

Electricity is the energy type with the greatest possibility of being used effectively and efficiently in practically every activity. As a matter of fact, there are many activities that can be accomplished only with electricity, such as plating or any other electrolytic process.

It is a pollutant-free energy that can be used cleanly not only in the immediate ambient, but also in the environment as a whole. With the high potential that exists for generating electricity in every Central American country, it no doubt would of-

fer a satisfactory solution to the pressing problems of oil imports and contamination. Even though this solution is simple in nature, it requires considerable time and non-existant funds for its implementation. Nevertheless, it would be a real solution; consequently, any energy program should include activities to encourage the development of new hydraulic and geothermic electric generating plants to make electricity available at lower prices.

Switching to Electricity: In some cases, it is more economical to switch from other types of energy to electricity. Specifically if an imported high-cost petroleum-origin energy is being used. This has encouraged several industrialists to study the possibility more closely. For instance, the University of Costa Rica presently is conducting a study of this issue in a couple of industries.

One food industry presently burning fuel oil has calculated and added all the costs of using fuel oil and now is considering switching to electricity. Within its calculations, the industry included the costs of; interest on the money tied up in fuel inventory; boiler operator and extra maintenance personnel; equipment depreciation differential; higher insurance premiums; direct cost of energy, etc. This demonstrates that calculating the cost of one energy compared to another requires much more than considering only the direct cost of heat content. In this particular case, for instance, the industry was paying

$0.82 per gallon of fuel oil and $0.055 per KWH. This industry is then paying for direct heat content only, $5.69 per million BTUs of fuel oil and $16.11 per million BTUs of electricity. Almost three times as much for electricity, and yet this industry considers it economically convenient to switch.

Demand Curve: The electricity demand curve in most cities is very uneven. It normally has two or three critical peaks during the day. In most cases the hydraulic plants do not have the capacity to meet those demands, so thermal plants have to be put in operation. The petroleum consumed by these plants could be saved if only the demand were distributed a bit better. This would require:

- programming industrial operations time periods,
- eliminating high-consuming operations during peak hours.

Both of these activities could be carried out through incentives, including preferential rates for low-demand hours and special discounts for demand reduction at peak hours.

General Electric Problems: In most industries, improper electrical installations were found, in addition to misusage of energy. This type of inefficiencies could be easily corrected at a low cost investment by:

a. lowering the power factor by installing capacitor panels,

b. increasing the usage of natural lighting by installing skylights,

c. eliminating faulty installations that cause electricity loss,

d. installing motors of the right capacity according to the power required for each operation,

e. providing training to all personnel to insure that electrical equipment and lights are used properly; including forming habits by which motors, lights, air conditioners, etc. are turned off when not in use,

f. installing two lighting systems; one, for operation and the other, for security purposes,

g. reducing maximum demand through improved programing of equipment being turned on and utilized,

h. raising the thermostat for air-conditioned operations,

i. installing central air-conditioning systems when necessary,

j. installing more efficient lighting systems and sources,

k. installing more efficient air-conditioning units.

Liquid and Gas Fuels

This group is composed mainly of petroleum-origin energy. There are exceptions, such as oils from wood pyrolysis and wastes from several agricultural processes with the potential to generate biogas, etc., but these are not generally used within the area. In an industrial context, this is the group

of fuels that must be utilized. Liquid fuels are mainly burned to produce a flame. The flame is then used in two basic forms:

a. to heat directly the material being processed or to heat the container where the material is kept. This can be done within a chamber or recepient, called a kiln, oven or cooking bat.

b. to heat a medium, usually water, that when elevated to the desired temperature, is transported either in the form of hot water or steam to wherever is necessary. This is mainly done within a chamber called a boiler or a heat transfer unit.

Following the previously described sequence of operations, it is simple to identify the basic problems with the utilization of liquid fuels.

Flame Production: To make the flame, the fuel is normally preheated to either gasify it or to lower its viscosity to allow a better atomization of it. This is then allowed to mix with air in a free or forced way, to pick up the required oxygen for combustion.

The main problem found in this process is the amount of fuel and air (oxygen) which are commonly mixed in inadequate proportions, causing improper combustion. At this point alone, there are places where more than 20% of the fuel is wasted. The main cause for this is faulty burners, inadequate injection pressure for either the air or the fuel, too low or too high preheating

temperatures, dirt and inadequate maintenance.

Flame Utilization: As mentioned previously, the flame is either used open or enclosed in a chamber. The main problem found with the use of open flames is that a large percentage of the heat content is wasted. This is compounded when the size, distance and distribution of the flame are inadequate. At this point cases were found where more than 50% of the energy was being wasted.

The use of flame in closed chambers presents a variety of problems, the most common being the following:

a) The fireplaces are not adequate, either because they have not been designed or constructed properly or due to lack of maintenance. This permits a free flow of heat without a rational utilization. The materials used in fireplaces must be replaced frequently, even if they are of good quality; otherwise, it is not possible to obtain the necessary retention or direction of the heat flow.

b) When heat is applied directly to the material, it is common to find more heat than is needed; therefore, a large percentage of it is wasted.

c) In the process of transferring heat to water, either by making the heat (hot gases) go through tubes or by making the hot gases heat the tubes where the water is, there are inefficiencies due to impurities deposited on either side of the tube. This is caused by water precipitations, if the

water hardness is improperly controlled, or by combustion residues, especiably in cases of inadequate combustion. These deposits insulate the tubes and do not permit adequate transfer of heat. To correct this problem the following actions are needed: 1) to control water hardness and 2) to periodically clean the inside and outside of the tubes.

d) Hot water or steam are seldom totally utilized, as there is always steam or hot water at lower temperatures that may be returned to the heating chamber for proper utilization of the energy still left in them. It was observed that in most cases the utilization of these elements (water and/or steam) was not adequate, thereby considerably reducing efficiency. This defficiency can be greatly improved with relatively little investment.

e) Heat loses in chimneys range from 7 to 30%. A large percentage of this heat could be utilized by installing economizers.

f) Insulation material for steam or hot water distribution lines or for heat transfer units is not used in many places. This improvement is also neither difficult nor costly.

There are several types of gas fuels, although only Petroleum Liquid Gas (LPG) is actually used in the region. This fuel is a mixture of hydrocarbons, mainly butane and propane, obtained from natural gasolines or through fractioning of crude petroleum. This fuel does not require preheating and does not have to be mixed with air. Once the flame is produced it works the same as liquid fuels and should be treated as such.

Solid Fuels

This energy group is composed of a large number of different combustible materials such as:

a) Wood, the energy of highest consumption in Central America.

b) Coffee wastes, including: wood from tree prunings which account for an estimated 20% of total wood consumption; coffee pulp, the outside portion of the berry; parchment, portion next to the seed; and the grounds left over after soluble coffee is extracted. A combined total estimate of 180,000 tons are produced yearly.

c) Sugar cane bagasse, with an estimated yearly production of 5 million tons.

d) Saw dust and wood trimmings highly produced by the lumber industry. Some wood specialists have estimated that the amount of waste produced by this industry would be sufficient to dry all the lumber sold in the area, if it were properly used and combined with solar energy. Nevertheless,

most of the lumber sold is not dried, which creates other types of wastes and problems outside of the scope of this study.

e) There are other solid wastes, such as rice husks, peanut shells, and other types of vegetable and animal waste.

When these solid products are used as fuels, they are either burned in closed chambers or allowed to burn in the open, basically in the same manner as liquid fuels.

There are three main differences between solid and liquid fuels, as far as program interventions are concerned. Otherwise they are the same.

a) Solid fuels do not require burners. In some cases feeders and forced air are required to provide the adequate amount of oxigen needed for proper combustion. However, in most cases feeding is done by hand and no forced air is used. Once the flame is produced at whatever rate of efficiency, there are no specific important problems aside from those mentioned with liquid fuels.

b) Humidity; solid fuels contain different levels of humidity at the various times after they are produced and depending on how they are stored or treated. Excessive humidity must be eliminated prior to combustion. If this is not done, part of the heat content of the fuel is wasted in such elimination. It was found out that in most places the humidity content of the fuels is not controlled, nor are such fuels stored or treated properly. It is estimated that a minimum of 20% of the heat content is wasted at this stage.

c) Ashes. Solid fuels produce ashes which, if not properly eliminated, cause combustion and heat utilization inefficiencies. It was observed that many fireplaces are not properly designed, which makes the elimination of ashes more difficult. Poor housekeeping was also observed, such as allowing ashes to remain in fireplaces. It is estimated that a minimum 10% efficiency improvement could be obtained by correcting designs and housecleaning practices.

The program should contemplate the inclusion of activities to cover these differences, otherwise they will be covered by the required program activities for liquid fuels.

Non-Conventional Energy

This is probably the most diversified group in terms of types and forms of energy. This is also the energy group that people generally know the least about.

The world in general has placed its hopes for the future on these energies. Nevertheless, realistically and within this program's limitations, no real impact on energy usage, volume-wise, should be expected. It is not the study's intention to discourage interventions in this area, as these by all means should be included. These efforts will help, undoubtedly, to provide needed know-how and encourage the development and usage of other energy sources.

Non-conventional energy often is so costly and sophisticated that it is placed beyond the proposed project's reach. Some of these energy types are: fusion, fractioning of nitro-

gen 15, photochemical processes, etc. Nevertheless, there is a variety of simple, economical types that must be included within the program.

One of the principle problems concerning the utilization of non-conventional energy is the lack of information, in all respects, such as design, capacity, operation, availability, etc.

Solar energy: With a relatively small investment, this type of energy could be utilized to heat water and dry substances. It was found that many industrialists with the potential to utilize it, later discarded the idea because they expected too much and discovered that it was not always possible to depend 100% on it. However, with the help of practical advice and objective demonstrations, they could become efficient users. There are already people in Central America utilizing solar energy for heating and drying purposes. This is in a way advantageous, although it may have a negative effect, as the designs and applications of some have not been successful.

Biogas: This is another talked-about source of energy that has been used in a few places, mainly in pilot plants. It has a great potential, but its use will not materialize until simpler and lower-priced units are developed. So far, in Central America most units are small and fed with animal faeces only. Unfortunately, there are not many successful operations. This has created some skepticism, which must be eliminated before a reasonable rate of usage may be expected. The target

group is interested mainly in large units, especially models which may be fed with vegetable waste. The development of this type of unit will be a positive contribution to the program.

Ecolic energy: This is another type of energy with the potential to greatly benefit many people, but as far as this target population is concerned, not too much should be expected from it.

Alcohol: This energy type has considerable potential for saving imported petroleum, but its impact is mainly restricted to the transportation sector as such. Nevertheless, it should be remembered that in the end, the industrial sector pays the cost of transportation of all raw material.

As previously mentioned, there are many types and systems defined within the term "non-conventional energy." Some of these, no doubt, offer excellent possibilities and should be considered within the proposed program. It is important to emphasize, however, that to promote realistically the use of these energy types, information and demonstration centers for this purpose must be established throughout the region.

Recommended Specialists: Based on program findings, the following types of specialists should be considered: Electrical engineer highly acquainted with simple measures to determine and correct electricity utilization deficiencies. Mechanical engineer specialized in design, repair and maintenance of various types of burners. Mechanical engineer specialized in boiler design and maintenance. Information and demonstration specialist to organize expositions throughout Central America.

SURVEY GENERALITIES

The results of the mail survey have been used throughout this study. They provided the basis for many of the statements made. However, there are other important facts which could be of interest to the designers and managers of the proposed program.

Following is a brief description of the various tables which present a sizable portion of the findings. See Attachment A, exhibits 3 through 100. If more details are needed, they may be found in the computer print-outs or directly in any of the 257 questionnaires that were answered. See exhibits Attachment B. Following are the results of the survey representing 2.9% of the target universe.

Exhibit 3. List of all participating productive units that answered the questionnaire, providing name, address and other data for a better classification of each.

Following is a brief description of each series of tables. Here comments made are related to totals, that is only in relation to Central America. There is one table for each country in each series, for further analysis if needed.

Exhibits 4 to 9. This series of tables presents industry's judgment as to how they rate the cost level of energy in relation to the total cost. This table also presents the declared energy cost range.

Industries that rated energy cost as	low	24%
" "	medium	36%
" "	high	40%

Energy Cost Range		
Between 0 to 9%	71%	of industries
" 10 to 20%	20%	"
Over 20%	9%	"

Here it can be observed that most industries consider the cost of energy as either medium or high. From the program's point of view this is encouraging, as under this concept industrialists are more willing to cooperate with program interventions. The higher the cost of energy in relation to all production inputs, the higher the degree of willingness to participate that may be expected from industry.

Exhibit 10. Although the questionnaire requested information on previous experience in formal energy programs, no answers to this question were received.

Exhibits 11 thru 16. This series of tables presents the percentage of production units that are willing to participate in an energy program and invest in energy improvement measures. It also shows the number of years considered an adequate investment payback period.

Willingness to participate	73% positive
	27% negative
Willingness to invest	80% positive
	20% negative

Payback period	1 yr.	9%
	2 yr.	22%
	3 yr.	29%
	4 yr.	6%
	5 or more years	34%

In a previous chapter of this document, it had already been commented that interest in participating in an energy program was high. This is confirmed again.

It is also interesting to note that most industries consider adequate an investment recovery payback period of 3 or more years, which provides the opportunity to consider a larger number of possible energy improvement investments.

Exhibits 17 thru 22. This series of tables presents the percentage of industries that considered as principal limitations to implement energy improvement, the following factors:

40%	Financing	12%	Others
21%	Information	8%	Incentives
12%	Technical assistance	7%	Lack of trained personnel

As can be observed, financing is the leading limitating factor. The need was also felt during the personal visits. It is therefore suggested that program activities address this need.

Exhibits 23 thru 28. This series of tables presents the annual average electricity purchased per industry. It also shows the yearly maximum and minimum purchased. There was little response to this question so the results should only be used on an individual basis.

Exhibits 29 thru 34. This series of tables presents the average power factor for industry and the average maximum demand. Here it can also be confirmed that electricity utilization could be improved by improving both, which is a relatively simple matter. There is no reason whatsoever to have a power factor lower than 95.

Industry average power factor	84
Low power factor	60
High power factor	99
Average maximum demand	9178 KW
Low maximum demand	8 KW
High maximum demand	102,000 KW

Exhibits 35 thru 40. This series of tables presents the voltage most commonly used by industry.

Industries mainly utilizing 110 volts	2%
" " 220 "	20%
" " 440 "	15%
" that receive primary voltage	63%

The previous percentages indicate that most industries buy higher voltage electricity, which is the right approach.

Exhibits 41 thru 46. This series of tables presents the percentage of industries that generate electricity, their comparative generating capacity and volumes generated:

- 34% of the industries indicated that they have electric generating units
- the maximum generating capacity declared is 6000KW
- the minimum generating capacity declared is 27KW
- the average generating capacity is 720KW
- 25% of the industries with generating capacity are contemplating to increase their capacity.

Only a few industries generate electricity. Most of the ones that own units only have them for emergency purposes. In most cases the only ones that generate electricity are those that have large quantities of combustible wastes, such as sugar mills.

Exhibits 47 thru 52. This series of tables presents the types of electric plants utilized. It can be seen that most of them are diesel plants which are the less expensive ones to operate. Steam turbines are mainly used by industries that have combustible waste materials.

Industries that have diesel plants	83%
Industries that have steam turbine plants	10%
Industries that have gasoline plants	7%

Exhibits 53 thru 58. This series of tables presents the fuels used for generating electricity by industry. The

information here practically confirms previous findings:

Industries that use	diesel	77%
" "	solid fuels	15%
" "	fuel oil	8%

Exhibits 59 to 64. This series of tables presents the average annual energy type used by industry. It also shows the maximum and minimum used. These tables also confirm the order by number of users for each type of energy.

Exhibits 65 thru 70. This series of tables presents the activities for which energy is mainly used in most industries.

Energy is mainly used for	producing mechanical power	58%
" "	heating purposes	21%
" "	drying	6%
" "	lighting	4%
" "	evaporation	4%
" "	compression	3%
" "	refrigeration	3%
" "	transporation	1%

Exhibits 71 to 76. This series of tables presents the number of boilers used by industry and their capacity.

Total industries that have boilers 46%

From the industries that have boilers, it was found that:

- Industries that have one boiler 50%
- Industries that have two boilers 37%
- Industries that have three or more boilers 13%

The capacity of the boilers used by industries are as follows:

From 1 to 50 HP	36%
From 51 to 100 HP	18%
From 101 to 150 HP	20%
From 151 to 200 HP	6%
Over 201 HP	20%

Exhibits 77 to 82. This series of tables presents boilers operating pressures used. It is logical that lower pressures are more widely used.

Industries using pressures between 10 to 100 psi	41%
" " " 101 to 150 psi	33%
" " " 151 to 200 psi	15%
" " " 201 to 250 psi	5%
" " over 250 psi	6%

Exhibits 83 to 88. This series of tables presents the fuel type used by industry to operate boilers.

Industries using fuel oil	52%
" " diesel	37%
" " wood	3%
" " other types	8%

Exhibits 84 to 94. This series of tables presents the percentage of industries that have certain types of solid waste, some of which could be utilized as an energy source.

Industries that have plastic waste		13%
"	" vegetable waste	16%
"	" rubber and nylon waste	4%
"	" metal scraps	18%
"	" textile waste	11%
"	" paper and wood waste	29%
"	" other non-combustible waste	9%

Exhibits 95 to 100. This series of tables presents the percentage of industries that have surplus energy in the form of hot air, hot water or steam. In most cases this surplus could be used in several forms, such as heat pumps, energy cascading, recirculation, etc.

Industries with surplus hot air		32%
"	" hot water	9%
"	" steam	14%
"	with two of above surpluses	27%
"	with all three surpluses	18%

Conversion Factors Used

1 TEP = 10^{10} calories

1 TEP = 7 barrels equivalent of petroleum (CEP)

1 TEP = 1.5 tons equivalent of coal (TEC)

1 KWH = 8.6×10^{-5} TEP

1 TEP = 11630 KWH

1 TEP = 7.8 B of kerosene

1 TEP = 8.2 B gasoline

1 TEP = 7.2 B of Diesel

1 TEP = 11.2 B of L.P.G.

1 TEP = 6.8 B of fuel oil

1 Barrel = 42 Gallons

BTU = 1055.056 joules

CALORY= 4.19002 joules

WATT-HOUR = 3600. joules

1 KWH = 3600 000 joules

1 KWH = 3412.14 BTUS

1 000 000 BTU = 293.07 KWH

12.3 Kwh/gallon of fuel oil for steam electric plants.

8.5 Kwh/gallon of diesel for steam electric plants.

10.7 Kwh/gallon of diesel for electric plants that are moved directly through a diesel-engine.

3000 Kcal/Kwh of bagasse sugar cane for steam electric plants.