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CENTRAL AMERICA ENERGY RESOURCES PROJECT

(596-0134) -- INITIAL EVALUATION

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CONTENTS

Section	Page
Acronyms and Abbreviations	i
Preface	iii
I. Executive Summary	1
A. Evaluation Objectives and Methodology	1
B. Project Description	1
C. Project Progress	2
1. Energy Planning and Situation Analysis	3
2. Geothermal Resource and End-Use Assessment	4
3. Peat Resource and End-Use Assessment	6
4. Costa Rica Mineral Reconnaissance	7
5. Private-Sector Involvement	8
6. Development of Technical and Managerial Skills--Technology Transfer	9
7. Project Coordination and Management	10
D. Recommendations	11
E. Project Design and Strategy	15
1. Intervening Investment Mechanisms	15
2. Cost-Effectiveness	15
3. Role of Regional Institutions	15
II. Introduction	17
A. Evaluation Objectives	17
B. Project Description	18
C. Evaluation Methodology	20
1. Standardized Questions	21
2. Relationship Between Project Design and Evaluation	22
3. Evaluation of Staff Performance	23
D. Organization of This Report	24
III. Energy Planning and Situation Analysis	25
A. The Need for Energy Data Analysis	25
B. Overall and Specific Objectives	26
C. Progress Toward Specific Objectives	28
D. General Assessment of the System's Utility	30
E. Shortcomings in Progress Toward Overall Objectives	31
F. Overall Recommendations	33

E. Country-Specific Findings and Recommendations 38
1. Regional Context 38
2. Guatemala 38
3. Honduras 40
4. El Salvador 41
5. Costa Rica 44
6. Panama 46
7. Belize 49

IV. Geothermal Resource and End-Use Identification 50

A. Background and Objectives 50
1. Technical Description 50
2. Project Component Objectives 51
B. El Salvador 53
1. Development of the Ahuachapan Field 53
2. The Ahuachapan Field Problem 54
3. LANL Strategy and Subproject Objectives 55
4. Findings and Recommendations 56
C. Honduras 60
1. Purposes and Objectives 60
2. Background 60
3. Findings and Conclusions 61
4. Recommendations 62
D. Costa Rica 64
1. Geothermal Developments 64
2. Findings and Conclusions 65
3. Recommendations 66
E. Guatemala: Direct-Heat End-Use Activities 67
1. Background 67
2. Subproject Objectives 68
3. Summary 74
4. Findings and Recommendations 74
F. Major Recommendations 76
1. El Salvador 76
2. Honduras 77
3. Costa Rica 77
4. Guatemala 77
G. Support Equipment for Central America 78
1. Subproject Purpose and Objectives 78
2. Background on Logging and Field Geophysics 78
3. Specific LANL Objectives 79
4. Findings 80
H. Expected Versus Actual Accomplishments 81

b'

V. Peat Resource and End-Use Assessment 89

A. Background 89
B. Costa Rica 89
1. Purpose 89
2. Physical Characterization of Peat 90
3. End-Use Analysis 90
4. Summary 92
5. Recommendations 92
6. Expected Versus Actual Accomplishments 93
C. Panama 94
1. Purpose 94
2. Resource Characterization 95
3. Feasibility Analysis 95
4. Summary 95
5. Recommendation 95

VI. Costa Rica Mineral Reconnaissance 96

A. Purpose and Objectives 96
B. Findings 96
1. Geochemical Survey 96
2. Preliminary Mineral Resource Assessment 98
3. Gold District Study 99
C. Data Base Maintenance 100
D. Summary 100
E. Recommendations 101
F. Expected Versus Actual Accomplishments 101

VII. Technology Transfer, Private-Sector Involvement and Economic Sustainability 104

A. Technology Transfer 104
1. Definitions 104
2. LANL Efforts 105
3. Findings and Conclusions 109
4. Recommendations 112
B. Private-Sector Ivnolvement and Economic Sustainability 114
1. Project Thinking Regarding Economic Sustainability 114
2. LANL Contact with Private-Sector and Investment Groups 115
3. Models for Joint Ventures and Profit-Sharing 117
4. Recommendations 118

C

VIII. Staff Performance, Project Coordination and Management 120

A. PASA Requirements for LANL Staff 120
1. Collaboration with Central American Institutions 121
2. Economic, Development and Financial Analysis of Energy Programs 122
B. LANL's Approach to Technical Assistance 124
C. Project Management 125
1. LANL 125
2. USAID/ROCAP 126
3. Advisory Committee 126
D. Recommendations 127
1. Improving Staff Performance 127
2. Planning, Budgeting and Reporting Practices 128
3. Improving Coordination with Central American Organizations and USAID Missions 129
4. Change in LANL Project Philosophy 130

IX. Logical Framework for the LANL Project 132

A. Logical Framework from March 1985 Project Plan 132
B. SES Attempt at Logical Framework in July 1986 134
C. Objective Tree for the LANL Project 135
D. Tentative New Logical Framework for LANL Project 137
1. Project Purpose 140
2. Private-Sector and Investment Output 140
3. Managerial and Technical Skills Output 141
4. Bringing Major Assumptions under Management Control 142
E. Recommendations 142

X. Monitoring and Evaluation System 143

A. Current Monitoring and Evaluation Situation 143
B. Building a Monitoring and Evaluation System 144
C. Logical Framework, and a Monitoring and Evaluation System 145
D. Project Planning and Installation of Project Monitoring System 146
E. Recommendations 146

XI. Summary of Recommendations 149

XII. Future Plans 160

Appendices:
A -- Scope of Work A-1
B -- LANL Overview Budget as of 31 May 1986 B-1
C -- Individuals Contacted C-1
D -- Participating Agency Service Agreement D-1
E -- Logical Framework Form E-1

ACRONYMS AND ABBREVIATIONS

AID	U.S. Agency for International Development
AMT	audio-magneto-telluric
APC	agricultural processing center
ARD	Associates in Rural Development, Inc.
BCIE	Banco Centroamericano de Integracion Economica
Btu	British thermal unit
CABEI	Central American Bank for Economic Integration
CACM	Central America Common Market
CCL	casing collar locator
CEL	Comision Ejecutiva del Rio Lempa, El Salvador
CEPAL	Comision Economica Para America Latina
CLUSA	Cooperative League of the U.S.A.
CONADE	Comision Nacional de Energia (National Energy Commission), Panama
CONSUPLANE	Consejo Superior de Planificacion Economica, Honduras
DC	direct current
DGMH	Direccion General de Minas e Hidrocarburos, Honduras
DGMH	Direccion de Geologia, Minas e Hidrocarburos, Costa Rica
DOE	U.S. Department of Energy
DSE	Direccion Sectorial de Energia, Costa Rica
ECLA	UN Economic Commission for Latin America, Mexico City, Mexico
ENEE	Empresa Nacional de Energia Electrica, Honduras
ENEL	Ente Nazionale per l'Energia Elettrica
GDS	gold district study
ICAITI	Instituto Centroamericano de Investigaciones y Tecnologia Industrial (Central American Institute for Research and Industrial Technology), Guatemala City, Guatemala
ICE	Instituto Costarricense de Electricidad, Costa Rica
IDB	Inter-American Development Bank, Washington, DC
IMF	International Monetary Fund
INC	Industrias Nacionales de Cemento, Costa Rica
INCAE	Instituto Centroamericano de Administracion de Empresas (Central American Institute for Business Administration), Alajuela, Costa Rica
INDE	Instituto Nacional de Electricidad, Guatemala
IRHE	Instituto de Recursos Hidraulicos e Electrificacion, Panama
kWh	kilowatt-hour(s)
LAN	local area network
LANL	Los Alamos National Laboratory
MBA	master of business administration
MT	magneto-telluric

MEM	Ministerio de Energia y Minas (Ministry of Energy and Mines), Guatemala
MIEM	Ministerio de Industria, Energia y Minas (Ministry of Industry, Energy and Mines), Costa Rica
MITRE	Massachusetts Institute of Technology Research Corporation
MW	megawatt(s)
OLADE	Organizacion Latinoamericana de Energia (Latin American Energy Organization), Quito, Ecuador
PASA	participating agency service agreement
PEEIR	Programa de Eficacia Energetica Industrial Regional
PMRA	preliminary mineral resource assessment
PP	project paper
RECOPE	Refinadora Costarricense de Petroleo, Costa Rica
ROCAP	Regional Office for Central America and Panama, U.S. Agency for International Development
SICAPE	Sistema de Informacion Centroamericana para Planificacion Energetica (Central American Energy Planning Information System)
SIECA	Secretaria de Integracion Economica Centroamericana (Secretariat for Central American Integration), Guatemala City, Guatemala
UCR	University of Costa Rica
UN	United Nations
UNDP	United Nations Development Programme, New York, NY
USAID	U.S. Agency for International Development
USGS	U.S. Geological Survey

PREFACE

This report presents the findings and recommendations of an initial evaluation of the Central American Energy Resources Project, project number 596-0134, conducted for the U.S. Agency for International Development's (USAID) Regional Office for Central America and Panama (ROCAP) in Guatemala. The evaluation was carried out by Associates in Rural Development, Inc. (ARD) of Burlington, Vermont, in Los Alamos, New Mexico, and Central America during the months of July and August 1986.

Members of the ARD field team included:

- Mr. Michael Gaffen--co-team leader, energy economics and planning;
- Dr. Roger Popper--co-team leader, project management and institutional issues;
- Dr. Tsvi Meidav--geothermal energy; and
- Mr. Alvaro Souviron--mineral resources and peat.

In the United States, the ARD team also included:

- Dr. George Burrill--evaluation manager and report editor, energy planning; and
- Ms. Judith Oki--team orientation and planning.

The final member of the team was Dr. Gabriel Dengo, who acted as host-country coordinator (his field of expertise is geology). He was a consultant to ROCAP, but traveled with the evaluation team and served as a sounding board on Central American natural-resource and institutional issues, as well as giving the team access to important policymakers.

The ARD team would like to thank a number of people and organizations for their assistance, understanding and hospitality during the course of this evaluation. First, the team wishes to thank Mr. Ron Lohrding, Mr. Vern Loose and Mr. Joe Frank of the Los Alamos National Laboratory (LANL) in New Mexico for providing documents and arranging meetings with LANL technical staff. Evaluation team meetings with project participants throughout Central America were arranged by two LANL Central American staff members, Mr. David Chavez and Mr. Gustavo Cuellar.

Second, the team wishes to express its gratitude to individuals at USAID/ROCAP--the mission director, Ms. Nadine Plaster; Mr. Carl Duisberg; and Mr. Dick Delaney for their guidance and understanding; and especially to Ms. Dora Vasquez,

who did a superlative job of typing and correcting a large portion of the first draft of this report. Thanks also go to the USAID mission energy officers who favored the team with their insights and frankness regarding the LANL project, including Mr. Peter Deinken, El Salvador; Mr. Doc Odele, Guatemala; Mr. Heriberto Rodriguez, Costa Rica; Mr. Jose Sanchez, Panama; and Mr. Lynn Sheldon, Honduras. Following the fieldwork in Central America, Mr. Jim Hester of AID/Washington took time to discuss the project with the evaluation team.

Finally, and above all, the ARD team thanks the many individuals, too numerous to mention, from Central American agencies collaborating on the LANL project, for their patience, hospitality and openness.

I. EXECUTIVE SUMMARY

A. Evaluation Objectives and Methodology

This report presents the findings and recommendations of an evaluation of USAID/ROCAP's Central America Energy Resources project, number 596-0134. The project was begun in January 1985, and the present phase of project activity is scheduled for completion in December 1986. The main focus of this evaluation is on activities and progress during the current period, although some consideration is given to longer-term issues. The objectives of this evaluation were to:

- evaluate progress toward achievement of the project purpose and contribution to the project goal;
- determine if the project purpose will be accomplished during the time frame established in the Project Paper (PP);
- determine whether implementation plans are adequate to achieve the project purpose; and
- assess the need for and nature of future possible activities.

During the week of 9 July 1986, the ARD evaluation team met with personnel from LANL and planned the evaluation effort. Fieldwork was undertaken in Central America between 14 July and 15 August, and included site visits and discussions with host-country, USAID-mission and ROCAP personnel. Initial discussions of the report outline and content and a debriefing were held with ROCAP during the period 30 July to 15 August. Additional documents were reviewed in the United States, and further analysis and report preparation were carried out prior to a debriefing with AID and LANL. A final debriefing was held at Los Alamos from 16 to 19 September.

B. Project Description

According to the PP, the goal of the Central America Energy Resources project is to:

> . . . improve the economic condition in Central America and help create employment through increased and more efficient utilization of the region's rich energy and natural resource endowment.

The project purpose, which leads to the project goal, is to:

> Introduce new technologies and assessment techniques into Central America that will allow each of the participating countries to better analyze their current and future energy needs, to develop nontraditional sources of energy, such as geothermal and low-grade fossil-fuel resources, found throughout the region, and to more effectively utilize the energy and mineral resources found in the region. The project will help the participating countries become self-sufficient in those areas over the long term.

Components of the Central America Energy Resources project for which progress and recommendations are summarized in the following sections include:

- energy analysis and planning,
- assessment of geothermal resources and end-uses,
- assessment of peat resources and end-uses,
- Costa Rica mineral inventory,
- private-sector involvement,
- training in technical and managerial skills-technology transfer, and
- project management and coordination.

Summaries of progress for each of the components are presented below. Then, recommendations for each component are given, followed by a brief discussion of project design and strategy issues.

C. Project Progress

The Central America Energy Resources project had a rapid start-up and has generally accomplished a great deal of work in a short period of time. For the most part, the technical work has proceeded on schedule. This is LANL's first major, long-term project with economic objectives in the developing world, and LANL appears to be willing to expend the required effort to "climb the learning curve," which is necessary to succeed at energy-based economic development. This evaluation attempts to view project efforts in this context and provide constructive analysis and suggestions for the consideration of AID and LANL.

1. Energy Planning and Situation Analysis

The energy analysis and planning component (budgeted at US$1,535,000) of the LANL project is referred to in project documents as the "Energy Situation Assessment." Energy analysis and planning activities have been undertaken in three major areas:

- an update of the report, ENERGY AND DEVELOPMENT IN CENTRAL AMERICA, by the Massachusetts Institute of Technology Research (MITRE) Corporation, prepared in 1980 under contract to USAID/ROCAP;
- design and development of a standardized country and regional energy data base;
- development of long-term planning methodologies to assist in the formulation of energy and resource policy; and
- development of an energy atlas.

The MITRE report update was completed in draft form in December 1985 and is an effective summary document, although some of the 1984 data and analysis is rapidly becoming obsolete. Furthermore, the report includes no critical analysis of energy policy and energy prospects, and would benefit from the type of economic projections that public investment organizations, such as the Inter-American Development Bank (IDB) and World Bank, or private international investors require before the initiation of energy projects.

The energy data base, Sistema de Informacion Centroamericana para Planificacion Energetica (SICAPE) has been installed, along with appropriate training, software and hardware, in every country but Belize and at a regional organization, Secretaria de Integracion Economica Centroamericana (SIECA). Counterpart staff are using the available data in a variety of ways. However, as is to be expected, additional work will be required before solid country and regional data bases are operational. Although a good start has been made, the data base currently has only limited potential as a policy tool because of problems with the existing energy data information and collection system, including that:

- the data base primarily contains only annual energy-balance data, with minimal quarterly or monthly information;
- extensive economic, financial and demographic variables are lacking, such as energy prices,

automobile and truck numbers, balance of trade, employment and housing stock;

- data on a regional or sub-country level have not been collected in a valid, consistent, historical manner; and

- the existing definitions for energy data categories as well as data validity and accuracy vary substantially by country.

A procedure for analyzing energy data (INTEGRA) has been developed and is being introduced in each Central American country. INTEGRA uses the Framework programming language to link spread-sheets that predict the effects of different energy-demand options and is an appropriate, flexible technology for the region. A workshop on INTEGRA is scheduled for September 1986, and case-study applications will be reviewed for each country.

The energy atlas is under development and is expected to be completed by December 1986.

In summary, the LANL project has established a good foundation for energy policy analysis. However, due to inadequacies in the data base and resulting limitations of the energy model, an effective energy policy tool is still under development and is a long-term goal of the project. More effective progress would have been made by professionals with more practical energy analysis and planning experience in a developing-country environment, and better knowledge of Spanish.

2. Geothermal Resource and End-Use Assessment

The geothermal assessment work (budgeted at US$4,048,000) undertaken by the LANL project has four objectives:

- assessment of the potential of new geothermal resources;

- diagnosis and prognosis for output problems at existing geothermal energy installations;

- provision of support equipment for the geothermal resource assessment; and

- feasibility studies and demonstrations of geothermal direct-heat end-uses.

The assessment of new geothermal resources in Honduras (budgeted at US$1,740,000) is a cooperative effort between LANL and USGS. Six sites have been mapped and characterized,

planned to prove the existence of a Honduran resource, with a high probability of making a major improvement in Honduras' energy balance. Further geothermal mapping of several promising fields in Costa Rica (US$210,000) is more difficult to justify, since Costa Rica already has excess energy. Also, Costa Rica is in the process of acquiring credit for the development of major geothermal resources identified before the LANL project began. Both the assessment activity and diagnosis of production problems (discussed next) have proceeded well and made scheduled progress toward their objectives.

The diagnosis of energy production problems for existing geothermal installations has focused on Costa Rica (US$458,800), but has also been undertaken in El Salvador. At the Miravalles field in Costa Pica, data have been collected and analyzed to address an output problem caused by calcium carbonate scaling on well liners. The LANL project has the opportunity to make a historic contribution to the Salvadoran energy balance by solving a grave output problem at the Ahuachapan geothermal field. It appears that by reinjecting geothermal waste fluids and drilling some additional production wells, at least some of the original planned output of 95 megawatts (MW) can be restored. At present, approximately 42 MW are being produced. Approximately US$26,000,000 in annual revenues may be gained by increasing the field to its original design capacity.

Apart from noncritical delays, the geothermal support equipment component (budgeted at US$754,000) has proceeded on schedule. A self-contained, geothermal well-logging truck, which is the finest equipment of this type available in the world, is being built by LANL for use in Central America. The plan is to deliver the truck in mid-November 1986 and begin training Central Americans in its use. The various countries will have to share in its operation and maintenance, but the exact mechanism for such collaboration has not yet been determined. Thus, the evaluation team foresees the following financial and management problems for the logging truck:

- high operation and maintenance expenses;
- lengthy training to reach self-sufficiency;
- problems transferring the equipment between the Central American countries; and
- poor maintenance because no single country will have a sense of ownership.

For the geothermal direct-heat end-use assessment in Guatemala (budgeted at US$570,000), the LANL project is planning two linked efforts. One is a study to test the economic feasibility of commercial-scale, geothermal direct-heat

operations. The other is a small-scale demonstration of geothermal direct heat for dehydrating vegetables, fruit and other agricultural products. With regard to the first, a comprehensive survey covering a broad range of potential direct-heat uses has been carried out. The study is still in draft form, so the economic analysis of the application for the local situation is still highly generalized. Second, the demonstration effort has poorly defined relationships with the GREMIAL organization (the domestic agricultural export guild) and the Indian Agricultural Cooperative, which may carry out the demonstration's commercial aspects. Planning for the demonstration has not yet determined the market profile of products to be dehydrated.

3. Peat Resource and End-Use Assessment

The objectives of this component of the project (budgeted at US$1,151,000) have been to:

- identify and characterize peat deposits in Costa Rica and Panama, and
- carry out end-use assessments in Costa Rica.

The LANL project has accomplished the identification and characterization of two peat deposits in Costa Rica and one in Panama. Characterization of the Costa Rican peat resources is at a more advanced stage than for the Panama deposit. This component is proceeding well and the quality of LANL's fieldwork has been good. The Panama peat is of similar quality to that found in northern Europe, but the Costa Rican peat discovered thus far is of lower quality. High-quality peat has a low ash content and high Btu rating. Costa Rica is using an ash cut-off that is higher than that which is traditionally used, which raises the tonnage found, but results in decreased quality.

Mining and utilizing Central American peat will be expensive because the bogs where the peat is found are wet and the climate humid, which makes drying difficult. In the case of Costa Rica, the peat bogs are far from most intended applications, so transportation costs will be high. At present, the costs of mining and transporting peat almost certainly make its industrial use uneconomical, although agricultural uses may still have immediate potential. An element that is missing from the project's peat resource work is a pre-feasibility analysis. Such an analysis should include economics, markets and a comparison of costs with appropriate alternatives.

In terms of end-uses, LANL has completed a thorough inventory of 27 worldwide peat uses, of which 13 might have potential for Central America. Although this inventory is solid,

the economic analysis is not yet sufficient to estimate eventual economic benefits. Thus far, costs in the original country of application, rather than cost estimates for Central America, have been used.

On the basis of existing information, the following observations regarding the economic feasibility of peat as an energy source for Costa Rica and Panama can be made. Current Costa Rican plans focus on a network of 5-MW electricity-generation plants, while Panamanian plans for peat concentrate on larger, 30-MW electricity-generation plants. For Panama, costs per unit of energy would be lower than Costa Rica, but even for Panama, peat-based electrical generation probably does not make economic sense at this time. Also, some of the other end-uses identified by LANL as promising are still experimental and require equipment that is not commercially available.

Planned end-use demonstrations for Costa Rican peat include:

- its use as fuel in a cement factory, and
- as a fuel for cooking stoves.

The program in the cement factory has reached an impasse because with full-scale burning operations, adaptation of the factory's operations for peat feedstocks may cost several million dollars, and a cost-benefit analysis is not yet available. The cooking fuel experiment is being conducted in Guatemala and would seem to be of questionable significance at present because the existence of markets for peat as a stove fuel has not been studied or proven.

4. Costa Rica Mineral Reconnaissance

The project's mineral reconnaissance effort in Costa Rica (budgeted at US$2,500,000) has three major components:

- a geochemical survey done by LANL;
- a preliminary mineral resource assessment (PMRA) carried out by the U.S. Geological Survey (USGS); and
- a gold district study (GDS) undertaken by USGS.

The results of the LANL geochemical survey of the San Jose quadrangle and a portion of Talamanca quadrangle are not yet available. Stream-sediment sampling is complete and has covered a larger territory than originally planned. It is the opinion of the evaluation team that the undertaking of a geochemical survey before completing and evaluating the results of the mineral

resource assessment for an area is not a cost-effective strategy. The geochemical survey should not have been undertaken until after the results of the PMRA had been evaluated, and then only if the additional work would provide information which effectively enhanced the probabilities of discovering economic mineral deposits. There is also a question as to whether a geochemical survey designed to analyze a very large number of elements (45) is a cost-effective approach. A review of similar work by LANL in other areas indicates that about 20 elements are generally sufficient to characterize a wide range of mineral occurrences.

The PMRA will include geologic, mineral-occurrence, geophysical and terrane maps. It is in the advanced stages of preparation, on schedule, and has been carefully executed. Submission to the USGS editorial board will occur in July 1986, and final publication was to be in July 1987. The PMRA will provide a statistical assessment of the probability of finding various types, grades and sizes of ore bodies. Perhaps its greatest value will lie in providing a true and realistic evaluation of Costa Rica's mineral potential.

For the GDS, regional geologic mapping, mapping of known deposits and selected sampling have been completed for the northwestern portion of the San Jose quadrangle. This program supplements the PMRA, and provides a more detailed evaluation of precious metals and other related mineralization.

5. Private-Sector Involvement

The Central American Energy Resources project proposed to:

> . . . involve the local and U.S. private sector so that resource and development activities lead to job-creating investments in commercial and industrial activities, based on the energy and other natural resources that will be identified. (Central American Energy Resources Project, March 1985, p. 4).

Private-sector groups that the project has contacted include the GREMIAL export promotion group in Guatemala, to collaborate on the geothermal direct-heat demonstration, and the Industrias Nacionales de Cemento (INC) cement factory in Costa Rica, which was to experiment with peat as an alternative to bunker oil. Collaboration with private-sector groups has not been fully developed by the project and will require more attention if project objectives in this area are to be achieved. For example, at the time of this evaluation, the local GREMIAL group was confused about its eventual role in the geothermal heat demonstration. The experiment on peat as an alternative to

bunker oil in the cement industry will probably not be done due to reasons discussed in a preceding subsection (I.B.3).

In the opinion of the evaluation team, the project's strategic thinking regarding investment in energy production and energy-based industry is weak. First, energy investment in Central America comes primarily from the public, not the private, sector. Second, mechanisms to attract and manage investment must be established before investors can be involved in any important way. There is still time for the project to create investment opportunities. LANL is very aware of the public sector's importance to energy investment. This awareness can be converted into a focused investment campaign. Also, a Costa Rican group (MINASA) has been identified that shows promise of being able to attract private-sector investment in mining.

6. Development of Technical and Managerial Skills--Technology Transfer

The objective of developing technical and managerial skill should be self-sufficiency in areas that are critical to energy-based economic development. In this subsection, progress toward and prospects for such self-sufficiency are summarized for each project component.

Central America could easily become self-sufficient in energy analysis and, with the project's help, has made good progress toward that objective. The energy planning area is more difficult, since the issues are as much organizational as technical. Costa Rica has been a good partner in working with LANL on technology transfer. The necessary next steps are policy seminars, improvement of data collection skills, and addition of economic and demographic data to the system.

Total self-sufficiency at geothermal assessment is beyond the scope of the project, and furthermore, self-sufficiency in this area is not a prerequisite to reaping economic benefits from it.

With the project's help, Refinadora Costarricense de Petroleo (RECOPE) in Costa Rica has become self-sufficient in the laboratory and fieldwork required for peat resource identification and characterization. However, it still lacks the ability to do analyses for assessing economic benefits and attracting investors to exploit this resource. In Panama, proficiency has been achieved in the field aspect of studying peat resources. Unfortunately, this progress in technology transfer may be in an area with little foreseeable economic payoff.

With LANL's help, Costa Rica has made good progress toward self-sufficiency at some of the mineral inventory work. LANL has delivered training in sampling techniques, and USGS has provided considerable training in the analysis of ore deposits--self-sufficiency in these areas is attainable. Geochemical analysis as a tool to identify mineral occurrences is probably beyond the project's reach, but Costa Rica could and should become self-sufficient at contracting and managing geochemical programs.

7. Project Coordination and Management

A key message of the energy situation analysis is that decisions and implementation should be based on rigorous study of the energy situation. Thus far, the project has not been able to follow its own advice. The planning of project operations is very detailed. However, strategic planning of the most cost-effective way(s) to reach the project's economic goals and purposes has received little attention.

In the original participating agency service agreement (PASA), AID specified that LANL project staff should be skilled in collaborating with institutions (including USAID missions) in Central America as well as relating energy technology to broader development planning and economic concerns. Relationships with the individual USAID missions need to be improved and communications increased. Some sources of USAID-mission dissatisfaction are:

- high frequency and short duration of technical assistance visits,
- large size of technical assistance teams, and
- lack of consultation and collaboration with USAID missions.

Technical assistance teams have included few Spanish speakers and have primarily utilized frequent short visits. Concerns have been raised regarding the effect of this mode of operation on project continuity, relationships with counterparts and the budget. The balance of skills on technical assistance teams and the advisory committee is not multidisciplinary--their expertise should cover not only in energy fields, but also economic planning and analysis, mineral economics, technology transfer, private industry and Central American affairs. Matrix management, the overall management scheme used by LANL, does not lend itself to cohesive planning, budgeting and staffing.

D. Recommendations

The recommendations presented here have two foci:

- areas that require further assistance, based on project progress to date, and
- request for additional assistance from LANL by Central American institutions.

Energy Planning and Situation Analysis

Policy seminars are needed to convert high-level energy decision-makers into sophisticated advocates of the LANL project's energy analysis and planning products. These seminars must be short and nontechnical. The Instituto Centroamericano de Administracion de Empresas (INCAE) has experience in organizing and carrying out this type of activity, and LANL should work with them.

The validity and reliability of the energy data base should be improved by introducing rigorous data collection and statistical methods. For example, expanded energy surveys should provide information on automobile and truck numbers, gasoline and diesel use, home cooking fuels and electricity growth potential. Economic and demographic components should be added to the data base to cover fuel and energy prices, employment and balance of trade.

The project must address the comparison of alternative policies and projects regarding import substitution, job creation and balance of trade. At a minimum, the system must be able to help LANL and Central American governments select and design project components.

In the area of energy analysis and planning, the project should seriously consider a technical assistance approach that includes resident advisors and more experienced personnel with good Spanish skills.

Geothermal Resource and End-Use Assessment

To help Central America develop its abundant geothermal resources, the LANL project should help design and install investment mechanisms and strategies, perhaps similar to those used successfully in the Philippines. Technical information cannot make up for a lack of investment mechanisms to develop resources.

Rehabilitation of the Ahuachapan geothermal installation in El Salvador should be the project's top priority. There is a chance for an immediate payoff, and enormous gains for the Salvadoran energy balance and economy.

In Honduras, the Platanares exploratory drilling program should be funded to completion. Money must be added so that exploratory drilling will permit an invest/discard decision regarding Platanares. The drilling must be sufficient to either prove or disprove the existence of an economic geothermal reservoir. The economic feasibility of geothermal electricity generation and direct-heat applications should be tested for the Pavana area near the Choluteca foreign-trade zone in Honduras.

LANL should carefully evaluate and more fully develop a strategy for utilization of the geothermal well-logging truck. Without a carefully designed plan for maintenance of that complex system, with budgets and an organizational framework, the equipment may deteriorate into uselessness.

The use of geothermal direct heat deserves more attention. Thus, a serious study of the economic feasibility of commercial-scale, geothermal direct-heat applications should be carried out in Guatemala. The small-scale geothermal dehydration pilot demonstration at Zunil must not be confused with the study of commercial-scale economic feasibility. A comprehensive set of agreements should be drawn up between LANL, Instituto Nacional de Electricidad (INDE) and GREMIAL covering provision of the geothermal energy supply, administrative responsibility for the project, operational budgets and use of profits.

Peat Resource and End-Use Assessment

The peat resource assessment should include focused pre-feasibility analyses. If the results are negative, resource identification efforts should be halted for now. The pre-feasibility analysis must estimate mining and transportation costs, and determine the maximum costs at which peat can economically replace alternative fuels. The pre-feasibility work should focus on producing energy and fuel cost criteria that warrant pursuing the possibilities for peat once again. Simple economic techniques of the "risk-analysis" type are called for.

Peat end-use demonstrations should be stopped for the time being, with the exception of the stove experiment in Guatemala, where commitments have already been made. Pre-feasibility analyses of high-potential end-uses, including the 30- and five-MW electricity generation plants proposed for Panama and Costa Rica, should be carried out. These analyses must include financial and market assessments.

Costa Rica Mineral Reconnaissance

The geochemical analysis process should be streamlined and speeded up. One possibility is to switch to two-track data processing, where selected elements are processed now and the remaining ones left for analysis at a later date. The elements to be processed now must be selected jointly by LANL and USGS. The criteria for element selection should be derived from USGS' geological work. If Costa Rica must wait until data for all 45 elements are processed and analyzed, then the attraction of investors and eventual economic benefits will be delayed. Also, pre-feasibility work of the risk, cost-benefit type should be added to the mineral inventory work carried out in Costa Rica.

Satisfactory formal arrangements must be made for storing geological and geochemical data and analyses in Costa Rica. Candidates as repositories for the data are the University of Costa Rica (UCR) and MINASA. Wherever the data are stored, both institutions should have access to the information.

Countries other than Costa Rica may request mineral inventories. For those, only the PMRA carried out by USGS should be considered initially. Geochemical work by LANL should wait until the geological work is done and specific areas that warrant geochemical analysis have been identified.

Private-Sector Involvement

The involvement of investors in energy development and energy-based industry will require the development of investment mechanisms and campaigns to attract public- and private-sector investors. This is an area that requires the project's attention if it is to produce economic benefits. Energy resources identified by the project must be analyzed and described to meet the requirements of the investment, as opposed to research, community. These efforts will require personnel with expertise in public- and private-sector investment, energy and energy-based industry, and Central American energy affairs.

Development of Technical and Managerial Skills--Technology Transfer

A key to effective transfer of technical and managerial skills (technology transfer) is to identify for each project component the degree of Central American self-sufficiency that is both feasible and worthwhile. Then, a self-sufficiency program should be designed as well as a schedule for reducing project assistance as self-sufficiency is reached.

Self-sufficiency objectives should vary according to the project component. For energy analysis and planning, a high degree of self-sufficiency is desirable. In the geothermal area, the development of Central American investment mechanisms is more important than self-sufficiency in assessing the resource. For the mineral inventory component, establishment of a serious mineral investment and development program must accompany technological self-sufficiency. For the peat assessment program in Costa Rica, technology transfer efforts must be directed at combining economic expertise with the geological skills already attained.

So far, technology transfer issues of an organizational nature have not been not addressed. There should be:

- diagnoses of the organizational structure surrounding energy-based development in the individual Central American countries;
- selection of "targets of opportunity," where self-sufficiency and economic benefits are feasible; and
- tailored, country-specific, organizational strengthening programs in the areas of energy planning and investment in energy-based development.

Project Coordination and Management

The project should form a Central American task force with full-time technical and management members. The project team should be truly multidisciplinary, including financial, economic and technology transfer experts, and Central Americans. The advisory committee should also be truly multidisciplinary. The locus of decision-making within the project should be shifted toward Central America and people in more direct daily contact with the region's energy and economic problems.

Technical assistance teams should be streamlined, and members should travel only when there is fieldwork to be done that no one else can handle. Project reporting should shift to meeting investment-community criteria, as should the monitoring reports sent to ROCAP.

There should be critical reviews of project progress at regular intervals. During these reviews, invest/discard decisions are analyzed and implemented, according to information generated by the project and changing economic circumstances in Central America.

Project monitoring and the SICAPE energy information system should be combined to the extent possible, since they share

information and communications needs. In addition, modems and electronic mail should be included in the system, if possible.

Memoranda of understanding between the LANL project and Central American institutions should be reviewed, sharpened and strengthened. They should define objectives and responsibilities, and overseas LANL staff should be given the authority to develop these memoranda.

E. Project Design and Strategy

1. Intervening Investment Mechanisms

The LANL project is a scientific and technological project with economic objectives. Between the technological and scientific work and the achievement of economic objectives, there are many intervening processes and obstacles that must be addressed. Intervening mechanisms between science and economics are missing from the project's design and thus, from project operations. The processes and obstacles here consist of investment mechanisms, the investment climate, investment campaigns and government energy development policy.

2. Cost-Effectiveness

In general, LANL's work has been technically excellent, but not always cost-effective in reaching AID's economic objectives. Areas where the lack of cost-effectiveness is most evident are energy analysis and planning, the geothermal resource assessment and geochemical portion of the Costa Rican mineral inventory. Two of the more important reasons for LANL's problems in achieving cost-effectiveness are a lack of multidisciplinary teams that include experts in the areas of economics, energy planning, energy investment and technology transfer, and a lack of well-defined invest/discard decision points toward which the technological and scientific work is directed.

As much intellectual rigor should be applied to the strategic planning for using energy as a lever for economic development as the project's technical and scientific work. Also, simple pre-feasibility calculations should precede expensive feasibility studies, so that only opportunities with high economic promise receive attention.

3. Role of Regional Institutions

The LANL project is more a series of bilateral projects within a region, than it is a regional project. The exception is

the energy analysis and planning component, where there has been significant collaboration and information-sharing among the Central American countries. The geothermal logging truck, which will require sharing resources and responsibility, also qualifies as a regional effort.

Currently, for the energy analysis and planning component, SIECA in Guatemala serves (at least theoretically) to unite the data bases of the various countries. INCAE serves as consultant on analysis and computer software matters. Expansion of both their roles into energy policy and planning areas will be necessary if economic benefit is to be derived from this activity. With regard to the energy resource and end-use components, the Instituto Centroamericano de Investigaciones y Tecnologia Industrial (ICAITI) is a potential source of further coordination and follow-on activity.

II. INTRODUCTION

A. Evaluation Objectives

The objective of this evaluation, as set forth in the scope of work (see Appendix A for a copy of the full scope of work for this evaluation), is to:

> evaluate progress toward achievement of the project purpose and contribution to the project goal, to determine if the project purpose will be accomplished during the time frame established in the Project Paper, whether implementation plans are adequate to achieve the project purpose, and if the work in progress accurately reflects implementation plans. . . . Finally, the evaluation will assess the need for and nature of future possible activities.

In addition to a comparison of actual and planned progress in reaching project objectives, the scope of work asks that the evaluation have a special "focus on project coordination, private-sector participation and staff performance." Also, the scope of work calls for an assessment of the degree to which the project has been able to generate interest among and the cooperation of national institutions, leverage of new funds and cofinancing, technical transfer, sustainability of programs, training, and staff ability to work and interact with national counterpart institutions and bilateral USAID missions.

Two tasks listed in the scope of work which lie outside a regular evaluation are:

> Review the logical framework prepared by Los Alamos and recommend changes, if needed.
>
> Prepare a monitoring and evaluation plan which can be used by Los Alamos and ROCAP to monitor project progress, with particular attention to tracking goal and purpose achievement.

The evaluation team found that the logical framework prepared for Los Alamos by an outside contractor was very weak. It is important to have an accurate, well-written logical framework for a number of reasons, including the fact that the logical framework forms the basis of a monitoring and evaluation plan. Thus, rather than recommend changes in the old logical framework, ARD has attempted to prepare a new one.

B. Project Description

> Los Alamos National Laboratory through a PASA is implementing the Central America Energy Resources project. The purpose of the project is to introduce new technologies and assessment techniques into Central America that will allow each of the participating countries to better analyze their current and future energy needs, to develop nontraditional sources of energy, such as geothermal and low-grade fossil fuel resources, found throughout the region, and to more effectively utilize the energy and mineral resources found in the region. The project will help the participating countries in becoming self-sufficient in those areas over the long term. The goal of the project is to improve the economic situation in Central America and help create employment through increased and more efficient utilization of the region's energy and natural resources endowment. (Statement of work for Central America Energy Resources project, Section C.1.)

> Goals are to promote near-term economic stabilization, to develop structural economic transformation aimed at achieving self-sustaining* growth over the medium term, and to promote broad distribution of the benefits of growth. (Logical framework analysis for Central America Energy Resources project, July 1986.)

These passages point to the "development" nature and driving force of the Central America Energy Resources project. Hence, the evaluation team was required to consider the design and progress of the project toward the accomplishment of development change as well as marketable and investment-oriented activities.

The Los Alamos National Laboratory (LANL) project includes the following components:

- geothermal resource assessment projects in Costa Rica, Honduras and El Salvador are exploring

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*The term "self-sustaining" is used in several ways and with several meanings in the evaluation scope of work and project documents, sometimes resulting in confusion. It can mean "self-sufficiency" in particular energy supplies, the lack of need for external technical assistance to perform several tasks, or the existence of a process that does not need external donor projects to keep it operating and growing (e.g., an economic development growth scenario).

geothermal potential for generating electrical energy and direct heat;

- the geothermal support equipment component is giving Central American governments the most technologically advanced well-logging rig and instrument available in the world for measuring the geothermal characteristics and potential of wells--training in the use and maintenance of this equipment is also being provided;

- geothermal end-use work in Guatemala is aimed at testing the feasibility of direct-heat applications for commercial and agro-industrial use;

- peat resource assessments in Costa Rica and Panama, and a peat end-use analysis in Costa Rica represent efforts to determine peat reserves and viability of their use;

- mineral assessment work being carried out by LANL, in cooperation with USGS and UCR, is evaluating the mineral potential of Costa Rica; and

- the energy situation analysis consists of collecting and analyzing regional energy and resource data, constructing a standardized regional data base, and developing long-term planning methodologies to assist in the formulation of energy and resource policy--this effort is being aided by computers distributed by the project to counterpart organizations.

Although no formal end-of-project conditions were identified in the PP, the following objectives represent a sense of where the project should be at its completion.

First, the project is to identify, quantify and assess the natural resource endowment possessed by countries in the region. This includes energy resources that can substitute for fuels that are currently imported, predominantly petroleum, as well as energy and other resources that could be used to increase revenues earned from the export of both energy and non-energy materials.

Second, the project is to create an analytical framework that will allow rapid comparison of energy and mineral development options in terms of the balance of trade, import substitution, direct costs, job creation, etc.

Third, through activities identified in the first two objectives, the project is to build technical and managerial

skills, so that a self-sustaining economic development process is established. This objective is to be achieved primarily through on-the-job training associated with specific project components, workshops, sponsored graduate-study participation and visits by regional technicians to Los Alamos.

Fourth, the project is to involve local and U.S. private sectors so that the resource assessment and development activities lead to job-creating investments in commercial and industrial activities, based on the energy and other natural resources identified.

The Central America Energy Resources project was funded in four installments. (Appendix B contains an overview budget prepared by LANL as of 31 May 1986.) The first installment of US$3.7 million was made in March 1985, and a second of US$1.5 million in September 1985. These first two installments, referred to as "Phase I" in project documents, consisted of funding for all project components, except the mineral resources assessment in Costa Rica, geothermal support in El Salvador and peat assessment in Panama. The third installment of US$2.5 million was made in January 1986 and consisted of funding for the minerals assessment in Costa Rica. The fourth installment of US$2.5 million was made in August 1986 and is referred to as "Phase II" in project documents. Phase II consisted of geothermal assistance to El Salvador, the peat assessment in Panama and additional money for all other components except the Costa Rica minerals assessment. A fifth installment of US$1.0 million will be obligated to the project in September 1986, bringing the total to US$11.2 million. Precisely how the final installment will be spent is still being determined.

C. Evaluation Methodology

ARD's evaluation methodology included the following steps:

- team preparation and planning (9, 10 and 13 July 1986 in Santa Fe, New Mexico);
- project background/context clarification (11 and 12 July 1986 at LANL in New Mexico);
- establishment with ROCAP of evaluation purposes, expectations, end products and agreement on work plan (14 July 1986 at ROCAP in Guatemala);
- data collection and analysis (15 July through 4 August 1986 in Guatemala, Honduras, Costa Rica, Panama and El Salvador);

- assembly and integration of findings into comprehensive report (1 to 15 August 1986 in Guatemala);

- review of outline for final report and initial debriefings with ROCAP (30 July through 15 August 1986 at ROCAP in Guatemala); and

- further drafting and revisions of report (18 to 31 August 1986 in Burlington, Vermont).

Many individuals were interviewed during the course of the evaluation, and they are listed in Appendix C. Given the complexity and widespread nature of such a regional project, the team had only limited time to spend with all those associated with the project. However, the ARD team did its utmost to gather as much information as possible from each individual and to see as many people as feasible, given time constraints and individuals' availability. The team also attempted to review all the reports and documents produced by the project which were important to the evaluation scope of work. The ARD team did not find any single repository for reports and information, and LANL did not have a list of all the project reports to give the team. Some reports were unavailable as they were still in draft, although the team appreciates those drafts that LANL did provide. An attempt was made to review every document, but it may well be that some were not seen and thus, some information was not available to the evaluation team.

During clarification of the project's background and context, it was requested that various documents, including a collection of all technical reports, be sent to the ARD evaluation team in care of ROCAP. Unfortunately, the reports did not arrive until three weeks later, on 4 August 1986, and thus, required perusal by the team's technical experts in the United States between 23 and 29 August.

1. Standardized Questions

To ensure complete coverage of all items in the scope of work, as well as some uniformity of structure across different project components and countries, a set of common questions for data collection and analysis was developed during the team's preparation and planning, and applied during assembly and integration of the findings. The general overall set of common questions was as follows:

- what was intended;

- what was the economic justification;

- what was achieved, and why or why not in terms of technical, management, economic factors, etc.;
- what are the economic implications, including estimates of capital and operating costs for implementation;
- what is needed to go from the current status to economic benefit;
- what is the quality of technical reports, including methodology, data collection, data analysis, utility, and inclusion of economic and social issues;
- what amount and quality of technology transfer has occurred, including formal and on-the-job training;
- how close has technology transfer come to Central American self-sufficiency; and
- what collaboration has there been with USAID missions and Central American institutions?

2. Relationship Between Project Design and Evaluation

Normal evaluation procedure is to base the design of an evaluation on the project design. The major components of project design are project objectives, at both the impact and work plan levels, and indicators for measuring whether those objectives are met. Thus, the project and evaluation designs are actually the same. The objectives and indicators used to design the project become the foci for its evaluation. Often, the clarity and logic of a project design are insufficient for an evaluation, which then requires a preliminary evaluation stage--design clarification. In the case of the LANL project, the lack of overall clarity in a good logical framework, or other formal project design, was extreme. Responsibility for the lack of a clear project design lies more with AID than with LANL. This made carrying out the evaluation difficult and did not permit a clear specification of project objectives until toward the end of the evaluation effort. In addition, this situation caused problems for the team in terms gathering and analyzing data over a short period of time for its evaluation of a very complicated project. Moreover, this occurred in conjunction with ongoing developments in clarifying project direction and objectives.

ARD's attempt to clarify the objectives and logic of the Central America Energy Resources project is presented in Section IX. Unclear objectives hinder project implementation and management as well as evaluation. A discussion of the

operational implications of the project's unclear objectives is also provided in Section IX.

It seems to the evaluation team that the central logical flaw in the project (in terms of its logical framework) has been the implicit assumption that scientific and technological analysis and reports will lead to the accomplishment of AID's economic objectives without major intervening activity. Intervening activity must include investment mechanisms and campaigns, modified energy policy, and the management of energy and industrial projects. The evaluation team recognizes that both AID and LANL personnel are very aware of this fact, and have spoken about their intention to implement such intervening activities. However, as this report discusses, these activities are not currently covered in project documents. Thus, there is a danger that the focus on these activities will be inadequate. Even if designed conceptually, they will not be monitored or reviewed under the current logical project design. AID has a long history of funding excellent studies and research projects that often yield no measurable benefits. The ARD team realizes that all the parties involved in this project see it as moving beyond a study and research effort, and hopes that this evaluation and project logical framework redesign will be a step in that direction.

3. Evaluation of Staff Performance

The evaluation scope of work emphasizes an evaluation of LANL staff performance as follows:

> The evaluation will focus on project coordination and staff performance.
>
> Evaluate project staff performance and their ability to work and interact with national counterpart institutions and bilateral USAID missions. Has communication and responsiveness to counterparts and USAID missions been adequate?

Measuring staff performance, especially in nontechnical areas such as those mentioned above, is extremely difficult and fraught with problems when done in a very short time frame, as in this type of evaluation. As a mutually agreed-on standard for review, ARD employed "General Qualifications Required of PASA Staff" (original PASA agreement between AID and LANL signed 29 March 1985, p. 3, see Appendix D). The PASA agreement is concerned with much the same staff performance areas as the scope of work for the evaluation.

D. Organization of This Report

ARD has attempted to make the organization of this report follow the outline of the scope of work as closely as possible. In some cases, this was not possible as the report would then have been disjointed and difficult to read. In other instances, there are items that cut across technical or subject areas. Where it was deemed helpful, an overview of the status for particular technical items from the scope of work is provided in the relevant section. Each section also gives the reader some guidance on its organization and what it is meant to cover.

The executive summary at the beginning of this report is intended to be a stand-alone document. It provides an overview of the key findings, analysis and recommendations resulting from this evaluation.

The first four sections of this report focus on the technological accomplishments of the LANL project. Section III discusses the energy planning and situation assessment work. Section IV details the geothermal resource and end-use identification. Section V focuses on the peat resource and end-use assessment component of the project. Section VI discusses the mineral reconnaissance efforts in Costa Rica.

The next four sections deal with broad issues that cut across technological areas. Section VII focuses on technology transfer and economic sustainability. Section VIII discusses staff performance, project coordination and management. Section IX is an analysis of design issues for the LANL project. Section X covers the project's monitoring and evaluation system.

Section XI reiterates the major recommendations made throughout the report. Finally, Section XII concludes the report with a discussion of future directions for the project.

Appendix A contains the scope of work for this evaluation. Appendix B provides an overview budget prepared by LANL as of 31 May 1986. Appendix C lists the individuals contacted during the evaluation. Appendix D contains the PASA agreement, and Appendix E presents a blank logical framework form.

III. ENERGY PLANNING AND SITUATION ANALYSIS

This section evaluating the energy planning and analysis component of the project begins with some background on the Central American energy situation and the need for energy data analysis and planning. There are several subsections on both the broad and specific objectives of the project's energy situation analysis component and progress made toward those objectives. The appropriateness of project activities and results are assessed in the context of the region's current and near-term energy-sector and mineral priorities. The final subsection presents findings and recommendations related to individual Central American countries participating in the project.

A. The Need for Energy Data Analysis

Some of the difficult economic conditions found in Central American countries today can be directly related to the energy problems of the past decade. Furthermore, resolution of energy problems is necessary to provide a positive framework for future economic growth. According to the Inter-American Development Bank (IDB), about 50 percent of the region's total external debt and 40 percent of public-sector investment can be attributed to the energy sector. This is primarily for payment of petroleum imports at relatively high world prices--at the level of US$30 to US$35 per barrel--and for construction of an extensive network of hydropower projects at relatively high interest rates. For example, Chixoy in Guatemala is in the final construction/repair phase at three times the initial cost estimate. The external debt payment for both imported oil and regional hydroelectric projects will continue to affect the region's economies. An effective, progressive energy policy is essential to mitigate the negative impact of past energy problems and initiate positive, new programs for growth.

Central American regional economics have been constrained by limited indigenous energy resource development and by requirements for imported petroleum. In 1984, five Central American countries--Costa Rica, El Salvador, Honduras, Guatemala and Panama--consumed 29 million barrels of oil, valued at approximately US$750 million. Only Guatemala produced two million barrels of oil, most of which was exported. This constraint on the limited economic and foreign trade resources of each country has had a detrimental impact on the region's economic growth and development.

An overview of the impact of energy on Central American economies indicates that there has been a reduction of financial support for investment in indigenous energy development. However, with prospects for declining world petroleum prices,

modest energy demand growth, moderate economic growth, and excess hydroelectric generating capacity, it appears that energy supply constraints will not be a major factor in Central America for the near to medium term. Energy demand for countries in the region will be affected not only by the growth rate of the economy, but also by the extent of current growth in emerging non-energy-intensive industries (e.g., the service sector in Panama and small manufacturing in Guatemala) and more efficient use of existing energy flow through conservation and positive pricing programs.

To mitigate the impact of energy constraints on the economy and improve energy policy formulation, the purpose of this part of the project is to develop an energy data base and model for each participating country as well as an assessment of appropriate planning technologies. These are to be employed to analyze and evaluate alternative energy policy options, and to encourage effective utilization of the region's energy and natural resources. Such an analytical framework and attendant technologies are to be created to allow rapid comparison of energy and mineral development options in terms of balance of trade, import substitution, direct costs, job creation, etc.

B. Overall and Specific Objectives

According to the LANL PP,* the energy situation analysis contributes to the following key overall objectives of the project:

- to create an analytical framework that allows rapid comparisons of energy and mineral development options in terms of balance of trade, import substitution, direct cost, job creation, etc.; and
- to build technical and managerial skills so that a self-sustaining economic development process is established--this objective will be achieved predominantly by on-the-job training associated with the project components, training workshops, sponsored graduate student participation, and visits by regional technicians to Los Alamos.

The exact time frame for achievement of these longer-term objectives is not clear to the evaluation team and could be anywhere from one to five years away, depending on the level of achievement that is intended or expected. In order to meet the

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*Central America Energy Resources Project Plan, submitted to AID in March 1985, and Phase II addendum, submitted to USAID/ROCAP in April 1986, by LANL.

above overall objectives, specific, narrower objectives have been put forth by LANL in two phases, as presented below.

Phase I Objectives

By the end of Phase I (December 1986), the following technical assistance will be provided:

- update of the MITRE study completed and report published;
- workshop held to disseminate the results of the energy situation update as well as to discuss energy problems and data needs;
- regional counterparts and training needs identified;
- computerization of readily available data in a framework compatible with the one available in Costa Rica;
- basic energy data requirements identified and surveys designed to collect missing data or update old information;
- maps for the resource and infrastructure atlas finished in preliminary form; and
- appropriate computer hardware provided to each counterpart agency.

Phase II Objectives

By the end of Phase II (added in April 1986), the project is to have achieved the following status levels:

- technical assistance and training requested by counterpart organizations provided;
- SICAPE energy data base maintained;
- activities of the development banks (World Bank, IDB, etc.) complemented;
- regional seminar held on national energy planning or energy demand estimation;
- draft of energy atlas completed; and

- country-specific objectives met, including specification of a macroeconomic model for Costa Rica, specification of energy demand models for El Salvador and Panama, a policy paper on energy for Honduras, strengthening of data base and energy planning capabilities in Guatemala, and outline of an energy plan for Belize.

The remainder of this section reviews the status of Phase I and Phase II activities, then analyzes progress toward the broader, overall objectives.

C. Progress Toward Specific Objectives

The progress of the energy situation analysis toward meeting Phase I objectives is described below. First, the MITRE study was revised using data from the Organizacion Latinoamericana de Energia (OLADE) and other sources, and a draft was issued in December 1985, with the title THE ENERGY SITUATION IN FIVE CENTRAL AMERICAN COUNTRIES. This report appears to be an effective summary document for an initial assessment of the energy situation in each country. However, energy and economic policy interactions can be complex within each country and involve many factors that are beyond the scope of a single chapter in a regional document. The report does not include a critical analysis of each country's current energy policy, medium-term prospects, energy and economic projections, and financial review, all of which are required prior to initiation of an energy project by the World Bank, IDB, or other private or public financial institution. For a comprehensive situation analysis, LANL could expand this report.

Second, a workshop was held at INCAE in Alajuela, Costa Rica, from 13 to 18 April 1986, to review energy data base requirements, Sistema de Informacion Centroamericana para Planificacion Energetica (SICAPE), energy planning and related computer operations. According to comments made to the evaluation team by participants, the workshop was well received and seemed to have been carried out in an excellent manner. A second workshop to review energy modeling, forecasting, INTEGRA and associated computer operations was scheduled to be held at INCAE in September 1986. The workshops on energy data base operations in April and energy modeling scheduled for September are an essential and successful element of the technology transfer and training aspect of this program.

Third, appropriate regional and country counterparts have been identified and training requirements assessed. SICAPE was designed to maintain a compatible data base for energy balances within each Central American country. The program was developed to be a user-friendly, acceptable, productive energy data base.

It has been highly praised by all users and meets most of its design goals. The program was designed for mid-level users, data base research assistants and other support staff, and requires little formal computer background to operate. Because of its effective design, it has encouraged additional energy data base operations and analysis projects (e.g., analysis of fuel source alternatives in Honduras and the tax situation regarding diesel, gas and oil).

Fourth, the SICAPE data base has been or is being installed in each country and regional energy analysis counterpart group to include readily available data. The SICAPE energy data base and analysis are designed to review the prospects for different energy policy programs. However, only physical energy units are installed on the energy balances at this time, with minimal financial, cost or price data for fuels and energy. Thus, it is not possible to evaluate the economic, employment or foreign exchange impact of changes in energy policy under the current system. LANL could expand the data base to include these elements.

Fifth, basic energy data requirements have been identified for each country. Programs to develop new energy data or update old information vary substantially by country. The energy data base and modeling system provided by LANL to counterpart agencies use two commercial programs developed by Ashton-Tate (dBase III and Framework II) which are available in English and Spanish. Both programs are state-of-the-art microcomputer programs for data bases and spread-sheets and the most appropriate product for the intended use. For example, Framework II allowed an analyst in Honduras to design a spread-sheet and graphic display for comparing the cost of different fuels at a proposed industrial plant. This project would have required three weeks using normal procedures, but was accomplished in one day using the program, a positive instance of spin-off technology training. Framework II appears to be designed to permit simultaneous multiple spread-sheet analysis, which is required for energy modeling.

Sixth, maps for resource analysis and an energy atlas were under development according to LANL, with an expected completion data of December 1986. The MITRE study was updated before Phase II of the present program was implemented, so it does not discuss minerals. A short discussion on peat does describe preliminary technical efforts and the location of potential resources. No information was available on maps for the resource and infrastructure atlas mentioned in the scope of work in connection with the mineral specialist.

Seventh, each counterpart agency was provided with a microcomputer (an IBM-XT model for SICAPE and other program operations) as well as associated hardware and software. In most offices, the availability of the computer system permitted new

and innovative analytical programs to be developed and used, either directly for energy policy analysis or indirectly in related areas.

D. General Assessment of the System's Utility

The key components evaluated below are the data base, computer resources, and the energy model.

The SICAPE data base has been installed with appropriate staff and resources in every country except Belize. The validity, accuracy and applicability of energy information available for these data bases vary considerably. In some countries, data accuracy may vary by 25 percent in rural regions, a particular concern with the use of wood, which is a major energy source. Data are generally collected through periodic surveys that use different protocols, definitions and collection methodologies, which has produced inconsistencies in the time-series evaluation of energy flow. SICAPE is designed to produce physical energy-balance information with minimal financial and economic data. The data base will run from 1970 to 1985, but definitions vary for each country, and a total Central America energy balance would be difficult to formally design. The collection and approval of energy data vary by country and type of energy, with a normal six- to eight-month time lag in the availability of data for publication, although most countries have a shorter delay for electric power information. The SICAPE energy balance is only designed for annual data, which are important for long-term projections, but inappropriate for short- to medium-term policy planning. Interaction among energy, demographic or economic data bases within Central America or with external sources, such as the International Monetary Fund (IMF), CITIBANK and the United Nations (UN), has not been developed.

The SICAPE data base was initially designed for Direccion Sectorial de Energia (DSE) of Costa Rica, using the dBase data base program, to provide a basic energy balance for policy analysis. In 1985, it was considered the most appropriate data base model to transfer to the other countries in Central America. However, analytical tools are dynamic, and they are being improved continually. The energy data base in Costa Rica has been expanded beyond the initial SICAPE approach and will include more disaggregated and regional energy data. This problem is inherent in all data base systems, and it can be anticipated that each country will develop its own variation of SICAPE to meet individual planning and policy requirements.

The computer hardware and software resources provided by LANL to each Central American counterpart agency are appropriate and excellent state-of-the-art tools for energy analysis. Each site has an IBM-XT microcomputer with a printer. The basic

software consists of Ashton-Tate products--dBase III for data base operations and Framework II for spread-sheets, graphics and report generation. This software is the most appropriate for user-friendly operations. The staff assigned to analytical operations were engineers and economists, although support personnel and secretaries were operating the computer programs, which indicates the software's effectiveness. Computer fluency skills varied, and each country is climbing the operational learning curve at a different rate. (One group accidentally erased the program and data base before developing a backup copy.) Computer maintenance is a potential problem as some agencies lack funds to repair defective equipment or even purchase diskettes.

The energy models used by each Central American country differ in scope, data, aim and purpose. The more advanced countries have a multi-sectoral, disaggregated model that is actively used for energy policy analysis. The developing countries are starting to gain expertise in formal analytical capabilities, data base information systems, and policy review. This individual and flexible approach for each country should be encouraged and supported by additional training, resources and equipment.

E. Shortcomings in Progress Toward Overall Objectives

LANL's progress toward the short-term objectives it has set for itself is satisfactory. However, progress toward short-term objectives does not assure achievement of the overall, broader planning, energy balance and economic objectives. The shortcomings that the evaluation team detected in the current approach are listed below. Note that these shortcomings apply more to planning and objective setting for the energy analysis component than they do to performance of LANL technical staff on the short-term objectives.

First, no computer model, data base or other analytical tools were available or developed by LANL to allow rapid comparison of energy and mineral development options in terms of balance of trade, import substitution, direct costs, job creation, etc., which is a basic goal of the project. This is a complicated and long-term effort, but does not yet seem to have been adequately addressed.

Second, little progress has been made in using energy data analysis to improve planning decisions at the counterpart organizations. Although the technical staff in each country appeared to encourage this goal, they indicated that most government decision-makers lacked confidence in this approach and cited decisions made on pragmatic or political factors, which differed from their recommendations. Government policy decisions

are based on many factors, and an effective analytical group will generate inherent confidence in its recommendations.

Third, the appropriate aim of the program is to develop recommendations for improved energy policy after reviewing the present and potential energy problems and programs in each country. This essential factor appeared to be missing from the draft energy situation report, and could not be evaluated. This complex task would require detailed analysis of the present and potential options available in energy policy for each country under different energy, economic and financial considerations.

Fourth, LANL's energy analysis and planning activities may be duplicated by other donors' efforts. International organizations, such as the World Bank, IDB, United Nations Development Programme (UNDP), UN Economic Commission for Latin America (ECLA) and others, have been engaged in energy-related activities for several decades. LANL's project paper indicated its plan to complement these organizations' energy activities. However, the coordination efforts appear to be inadequate. In fact, the team found that several project planning activities were in potential conflict with other existing development-agency energy programs. Discussions on mitigating conflicts or using other energy models are continuing with LANL and the counterpart organizations.

Summary

The evaluation team's general conclusions concerning the LANL energy data base and analysis programs are:

- a foundation has been established for effective energy policy design, although the details vary substantially by country;
- energy data are not yet at the level of validity or availability required for extensive, detailed analysis and planning;
- existing energy surveys and data collection efforts in some countries do not provide sufficient information to support policy and modeling programs;
- available economic, financial and demographic data have not been incorporated into the energy data base;
- the microcomputer hardware and software available at most counterpart organizations in Central America are not sufficient for the data base report and analytical requirements; and

- energy data base reports and analyses have not been used extensively in energy policy decisions or made available to appropriate government officials.

Based on the evaluation team's review, a subjective comparison of energy data and analysis programs by country is provided in the table on the following page. This comparison needs to be refined by project staff and used as one of the guides for determining where to place future project resources.

F. Overall Recommendations

Based on the evaluation team's findings and conclusions concerning achievement of project objectives, the recommendations presented in this section were developed for the regional activity and this project component in general. Specific recommendations for each country are provided in Section III.G.

First, LANL should revise the energy situation report, ENERGY SITUATION IN FIVE CENTRAL AMERICAN COUNTRIES. This report was completed in December 1985, but may be considered obsolete due to rapid changes in the world energy situation. It is recommended that the information in the report be updated to include final data for 1985 for each country and a regional review. The collapse of world oil prices, from US$28 per barrel in December 1985, when the report was written, to the recent level of US$9 per barrel, will have a significant impact on energy policy and programs for each country. The report should be revised to include the potential long-term impact of lower oil prices on energy policies. A basic justification for the project was the need to mitigate the economic impact of high-priced oil for Central American countries, but the collapse of the world oil market could eliminate the economic justification for many current and planned energy projects. Under current economic conditions, it would be difficult to qualify certain project activities for financial investment by either development or private investment banks. In addition to providing a historical and current status of the energy balance in each country, the report should provide critical analysis and recommendations to improve the current energy policy situation under different scenarios and projections.

Second, energy data and analysis training should be increased. The workshops can be considered a strong aspect of the program. Discussions between the team and participants at the sessions indicated that this approach should be increased to four or five workshops a year on a regular basis. Suggested topics could range from recent energy modeling operations and procedures to a broad group of basic engineering/economics/ statistics review courses. Workshop participants have widely varying technical backgrounds, and the training sessions could

provide an important element in more effective policy development for each country. INCAE has a strong regional reputation and has developed a curriculum in conjunction with the Harvard master of business administration (MBA) program. The INCAE location is very convenient, providing a campus setting that is just a short drive from an international airport. LANL could develop a joint series of programs with INCAE staff and institutionalize the operation with a periodic faculty exchange. A special semiannual workshop for the energy ministers of each country could be an important aspect of this program. This would provide an informal forum for discussion of international, national and regional energy policies at INCAE by each country's decision-makers with LANL's assistance. Additional training programs could be established for counterpart staff in statistics, economics, modeling and policy analysis at an advanced level, at LANL or another appropriate U.S. facility.

Third, computer resources in Central America should be expanded. The microcomputers distributed to counterpart organizations are the foundation for the energy data base and analysis system. LANL should expand the microcomputers' capabilities to permit better availability of information and more effective dissemination. Suggested additions include:

- Modems--a 300/1200-BD modem should be provided for each computer to permit rapid exchange of information, data and reports among LANL, each organization and other data bases.

- Plotter/printers--a graphic display can more effectively present data and analysis reports than the current tabular system. Framework II's graphic system is a basic approach, but other programs (e.g., Energraphics, Enercharts, Harvard Graphics, Graphwriter, Chartmaster, etc.) can develop complex graphics and charts that are essential for simplified presentations of complex information. A graphics card would be required for the computer, as well as any of a wide range of plotters or high-density dot-matrix printers.

- Tape backup--to preserve large data bases and models in a rapid manner, a 10- or 20-megabyte tape backup system should be provided. The current diskette backup approach requires several diskettes and can take over an hour to save the program and data.

- Power backup--fluctuating electrical current and periodic blackouts or brownouts would suggest a battery backup system to minimize program deterioration or loss during a crash.

- Additional microcomputers--as the work load and utilization rate at each workstation increases, it would be helpful to have additional equipment. A new IBM-XT or IBM-AT with a 30-megabyte hard disk could be installed in a local area network (LAN) to expand the total capacity in series.

- Econometric software--there are several statistical and econometric software packages available to assist with analysis. RATS is available in the economics sections of most U.S. embassies in Central America. Other similar programs (e.g., 4CAST) are available and could be used to provide analytical assistance combined with training.

- Training--computer operations can be complex, and staffing will change periodically. It would be helpful to provide a review and advanced energy data base and modeling training session on a periodic basis (perhaps every three months), including expert presentations of a general nature, in addition to reviewing the latest techniques for energy data bases and modeling.

- Maintenance--periodic repair and maintenance of computer hardware and software must be provided by LANL. Arrangements should be made with a local computer repair facility or via LANL to ensure equipment availability. Some agencies have only minimal repair funds, and at one location, a defective keyboard prevented normal use of the data base for three months.

Fourth, <u>the project should assist with additional data base design, development and operation</u>. Each Central American country has a potential problem regarding the availability, validity or consistency of data used in the energy balance. LANL should assist in designing data survey forms to ensure the expansion of energy-balance information. To provide information for economic analysis of energy options, the data base must be expanded to include financial, pricing and social data. Energy modeling and analysis are only as effective as the validity of the basic data. The survey procedures, operations and approach could be improved using more rigorous statistical methods. The project could develop a regional and country data-base collection approach to improve the information available. The U.S. Department of Energy's Energy Information Administration has extensive experience in energy data collection operations, which could be applicable to the Central American region. The International Division of the Census Bureau, U.S. Department of Commerce, provides training, data base and survey design, and other informational assistance to developing countries which could be

useful in Central America. An energy dictionary applicable to Central America could be prepared to aid regional experts.

Fifth, the project should provide more assistance in using energy models as policy analysis tools. Designing and developing effective energy models to be used as primary tools in policy analysis are very difficult tasks. Most industrialized countries, including the United States, have a plethora of overdesigned energy models that are more effective at "back-casting" than forecasting. The initial approach of the LANL program was to provide a framework for each Central American country to develop its own energy model and evaluation system, depending on local conditions, data, staff and other resources. This approach could be effective and allow more advanced countries (which can provide assistance to other countries and LANL) to expand their analysis beyond LANL's scope, while providing basic support to those countries needing extensive assistance. LANL energy modeling and analysis projects should be broadened to develop a critical methodology for reviewing alternative energy policy scenarios, and economic, employment and trade factors. The projects should be designed to encourage foreign investment.

Sixth, the project should support a regional energy data and analysis center in Central America. Although counterpart organizations have been selected for each country, a Central American regional institution has not been chosen for a regional data base and energy model. SIECA might be an appropriate agency for regional energy/economic analysis. It was established in 1961 as the secretariat for Central American Common Market (CACM) activities and has recently analyzed the regional economic, political and legal aspects of energy. SIECA is actively working to encourage economic interchange among Central American countries. LANL has supplied SIECA's energy group with computer support and the SICAPE data base. SIECA maintained the AID-funded PEEIR (Programa de Eficacia Energetica Industrial Regional) energy data base with detailed country-level data from 1960 until 1982, when it ceased to function due to the collapse of CACM. LANL could establish a regional presence via SIECA in Guatemala, using staff who are cognizant of the individual problems and prospects for each country. Despite its complexity and the inclusion of conflicting data, policies and problems, a regional model could be initiated by SIECA as a basis for renewed interest within CACM. If SIECA is not acceptable or appropriate, then an alternative regional institution should be found.

Seventh, the project should support future technical assistance to provide a framework for energy policy analysis at the regional and country levels. The Central America Energy Resources project has provided a substantive foundation for energy policy analysis at both the regional and country levels. However, to provide essential information for energy and

investment decision-making, the following potential topics could be added to the LANL schedule to complement existing or anticipated programs:

- financial and monetary review of energy projects;
- electric power demand--review of the behavior of the industrial, residential and commercial sectors, and their relationship to economic, financial and demographic factors;
- electric power simulation--construction of a statistical model of the electric power industry to forecast demand;
- electric power investments--design and construction of an electric power generation and transmission expansion model to fit the characteristics of each country;
- electric power interconnection--development of a Central American electric power interconnection model, including common planning and operational requirements to minimize additional power plant construction;
- evaluation of oil imports--review of the San Jose accord, including a cost/benefit approach to alternative oil purchasing agreements;
- wood supply and market assessments--complete fuelwood market studies and data on wood supply and reforestation programs as part of energy planning exercises;
- review and compilation of data already assembled locally on alternative energy systems, particularly for stand-alone systems such as wind and solar;
- economic energy policy--including review of fiscal policy in the petroleum sector for each country, designed to continue economic growth and maximize tax revenues while minimizing economic distortions; and
- energy conservation--development of detailed review of the potential for energy conservation in the transportation sector, which is the largest petroleum consumer (as far as the evaluation team is aware, the project has not yet done anything in this area).

G. Country-Specific Findings and Recommendations

1. Regional Context

CACM is composed of El Salvador, Guatemala, Honduras, Nicaragua and Costa Rica and was established in 1961. Although Panama and Belize have applied for membership, political problems have limited their full participation. In addition to designing common tariffs, regional integration includes a common payment system, a regional bank--Central American Bank for Economic Integration (CABEI), a common investment incentive, an industrial program and a permanent secretariat (SIECA).

CACM was an important factor in the economic growth of Central America, in general, and Guatemala, in particular, from 1960 to 1980. Regional trade has declined during the past five years due to the negative impact of balance-of-payment problems in all five countries simultaneously. Measures taken individually to mitigate trade deficits have caused interregional trade to deteriorate further. The clearinghouse has ceased to function effectively, and Guatemala is owed $200 million by the CACM trading partners.

2. Guatemala

Guatemala enjoyed decades of real economic growth until 1981. However, since 1982, the country has experienced stagnant and negative growth. This was due partly to a recession in industrialized countries, increased world oil prices, decreasing prices for export products from Guatemala, and regional political turmoil. The prospects in the near term are not good due to the large external debt. To overcome the basic problems, it is essential that fundamental changes occur to produce employment in the private sector, and a shift away from agriculture and light manufacturing industries that led to the growth of the 1970s.

Guatemala is unique in Central America in that it produces and exports crude oil. However, current production has dropped to the lowest level in a decade. Domestic crude oil that is not consumed at power plants is exported to Texas for refining, as the high sulfur content cannot be refined at the Texaco refinery at Escuintla, which is the only one in Guatemala. The geological formation that Guatemala shares with Mexico offers prospects for additional oil, and five drilling groups are exploring new production possibilities. The Chixoy hydroelectric power plant recently came on-line, five years behind schedule, thus reducing oil requirements, but it cost three times the initial estimate, which intensified the foreign debt problem.

The energy data and analysis function is under the direction of the Ministry of Energy and Mines (MEM). They are developing an energy plan and model under a UNDP program, which is more disaggregated and sector-specific than the SICAPE data base. The UNDP model is scheduled to be operational by October 1986 on a Texas Instruments computer system and turned over to MEM for development of the midterm energy plan. Available energy data in some sectors, primarily wood production for home heating, cooking and residential consumption, require an expanded series of surveys. There is the potential for alternative energy sources in this country, including geothermal, peat, coal, biomass, solar energy and wind power. However, these energy sources have not yet been fully evaluated in an economically and technically effective manner. Those sources that are not already being addressed by the project, but which would be of most interest, are probably those most easily adapted to remote or stand-alone systems where grid development is uneconomical. How important the supply of such energy is to further economic development is unknown for the purpose of this evaluation.

To assist the energy data and analysis effort, the following steps are recommended:

- Provide further assistance to MEM in developing its energy model effort--Guatemala's MEM is the counterpart organization for data base and modeling support. A detailed, disaggregated energy model is under development by UNDP and due to be completed in December 1986. LANL could continue model operation, assist in designing and conducting additional data surveys, and provide training and equipment. On-site support by an energy economist would help in developing demand data and analysis for the transportation, residential and industrial sectors on a regional basis.

- Improved energy efficiency and conservation in the industrial and transportation sectors should be investigated. An analysis of the transportation-fuel pricing policy and its impact on transportation patterns could assist in developing more efficient energy use.

- The MEM alternative energy group is exploring the prospects of using domestic geothermal, peat, coal, biomass and solar power for specific applications. Prior to development of a technical feasibility study, it is essential that an economic analysis and cost/benefit review be developed to determine a realistic approach under current energy price specifications.

3. Honduras

The decline in the economy of Honduras reversed in 1984, due to completion of the El Cajon hydroelectric plant, among other factors. However, over the decade, slow economic growth and a possible recovery are expected, if economic confidence returns and higher levels of expectations resume. The level of external aid and belligerence in the region will continue to be important factors.

Electric power in Honduras is produced almost entirely by hydroelectric facilities, including the new El Cajon facility, which will provide export potential. The largest energy source is wood, which has caused concern about deforestation. The cost of imported petroleum has a negative impact on the country's balance of payments.

Consejo Superior de Planificacion Economica (CONSUPLANE) is the institute in charge of energy data development, planning and analysis for Honduras. There are a number of apparent problems to indicate the real need for more attention to the country's situation. Discussions with CONSUPLANE staff indicated that:

- data validity and assimilation is a problem;
- staff availability for energy studies is inadequate;
- technical training on computers and analysis is required;
- the SICAPE data base and backup were accidentally erased from the computer, and weeks were lost while waiting for a replacement to arrive;
- the government does not give a lot of weight to CONSUPLANE studies in making policy decisions;
- there is a data delay of nine to 10 months, i.e., 1985 data will not be available until October to November 1986;
- the energy balance data are inaccurate by 10 to 20 percent for some years;
- only annual data are available, but there are plans for quarterly and monthly data next year; and
- extensive financial, economic and demographic data are not on the data base--they use the UN data in New York for Honduras information since the economic ministry appears to keep data only for external use.

However, the staff is learning. For example, they developed an innovative fuel comparison project using Framework II. This project was expected to take five to six weeks, but was completed in only two days on the computer. After discussions with the energy data and analysis staff in Honduras, the following recommendations are made by the evaluation team:

- CONSUPLANE requires extensive support in training, computer hardware and software, modeling design and development, political and staff strength, improved communication, computer maintenance and institutional stability;

- data surveys must be developed and used for energy balances;

- financial, economic and demographic data must be installed on the data base;

- alternative energy and petroleum pricing policy studies should be developed to determine the appropriate level for them;

- the large consumption of fuelwood indicates a problem in reforestation for some regions--this topic may require further environmental/forestry work and an assessment and study of potential alternative energy sources;

- energy demand management is inadequate, and a management approach needs to be developed to strengthen this area; and

- alternative energy sources, including geothermal, peat and biomass are potentially available--cost/benefit and risk analysis studies should be done for each potential energy source.

4. <u>El Salvador</u>

After a long period of economic decline, the economy in El Salvador began to show positive growth in 1985. Continued growth is expected if tensions in the countryside do not increase, as external financing will continue with growth in the world economy. The government has announced a medium-term economic policy plan to 1989, which is designed to increase employment, restore the 1978 level of economic activity and improve living conditions. This economic stabilization program has been helped by the high price of coffee exports and low price of petroleum imports. However, excessive deficits due to the electric power sector (65 percent) will continue to have a negative impact on

the economy. As in other Central American countries, the high degree of firewood use has resulted in deforestation.

Energy problems and prospects in El Salvador are affected by the vulnerability of the electric grid and transportation system to disruption by armed groups. This requires the continuous availability of excess electrical power capacity to compensate for periodic shortages.

Discussion with Comision Ejecutiva del Rio Lempa (CEL) staff indicated that:

- the energy data base has been established and is used for analysis and modeling projects;
- the data base requires expansion and new surveys;
- the data on wood, which is a major component, is considered accurate to only within ±25 percent, as the last survey was done eight years ago;
- they have established an energy model on Lotus which is not compatible with Framework II and feel that a conversion would take six months, although it might be possible to do it in as little as one month;
- they have a good statistical and regression analysis program and appear to be well trained in its use;
- the government macro-energy model has been developed for the energy sector, but lacks extensive economic data;
- they have financial and trade (oil export/import) data on their data base;
- the data base staff numbers five and the analysis group six, with four support staff members, all at CEL;
- CEL energy data and analysis staff appear to be good and highly motivated; and
- although energy modeling and analysis has a place in decision-making, political considerations dominate.

The energy problems in El Salvador are unique due to potential conflicts with armed groups periodically destroying the electric grid or transportation system. CEL has been the center for energy data analysis and should be supported in its continuing efforts. The energy data base is good, but can be expanded into more industrial sectors and used for planning

requirements to improve energy efficiency in the main industries. Alternative energy sources, particularly geothermal power at Ahuachapan, should be expanded. Additional alternative energy, including solar power and conservation studies, may be developed. A recent energy model funded by IDB could be used and expanded to develop detailed gas/diesel pricing policy. Due to the vulnerability of power plants, redundant electric facilities must be designed. A model of alternative grid interconnections could be developed by LANL, using risk analysis for each facility.

Recommendations for LANL energy projects in El Salvador include:

- CEL should continue to effectively use LANL support for its data base operations;
- assistance is required in designing and carrying out field surveys on energy consumption data for the residential, commercial and industrial sectors;
- the energy model used by CEL could be improved by including more disaggregated data, and a Framework II-Lotus exchange may be available for dual model use;
- energy efficiency in the industrial and transportation sectors can be improved through studies and energy audits (ICAITI has a data base of similar studies);
- the pricing system used for gasoline and diesel fuel could be analyzed to determine whether it is appropriate or alternative systems should be recommended;
- a model of the electric grid could be developed to determine potential redundancies and vulnerability to disruption--a loss analysis could be developed for each link in the grid to minimize disruption;
- the potential for additional geothermal power at Ahuachapan should be analyzed, including a current cost/benefit review--if reinjection is considered to reduce production declines, this should be analyzed for optimal design; and
- development encouraging foreign investment could be considered in the energy area (e.g., geothermal)

5. Costa Rica

After a period of rapid growth from 1960 to 1978, the economy of Costa Rica began to deteriorate in 1979. It has not recovered to the 1978 gross domestic product level of US$1,630 per capita in 1979. The economic fall was due to a drop in coffee prices, CACM's collapse, an increase in oil prices and increased external debt. Faced with these problems, the government attempted to compensate by increased external borrowing. This problem accelerated, which resulted in further economic decline. During 1983, industry was estimated to be operating at 50 percent of its capacity. A small recovery is beginning, encouraged by increased coffee prices, lower oil prices, reduced imports and a stringent monetary policy.

As with other Central American countries, Costa Rica needs to increase its energy supplies to meet the economy's requirements as growth returns to normal. The major energy investment has been in developing hydroelectric facilities that comprise almost the entire electric power sector. The grid has expanded to reach over 85 percent of the population. There is increasing interest in alternative energy sources, including geothermal, peat, coal, biomass and solar power. Each energy source has been investigated to varying degrees on the technical and economic levels. Due to its extensive waterway system, Costa Rica has a comparative advantage in hydroelectric production. As a first link in the Central American electric grid, Costa Rica is now selling electric power to Panama, Nicaragua and Honduras. It is anticipated that the current surplus electric power capacity will be utilized in renewed economic growth, then electricity will be imported or new hydropower facilities required. However, due to financial constraints, incremental electric power will be limited to meeting domestic requirements, not for export.

The energy data base, planning and policy are controlled by DSE. This is an efficient group of economists and engineers who have developed the most advanced energy data base and model in Central America. The new energy minister worked on the LANL review of energy in Central America and is familiar with energy data and policy in the region. Discussions at DSE indicated that:

- the DSE energy model is more disaggregate and sectoral than the LANL approach in SICAPE, and is at the level of energy analysis and modeling that some of the other countries could hope to reach in two to five years;

- although the energy data base is effective and includes financial and demographic data, some surveys are inadequate, particularly in the wood and residential sectors;

- the LANL energy data base, SICAPE, has proven to be an energy data base and report generator that is effective and easy to use, and although it is below the level of the DSE system, it provides a wide range of energy balance data in an efficient and rapid system;

- the computer facility provided by LANL complements the other IBM microcomputers used by DSE--the staff appears competent and conversant in computer and energy-modeling efforts; and

- the DSE energy model is more advanced than the economic model of the Costa Rican Ministry of Economics and is pushing the ministry to develop more efficient and interactive model operation.

After discussions with DSE and others, it is recommended that:

- the energy data effort at DSE is very good, but additional data for the residential and wood production sectors must be developed--LANL can assist with survey design and development;

- the DSE/MEDEE energy model is a disaggregated, multi-sectoral one that should prove effective for a wide range of energy analysis problems--this model would require further support and refinement over the coming years;

- the DSE model requires further definition of regional energy prospects and data--LANL could assist in this effort;

- studies of the potential for alternative energy sources, including peat (at Limon), geothermal (Miravalles), coal and solar power have been initiated--although these possibilities are technically feasible, it is essential that a cost/benefit analysis be initiated prior to further feasibility studies;

- although fuelwood has been a major source of energy in the rural areas, accounting for about one-third of total energy, its use is declining in relative terms--however, depletion of forestlands presents problems, and a study of the environmental and ecological impacts of this should be undertaken;

- model analysis should be initiated to evaluate pricing considerations in the transportation

sector--the model could assume that energy prices should reflect costs and then review the distortions caused by the current price system;

- policies promoting the rational use of energy could be developed with a transportation model reviewing alternative transportation modes and fuel uses;

- a program to attract private financing for new energy investments is being developed to save scarce financial resources in potentially risky ventures--a legal framework to encourage foreign participation could be initiated or initially eliminate constraints in the current code for foreign participation;

- an electric grid model could be developed to determine the optimal price structure for domestic and export use of this valuable energy commodity; and

- due to the relatively advanced state of the energy data base and modeling system, DSE could be presented as an effective example of the advantage of using energy data and analysis operations--its frequent participation in interregional energy policy and analysis meetings indicates its social responsibility for transferring its energy planning technology to neighboring countries.

6. Panama

Panama is undergoing a political and economic transition, and the prospects for the near term are not favorable. Panama is heavily dependent on the internationally oriented service sector, which is not expected to provide sufficient impetus for economic growth. The international banking industry plays an important role in the economy and is heavily dependent on offshore business. Panama's per capita oil, electric power and energy consumption is the highest in Central America. This is because Panama is primarily a service economy, with a small agricultural sector.

Panama is heavily dependent on imported oil and has minimal hydroelectric potential, unlike the other Central American countries. An electric line connection to Costa Rica has been operational since March 1986 and will assist in incremental demand. The Panama Canal Zone is self-sufficient in energy and not part of Instituto de Recursos Hidraulicos e Electrificacion (IRHE). Studies on alternative energy sources, including solar and wind, have been completed but with inconclusive results.

Comision Nacional de Energia (CONADE), the energy data base and planning function of IRHE, has developed a wide range of studies on energy and oil consumption. Although using simple methods (straight-line forecasting), they appear appropriate for the data. The energy studies and analysis appear more advanced than the economic analysis planning of the government, and they are forcing the Minister of Economics to develop more sophisticated methods. Special studies have been completed on gasohol, which appears promising. However, the study conclusions and report were not available. Other CONADE energy data findings are listed as follows:

- The SICAPE data base is helpful and has been used for projects.

- The energy balance data are available for 1970-85 for Panama, but only from 1970-81 for the canal. The missing canal data are due to different definitions and potential government restrictions since the new Canal Treaty. The canal data are available but CONADE has no staff allocation to get access to and develop the data base.

- All Panama projections are without canal data. Although the canal will revert to Panama by the year 2000, there is no plan for an integrated energy analysis.

- There has normally been a three-month lag in energy balance data, with the 1984 data available in March 1985, although the 1985 data will not be available until October 1986, due to staffing problems.

- There are no price, cost or financial data in the data base.

- Monthly and quarterly data on electric power and oil are available, but seldom used. Monthly data are revised up to two years after the fact.

- The energy analysis staff at CONADE includes 24 economists, engineers and support in three divisions.

- An Onyx computer and three terminals are used for regular data base operations. The system is five years old and slow.

- The energy analysis group uses the SAS statistical analysis package and plans to buy an IBM-AT.

- The group has had a defective keyboard on the LANL IBM-XT for three months and been unable to repair or replace it.

- Colon has a coal-fired electric plant using Colombian coal. Additional coal imports are likely for electric and cement requirements.

CONADE, the planning group of the INDE electric power sector, requires further help in energy data base design, development and access. The lack of current valid energy data has constrained energy analysis. A new data collection effort is needed in the transport and residential sectors. Energy projections have been using straight-line forecasts, but more sophisticated methods should be introduced and supported. The energy data base for the canal is treated independently of Panama. Procedures to integrate the two data systems must be encouraged. Panama data are available from 1970-85, the canal from 1970-81 only. The high level of oil use in transportation indicates the need for a study on potential conservation programs. Additional economic analyses on peat, coal and solar must be undertaken before further development of these alternative energy sources occurs.

A review of the energy data base and analysis situation in Panama produced the following recommendations:

- The CONADE energy analysis groups needs continued support and technical training in data bases and energy analysis.

- Additional computer equipment is required, including a modem, printer/plotter, LAN and econometric and statistical software.

- Additional data base and analysis training sessions on site would be helpful, considering the 24-person staff.

- Additional interaction with other Central America SICAPE users would assist their learning; modem or report interactions are recommended.

- Defective computer equipment would require a maintenance contract paid by LANL.

- Additional data development and surveys are needed in a wide area, particularly wood and industrial petroleum use.

- Alternative energy studies on solar and wind should be completed using current cost/benefit analysis.

- Although peat and coal have been found, an effective evaluation of the economics and risk analysis of using these resources for electric power or cement should be initiated.

- In general, studies on improved energy efficiency should be developed for the industrial sector, including audits and data.

- Since the transport sector is the major consumer of petroleum products (gasoline and diesel for cars, trucks and buses), a study and potential recommendations of conservation methods should be developed, including improved training of fleet drivers and mandated periodic maintenance of vehicles.

- In general, the Panama energy data and analysis group is assimilating the data and modeling approach and, in addition to more equipment, training and staff, could need more effective support from the ministry level.

7. Belize

Belize was added to the LANL Central America Energy Resource project in 1986, and an initial assessment team visited Belize to review the energy data and analysis activities. The evaluation team scheduled a visit, but the trip was cancelled at USAID/Belize's request.

Based on available information, it appears that Belize is the Central American country with the greatest need for energy data and analysis assistance. Reports indicate that the data base is rudimentary and energy modeling nonexistent. There is no current staff with the dedicated task of collecting energy data, analyzing them and developing policy. It appears to be an excellent opportunity to train and develop resources for current energy policy planning methods. An additional, important incentive is strong support from government decision-making levels. However, the technology transfer process could be lengthy, requiring simultaneous energy data, analysis and computer expertise resource development.

IV. GEOTHERMAL RESOURCE AND END-USE IDENTIFICATION

A. Background and Objectives

1. Technical Description

This prefatory section is intended to provide the nontechnical reader with a basic understanding of the technology employed in geothermal resource development, some normal problems encountered in managing a geothermal field and certain aspects of the debate on handling waste geothermal fluids.

In a liquid-dominated geothermal reservoir, such as the Ahuachapan field in El Salvador, geothermal fluid fills the pore spaces of the reservoir as a hot liquid. The high pressure of colder water above the reservoir keeps it from boiling as gaseous steam, just as the cap on a car radiator keeps the water inside the engine in a liquid state. If the pressure on the reservoir were relieved, the liquid would gush up, part of it flashing into steam as it moves up the borehole. Typically, about 20 percent of the total mass of hot pressurized water would be converted into steam with the rest remaining as superheated water. By controlling the valve opening at the wellhead, the pressure of the steam-liquid mixture can be controlled.

Typically, wellhead pressure is maintained at 60 to 90 pounds per square inch (psi). Steam separates from liquid water at this pressure and is conducted as a gas to run a high-pressure turbine. In a single-flash cycle, the water separated from flashed steam is discharged or reinjected at a temperature of about 150°C and pressure of around 60 psi. In a dual-flash unit, such as Unit 3 at Ahuachapan, the liquid water that is separated from steam at 150°C is allowed to decompress to five or 10 psi above normal atmospheric pressure. In this process, more steam is formed, which is conducted into a low-pressure turbine. The boiling water from the second flash separator comes out at about 110°C and is discharged or reinjected. The second flash increases overall utilization of heat energy by about 10 to 15 percent (for example, about 10 of the 95 MW at the Ahuachapan field is nominally due to secondary flash).

Pressure in geothermal fields drops over time due to two distinct forms of performance decline. First, individual well performance decline may be associated with plugging the pore space in the borehole's immediate vicinity or within the well itself due to the deposition of various minerals, casing collapse or other factors. This decline rate usually differs from well to well and must be dealt with as part of routine maintenance in a

field. Second, reservoir decline is due to a pressure reduction in the entire reservoir, which is due to either a mass extraction rate of hot fluids that exceeds the normal recharge rate and/or encroachment of cold water.

An increasingly common procedure to arrest reservoir decline is to recharge the reservoir by reinjecting around the periphery the boiling water fraction separated from the steam. This is about 80 percent of the total mass that has come to the surface in a typical liquid-dominated reservoir. The risk of injecting fluid at a lower temperature near a hot reservoir is that if the colder water travels too quickly toward production wells, it will not have enough time in contact with the hot rock matrix. Hence, it may cause cooling of the reservoir at a rate that is faster than desired. To reduce the risk of reservoir cooling at an unacceptable rate, injection must be done sufficiently far away from the producing reservoir, but close enough to be in the same stratigraphic horizon, so that pressure will be transmitted back to the production zone. If the fluid is injected across an impermeable boundary, it will do nothing to maintain reservoir pressure.

A distance of two to three kilometers in a moderate permeability horizon is approximately the correct distance to meet both criteria, providing immediate pressure support and minimal reservoir cooling. However, the proper distance for a particular field can only be determined analytically through computer simulation of the reservoir, taking into account rock permeability, the structure and stratigraphy of the reservoir and other factors. Some corrections to the model will be necessary with time, since input into the simulation model is never as complete as required.

2. Project Component Objectives

Due to its volcanism and related geologic forces, Central America is one of the richest regions on earth in terms of commercially exploitable geothermal resources. These resources have been variously estimated to be capable of supporting several thousand to a few tens of thousands of MW in equivalent electrical power capacity. Yet, the total actual installed capacity at this time is only 120 MW--95 in El Salvador and 35 in Nicaragua. By comparison, in the Philippines, where geothermal development began later than in Central America, a total installed electrical capacity of over 700 MW is now in service.

Geothermal power is an excellent complement to hydropower because it is a reliable base-load supply source, undisturbed by seasonal or annual effects. Moreover, economies of scale do not affect geothermal power plants that are greater than about 10 MW. Hence, they can be added in relatively small increments without

straining the economies of small countries, unlike major hydro installations. Because of this independence from economies of scale (above 10 MW), small plant additions can be added on an as-needed basis, thus avoiding the problem of overbuilding. Finally, geothermal plants can be started and completed in less than half the time needed for hydro projects.

A single MW of indigenous power (from hydro, geothermal or any other source) that replaces imported petroleum saves the local economy about US$175,000 annually, at US$16 per barrel with an 80 percent load factor. Aggressive development in Central America of abundantly available geothermal power at the rate of development in the Philippines would generate an additional gross product in excess of US$100 million per year in fuel alone and US$300 million annually in terms of the total value of the electricity. The Philippines success story lies in the development of a foreign investment policy that encouraged U.S. private capital investment during the early phases. In recent years, after training from the foreign private firm, the Philippines national oil company has actually exceeded the outside investor in its rate of geothermal power development.

In addition to electrical power development, geothermal fluids are ideally suited for direct-heat (nonelectrical) uses. In effect, because of the basically low temperature of geothermal fluids (seldom exceeding 250°C), the thermodynamic conversion efficiency of geothermal heat to electricity is quite low, on the order of 12 to 15 percent. On the other hand, when geothermal fluids are used directly to cook, dehydrate, cool or freeze, the actual conversion efficiency is 50 to 60 percent, about four times greater than for electricity production. In other words, one calorie of geothermal heat does about four times as much useful work when used directly for heating or cooling compared to electrical production. (Even at its low thermodynamic efficiency, geothermal power has been determined by the California Energy Commission to be among the lowest cost alternatives available in California, well below nuclear, coal- or oil-based power.)

The price of geothermal heat that can be made available for agro-industrial purposes can be further reduced when the liquid discharged by a geothermal power plant is used prior to its disposal. Typically, a geothermal plant disposes of fluid that is about 150°C at the outlet of a single-flash plant (see the following discussion of the Guatemala direct-heat use project). The discharge contains about one half the heat that was originally obtained from the borehole. That heat could be considered "free" heat energy, other than the cost of the connection between the power plant separator and subsequent disposal. Hence, large amounts of low-cost heat are available at the site of any geothermal power plant. Even with modest development of geothermal power--for instance, several hundred MW

by the mid-1990s, the amount of waste heat available for agro-industrial purposes would far exceed any reasonable level of development.

For example, the team figured that the entire Zunil dehydration pilot plant, which would employ several tens of laborers, would only use about one percent of the total heat output from the adjacent well (Z-3) and around three percent of the energy in the wasted fluid from that well. In another case, the amount of heat being dumped into the ocean from the Ahuachapan plant in El Salvador when it was at full 95-MW capacity was enough to operate a dehydration plant 500 times greater than the proposed Zunil facility, even though the Ahuachapan plant extracts more heat out of the geothermal fluid than a single-flash plant.

In summary, geothermal power development in Central America can greatly contribute to reducing foreign currency expenditures for petroleum imports, accelerate industrialization because of the potentially competitive price for electricity compared to that paid in highly industrialized countries, and support many agro-industrial projects which would benefit from low-cost heating or cooling for their operations. The support of USAID/ROCAP for rapid development of Central America's abundant geothermal resources, by helping different countries to overcome a variety of problems associated with that infant industry, can provide immediate tangible benefits as well as a major positive impact on the region's economies in the long run. Although not explicitly stated, the team concluded that the project has two objectives--to solve some immediate problems and introduce new technologies via actual demonstrations and training.

The remainder of this section is organized geographically, with each country's project described in terms of its goals, LANL's level of achievement and any weakness in either strategy or the final product. Geothermal support equipment is discussed in a separate section (IV.G), since that program component serves the entire region. Training and technology transfer are discussed in two different locations--first, as they specifically apply to any given country and again, in a general way in Section VII.

B. El Salvador

1. Development of the Ahuachapan Field

The Ahuachapan geothermal power plant installation is the oldest in Central America. The field was discovered during drilling in the late 1960s as part of a UNDP-sponsored program. By 1975, the first power unit of 30 MW was in service. However,

it was evident that the field was prolific. Hence, a second 30-MW unit was installed a year later, in June 1976. Without adequate reservoir simulation, the outside contractor (Electroconsult) has concluded that the field could support a third unit, which would be partly (about 25 MW) powered by new wells with the rest (around 10 MW) supported by installing a secondary flash to utilize some of the wasted energy from the single-flash Units 1, 2 and 3. According to Electroconsult, all this could be done without reinjection of wastewater to recharge the geothermal reservoir because of the apparent size of the resource supplying it. Many professionals, including those from the UN, UNDP and CEL, did not agree. However, Electroconsult's view finally prevailed when supported by evidence that some cooling of the reservoir did occur when reinjection was tried. The third 35-MW unit was installed in November 1981.

Subsequently, waste geothermal fluid from the secondary flash unit, discharged at about 110°C, was dumped into the ocean approximately 70 kilometers away through a hot-water conduit, the "Canaletta." Discharging into the ocean began around 1977, when the Canaletta was finally completed, about two years after the start of operations at Unit 1. Up to that time, most of the geothermal effluent was reinjected at the very edge of the producing field, providing valuable empirical data on potential cooling effects in the field.

2. The Ahuachapan Field Problem

In 1981, Ahuachapan generated approximately 42 percent of the electrical power required in El Salvador. Not only was it reliable as a base-load, but it has also been in the most secure part of the country, relatively safe from guerrilla activity. Unit 3 was added to the two other units, which boosted the total potential plant capacity to 95 MW, but geothermal energy supplied from the drilled wells never exceeded about 70 MW. At the same time, reinjection, which had been practiced on a limited basis up to that point in time, was totally curtailed for fear of cooling the reservoir. From 1981 to 1984, total fluid production capacity dropped from around 22 million tons per year to approximately 16.3 million tons annually, an alarming compounded decline rate of 20 percent per year. At present, Ahuachapan supports only 41 MW, a drop of more than 50 percent from its design capacity, and the decline continues, although at a slower rate. Unless this problem is dealt with, the decline will continue until the rate of discharge from the existing well field stabilizes at the natural recharge rate.

The impact of the disastrous decline of Ahuachapan on the Salvadoran economy can be readily estimated, since the shortfall is being compensated for using imported petroleum. The difference between 95 (design capacity) and 42 MW (current actual

production) is about 370 million kilowatt-hours (kWh) per year. The value of imported oil necessary to make up that shortfall, at US$11 per barrel (the current price), is around US$6.4 million per year. The value of the oil plus idle plant capacity, which is being paid back on loans granted to El Salvador, is about US$26 million annually at seven cents per lost kWh or slightly over US$2,000,000 per month.

There is no single project that USAID/ROCAP can undertake which would have a more immediate payoff to any country in the region than restoration of the Ahuachapan field to its full capacity. In light of that assertion, the team examined the LANL program and makes certain recommendations which would initially slow the decline of the Ahuachapan field and, ultimately, bring it up to its original design capacity.

3. LANL Strategy and Subproject Objectives

The study of the Ahuachapan field was not included in the original scope of work for LANL. Early in 1986, discussions were initiated between LANL representatives and CEL concerning the possible use of LANL's borehole logging truck to solve some problems in the Ahuachapan field, which were defined as follows:

> The El Salvador Geothermal Support Project component responds to direct requests from the local USAID mission office and Comision Ejecutiva del Rio Lempa (CEL) for assistance at the Ahuachapan field. Production at this field is steadily declining and a well-logging program is desired to investigate the characteristics of the reservoir and wells responsible for this decline. At the present time, almost no high temperature well-logging capabilities exist in Central America. (LANL, April 1986, final addendum to PP, page 28.)

The 1986 PP addendum goes on to state the benefits of a well-logging program as being able to:

- identify individual damage (i.e., well decline), and
- provide precise data to upgrade reservoir models in the development of reinjection strategies.

As a strategy to achieve these objectives, LANL proposes to conduct detailed well logging, which would permit remedial action for wells that are found to be damaged, or to provide improved pressure data for a better computer model of the existing reservoir. Subsequent studies, not defined in terms of time, "would provide critical input for integrated reservoir

engineering investigations that would culminate in the design and implementation of an effective spent-brine reinjection program."

According to the original plan (p. 37), the logging truck was due to arrive in Ahuachapan by mid-August 1986. During the field visit, the team was informed that due to manufacturing delays, shipment of the truck would be postponed to about mid-November or later. In addition, the final down-hole logging report was to be delivered to CEL by mid-January 1987. Presumably, it will be delayed by three months as well, to mid-April or later. No program or dates have been indicated for the proposed follow-on reservoir modeling, nor plans for subsequent remedial action that would follow analysis of the results of the reservoir model.

The only expected deliverables for this program phase in 1986 are the actual start of logging at Ahuachapan, training CEL and other professionals in the theory and practice of using LANL's sophisticated logging truck, printed copies of actual logging runs and perhaps some preliminary reports of results for logging runs that are completed in 1986. Also, it is understood that LANL will soon complete the operation manual for the logging truck.

4. Findings and Recommendations

Data gathered by the evaluation team--in the form of reports and field pressure-decline graphs as a function of extraction rate--and discussions with Salvadoran professionals clearly indicate that the major problem at Ahuachapan is that the field management strategy designed by Electroconsult is wrong and has resulted in a disastrous decline in pressure and fluid supply rate for the reservoir. Well declines due to individual well damage may be secondary contributors to the total fluid supply decline. Since the causes of the decline in fluid supply rate are so clearly evident, the team strongly recommends modification of LANL's strategy to assist in the solution of the problem, which will require a significant budget increase for that task.

The evaluation team concludes that slight cooling of the reservoir occurred during the period when partial reinjection was practiced because it was done much too close to the producing wells, 200 to 500 meters away. In effect, peripheral production wells were utilized as injectors. Computer modeling, based on inputs that have already been determined for bulk permeability, structure and stratigraphy, should determine a safe distance for injection without having a significant impact on reservoir cooling for several decades (the team guesses two to three kilometers). It should be added that after peripheral reinjection was stopped, the reservoir recovered to its original temperature.

The apparent reason for the fact that reinjection was stopped after the addition of the Unit 3 power plant, which includes a secondary flash unit, is that the field manager was concerned about the impact of reinjecting the colder discharge fluid from the secondary flash. Before the secondary flash unit was built, the temperature of the discharge fluid from the first flash was about 150°C. After adding the secondary flash, the discharge temperature dropped to around 110°C, a significantly colder injectate. Field management must have concluded (correctly) that if 150°C injection caused some cooling problems, the 110°C fluid would cause greater cooling. Hence, reinjection was effectively stopped, which resulted in the disastrous output decline.

The evaluation team's proposed revised strategy consists of several activities. First, a team made up of a hydrologist and a hydrothermal reservoir engineer would immediately begin evaluation of the massive set of geological, hydrological, and reservoir production and injection data to determine reservoir flow patterns and recharge zones. The object would be to identify areas for additional production wells that would augment the present field's supply capacity and potentially valuable reinjection sites. The evaluation team's preliminary data review suggests that recharge of the field flows from the southeast and the main feeder zone for the entire reservoir has not been tapped as yet. The problem of locating good sites for reinjection may be more complex. In the meantime, it is recommended that additional drill pads be readied about one kilometer southeast of the proposed sites for new wells (Ah-33, Ah-34 and Ah-35). This conclusion should officially be brought to the attention of CEL's management immediately.

Second, in parallel, a LANL geophysical team should conduct deep DC-resistivity studies southeast of the existing production field to define its extent and assist in locating additional production well sites, and reinterpret existing magneto-telluric (MT) data gathered by Geosystem, Inc., an Italian consulting company. Although the quality of their data and interpretation appear to be questionable, these data are being employed as the sole source of geophysical support for selecting new drill sites. Based on the OLADE methodology, CEL does not wish to drill production holes without prior geophysical surveys. In the evaluation team's view, this approach is incorrect since borehole data are the very best source of information for predicting reservoir geometry.

Third, the logging crew should run its suite of tools independently to determine the extent of individual well damage and collect precise pressure and temperature data, which would assist the hydrologist and reservoir engineer in their interpretation. The logging findings will be integrated in the fifth task below, the reservoir simulation exercise. However,

logging data are not critical for correcting the reservoir's decline.

Fourth, LANL should also provide any of its findings to CEL's chief geologist on a quasi real-time basis because CEL is planning to drill three new wells in the field and LANL's findings may modify the final drilling locations. The evaluation team took the liberty of providing several drill-hole location alternatives during its field visit, based on an examination of the data shown them. These alternatives could undoubtedly be improved with a more detailed analysis of the data or the generation of new information.

Fifth, a team experienced in geothermal reservoir simulation should be brought in as soon as possible to carry out the simulation. The evaluation team strongly recommends the Lawrence Berkeley Laboratory geothermal reservoir engineering group for this task because of its considerable experience in predictive geothermal reservoir modeling.

Sixth, a detailed analysis should be done to estimate the cost of the additional production wells required to bring the field back to its full capacity (plus some reserve) and for drilling all of the injection wells. A report on that analysis should be made available to potential funding organizations (e.g., ROCAP, AID, CABEI, etc.) as soon as possible to ensure that funds are available when needed.

Seventh, a PERT chart should be prepared for all activities to prevent any delay in actual drilling, injection strategy completion and mechanical engineering for the entire system. For example, required funds should be secured by the time the reservoir engineering and hydrology team has completed its work.

The first four tasks and the seventh should be completed in 1986. The fifth and sixth may require work through March or April 1987. The evaluation team does not consider the delay in the arrival of the logging truck to El Salvador to be a critical issue because the data it would provide would be supplementary, rather than critical, to the development of a resuscitation strategy for the Ahuachapan field.

The evaluation team believes that the above rescheduling may accomplish rehabilitation of the Ahuachapan field and its augmentation to the power plant's full design capacity several years earlier, which could become the most tangible contribution of LANL and USAID/ROCAP in Central America as part of the project. Since the measurable benefit to El Salvador's economy of bringing Ahuachapan back to full capacity is about US$26 million per year, the entire LANL program will be paid off several times over if, as a result of LANL's efforts, Ahuachapan attains full production several years earlier than expected.

Assuming a four-year gain through aggressive rehabilitation efforts, the Salvadoran economy would realize a total savings of about US$108 million. The evaluation team estimates the cost of rehabilitating the Ahuachapan field--through drilling required make-up production wells and a full set of injection wells--at about US$25 million, and could be as high as US$30 million if some spare capacity is provided. The total investment in field rehabilitation would be paid back 100 percent from one year's gain in revenues.

The team doubts the wisdom of using the fluid separated from steam in the first stage of flashing for a secondary flash if the reservoir is restricted in terms of area. On first examination, it may appear that going through two stages of flashing makes better use of the resource because of the increase in overall electrical power production for the same amount of extracted fluid. On the other hand, reservoir simulation may prove that the contribution of the fluid separated during the first flashing stage is greater as a medium for both heat and water recharge. In such a case, it may be that a single-flash operation results in greater long-term benefits.

If additional scientific investigations and production drilling show that the Ahuachapan geothermal field is small in terms of area, there may be no room to locate injection wells far enough away from production wells within the field perimeter--in that case, the higher the temperature of the injectate, the slower the cooling rate at the locations of producing wells. Furthermore, the actual experience of injection history during the early years of field operations clearly demonstrated that alternating injection between two sides of the field actually works. As adjacent production wells cooled down in response to nearby injection, the field manager would stop injection on that side of the field and inject on another side. Within a year or two, the cooled production wells on the side where injection was stopped would recover to their original temperature.

Recalling the difference of about 40 to 50 calories per gram between water discharged after the first and second flashes, it may turn out that recharging the reservoir at the higher temperature (if there is no room to locate injection wells further away from production wells) is more beneficial in the long run than the marginal gain of about 10 MW which is obtained if a dual-flash system continues to be utilized. The team also believes that injection wells will scale up more rapidly at the lower injection temperature because the precipitation of silica out of slightly concentrated geothermal liquid is inversely proportional to the temperature of the injectate. The issues raised here should be evaluated during reservoir simulation with a power plant design engineer, who would evaluate the contribution of the second flash and costs associated with design modification of Unit 3. A geochemist might provide input on

injection well scaling potential at different temperatures. It is recommended that this reservoir management strategy review should begin early in 1987 to dovetail with the reservoir simulation exercise.

C. Honduras

1. Purposes and Objectives

The objectives of the Honduras geothermal reconnaissance have been defined by LANL as follows:

> The purpose of the Honduran geothermal reconnaissance project is the identification of promising sites for geothermal electric power production. This involves gathering surface and subsurface geologic evidence upon which to base predictions of likely fluid temperatures at depth in specific locations. Surface geology, geochemistry, shallow drilling and deep resistivity tests are combined to identify specific locations and depths at which fluid temperatures are likely to be high enough to support electricity generation. (Central America Energy Resources Project, April-June 1986 Work Plan)

2. Background

The geothermal manifestations in Honduras may be considered modest in comparison with those of other Central American countries, although certainly abundant relative to other nations. A field trip by UN experts in 1976 identified several areas as having potential for geothermal power production. In 1977, a U.S. consulting company, Geonomics Inc. of Berkeley, California, carried out the first geophysical surveys for some of the identified localities with encouraging indications. In 1980, another U.S. consulting organization carried out a slightly more detailed geological and hydro-geochemical survey of the country and enlarged the list of potential targets for detailed geothermal exploration. The work by LANL is a natural follow-on to the above programs, providing detailed geological, hydro-geochemical and geophysical data for six target areas--San Ignacio, Platanares, Azacualpa, La Ceiba, El Olivar and Choluteca (Pavana). Initially, some shallow thermal gradient drilling was to follow the completion of the drilling phase. That approach has been abandoned in favor of two intermediate-depth test holes (about 500 meters) at the most promising sites.

In parallel with LANL activities, UNDP signed an agreement with Empresa Nacional de Energia Electrica (ENEE) in January 1985 to provide a geothermal exploration program for the central region of Honduras. The total external budget for that project is US$2.29 million, of which the Italian government has contributed $1.7 million and UNDP, US$0.59 million. In addition, ENEE is committed to provide 1.34 million lempiras (or US$670,000 equivalent) in equipment, facilities, personnel and services. DAL, an Italian consulting firm, was selected as the project contractor.

Some concern arose about possible duplication of effort since two of the sites to be covered by the LANL/USGS team (San Ignacio and Azacualpa) were also included in the UNDP program. This was theoretically resolved in a series of conferences between the LANL/USGS and Italian teams. In general, the Italian team felt it was necessary to carry out large-scale regional studies, following the OLADE methodology, covering an area of several hundred square kilometers around each geothermal target. The LANL/USGS team tended to conduct detailed hydro-geochemical and geophysical surveys for areas covering only a few tens of square kilometers around each site with geothermal manifestations. The document summarizing the meeting of the two teams is couched in politely diplomatic language, but reveals major differences in approach. To an outside reviewer working in the industrial sector, the debate between the Italian and LANL/USGS teams is reminiscent of early Medieval debates between the Roman and Byzantine churches on the true axioms of faith--the OLADE geothermal exploration methodology was valiantly defended by the Italian scientists, politely ridiculing others for deviation from the accepted truth.

The resulting compromise was that the LANL/USGS team would do detailed work for three overlapping sites, while the Italian team would provide a larger-scale geological, volcanological and geophysical framework, which would provide an intellectually satisfying, unified, geothermal field theory. The Italian team also undertook to assist ENEE in developing a geochemical laboratory and provide training in that area. In addition, the UNDP program has US$250,000 for shallow to intermediate-depth drilling. Presumably, the UNDP drilling will be done in the San Ignacio area and LANL drilling in the Platanares area, but no final agreement has been reached on that subject.

3. Findings and Conclusions

First, the LANL/USGS team has completed hydro-geochemical investigation of the six geothermal sites. A report on the results of these studies has been written and is in the final editing stage. The work conducted appears to be complete in every sense for this stage of exploration, and the report is

excellent. There is little doubt that this definitive work will be the basis for any follow-on activities in the areas investigated. The contribution of the USGS survey team to LANL's effort is considered to be of great value. USGS should continue to be invited to participate in any future geoscientific investigations.

Second, a final project report for Platanares has been printed in English and Spanish. The key findings are that a reservoir of 220°C or higher has been confirmed and the calculated hot water leakage to the surface is equivalent to the energy requirements for a five- to eight-MW plant. The actual size of the reservoir may be able to support a much larger plant because of the extent of leakage manifestations over two or three square kilometers. Preliminary indications, yet to be supported by geophysical fieldwork and test drilling, may verify the impression that the reservoir is shallow.

Third, reports on the results of the geothermal investigations are currently being prepared for San Ignacio, Azacualpa and Pavana.

Fourth, self-potential and gravity surveys have been partially completed. Final reports are to be submitted by 31 December 1986, as scheduled.

Fifth, preparation for intermediate drilling (i.e., contract negotiations with a drilling contractor) has been completed, with the objective of finishing at least one, but more probably two, intermediate-depth holes during the fourth quarter of 1986.

Sixth, drilling to reservoir depth and full-fledged well testing, accompanied by economic analysis, are the key to obtaining financial support from banking institutions. Geothermal development throughout Central America for electrical and nonelectrical purposes would be greatly accelerated if full-depth, production-diameter wells are drilled in areas with the potential for economic development.

4. Recommendations

The LANL/USGS team has provided a properly focused evaluation of six geothermal sites, resulting in valuable guides to rank those sites in terms of their favorability for further investigations and potential test drilling. The excellent reports produced thus far are important milestones in the orderly development of the geothermal resources in Honduras. The evaluation team believes that LANL's more focused, detailed work will provide greater benefits than the UNDP effort. It is anticipated that follow-up geophysics would provide valuable data for ranking sites chosen for detailed geophysical mapping.

The budget for drilling, which is barely sufficient for two holes about 500 meters deep, is considered inadequate. Attempts should be made to double or triple it through budget substitutions, additional ROCAP support, ENEE logistical support (i.e., camp and site preparation, which would reduce the drilling contractor's charges for non-drilling activities) or an outright contribution by ENEE. After all, ENEE would normally borrow money for hydro-project pre-feasibility studies. There is no reason it could not obtain funds to support geothermal pre-feasibility studies that have reached the test-drilling phase. The excellent data gathered by the LANL/USGS team in the hydro-geochemical phase should provide ample support for borrowing additional funds, if necessary.

The evaluation team's strong recommendation regarding test drilling (even if it is merely slim-hole, intermediate-depth) lies in the fact that the exploratory drilling phase may actually confirm the existence of a reservoir. In addition, it may provide quantitative data on the actual reservoir temperature and chemistry as well as reservoir permeability. If successful, the exploratory drilling phase takes years off the actual sequence of steps to finance production drilling and power plant construction. For example, the evaluation team's field examination of the proposed drilling site and depth for the second Platanares hole suggests that a 500-meter hole may bottom just above the controlling fault which leaks boiling water into the river. If the controlling reservoir factor is the fracture zone associated with the fault, a sufficient budget should be available to reach that fault, if no permeable reservoir is encountered at a shallower depth.

The evaluation team recommends that LANL carry out an economic pre-feasibility study for combined electrical and direct-heat use of geothermal power at Pavana, near Choluteca. The DC resistivity survey conducted in that area has fully defined a relatively small, but shallow, reservoir. The site is, in effect, ready for production drilling. The geochemical studies indicate that the reservoir temperature would not exceed 160°C or so, making it seem less attractive. However, a development near Choluteca has several advantages--it is near the agriculturally rich Choluteca area, on a flat valley floor that would require minimal site preparation, near a highway and excellent accommodations, and very close to a port. Intergovernmental negotiations are now taking place to make the Choluteca area a foreign free-trade zone, which would result in considerable economic activity in the area. It would undoubtedly create a need for refrigeration or freezing plants for meat storage near the port.

D. Costa Rica

1. Geothermal Developments

Starting in 1975, the national electric power company, Instituto Costarricense de Electricidad (ICE), began exploring for geothermal resources. The initial reconnaissance program resulted in the conclusion that the Miravalles region in the Guanacaste Province was a promising target. After a delay of over three years (due to the lack of a comprehensive exploration and development plan from start to finish), several successful holes were drilled in 1979 in the Miravalles geothermal field. Present data suggest that it could support 150 MW or more of geothermally based electricity. In 1985, after a delay of another five years, Electroconsult completed a detailed feasibility report for the first 55-MW unit. A feasibility study is now underway for the second 55-MW unit. The first unit is scheduled to go on line in 1991, the second in 1993, and a third is tentatively scheduled for 1998. Sources of financing for the first unit were IDB (50 percent), the Japanese government (35 percent) and Costa Rican national resources (15 percent).

At this time, ICE has a total of about 789 MW of installed capacity, of which about 30 percent is based on thermal power, the balance being hydro. The Arenal dam provides 330 MW or about 42 percent of the entire system capacity. At this point, Costa Rica has excess electrical capacity because the growth rate of the economy has been slower than expected and decreases in the purchase of electrical power by Nicaragua. ICE aims to diversify its electrical resources by studying new potential hydro resources. If geothermal power is proved to be reliable to ICE's satisfaction, it may provide the diversity, base-load reliability and petroleum import reduction that the country needs.

Problems were encountered during test operation of the Miravalles wells. The chief problem has been identified as calcium carbonate scaling at the slotted liner openings of the production interval and inside the production casing. This well decline restricts the output of individual wells, making field development and maintenance costs higher than anticipated.

In addition, ICE has expressed a desire to obtain assistance in surveying other geothermal sites outside the Miravalles area, to provide it with the information needed for long-term rational planning of its electrical resource development. It should be remembered that hydro project developments normally require 10 to 15 years for implementation. Hence, planning for any major hydro project to start operating at the turn of the century should begin within the next year or two. However, the decline in electricity sales has reduced the pressure on ICE's planning department.

In parallel to its discussions with LANL, ICE has concluded an agreement with Ente Nazionale per l'Energia Elettrica (ENEL), the Italian national power company, to conduct a very large-scale geothermal reconnaissance survey of the entire backbone of the country, initially covering about 60 percent of Costa Rica, approximately 25,000 square kilometers. The reconnaissance survey would cover the entire Cordillera belt, from San Isidro to the southeast (about 60 kilometers to the southeast of San Jose) all the way to the Nicaraguan border to the northwest. The total project cost is estimated at about US$2,000,000 in 1982 dollars, of which about 14 percent would be ICE's contribution in kind, with the rest coming from ENEL. The project will be run under the aegis of the UN, but ENEL will act as project manager. It is due to start in January or February 1987 and will last 27 months. In the opinion of the evaluation team, this effort by ENEL, UNDP and ICE reduces the importance of any additional reconnaissance.

ICE's discussion with LANL revolved around two areas of support that ICE considered to be of value--assistance in solving issues surrounding the reduced output of wells in the Miravalles field, and detailed geological, geochemical and geophysical mapping of certain geothermal targets in the Rincon de la Vieja and Tenorio areas, bounding the Miravalles field to the southeast and northwest, respectively.

2. Findings and Conclusions

To solve issues surrounding the scaling problem in the Miravalles field and provide precise temperature, pressure and fluid entry information, LANL imported its own (i.e., the U.S. Department of Energy's) logging unit from the United States. Logging the temperature, pressure and flow of several wells was successfully conducted and basic data obtained. This was done partially under flowing well conditions, which severely tax the integrity of any down-hole tools.

In parallel, LANL completed the design of a new logging truck, including all of the software, hardware and down-hole tools. It also managed the procurement and fabrication of that unique equipment. Despite a delay of several months, it is now anticipated that the new logging unit will arrive in Central America in mid-November. In the opinion of the evaluation team, that delay is not critical to any of the projects in the region.

The highly sophisticated data, which were obtained under conditions that are beyond the measurement capabilities of giant service companies (e.g., Schlumberger or Halliburton), will permit scientists and engineers to take remedial action, where necessary. The evaluation team believes that the logging and sampling effort at Miravalles will likely provide the necessary

engineering and scientific data to implement corrective measures for the well-scaling problem.

To summarize:

- the first cycle of borehole logging and fluid sampling at Miravalles has been successfully accomplished, and important data for remedial work, as well as analysis of the causes of scaling, have been obtained;

- completion of logging activities in the remaining holes will provide information that is as valuable as the data obtained from holes that have already been logged;

- the work plan for geothermal reconnaissance of the Guanacaste Province overlaps with that of UNDP and ENEL--duplication of effort may occur if no coordination is achieved, and there is no acknowledgement in either UNDP or LANL documents of effects planned by the other entity; and

- Costa Rica is currently a net energy exporter and, hence, is not under the same pressures as El Salvador, Honduras or Guatemala.

LANL plans to complete the logging program at Miravalles, providing ICE with a comprehensive set of logs as well as samples of geothermal fluids collected by LANL's down-hole string at reservoir depth (unaltered by flashing and pH changes that would take up in the hole). Separately, LANL is considering doing detailed geoscientific mapping of the Rincon de la Vieja and Tenorio areas in the Guanacaste Province. This proposed effort would continue until 1990, according to LANL's proposed work plan. The resulting reports would not include any feasibility or pre-feasibility analyses, but would make recommendations for future work on such analyses, presumably during the post-1990 period.

3. Recommendations

First, the ARD evaluation team recommends that there be no consideration for funding of the geoscientific reconnaissance effort in Guanacaste Province until:

- a meeting is held with UNDP and ENEL to find out the precise scope of their work; and

- an economic and planning analysis is made of the feasibility of conducting a highly detailed

geoscientific set of studies, the results of which may not be put to use in the form of exploration drilling for many years.

In general, the evaluation team believes that the degree of detailing for a prospect, which is often done as an iterative process, should be commensurate with the decision process to invest in the given target.

Second, upon analysis of the energy situation in Central American countries, it is the opinion of the evaluation team that funds allocated for the Costa Rican reconnaissance project would be better utilized in solving the problem of the Ahuachapan reservoir's decline or for other valuable projects.

Third, as part of the solution to the scaling issue, the evaluation team recommends that LANL employ a geothermal reservoir chemist to investigate the feasibility of eliminating scaling in boreholes. The actual location of scaling in a borehole can be controlled to some extent by controlling wellhead pressure and flow rate. If the flow rate is restricted by partially shutting down the wellhead valves, scaling will tend to occur further up in the hole, away from the slotted liner at the bottom. Scaling removal from blank casing by mechanical cleaning is a common procedure in some geothermal fields. Total flow from any given well can be increased to compensate for higher wellhead pressure (i.e., restricted flow) by increasing the diameter of new wells. Various chemical companies have come up with additives that eliminate carbonate scaling at a modest cost. Detailed engineering and cost analyses could be profitably conducted and actual testing done by ICE. An advisory panel is looking into the use of chemical additives as scaling inhibitors.

E. Guatemala: Direct-Heat End-Use Activities

1. Background

The utilization of low-cost or free geothermal heat (or waste heat from geothermal power plant operations) in agro-industrial processes can create highly profitable, value-added products. In general, this can generate an important domestic and foreign revenue base for the country as a whole, but especially the agricultural sector. Geothermal heat is particularly suited for direct-heat uses when associated with a geothermal power operation. If used by a dehydration plant, the amount of waste heat discharged by a typical geothermal well would be sufficient for an operation about 20 to 30 times larger than the pilot plant proposed for Zunil (see a later section).

Large paper and pulp production facilities have been in operation in Rotorua, New Zealand, for decades. All of the space heating in Reykjavik, Iceland, is provided by geothermal power (about 100 MW equivalent). There is a major onion and garlic geothermal dehydration plant in Brady, Nevada. Milk sterilization using geothermal heat has been done in Oregon. Ethanol was produced in Nevada utilizing low-grade geothermal power. The eastern bloc countries use geothermal heat in greenhouse operations on a large scale. Salt production using geothermal heat is done in the Philippines.

In summary, geothermal energy can be used for dozens of agricultural and industrial operations at very significant cost savings. All industrial or agro-industrial processes that require moderate-temperature heat energy can benefit from the low-cost geothermal heat which is widely available in Guatemala. This is especially true in areas where geothermal plants may be constructed, since they will be discarding about half of the energy produced by the wells as waste heat. Low-cost geothermal heat can be the basis for internationally aggressive export industries in almost all Central American countries.

2. Subproject Objectives

The objectives for this project have been described in the Central America Energy Resources project document of March 1985 and are further amplified in the April 1986 final addendum. The primary purpose was summarized in the LANL quarterly work plan (October-December 1985) as follows:

> The Direct Application of Geothermal Heat in Guatemala component is designed to identify the potential for the use of low- to medium-temperature fluids to provide process heat in agricultural, commercial and industrial applications. The use of geothermal fluids in this way would provide direct substitution of an indigenous, renewable resource for imported petroleum.

Project reports give the following further information on the objectives of geothermal direct-heat activities in Guatemala:

> The program has two major short-term tasks: the early establishment of a small demonstration project . . . and a feasibility study for a later, commercial-sized agricultural processing center (APC). Longer-term goals are the building and operation of the APC and also a feasibility study of a geothermal heat system servicing the industrial park near the Amatitlan geothermal area. The only significant effort at present is being applied to

> the short-term tasks. (A SURVEY OF GEOTHERMAL PROCESS HEAT APPLICATIONS IN GUATEMALA, in draft, July 1986, p. 5.)

According to LANL,

> The evolution of thinking regarding geothermal direct-heat activity appears to be as follows. Much of the survey work was directed at the resource around Amatitlan (about 25 kilometers south of Guatemala City), at the request of MEM and INDE, Guatemalan counterpart organizations. The other geothermal field, which is more developed, is at Zunil, and although a survey was done for the area, INDE was emphatic that Zunil was to be reserved for power generation only. However, in December 1985, INDE reversed its position, and possibilities for using geothermal heat for agricultural processing arose because Zunil is located in the middle of a rich agricultural region. AID urged LANL to select agricultural processing. MEM and INDE concurred, and a program was then planned for two geothermal heat-use activities--an early demonstration of a small fruit and vegetable dehydration facility, and a feasibility study of a commercial freezing and dehydration plant.

It is anticipated that the plant will use heat and power supplied by INDE and be operated by the private sector. INDE is contributing a significant amount of manpower to help make this project a success. Funding constraints in FY86 caused most of the effort to be concentrated on the small demonstration. However, increased funds for FY86 will permit a market survey that will be followed by a feasibility study of the full-scale plant after a period of operating the small demonstration facility.

Feasibility Study

Thus far, the feasibility study for a commercial-sized agricultural processing center consists of two elements:

- a preliminary economic argument; and
- a survey of direct-heat applications

The preliminary economic argument in favor of the economic feasibility of the agricultural processing center is as follows:

> In the present configuration, without additional, closer industries, preliminary calculations yield

> heat costs from $2.00 to $5.00 (US) per million Btu. This compares favorably with a cost from petroleum-based fuels of about $8.00 per million Btu (at oil prices just before the recent decrease). On the other hand, for larger, favorably placed industries, heat costs down to $1.00 per million Btu are anticipated. It is most favorable if geothermal heat costs can be less than the costs for competitive fuels. However, it must also be remembered that even if the costs between competitors are equal, the geothermal heat is indigenous and decreases the need for petroleum imports. (A SURVEY OF GEOTHERMAL PROCESS HEAT APPLICATIONS IN GUATEMALA, in draft, July 1986, p. 16.)

Presumably, efforts are being made to expand on these preliminary calculations and apply models that take current oil prices into account. It would be a major step forward if the energy situation analysis component of the project could be used to compare different direct-heat applications.

Project documents describe the direct-heat survey work as follows:

> Two surveys have been made of the possibilities for industrial application of geothermal process heat. These surveys cover 35 industries in the Amatitlan and Zunil areas and were concerned only with existing industries. (A SURVEY OF GEOTHERMAL PROCESS HEAT APPLICATIONS IN GUATEMALA, in draft, July 1986, p. 11.)

LANL has retained the services of ICAITI to assist with the identification of direct-heat use opportunities. Contributions were also made by MEM and INDE. The study identifies specific direct-heat applications for various areas of Guatemala. It also specifies potential future uses that could serve as the basis for new industrial developments. That study, now in the final editing stage at LANL, has identified various direct-heat uses that might be implemented at or near the geothermal sites. Existing industries with operations that consume a large amount of heat energy have been surveyed by MEM and ICAITI. They include beer production, hotel operations, polystyrene foam production, and textile sanforizing and drying. These facilities require the transportation of heat to them. Hence, the heat source must be located nearby for economic utilization. On the other hand, new industries may be willing to relocate to be near an abundant, low-cost energy source. However, to achieve such relocation, an agency for economic development must create appropriate industrial parks and clearly specify the terms for obtaining land, services and heat energy. At this point, none of that exists in Guatemala.

ICAITI has also identified some potential new opportunities for harnessing low-cost geothermal heat in the Amatitlan and Quetzaltenango areas. First, a plant to produce 10 million gallons of ethanol per year is proposed. Ethanol can be used to make gasohol, a gasoline/ethanol mixture that can serve as a normal fuel for vehicles and could save the Guatemalan economy the importation of 10 million gallons of gasoline per year. (Cars operating on pure ethanol are common in Brazil, the world leader in the use of ethanol as vehicle fuel.) Ethanol is a common product in chemical operations. The United States imports large quantities of ethanol, mainly from Brazil. Since the raw material for ethanol is sugarcane, underutilized sugar plants in Guatemala may get a new lease on life as a source of bagasse for ethanol production plants. The total investment required for this program would be about US$10 million.

Second, an ambitious proposal for the production of polyethylene would use ethanol as a raw material. A comprehensive market survey, process analysis and study of financing availability must be carried out prior to consideration of this alternative. The total required investment is estimated at US$44 million.

Third, about 70 percent of the salt consumed in Guatemala (i.e., approximately 35,000 tons per year) is imported from Brazil. Refined salt production of about 10,000 tons annually could be accomplished with an investment of about US$700,000 per year.

Fourth, ICAITI believes that local demand for methanol will be one million gallons per year by 1990. This project would require an investment of about US$10 million.

Fifth, it is estimated that about 10,000 tons of bleached pulp from sugarcane bagasse can be produced annually for a capital investment of about US$22.6 million. This project may reduce imports of pulp into Guatemala and Central America.

All of these proposals are accompanied by rudimentary economic analysis. So far, the analysis exists only in draft form, so a detailed criticism here is not warranted. However, it is fair to note that AID and ARD economists who have examined this work are concerned that the utility of the final product may be limited by the following weaknesses:

- the economic analyses include little market assessment;

- production costs for some applications are unrealistic and other are so high as to be noncompetitive;

- at times, electricity costs are included when the purpose of direct heat is to eliminate the need for electricity; and

- transportation costs are not always considered.

The objective of the feasibility work should be a "bankable" study that will attract investment for the development of geothermal direct heat and industry based on it. The components of such a bankable study would seem to be the identification and quantification of production methodology and costs, a market for products, marketing mechanisms, economies of scale for transportation and marketing costs, and competitiveness in terms of product quality and sales prices. Some market assessment for dehydrated products is being carried out on behalf of the Zunil direct-heat demonstration by CLUSA.

Zunil Direct-Heat Demonstration

LANL has identified the opportunity to design and install a geothermally based dehydration pilot plant at Zunil as a potentially valuable demonstration. In Zunil, high temperatures (nearly 300°C) have been proven through drilling, and a very significant amount of waste heat is readily available. LANL has completed a preliminary design of the dehydration plant that is now under review. INDE has given verbal consent for utilization of the unused part of the level ground next to the third well (a lot of about 18 by 70 meters) for the demonstration plant.

The following is a brief description of the Zunil geothermal direct-heat demonstration:

> The demonstration project is a food-drying facility that is being designed and sited jointly by INDE and LANL. INDE will provide the geothermal fluid source. The material for its construction and the labor for operation will be paid for by LANL, while INDE will provide the labor for its construction. MEM will participate in the market studies needed to select foodstuffs to be treated during the demonstration. (A SURVEY OF GEOTHERMAL PROCESS HEAT APPLICATIONS IN GUATEMALA, in draft, July 1986, p. 5.)

The demonstration will consist of a small, versatile demonstration plant that can dry any of a number of different agricultural products. Some or all of the following will be dehydrated--garlic, onions, apples, apricots, peaches, pineapples and bananas. AID is considering providing a food-processing specialist for a period of one month. As currently planned, the drying plant will occupy space on a hillside near the geothermal

well. The evaluation team expressed fears that this space is too small, even for a pilot plant, and allows little room for storage, offices, turnaround space for trucks or expansion (in case the plant is a success). Also, the location of the plant so near the geothermal source may result in health hazards and equipment damage from corrosion due to the sulfur fumes. However, some of these concerns were being addressed by LANL in response to suggestions from the evaluation team.

Charts describing the brief demonstration of geothermal direct-heat applications at Zunil give the following objectives--generate employment, reduce fuel imports and energy costs, and save crop marketability. These are hypotheses that must initially be tested, not proven facts that merit demonstration. The Zunil direct-heat demonstration seems to be reversing the order of proving the economic feasibility of a technology before publicizing and promoting it. The ARD team fears that the Zunil direct-heat demonstration may raise false expectations regarding direct heat and burden Guatemalans with operating costs that cannot be covered. If these are specific technical or economic questions, they need to be clearly stated.

The following discussion is based on conversations with project participants and a review of project documents. It attempts to develop a solid rationale for the Zunil pilot project. If the objective of the demonstration is not to produce a bankable economic feasibility study, it still might be used as a "learning laboratory" or experiment to learn lessons in technical and especially, management and organizational areas. There seem to be some technical lessons to be learned from the Zunil demonstration as well as lessons regarding the dehydration of different Guatemalan products. However, there may be more to learn from the Zunil demonstration in terms of management, control and participation than the technology or production costs. If designed and managed properly, it seems that the Zunil demonstration might be a setting for determining the most effective management, control and pricing structure for the delivery and use of geothermal direct heat. Obviously, more can be learned about pricing if users are charged.

The idea of the Zunil demonstration might be to learn about managerial and organizational structure, and train local people in the operation of a geothermal dehydration plant. If so, the project is not off to a very good start by failing to involve GREMIAL in a more active role. When the evaluation team met with the local GREMIAL staff in Quetzaltenango, they were enthused about the demonstration's potential, but also concerned about their role and the eventual benefits.

The Zunil pilot demonstration will definitely be used to train Guatemalan technicians in managing a geothermal plant and dehydrator. This training must include technical installation,

pricing, promotion, marketing and accounting. Before such training is undertaken, LANL should be clear that the demonstration has good economic and financial prospects.

3. Summary

This subsection summarizes the progress of the LANL project on geothermal direct-heat applications relative to the official objectives listed in project planning documents. In terms of establishing counterparts and training them in appropriate methodologies, solid contact has been established with INDE, but only an uncertain relationship has been initiated with GREMIAL. In both cases, a clear definition of the objectives, benefits and division of responsibility regarding direct-heat applications is lacking.

The survey of direct-heat requirements and applications, along with selection of the most promising uses, is in draft. It is a preliminary survey of direct-heat uses in geothermal areas. The economic analysis should be considered preliminary and not the definitive basis for selection of the most promising uses.

A technical exchange meeting to disseminate information about direct-heat applications and solicit comments from the private sector was held, but cannot be the last meeting if this component is to succeed. Meetings to disseminate substantive results from the feasibility and demonstration work will be needed.

The final objective--selection of the two most promising applications and completion of feasibility studies--has been met in a modified form through the selection of dehydration of agricultural products.

4. Findings and Recommendations

Economic Feasibility Study

Finding: To launch a serious geothermal direct-heat program throughout Central America, a bankable study of economic feasibility is needed, probably focused on the processing of agricultural products.

Recommendation: A detailed study of commercial-scale, agricultural-processing applications of geothermal direct heat should be conducted, based on data obtained from the demonstration plant. The components of such a study should be the identification and quantification of production methodologies and costs, product markets, marketing mechanisms, transportation

and marketing costs, and the competitiveness of product quality and sales prices.

Zunil Pilot Demonstration

Finding: Documents and conversations with participants revealed confusion regarding the objectives of the geothermal direct-heat application project at Zunil. It is unclear whether a demonstration, experiment or feasibility study (or some combination thereof) is planned.

Recommendation: The objective of the Zunil geothermal direct-heat application must be defined before going any further. The lack of clarity concerning objectives and the division of benefits and responsibility is already harming relations with counterpart groups.

Finding: At Zunil, LANL will be demonstrating a technology application whose economic value for rural Guatemala has not yet been proven, even in a general way.

Recommendation: Care must be taken to avoid saddling Guatemalans with operating costs that may not be met by sales revenues. The way to accomplish this objective is through agreements with GREMIAL, the Indian Agricultural Cooperative and INDE for follow-on management after the one-year LANL demonstration. An agreement should be made with GREMIAL regarding operation of the plant, with INDE's concurrence--that agreement should contain provisions regarding management after the end of the LANL demonstration phase.

Finding: The current written agreement with INDE is general and does not cover the specific issues raised by the Zunil demonstration. No decision has been reached concerning the terms of heat supply by INDE prior to start-up of the Zunil power plant in 1990 and thereafter. No agreements are in place with GREMIAL as to operation and management of the plant during the demonstration phase and afterwards. No discussions of any type have been held on duration of a lease for the land where the plant is to be built.

Recommendation: Before undertaking the Zunil demonstration, an agreement with INDE, GREMIAL and the Indian Agricultural Cooperative must be written that covers the following areas--tenant rights on INDE land, continuity of the heat supply, conditions under which heat curtailment must occur, price and form (pressurized hot water) of the heat, and responsibility for disposal after the geothermal fluid passes through the pilot plant.

Finding: LANL management has made inadequate utilization of its local representatives, who are fully capable of negotiating the above agreements if so directed.

Recommendation: Local LANL representatives must be given the responsibility to negotiate and sign agreements with local organizations.

Finding: More can be learned about the pricing and management of geothermal direct heat if users are charged for it.

Recommendation: Consideration should be given to charging direct-heat users a price similar to that required under unsubsidized operating conditions.

Finding: Analysis of hydrogen sulfide emissions has shown that the amount of poisonous gas discharged at the Zunil site is at levels deemed by LANL to be noninjurious.

Recommendation: A permanent hydrogen sulfide emissions monitoring and alert system should be included in the plant design.

Bi-Phase Well Power

The proposal to place a new, relatively unproven, turbo-generator (the so-called bi-phase machine) in service has fallen by the wayside because of a change in fluid characteristics at Zunil.

F. Major Recommendations

The following are general recommendations. They are not intended to exclude activities that spill over from 1986 (for whatever reason), nor are they meant to eliminate other, smaller components of the overall program.

1. El Salvador

Hydrological, reservoir engineering geophysics and well-logging activities should be carried out to provide the necessary data to locate new production and injection wells. An intensive three months should be spent on hydrology, geophysics and well logging. Reservoir engineering and supportive geology, hydrology and well logging should continue throughout the well-drilling program. Reservoir engineering should continue for a minimum of six months after the completion of drilling. Lawrence Berkeley Laboratory should be invited to collaborate. A report on the total cost of designing, drilling and hook-up for the Ahuachapan

rehabilitation program (production and injection wells included) should be prepared early in the program. Contacts with financial sources should be initiated. The minimum total duration should be 30 person-months.

2. Honduras

The geophysical studies at Platanares should be completed. LANL should solicit funds for the larger, intermediate-depth, drilling program. The project should drill at Platanares and prepare a report. If a commercial reservoir is encountered during drilling, a well-testing program and preliminary reservoir engineering should be conducted. The well and reservoir report should then be written. An economic analysis of the opportunity for consideration by the financial community should be prepared and a counterpart trained. Six to nine months are required for this work.

The Pavana area should be evaluated for direct-heat uses. The foreign free-trade zone at Choluteca should be discussed with the government and funding for cofinancing of the project sought. A pre-feasibility and marketing report should be prepared. If drilling funding is obtained, the project should drill and evaluate its results. Then, a feasibility report should be written. Depending on financing, this should take three to 15 months.

3. Costa Rica

The project should log the wells at Miravalles, train a counterpart and prepare a technical report to solve scaling problems. Geothermal reconnaissance should be cut back to an absolute minimum or eliminated altogether because of its low priority. Logging and report writing will each take three months.

4. Guatemala

The project should complete the redesign of the geothermal direct-heat facility with the help of an outside industrial engineer who has food technology experience. A feasibility report should be prepared. Negotiations and contracts with INDE and GREMIAL should be completed. The facility should be constructed and managed by GREMIAL in collaboration with the Indian Agricultural Cooperative. The staff should be trained. A final report should be prepared, and the feasibility report revised.

G. Support Equipment for Central America

1. Subproject Purpose and Objectives

LANL proposed to design, specify, fabricate and deliver three advanced geophysical instrument packages to Central America. These systems would assist in the exploration, development and operational maintenance of geothermal fields in the region. This advanced technology would be transferred into the region before actual utilization of specific systems to solve particular scientific and engineering problems and provide initial training for local professionals in use of the equipment and interpretation of the data obtained. This training is to be provided in the field and classroom exercises at home and LANL. Ultimately, LANL hopes that the professional skills of Central Americans engaged in geothermal energy exploration and development will be enhanced through the collaborative fieldwork and classroom exercises.

2. Background on Logging and Field Geophysics

Logging Equipment

Geothermal wells, with their high temperatures and pressures, occasionally corrosive fluids, high fluid velocities and other problems, constitute a notoriously difficult working environment. None of the major borehole logging companies, such as Schlumberger or Halliburton, provide tools that can operate at temperatures higher than 150 to 175°C. They normally demand that geothermal clients cool their wells below these temperatures before they agree to lower tools into the boreholes. Naturally, when a temperature profile is one of the desired parameters, cooling the hole prior to logging makes no sense.

Starting about 15 years ago, LANL began research on hot dry rock technology, to extract heat from hot rocks that have no porosity or permeability. Upon discovering the absence of satisfactory tools to measure properties of hot subsurface rocks, LANL proceeded to develop them. Within a few years, LANL scientists designed and fabricated the finest high-temperature logging suite of its type anywhere in the world. Not only was the LANL equipment able to withstand the hostile conditions at depth, but could actually record up to six different variables in a single run, with higher precision than was possible before. Because of the very demanding conditions and precision achieved, the cost of manufacturing this equipment is very high, approximately US$750,000. Currently, there are only three LANL-type, high-temperature logging trucks in the world, one of which

is destined to go to Central America. At this point, the commercially oriented geothermal industry in the United States must manage with geophysical borehole tools that are less sophisticated and less precise than LANL's systems, but which are also less expensive and simpler to operate.

Field Geophysics

Sounding the resistance to electric current flow has been a classic technique in geothermal exploration. Since hot water conducts electricity better than cold, changes in electrical conductivity with depth can be useful in locating and determining the geometry of hot water reservoirs. Two basically different techniques are employed in sounding the electrical conductivity layering of the earth--active and passive. In the active method, direct-current (DC) resistivity, an electrical generator provides a DC signal that is injected into the earth. Through control of the distance between the electrodes on the surface, it is possible to vary the depth of investigation. In the passive method, the feeble natural signals associated with electromagnetic storms in the atmosphere are employed as the signal for providing the earth. Longer electromagnetic waves penetrate the earth more deeply; shorter waves penetrate less deeply. Hence, a layering of the earth's resistivity structure can be obtained. The natural signal is very noisy and requires exceptionally sensitive hardware and highly sophisticated software to convert the random electromagnetic noise into a useful exploration tool.

3. Specific LANL Objectives

LANL decided to provide the Central American countries with assistance in two major areas:

- where current technology in the region is lacking; and
- geothermal well logging and electrical resistivity mapping of suspected geothermal reservoir targets.

The logging truck designed and fabricated under LANL's supervision has the following capabilities:

- precise real-time temperature measurements in the hole;
- precise real-time pressure measurements;
- spinner measurements that identify the depth at which geothermal fluids enter the well;

- a caliper tool that measures the precise diameter of the hole to identify the exact extent of scaling;

- a casing collar locator (CCL) that tells the operator at the surface where the casing collars are actually located; and

- a water sampler capable of collecting a sample at any depth, sealing it off and bringing it up to the surface in its original state, before flashing, precipitation and other contamination.

LANL hopes to solve specific problems in El Salvador, Costa Rica and Guatemala by using this sophisticated system, while training local professionals in its use.

Separately, LANL has completed the construction of a high-power DC resistivity system and a highly sophisticated, passive exploration, audio-magneto-telluric (AMT) system. The term AMT simply refers to the natural electromagnetic signals at the audio range. AMT provides for earth probing to a depth of about one kilometer. It is faster and cheaper than a full-fledged MT system (US$100,000 to US$150,000 compared to US$300,000 to US$400,000), but does not provide the same probing depth. The two resistivity systems would improve geophysical exploration capability in the region, provided that local technicians and scientists are properly trained in gathering and interpreting the data as well as system maintenance.

4. Findings

First, the logging-truck system has been designed, equipment procured, and installation is taking place at the time of preparation this report. The truck will be delivered, according to LANL, by mid-November 1986, about three months behind schedule. A major unresolved issue revolves around providing an exceptionally sophisticated system of very high precision to Central America, as opposed to a set of simpler, cruder tools for borehole measurements that are common in ordinary industrial uses. (In fact, caliper logging is unavailable to the U.S. industry, except when the hole is cooled significantly.) While it may be satisfying to provide Central America with the latest and best technology available, the risks associated with equipment breakdown are higher with more sophisticated equipment. The same comments regarding maintenance hold true for the AMT system. However, it is relatively easy to ship the entire AMT system in a couple of suitcases for repair in the United States. It is recommended that a Central American consortium be created for the logging truck. An operating strategy for the post-LANL era should be developed and potential operators, which will require 12 months. It is further recommended that the logging

truck should remain USAID property in LANL's custody until the Central American consortium demonstrates the technical and financial ability to keep the logging unit in operating condition.

Second, the DC resistivity system has been designed, fabricated and tested. It is to be shipped via El Salvador or Honduras.

Finally, it is expected that the AMT system will be delivered soon. LANL should design an extensive training program for technicians and geophysicists (or physicists to be trained as geophysicists) to operate and service the system and interpret data. Programs of about six months per technician and two to three years of academic study plus hands-on work for geophysicists should be designed with appropriate budgets. It is assumed that such training will be provided in the United States.

H. Expected Versus Actual Accomplishments

In this section, each item from ARD's statement of work is reproduced, as it was stated by ROCAP for the geothermal component (Section A.2.a), followed by a brief discussion of the actual status of each work component. The page numbers provided for each item refer to Appendix A of this report, where the entire statement of work for the evaluation is presented.

> A detailed compilation and evaluation of prior work in Honduras completed and published as a technical report. Pertinent data from existing oil wells included, as appropriate, for comparison with prior geological findings. (p. A-3)

This item is covered adequately in several reports by LANL and its excellent collaborating team from USGS.

> A reconnaissance-scale field investigation completed with emphasis concentrated in identified areas of potential geothermal interest. A technical report published that includes updated geologic maps, details of the lavas and pyroclastic rocks for identifying the nature of the heat sources, radiometric rock age dating results, and geologic cross-sections for the most promising geothermal areas. (p. A-4)

This topic is covered in various forms in several reports by LANL and the USGS team. They have produced a fine set of reports.

> A comprehensive field sampling effort of the hot and cold springs and active fumaroles completed. A technical report published that includes major/trace element chemistry, stable isotope data, tritium concentrations, gas compositions, CO_2 isotope data, geothermometer temperature data, localized structure/alteration maps, and hydrologic models of potential geothermal systems, including estimated age and recharge characteristics of the system. (p. A-4)

A superb report was prepared at the end of this task. It is a magnificent piece of work.

> Based on detailed interpretations of the field and laboratory data, two or three areas in Honduras identified as the most promising sites for future geothermal developments. (p. A-4)

This was completed as part of the preceding task and is highly satisfactory. The recommendations made by LANL/USGS flow logically from the work. However, the reports address only a technical ranking. There is no ranking based on regional, strategy-oriented considerations, such as transmission-line availability or local demand.

> Shallow temperature gradient wells drilled at the most promising sites to obtain lithologic and geothermal gradient data. (p. A-4)

LANL has opted to transfer the budget from the shallow temperature program to two intermediate-depth holes that might penetrate the reservoir. This is a wise move. A contract with the driller has been signed. The estimated starting date for drilling at Platanares is 1 October 1986. The budget for the intermediate drilling program is insufficient and should be augmented, if possible.

> A geophysical testing program including audio-magneto-telluric (AMT) soundings and deep DC resistivity measurements initiated at the most promising geothermal development sites. A preliminary technical report published on initial geophysical results. (p. A-4)

The AMT geophysical system is behind schedule. LANL was unable to give an estimated date for delivery, but the best guess is early 1987.

> Trained professionals from ENEE and DGMH (Honduras) will have participated in all field investigations and data interpretation activities. Periodic

> seminars presented at both organizations to describe the techniques, equipment, and evaluation procedures being implemented by the Los Alamos-Honduran team. (p. A-4)

Only ENEE professionals have been involved. According to reports, ENEE and DGMH do not get along. LANL provided short training in the field and at Los Alamos that must be considered limited. Much training cannot be expected in such a short time period.

> Hondurans hired for field support activities throughout the duration of this project component. (p. A-4)

This has been accomplished. As discussed elsewhere, further training and education should be provided for longer time periods in the United States.

> A report published that includes specific recommendations for completing the pre-feasibility study of geothermal resources in Honduras. (p. A-4)

This report has been delayed.

> Professionals from ENEE and DGMH will have received intensive field training in the latest volcanology, geology, geochemical and geophysical exploration techniques. (p. A-5)

One could not call the training "intensive," rather, it is an introduction to all the topics mentioned. It takes years to train professional earth scientists before they can be considered mature, independent professionals. Two or three professionals in each country should be sent to U.S. graduate schools that are strong in these respective training areas. In addition, they should spend one to two years with an operating field research organization, such as USGS, LANL or private companies.

> A surplus well-logging rig overhauled, equipped with high-temperature, armored, seven-conductor, geothermal logging cable suitable for use in the Miravalles wells, tested in a U.S. geothermal well, and shipped to the Miravalles field in Costa Rica. (p. A-5)

This task was completed in February 1986. Excellent logging results were obtained and satisfactory reports on those results published.

> Working with ICE scientists and engineers, a Miravalles well-logging program developed. (p. A-5)

> A selection of high-temperature geothermal well-logging tools, consistent with the requirements of the Miravalles well-logging program, tested and shipped to the Miravalles field in Costa Rica. (p. A-5)

The logging program was completed. As planned, the tools are to be shipped to Ahuachapan in September 1986 for final down-hole testing. Useful papers on the logging results were published.

> Working with ICE and University of Costa Rica scientists and engineers, a data acquisition system fabricated and installed in a facility at the Miravalles geothermal field. (p. A-5)

The data system is in use at Miravalles and will be part of the logging unit.

> A well-logging program conducted in the Miravalles geothermal wells. (It was anticipated that three to four wells would be logged and a minimum of six to eight different logs obtained for each well). (p. A-5)

The logging was completed in February 1986. The results of this useful work are to be published by LANL.

> ICE personnel trained in the operation of the logging rig, the operation of the down-hole logging tools, and the interpretation of the data from the tools. (p. A-5)

Training was limited by the actual time devoted to it. It could be called an "introduction to training."

> The proposed well designs, casing schedules, completion techniques, and drilling fluid programs for future wells at Miravalles evaluated on the basis of the logging data obtained from the existing production wells. (p. A-5)

This has not been done yet. It should be done with a consulting drilling engineer. See more detailed recommendation in Section IV.F.3.

> A compilation and evaluation of prior work in Costa Rica completed and published as a technical report. (p. A-5)

A <u>reconnaissance</u> report on geoscientific aspects of Costa Rica's geothermal geology has been completed. It should be

considered merely a preliminary report, adequate for target selection.

> A limited reconnaissance-scale field investigation completed with emphasis concentrated within the Cordillera de Guanacaste. A technical report published that includes map improvements based on stratigraphic analysis, characteristics of pyroclastic rocks associated with young volcanic fields, radiometric rock age dating cross-sections for the most promising geothermal areas. (p. A-6)

This was reported to be 75 percent complete, with a revised promised delivery date of February 1987.

> A limited field sampling effort of the hot and cold springs and active fumaroles completed. A technical report published that includes major/trace element chemistry, stable isotope data, tritium concentrations, gas compositions, CO_2 isotope data, geothermometer temperature data, and preliminary hydrologic models of potential geothermal systems including estimated age and recharge characteristics of the system. Results primarily limited to areas within the Cordillera de Guanacaste. (p. A-6)

Samples have been analyzed. The report is in writing. No delivery date was stated.

> Trained professionals from ICE will have participated in joint Los Alamos/ICE field investigations and in the data interpretation activities. Periodic seminars presented by professionals of both organizations at ICE to describe the techniques and evaluation procedures being implemented. (p. A-6)

> As a training vehicle, Costa Ricans will have been involved in field support activities throughout the duration of this project component. (p. A-6)

The usual field training was provided. It was not lengthy enough to make Costa Ricans instant independent experts.

> An informal report drafted that includes recommendations for completing the reconnaissance and initiating the pre-feasibility study of geothermal resources in Costa Rica. (p. A-6)

This was reported to be 70 percent complete.

> Technical specifications for a state-of-the-art geothermal logging truck developed, procurement contracts awarded, and the basic logging truck fabricated and delivered to Los Alamos. (p. A-6)

This work is reportedly complete.

> Required data acquisition equipment ordered, delivered to Los Alamos, and installed in the logging truck. (p. A-6)

This work is reportedly complete.

> The high-temperature, seven-conductor, logging cable ordered, delivered to Los Alamos, fitted with a high-temperature cable head, and installed on the logging-truck cable drum. (p. A-7)

This was accomplished.

> Los Alamos engineers will have performed a thorough check of all logging truck systems, electronic components, and the high-temperature cable using a local geothermal well. Any noted deficiencies corrected and the required logging accessories, miscellaneous equipment, and spare parts packed in the logging truck. (p. A-7)

This was reported to be 50 percent complete and should be entirely finished by November 1986.

> A detailed operating handbook prepared for the operation and scheduled maintenance of the logging truck. (p. A-7)

The handbook was reported to be available in the logging truck, in both English and Spanish.

> The logging truck and associated equipment shipped to Central America. (p. A-7)

This is expected to be three to four months late (November or December 1986).

> Technical specifications for the down-hole logging tools developed, procurement contracts awarded, and the tools fabricated and delivered to Los Alamos. (p. A-7)

This was reported to be 90 percent complete.

> Los Alamos engineers will have performed a thorough check of all down-hole tools, correct any noted deficiencies, prepare operating instructions for their use, and ship the tools and spare components to Central America. (p. A-7)

This will be done when the tools are returned from the Costa Rica field test.

> Technical specifications for the DC resistivity system developed, procurement contracts awarded, and the system fabricated and delivered to Los Alamos. (p. A-7)

The system has been designed, fabricated and tested. It is ready for delivery.

> Los Alamos geophysicists and engineers will have performed a thorough check of system performance, corrected any noted deficiencies, prepared an operating handbook for its use, and shipped the system to Central America. (p. A-7)

This is reported to be complete.

> Technical specifications for the audio-magneto-telluric (AMT) system developed, procurement contracts awarded, and the system fabricated and delivered to Los Alamos. (p. A-7)

The specifications have been developed, and the system is now in the final stage of testing. The estimated delivery date is the end of 1986.

> Management arrangements for the dedicated truck system are finalized. (p. A-7)

LANL estimates that arrangements are 65 percent complete, but the ARD evaluation team estimates that they are only 10 percent complete.

> Survey of direct-heat requirements completed. (p. A-8)

A survey was completed by LANL and a subcontractor, ICAITI, with the help of MEM and INDE. The report was presented to LANL for English editing. It is an excellent start at sorting out opportunities for economic development using geothermal energy.

> Counterparts established and trained in the appropriate methodologies. (p. A-8)

A counterpart, GREMIAL, was identified. No agreements and no training have occurred as of this date.

> Direct-heat applications surveyed and most promising selected. (p. A-8)

A survey was completed. Five potential dehydration applications were identified. No economic or marketing data have been provided. The latter should be carried out as an integral part of the demonstration operation.

> Technical exchange meeting held to disseminate information about direct-heat applications and to solicit comments from the private sector. (p. A-8)

Three technical meetings were held with GREMIAL, INDE and MEM. The dehydration project and products were selected.

> Two most promising applications selected and feasibility studies completed. (p. A-8)

One preliminary application has been selected--the dehydration of agricultural products, but no feasibility study has been done.

V. PEAT RESOURCE AND END-USE ASSESSMENT

A. Background

Peat is an organic-rich sediment produced in marshes and swamps from decayed plant material. It can be used in agricultural and chemical industries, and under certain conditions, as a fuel. In the United States, the use of peat is primarily restricted to agriculture. A few pilot-plant research efforts have been conducted for gas production, and a peat-fired, 200-MW power plant in North Carolina is in the planning stage. Peat has been used in northern Europe for home heating and cooking for centuries, and is currently being used as a fuel for electricity production from steam turbines in Ireland, Finland and Russia. Other energy-related applications are being investigated at the conceptual laboratory stage. In 1980, about 220 million tons of peat were produced, of which 90 million tons were used as an energy fuel, mainly in the Soviet Union, Finland and Ireland (source: FUEL PEAT FOR DEVELOPING COUNTRIES, World Bank, March 1984).

Each peat location must be reviewed independently to determine its characteristics. For combustion applications, high calorific content--approaching 10,000 Btu/pound (23 MJ/kg)--is required. In Ireland and Finland, peat with a minimum of 12,500 Btu/pound (25 to 30 MJ/kg) and a low dry-ash weight content of one to five percent is preferred, although 25 percent ash is considered as the upper limit for peat suitable for industrial energy applications.

B. Costa Rica

1. Purpose

The peat end-use assessment program in Costa Rica was initiated as a concurrent effort between LANL and RECOPE upon realization of the latter's efforts to identify substitute materials for petroleum-dependent industries and local electrical generation. As originally designed, the project consisted of four interrelated, mutually dependent activities:

- characterize Costa Rican resources;
- analyze end-uses applicable to Costa Rica;
- educate the private sector and solicit input; and

- train local engineers/economists in technology comparisons and feasibility methodology, and geologists in peat sampling and analysis.

The results of the first two activities are discussed in the remainder of this section. Private-sector relations, training and technology transfer are addressed in Section VII.

2. Physical Characterization of Peat

Preliminary identification of two peat deposits and their characterization in terms of size and quality has been completed. This work has been carefully executed and is sufficiently detailed to provide the basic data required for local end-use selection and pre-feasibility studies. One concern is that RECOPE has unilaterally decided on a 30-percent cutoff for the ash content in its peat deposits. This will result in an apparently higher tonnage of usable peat. However, it will be necessary for all analyses to take into account the additional costs associated with such a high-ash product.

3. End-Use Analysis

End-uses are discussed in the following two subsections. The first reviews preliminary investigations conducted by LANL, and the second, follow-up work done by RECOPE with technical assistance from LANL.

End-Use Inventory

An interim report on the Costa Rican peat program issued by LANL in September 1985 summarizes the results of its initial study phase, and includes brief descriptions of energy-use characteristics in Costa Rica, energy- and agriculture-related imports, industrial locations, known and potential peat sites, weather patterns and associated environmental issues. It also analyzes 27 end-uses that are either commercially available or in developmental stages and selects 13 for further investigation. Several follow-up procedures are recommended, including a decision analysis methodology to select the most promising applications, as well as detailed feasibility studies.

The LANL report provides an overview of Costa Rican market conditions and worldwide peat use. Technical descriptions and environmental issues are included, costs given for countries where the application or study was made, and costs for alternative products (e.g., diesel fuel, bunker oil, etc.) used in Costa Rica are also supplied. However, as an end-use analysis, the report lacks sufficient economic data for an

adequate evaluation of peat applications in Costa Rica. Moreover, several of the uses considered to be competitive represent experimental applications, require equipment that is not dimensioned to meet Costa Rican requirements and is available from only one supplier (three in the USSR and one in Finland), or address an unproven market (i.e., waxes, ethanol, ammonia and activated carbon).

Specific Applications

During meetings with RECOPE, the ARD evaluation team had the opportunity to discuss the four main peat applications being considered for Costa Rica:

- a network of small (less than five MW) electric generators to service outlying communities;
- a small (under five MW) plant to alleviate peak-hour power drops at the Limon refinery;
- replacement of bunker oil in the cement industry; and
- horticultural applications.

The first three applications indicate that economic and technological feasibility considerations have not been fully addressed, and are not in line with LANL's recommendations.

In the case of fluidized-bed boilers for electrical generation, there are few commercially proven peat-fired plants with a capacity of less than five MW, and capital costs per kilowatt of output have been estimated at three to four times that of a larger plant. Electricity generation from small-scale fixed-bed gasifiers is also in the experimental stages, and requires both continuous maintenance and low-ash feedstocks. In addition to technical uncertainties, peat-fired plants are not flexible enough to be economical for peak-hour energy supplementation. The cement industry has indicated a reluctance to consider peat as an alternative to bunker oil until feasibility studies, indicating that such replacement has economic merit, are conducted. Horticultural applications could be a viable local use for peat from mountain areas with a low energy content, but which is more appropriate for agricultural purposes.

Information received from LANL after the field review was completed indicates that a contractual agreement has been reached with ICAITI for a laboratory testing program to determine the suitability of peat as a substitute for fuelwood in Central American domestic cookstoves. The information also indicates

that RECOPE has provided ICAITI with a sample of peat from Costa Rica, which will be the raw material for this test. Following completion of the laboratory tests, market studies to justify program implementation should be conducted. If wood is the fuel that peat will replace, the normal procedure to follow would seem to be the execution of fuelwood market studies and an analysis of various stove types before undertaking testing of selected stoves. It should also be noted that a cooking fuel application for peat was not considered economically competitive by LANL in their September 1985 interim report on the subject.

When asked about their reticence with regard to feasibility studies, RECOPE personnel advised the ARD evaluation team that they did not have enough data and that a poll had been initiated to define major industrial needs. They were also considering a major energy plan to equate diesel consumption with production from their refinery by replacing diesel generation with peat-fired equipment, even though this might necessitate subsidizing policies.

4. Summary

The LANL peat program has accomplished the identification and characterization of two Costa Rican deposits, and has also achieved a good measure of success in:

- the practical training of local geologists, and
- transferring responsibility for the project to RECOPE.

The end-use inventory comprehensively summarizes worldwide peat applications and Costa Rican energy-use characteristics. Peat represents a potential energy and industrial resource, and certain local agricultural applications have immediate merit, particularly where markets do not require industrialization or extensive transportation.

5. Recommendations

First, more in-depth feasibility, technical and marketing analyses are required and should be carried out by LANL to investigate the cost/benefit justification of a peat program before proceeding any further. The Costa Rican peat program has not yet proved that it meets the cost/benefit objective that it originally set out to accomplish.

Second, for financial feasibility studies, enough data are available to conduct pre-feasibility analyses for the diverse applications being considered by RECOPE and to determine whether

or not to proceed with the project. Where specific data are not available, educated assumptions can be utilized to arrive at a best estimate of the cost and competitiveness of the selected peat-derived energy end-uses.

Third, justification from market studies for the selected end-uses is not available at present. Markets for peat-related energy applications, and its use as a domestic cooking fuel, have to be thoroughly investigated and confirmed to complete any cost/benefit analysis of the peat program.

Fourth, relative to technical studies, if the pre-feasibility and market studies indicate viable applications, a more exhaustive study of available technologies should be conducted. Only commercially proven technologies should be considered for peat mining and end-use applications. Experimental and unproven technologies can be disastrous in remote locations where spare parts supplies and competent technical maintenance personnel are unavailable.

Fifth, further studies for horticultural applications with economic merit should be conducted to ascertain the quality and marketability of the product.

6. Expected Versus Actual Accomplishments

This subsection summarizes the status of the various activities of this subproject. Items from ARD's statement of work from ROCAP (Section A.5.b) are reproduced and the actual status of that component discussed briefly. The page numbers provided after each item of the scope of work refer to those in Appendix A of this report, where the entire statement of work for the evaluation is reproduced.

> Potential end-uses analyzed with regard to Costa Rican market conditions and regional characteristics, including literature review of worldwide peat use and associated costs. (p. A-8)

The interim report issued in September 1985 by LANL presents a comprehensive overview of worldwide peat applications and associated costs, brief descriptions of Costa Rican market conditions and energy-use characteristics, and identifies known and potential peat sites, weather patterns and environmental issues. Thirteen end-uses are selected for further investigation.

> Technical exchange meetings held to educate private-sector members in peat end-uses and to solicit their input. (p. A-8)

As of the writing of this report, the only contact with the private sector had been with INC, which was reluctant to consider peat as an alternate fuel for its plant.

> Physical characterization of peat completed and results incorporated in selection of most promising uses. (p. A-8)

A preliminary characterization of the resource's size and quality shows the work has been carefully executed, but the results have not been incorporated in the selection of promising end-uses.

> Costa Rican engineers or economists trained in technology comparisons and feasibility methodology. Geologists trained in peat sampling and analysis. (p. A-8)

The training of geologists in sampling and analytical procedures has met the stated objectives. No effective training has been provided to engineers/economists in technology comparisons and feasibility methodology. A technical seminar in field and economic practices proposed for March 1986 was canceled at AID's request.

> Report completed with cost/benefit analysis of up to three of the most promising end-uses, including preliminary design, site selection and environmental analysis. (p. A-8)

Neither the report nor preliminary drafts were available to the ARD evaluation team.

C. Panama

1. Purpose

No scope of work for the Panama peat project was provided to the evaluation team. The following objectives represent information gleaned from LANL quarterly reports and conversations with IRHE in Panama:

- characterize Panamanian resources;
- analyze the feasibility of one peat-fired, 30-MW plants for electricity generation; and
- educate local geologists in sampling and assaying.

IRHE personnel attended an INCAE meeting in Guatemala at which LANL made a presentation on Costa Rican peat. IRHE requested that LANL initiate a peat exploration program. Based on information provided by LANL and IRHE, the results of the program are discussed below.

2. Resource Characterization

Through innovative exploration practices, LANL has identified a large peat resource in the Changuinola region of northwestern Panama. Preliminary characterization of a deposit of good-quality peat--high Btu content (over 10,000 Btu per pound when dry), and low ash (two percent) and sulfur content--has been accomplished through grid sampling and analytical procedures, executed primarily by IRHE with technical support from LANL.

3. Feasibility Analysis

LANL has promised to complete a feasibility analysis for the peat-fired, 30-MW plants by the end of 1986. There is commercially proven technology for peat-fired boilers utilized to generate electricity in the 5- to 60-MW range. Critical factors that must be considered in this feasibility study are capital investment, production costs and transportation costs in order to effect a fundamental comparison with hydroelectric generation planned for the same area.

4. Summary

A major peat resource has been identified in Panama, and an application with available technology and possibly competitive costs is being investigated. IRHE's training has been effectively accomplished insofar as resource evaluation techniques, but it is still dependent on LANL for feasibility studies.

5. Recommendation

Even though the end-use considered for Panama appears to have a certain measure of cost/benefit justification, no further work should be conducted until pre-feasibility, technological and market studies have been completed (similar to those recommended for Costa Rica), and there is a clear indication that peat-based electricity generation is a viable alternative to petroleum products and/or the hydroelectric plant which is presently being considered for northwest Panama.

VI. COSTA RICA MINERAL RECONNAISSANCE

A. Purpose and Objectives

This project was started by LANL in January 1986. LANL has conducted similar reconnaissances in other areas, including a geochemical survey of Alaska, with a folio publication as the end product. USGS is currently engaged in a "conterminous U.S. mineral appraisal program" and recently completed a mineral resource assessment of Colombia, where it utilized techniques similar to those employed in Costa Rica.

The Costa Rica mineral reconnaissance project consists of three components that are designed to provide an assessment of the country's mineral potential when they are eventually linked:

- geochemical survey,
- preliminary mineral resource assessment, and
- gold district study.

The first is being conducted by LANL, and USGS has been subcontracted to undertake the second and third components.

USGS, LANL and the Direccion de Geologia, Minas e Hidrocarburos (DGMH), as well as UCR and MINASA in Costa Rica, provided the information that was used to evaluate the results of this program. Visits were made with LANL in Los Alamos and with USGS in Menlo Park, California. For the sake of clarity, each subproject is discussed separately in the following sections.

B. Findings

1. Geochemical Survey

As proposed by LANL, this subproject had the following objectives:

- plan a reconnaissance-scale, stream sediment sampling program for all the San Jose and a portion of the Talamanca 1:200,000-scale quadrangles, and analyze all samples for up to 45 elements;
- evaluate the data collected and then publish the results in a brief report and map folio;
- reformat the information for use by DGMH and UCR;

- train DGMH and UCR personnel in order to create a manpower source for future programs;
- create a San Jose and Talamanca data base; and
- present the results to DGMH and UCR.

Programmed sampling of the San Jose quadrangle and a portion of the Talamanca quadrangle has been completed. In addition, the Quepos and Golfito quadrangles have been sampled. The sampling density is approximately one sample per 15 square kilometers, and the minus-80-mesh portion of each sample will be assayed. These parameters were chosen following a pilot study in a known gold district and are within generally accepted norms for this type of survey.

The analytical procedure for each sample is neutron activation and X ray fluorescence for 45 elements, and the estimated cost per chemical analysis is US$100. The analytical and data-processing portion of the program is behind schedule due to the late implementation of the project.

Analysis for 45 elements is high for a preliminary geochemical survey. Generally, a maximum of 20 elements is sufficient to characterize areas with important mineral resources. A similar USGS reconnaissance program for a portion of Oregon, which was completed in 1986, analyzed for 18 elements, except in areas where analysis for additional chemical information was justified. Private-industry surveys are usually even more product-specific, as 10 elements or less are normally analyzed.

LANL's computer systems can integrate multi-element combinations with other geological data to produce maps in which areas with mineral potential are highlighted. Nevertheless, an examination of work performed by LANL for the U.S. Bureau of Land Management, which is very similar to that being conducted for Costa Rica, indicates that about 20 elements are generally sufficient to characterize and identify areas with potential for a wide range of mineral occurrences.

The lack of selection in the analytical procedure results not only in increased assay costs, but also higher downstream costs, as indicated by LANL's budget of US$816,000 for processing and evaluation of the geochemical data. This represents over 50 percent of LANL's total mineral exploration budget. LANL considers that the 45-element analysis will not only be useful for mineral resource assessment and exploration, but also land-use, agriculture, health and environmental-monitoring programs. The evaluation team did not see information which specified the types of analysis to be employed for these additional uses, nor

has the need for such information been well documented in project materials.

Contacts with mining company personnel who are active in Alaska indicate that LANL's Alaska folio is too generalized for practical use. However, these companies found that the tapes containing the basic analytical data were useful to define areas with mineral exploration potential through more detailed analysis of selected elements, interrelationships between elements known to occur together, and integration of other known geological information, such as lithology, with the geochemistry.

At a meeting with the director of the Central American School of Geology at UCR, these aspects, which are critical to follow-up investigations, were discussed. The team was advised that no plans have been made for the transfer of tapes with geochemical data, nor for the computer equipment required for more selective data treatment. It was indicated that UCR will receive the final folio with included maps and reports, plus original sample collection data forms, sample splits and rock samples pertaining to the survey.

2. Preliminary Mineral Resource Assessment

The objectives of the PMRA subproject were to produce a quantitative assessment of Costa Rica's mineral potential and effect related technology transfer through the completion of the following tasks:

- compilation of geologic, geophysical, mineral occurrence and terrane (domain) maps;
- preparation and publication of a final report on this compilation; and
- preparation and presentation of a mineral deposit models course in Costa Rica.

All maps are in advanced stages of preparation and available for preliminary review. It should be noted that USGS and LANL were not given clearance to work on this project until January 1986, so some of the completion dates in the scope of work are not applicable. The maps are on a 1:500,000 scale and include:

- an updated geologic map incorporating recent information and USGS mapping to the Costa Rica quadrangle maps published in 1982;
- geophysical maps with compilations of all available gravity and aeromagnetic information which provide good coverage of the country;

- a mineral occurrence map and report that identifies and characterizes known ore deposits; and

- a terrane or domain map that identifies areas with geologic characteristics which are favorable for specific types of mineralization, to be accompanied by a report providing a statistical analysis of the probability of occurrence for various ore bodies as well as their estimated grade and size.

Report writing is on schedule, and drafts are ready for distribution to LANL, DGMH and UCR for review and editing. This process should be completed by the target date of September 1986. The final PMRA manuscript, including maps and expanded explanations, was to be submitted to the USGS editorial board by 15 July 1986. This deadline and other partial completion dates outlined in the scope of work have not been met due to the project's late start. All of the work appears to be well done and is satisfying the objectives laid out for this activity. The final publication date is set for July 1987.

The mineral deposits model course was carried out and is discussed in Section VII.

3. Gold District Study

The objectives of the GDS subproject were first to evaluate the gold potential of the northwestern portion of the San Jose 1:200,000 quadrangle through detailed examination and mapping of all known mineral deposits as well as selected regional geologic mapping and, second, to train local personnel. The above objectives were to be accomplished by completing the following tasks:

- geologic mapping of the district,

- an exploration target map,

- a final report, and

- preparation and presentation of a mineral resource assessment course in Costa Rica.

Geologic mapping of the district began in February 1986 and was completed by July. Preliminary maps examined at USGS indicate that this task was well executed, and various scale maps adapted to different situations have been prepared.

As discussed in the preceding subsection on PMRA, map compilation was extended to cover most of Costa Rica. Exploration target maps and an accompanying report appraising the

country's mineral potential and indicating the most favorable locations for the existence of various mineral deposits have been prepared.

The final GDS report was to be started by 31 May 1986 and should include LANL components (e.g., geochemical maps). However, due to the time required for sample analysis and data interpretation, this integration has not been completed.

The mineral resource assessment course has been scheduled and is discussed in Section VII.

C. Data Base Maintenance

Maps, reports and folios for the geochemical reconnaissance survey, PMRA and GDS will be delivered to Costa Rican counterpart organizations. RECOPE has been designated the recipient of peat information and has also been provided with data-management equipment.

Geochemical survey, PMRA and GDS information is scheduled for delivery to DGMH, which does not have either the equipment or personnel required to store the data. Both UCR and MINASA are better equipped to handle data, and a decision should be made as to which organization will be entrusted with the mineral reconnaissance information. The availability of computer tapes with raw geochemical data and convenience of having equipment that can provide more specific data integration and analysis already been discussed in the section on the geochemical survey (VI.B.1). To implement follow-up that will eventually lead to the definition of prospective mineral areas and interest private investors, a computerized data-handling system should be made available.

Finally, it is the team's understanding that decisions regarding the final publication of reports will be made by the Costa Rican government. A schedule and procedure for distributing these reports to the general public should be agreed on at an early date.

D. Summary

For the geochemical survey, field sampling for a larger area than originally planned has been completed using standards normally accepted for this type of survey. Folios for the San Jose and Golfito quadrangles are being prepared.

The various maps and accompanying texts for the preliminary mineral resource assessment are being carefully prepared and provide useful and complete information. The terrane map and

report will present an appraisal of Costa Rica's mineral potential, thus providing a basis for objective estimates of this potential.

The tasks associated with the gold district study have been completed satisfactorily, although delays have occurred due to late implementation of the program. In conjunction with the PMRA program and by providing additional data for a mineral resource appraisal of Costa Rica, GDS will help accomplish the objectives of the mineral reconnaissance program.

E. Recommendations

First, future work should depend on the results of preliminary mineral assessments such as that conducted by the USGS in Costa Rica. Additional work should only be considered when the preliminary assessment indicates good potential for economic mineral discoveries.

Second, in terms of cost-effectiveness, more in-depth studies such as geochemical surveys should be justified economically. Incremental expenditures should only be undertaken if they will produce a measurable increase in the probability for mineral discoveries and recovery of capital investment. When geochemistry is considered, programs must be streamlined to include only analyses for key elements, as indicated from previous experience.

Third, since the final objective of this type of program is to interest private industry in the development of mineral resources, they should be consulted at an early stage and their recommendations incorporated in program planning. An experienced representative of the mineral industry should be added to LANL's advisory group. AID could also profit from having experienced mineral-industry executives review future mineral-related programs.

F. Expected Versus Actual Accomplishments

This section presents a brief summary of the status (as of mid-July 1986) for the various activities in this subproject. Due to the length and detail of the statement of work provided to the evaluation team by ROCAP (Sections B.1, B.1.a and B.1.b), work component descriptions have been summarized and in certain cases, grouped together when they refer to similar material. The page numbers provided for each item from the scope of work refer to Appendix A of this report, where the entire statement of work for the evaluation is reproduced.

> Collection of reconnaissance-scale stream-sediment samples for all of the Provincia de San Jose and a portion of the Talamanca 1:200,000-scale quadrangles. (p. A-8)

This work has been completed. In addition, the Quepos and Golfito quadrangles were sampled. The sampling density was one sample per 15 square kilometers.

> Analysis of samples for up to 45 elements. Evaluation, publication and reformatting of data for use at DGMH and UCR. (pp. A-8, A-9)

The sampling has been completed, and analysis and data evaluation are in progress. Folios are being prepared for only the San Jose and Golfito quadrangles.

> Training (transfer of expertise and creation of manpower resource) -- involve DGMH and UCR personnel in field activities, and in planning, analysis and interpretation stages at LANL. (p. A-9)

Practical field training has been completed. One visit by a UCR representative to LANL for planning activities was documented. Involvement in analysis and interpretation stages has been scheduled, and training in sampling techniques has occurred.

> Enhancement of UCR facilities through library purchases and equipment upgrades. (p. A-9)

AID regulations did not permit this activity.

> Creation of a data base and presentation of results. (p. A-9)

The data base is expected to be completed by November 1986.

> Compilation of geologic, geophysical, mineral occurrence and terrane maps. (p. A-9)

All maps are in advanced stages of preparation. Good-quality drafts were available for review.

> PMRA final report complete by 30 June 1986. Final review by 1 October 1986. (p. A-10)

A draft report was completed and ready for distribution to LANL, DGMH and UCR for review and editing.

> Mineral deposit models course. (p. A-10)

This course was presented at UCR 10-27 March 1986. The course, given in Spanish, was attended by 30 participants. It was well received.

Geologic mapping complete by 30 November 1985. (p. A-10)

The mapping was started in February 1986 and completed by July 1986. Various maps adapted to different situations were prepared. The work was well executed.

Exploration target map, final GDS report in conjunction with LANL. (p. A-10)

Maps were prepared with information from USGS. LANL's input is under preparation.

Mineral resources assessment course. (p. A-10)

The course and a Spanish-language text have been prepared. Course presentation was being scheduled.

VII. TECHNOLOGY TRANSFER, PRIVATE-SECTOR INVOLVEMENT AND ECONOMIC SUSTAINABILITY

A. Technology Transfer

The topic of technology transfer is mentioned frequently in LANL planning documents. The most succinct statement is as follows:

> . . . build technical and managerial skills so that a self-sustaining economic development process is established. This objective will be achieved predominantly by on-the-job training associated with the project components, training workshops, sponsored graduate-student participation and visits by regional technicians to Los Alamos. (CENTRAL AMERICA ENERGY RESOURCES PROJECT: PLAN FOR CONCURRENT PHASES I AND II, LANL, Los Alamos, New Mexico, March 1985, p. 4.)

The evaluation scope of work refers to technology transfer in the following manner:

> Assess the degree to which the project has been able to . . . transfer generated information and strengthen these national organizations. Assess plans to continue with this transfer/strengthening activity and make recommendations to improve it.

As training is such an integral part of technology transfer, the training program carried out by the project has also been included for review in this subsection.

1. Definitions

A classic definition of technology is ". . . any tool or technique, product or process, or method of doing or making by which human capability is extended."[1] Thus, technology transfer is the movement of a tool, technique, product, process or method from people who possess and understand it (technology suppliers) to those who desire and incorporate it into their lives and work

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[1]Lionel Goldring, "The Management of Science and Technology," lecture series at New York University, 1976, quoted in Harvey W. Wallender III, Technology Transfer and Management in the Developing Countries (Cambridge, MA: Ballinger Publishing Co., 1979), p. 26.

(technology users). Technology is transferred when the technology user possesses, uses and controls the technology at issue. Awareness of the technology's existence and receiving its outputs are not sufficient. To use Wallender's simple example,[2] if a plumber comes to your home and unstops or repairs a pipe, he is providing a service. However, if he also shows you how to make the repair yourself, he is transferring the technology.

This distinction is particularly important when the technologies or techniques that are being introduced, adapted and maintained are sophisticated and require specialized training and equipment, such as the resource-assessment procedures being provided by LANL staff. The issue then becomes, as noted in the evaluation team's scope of work:

> . . . the degree to which the project has been able to generate interest and cooperation in national institutions, its ability to provide necessary technical assistance, transfer generated information and strengthen these national organizations.

In addition, since the project's technology transfer process is seen as a long-term commitment, the team was also asked to examine upcoming activities to determine if they will further the technology transfer process--"assess plans to continue with this transfer/strengthening activity and make recommendations to improve it."

2. LANL Efforts

In addition to introducing hardware and analytical tools, technology transfer in the LANL project consists of both formal and on-the-job training in technical skills. Some very successful examples of technology transfer in terms of training are discussed below. However, there appear to the evaluation team to be two basic weaknesses in LANL's approach to the project thus far. First, the planning that has been carried out regarding how to accomplish the necessary technology transfer is insufficient if project objectives are to be achieved. Second, organizational capability (as opposed to individual skills) has been given little attention. The institutional capability to operate and manage a complex technology is usually not the sum of the individual capacities of the organization's technicians and specialists. Managerial, policy and other areas need attention and improvement when building viable, solid organizations.

A summary of the LANL project's formal and on-the-job training activities is presented in the table on the next page.

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[2] Ibid., p. 28.

Concentrations of training and on-the-job experience where signs of self-sufficient capability might be expected are shown for four areas--energy situation analysis throughout Central America, geothermal exploration (especially in Honduras), peat assessments in Costa Rica and Panama, and the mineral assessment in Costa Rica. These areas, which have received the most attention and resources, are discussed in the following subsections.

Energy Situation Analysis

A basic aim of the energy situation analysis component is effective technology transfer from LANL to Central America. LANL has contributed resources in the form of hardware, software, training and support services. The hardware consisted of IBM computer equipment, and the software consisted of the SICAPE data base and the INTEGRA energy analysis software.

The workshop on energy data base operations in April and the workshop on energy modeling scheduled for September, both at INCAE in Costa Rica, can be considered successful training efforts. Discussions with participants at the sessions indicated that four or five workshops a year might be considered. Weaknesses in the current design are the lack of a link between energy analysis and economic planning, and of clearly enumerated goals defining self-sufficiency for each country and permitting LANL's departure.

Costa Rica has the most advanced energy data and analysis operations in Central America. Thus, much of the technology transfer occurred between Costa Rica and the rest of Central America, using consultants hired at INCAE as a conduit. LANL catalysis of such "horizontal" technology transfer is healthy

An example of the division of responsibility for technology transfer between LANL and experts from Costa Rica is the regional seminar planned for 8-12 September 1986. Central American personnel, under contract to LANL, are to present approximately 80 percent of the material. The aim of self-sufficiency in energy planning and analysis must address the potentially larger problem of acceptance and utilization of economic planning within governmental operations in each Central American country. The organizational, managerial and structural design of the governments are potentially greater constraints to improved energy programs than are technological problems.

Geothermal Program

In Honduras, there has been formal and on-the-job training for ENEE professionals in field mapping, water and gas sampling, and hydrochemical data interpretation, both in the field and at

Los Alamos. As a result, ENEE staff are now able to collect reliable field samples. There has also been introductory training in volcanology, geology, and geochemical and geophysical exploration techniques. However, up to now, training in these areas has not been as "intensive" as prescribed in the project plans. Perhaps it was a mistake to promise "intensive" training in the context of limited field exploration work.

In Costa Rica, training in geothermal technology has been limited to in-field instruction in the use of logging rigs. Little training in field investigation and data interpretation has occurred. The training in logging-rig use provided so far does not approach that necessary to produce self-sufficient logging teams. This is discussed below in greater detail, but CEL in El Salvador seems to have the most potential for self-sufficiency in well-logging operations, because of its long history in operating the Ahuachapan field.

The LANL project is about to introduce a highly sophisticated, self-contained geothermal well-logging truck to Central America (price US$750,000). The logical framework analysis of the self-contained logging truck component reads as follows:

> The well-logging truck will be used on the project throughout Central America and its use and maintenance will be controlled by international cooperative agreements. LANL will provide training on maintenance and use. Actual operation and use is a counterpart government and LANL cooperative responsibility.

The presently envisioned scheme, as reported in a document entitled MANAGEMENT PLAN, GEOTHERMAL WELL LOGGING OPERATIONS IN CENTRAL AMERICA, proposes the establishment of a "Central American well-logging panel." Membership in the advisory panel would include representatives of the four electric utilities, AID and LANL. LANL has agreed to carry the entire financial burden of operating the logging equipment for the "initial field operations in each country," which presumably amounts to 90 days per country, for a total of one year. No agreement or proposal for the operation of the equipment beyond the "initial" first year has been presented yet.

LANL has proposed that it train technicians and engineers in all four countries to operate the logging truck and geophysical equipment. No clear statement of responsibility for any of the equipment after the initial phase has been made. It was implied that the professionals in each country would operate the equipment when it is delivered, an arrangement which is unlikely to work for the following reasons:

First, the logging truck consists of highly sophisticated systems combining mechanical and electronic components. The same set of technicians and engineers must remain responsible for the operation of the logging truck if it is to last. Scheduled maintenance, continuous repair records, and experience in solving normal operating problems are best achieved when one single group is responsible for them. Also, there is little incentive to learn to operate and maintain the logging truck and to do it well when stewardship of the truck is only temporary.

Second, three months of training in any one country is going to be insufficient for any group of professionals to master all aspects of operation and maintenance. According to the evaluation team's estimate, it would take two years to train geophysical logging truck operators to become totally independent. The logging truck training would presumably consist of three parts:

- interpretation theory and practice for the different types of logs that the logging truck is capable of producing;
- introduction to the mechanical and electronic hardware and software contained in the truck; and
- elements of troubleshooting.

LANL presented no data on the cost of routine operation and maintenance of the truck during the "LANL phase" or during subsequent years. The evaluation team estimates the cost of truck operation to be in excess of US$500,000 per year for replacement parts, operations and maintenance. The US$500,000 includes replacement costs for lost logging tools, and LANL personnel costs. Total loss of the logging tool inside a collapsed hole may happen every 10 runs at worst, and every 100 runs at best. The evaluation team estimates the total loss of a logging string to cost about US$100,000. If the tool is lost every 20 runs, then costs for replacing the tool amount to US$5,000 per run.

Peat Assessments

The training of Costa Rican geologists from RECOPE in sampling and analysis has worked very well. RECOPE personnel are carrying on field investigations, sampling and assay analysis with minimal technical support from LANL, and have set up a peat analysis laboratory which should be self-sufficient in the near future. In Panama, IRHE personnel are conducting the sampling of Changuinola, while LANL continues to provide chemical analysis.

However, the training of engineers or economists in technology comparisons and feasibility methodologies has not been planned or offered, and this has resulted in a lack of interest from private industry and, more importantly, in the continuation of a program which may not have clear economic value. Training in strategic thinking and analysis that leads to clear investment decisions has not yet occurred.

Costa Rica Mineral Assessment

The course on ore deposit models in Costa Rica, presented by USGS at UCR, was given in Spanish and attended by 30 participants. The course was well received and considered useful. Unfortunately, the course was given concurrently with LANL project fieldwork. As a result, Costa Rican geologists participating in the fieldwork were unable to attend the course. The evaluation team believes that the course on ore deposit models could be enlarged as a series of courses emphasizing practical fieldwork.

Sampling and assay training, delivered by LANL and contractors (recent U.S. college graduates), was less well received. Central American geologists acquainted with the experience felt that the procedures taught were too simple to be called training, and did not give students insight into geochemical theory, economics, feasibility, or in-depth geological evaluation. Various observers remarked on the instructors' inexperience, cultural insensitivity and lack of Spanish language skills. Apparently, a contracting team of Costa Rican geology professionals had been offered as an alternative to the college graduates, but was not acceptable to LANL.

During the second half of October 1986, three DGMH geologists and three from UCR are to spend a week at LANL. They will participate in the analysis and interpretation stages of the geochemical assessment and will spend another week touring gold mines with USGS. DGMH had proposed that a smaller group work at LANL for a longer period of time to ensure more in-depth training, but this proposal was not accepted. Also a mineral assessment course will be presented in Costa Rica for which USGS has prepared a textbook.

3. Findings and Conclusions

Energy Situation Analysis

The evaluation team concluded that the project component where technology transfer is most successful, and self-sufficiency most feasible, is energy analysis and planning.

However, the current strategy, while it may lead to self-sufficiency in analysis, will not lead to self-sufficiency in planning. Weaknesses in the current approach are the lack of a link between energy analysis and economic planning; of adequate economic data; and of clearly enumerated goals defining self-sufficiency for each country and permitting LANL's departure.

Self-sufficiency is not only feasible for energy analysis and planning, but it is also necessary to reaping economic benefit from it. First, it takes a long period of continuous effort for analysis to be converted into policy by decision-makers. Second, models for projecting supply and demand require collection and analysis of data over long periods of time. Finally, it is essential that the counterpart organizations in each Central American country actively design and develop energy policy programs. Although LANL experts can assist in providing a framework, only indigenously developed energy programs will produce internal support for long-term implementation.

Although it would be difficult to devise an accurate cost/benefit analysis for the energy data and planning component for each country, a quantitative comparison would be helpful. UNDP is currently completing an energy analysis technical assistance project in conjunction with MEM in Guatemala. The project is designed to develop an energy demand model by sector and region to review energy investment policy. This task includes the establishment of a data base, information surveys, and associated computer software and hardware. It would appear that the UNDP approach of providing resident energy economists working in conjunction with government experts can provide a long-term technology transfer benefit at a lower cost. It is suggested that the LANL energy group review the energy planning technology transfer approach of UNDP, World Bank, IDB and other similar organizations.

Geothermal Program

In geothermal matters, self-sufficiency goes far beyond project efforts and plans. It takes six months to one year of fieldwork, as well as operations at headquarters, to train a geophysical field technician to operate geophysical field equipment reliably. It would take three to four years to train a non-geophysicist (an electrical engineer, for example) to become a geophysicist. This includes about two years of formal university training and another two years of field experience.

A high degree of technology transfer in this area is probably unnecessary to the economic benefit of the project's geothermal assessment component for two reasons. First, geothermal resource identification is justifiable on purely

economic benefit grounds if it succeeds at attracting investment in energy development and in energy-based industry. Second, well-done and thorough energy resource identification should cover needs far into the future and will not need to be done on an ongoing basis.

Peat Assessments

In Costa Rica, LANL has contributed to self-sufficiency at the field and laboratory levels necessary for the exploration, identification and characterization of peat resources. Unfortunately, expertise in energy and mineral-resource identification may do more harm than good unless accompanied by skills in economic analysis. Appropriate training is required to bring these elements into balance.

Costa Rica Mineral Assessment

Self-sufficiency in terms of the geological fieldwork necessary for identifying mineral target areas can be attained. Also, a trained manpower source suitable for sampling campaigns is attainable. Self-sufficiency at geochemical work is probably beyond Costa Rica's financial reach because large investment in laboratories is necessary. Costa Ricans can be trained to be self-sufficient at managing and contracting the geochemical assay work, however.

Prospecting and sampling self-sufficiency are not only feasible, but probably necessary for maximizing Central American economic benefit from the mineral inventory component of the LANL project. Prospecting for mineral wealth must be a continuous, rather than periodic, activity if deposits are to be found. Such an effort requires not only trained manpower, but also an organization to employ and manage the manpower.

A conclusion which can be drawn from the above findings is that technology transfer is feasible and necessary to economic benefit to varying degrees for the various LANL project components. In the paragraphs below, the evaluation team submits that technology transfer for a high level of self-sufficiency is:

- both feasible and necessary for the energy analysis and planning component;
- partially feasible and necessary for the mineral inventory component;
- only partially feasible and probably not necessary for the geothermal assessment program; and

- feasible for peat deposit identification and characterization, but may be of dubious value due to the problem of economic attractiveness.

4. Recommendations

Energy Situation Analysis

Urgent technical transfer needs regarding the energy situation assessment are:

- policy-level seminars conducted by INCAE where policymakers become educated consumers of the information and analysis contained in SICAPE;
- extension of technical assistance beyond data collection and analysis to energy policy formulation on the basis of data;
- self-sufficiency criteria and strategies for each Central American country based on the above description; and
- a phase-out schedule for LANL as Central American self-sufficiency is reached.

Of particular importance is the first recommendation because, in addition to transferring technology, the policy seminars contribute toward economic sustainability. The objective of the policy-level seminars would be to convert energy analysis into energy policy and thereby climb the objective tree in the table in Section IX.C. A workshop for the energy ministers of each country could provide a forum for discussion of regional and national energy policies. Possible venues for the policy seminars are INCAE and SIECA.

Geothermal Program

First, to maximize the benefit from geothermal resources, the required technology transfer should continue to be included in the development and management of the resources, not only in their discovery and assessment.

Second, discussions must commence early with potential beneficiaries of the logging equipment to ensure that they are ready to take over the costs of operations and maintenance after the one-year, project-funded logging program is over. It is recommended that the logging truck remain the property of the U.S. government until such time when the local service

organization has met acceptable standards and a budget for routine maintenance has been established.

Third, if the beneficiary countries do not take over the cost of operation and maintenance after the one-year free service period, the evaluation team recommends that the truck be sent back to the United States rather than being allowed to deteriorate.

Finally, opportunities should be provided for long-term training for professionals in geothermal areas. Two professionals from each country should be provided with the opportunity to complete master's degrees in geophysics in U.S. universities with strong applied geophysics programs and geothermal interests (e.g., University of Utah, San Diego State University, University of California at Riverside).

Peat Assessments

With LANL's help, RECOPE in Costa Rica has become self-sufficient at research in an area that may have little economic promise. LANL must continue to restrain RECOPE from proceeding down this road and help it find ways to more profitably use the human resource that has been developed. One way to do this may be to give RECOPE risk analysis training so that it comes to its own conclusions regarding the economic viability of peat.

Costa Rica Mineral Assessment

A modest, limited self-sufficiency objective must be established for the Costa Rica mineral assessment program. The objective must take into account employment opportunities in Costa Rica. Without a Costa Rican mining industry, geological and geochemical skills are of little value.

It is recommended that satisfactory formal arrangements be made for storing geological and geochemical data in Costa Rica. Possible repositories for the data include UCR and MINASA. Wherever the data are stored, both institutions must have access to the information.

Overall Institutional Strengthening

In cooperation with USAID/ROCAP and USAID missions, LANL should assess what is needed to create viable, capable organizations in its technology transfer efforts. Training directed at strengthening organizations must be based on analysis of organizational weaknesses. Often such analysis will conclude that management and system installation should accompany or even

take precedence over technical training. Organizational capability levels should be set, and training should be used to work toward them. It should be remembered that:

- one of the project's objectives is to attract investment for energy-based economic development; and

- investment decisions are sometimes based as much on confidence in the organizations that will manage the investment as they are on characteristics of the energy or mineral resource.

B. Private-Sector Involvement and Economic Sustainability

In the evaluation scope of work, economic sustainability is referred to this way: "Has the project capitalized on opportunities to collaborate with other projects, lever new funds or promote cofinancing?"

Economic sustainability is a long-term process. Thus, it is too early to judge the ultimate impacts of the LANL project in this area. However, it is not too soon to examine the soundness of strategies for achieving economic sustainability.

1. Project Thinking Regarding Economic Sustainability

Economic sustainability is mentioned frequently in LANL project planning documents. The most succinct statement is:

> Involve the local and U.S. private sector so that the resource assessment and development activities lead to job creating investments in commercial and industrial activities based on the energy and other natural resources that will be identified.

The problem with the above statement is that what the project really needs is public-sector investment in energy development which, in turn, may lead to private-sector investment in job creation. It is not serious that the language is off-target, but it is serious that the attraction of public-sector investment in energy development is not yet a major part of the LANL project. Thus far, LANL's collaboration with public-sector organizations has been in technical areas. Assistance in developing investment mechanisms must be included if the project's economic objectives are to be reached.

2. LANL Contact with Private-Sector and Investment Groups

Private-sector and investment groups with which the LANL project has had contact include GREMIAL in Guatemala, and INC and MINASA in Costa Rica. GREMIAL is an export promotion group made up of people from a broad range of Guatemala's private sector. INC is a cement factory, and MINASA is an organization with responsibility for attracting investment to natural resource development. These three are the only private-sector contacts being developed by the project which the evaluation team reviewed in the field. However, according to LANL, several U.S. companies specializing in the geothermal, peat and mineral areas have been contacted.

GREMIAL, Guatemala

The notion of involving the private sector in employment-generating investments led to the participation of GREMIAL in the geothermal direct heat demonstration in Guatemala. At the time of the evaluation team's visit to LANL, LANL understood GREMIAL's role to be largely marketing of the demonstration's products (dehydrated fruits and vegetables) and marketing studies. However, at the time of an evaluation team meeting with the local (as opposed to national) GREMIAL in Quetzaltenango, GREMIAL's local members were confused about their role. On the one hand they were enthused about the potential of the demonstration. On the other hand they were worried about their role and eventual benefit.

Topics discussed at the meeting were:

- GREMIAL's local members had thought their role would be substantial, and now they suspect that they are being used just to get opinions and make the project look good, but that they will not benefit;

- GREMIAL offered to have the project put on private land so that it could be part owner and therefore participate substantively--this offer was turned down by INDE due to its charter restrictions;

- INDE (the government operator of the geothermal facility) says GREMIAL will appoint the team to work in the facility--GREMIAL is not impressed with this suggestion; and

- the local GREMIAL recommended that respective responsibilities and participation be put down on paper--however, the LANL regional project coordinator had to demur because he did not have authority to make executive decisions on behalf of

LANL, and because the official agreement was between LANL and INDE and not with GREMIAL. In effect, the best results would be obtained if a quadripartite agreement (LANL, INDE, GREMIAL, Indian Agricultural Cooperative) were to be concluded.

INC, Costa Rica

Industrias Nacionales de Cemento of Costa Rica is one of the largest consumers of bunker oil in the country. Preliminary discussions to investigate oil replacement by peat or coal had been initiated. RECOPE advised the evaluation team that these discussions were ongoing and that INC had agreed to test a 100-ton peat sample at its Cartago plant.

At a meeting with the general manager of INC, the evaluation team was advised that no such test was being considered, that a preliminary study they undertook indicated that a peat-handling facility would require an investment of US$3 to US$6 million, and that RECOPE had been unable to provide enough supporting data on peat costs, availability, quality, transportation costs, etc., to warrant considering the matter further.

MINASA, Costa Rica

The project has had only minor contact with MINASA. However, it is worth some discussion because MINASA represents the type of activity LANL must promote if its scientific work is to bear economic fruit.

MINASA'S major role is attraction of foreign investment for development of mineral resources. MINASA has participated in several mineral-related projects in cooperation with international agencies. The projects include a study for radioactive occurrences, a data filing and retrieval system for known mineral deposits, and an ongoing evaluation of gold placers in the Osa Peninsula in cooperation with the government of Finland.

MINASA has also put together a first-class program for promoting mining ventures. Contacts have been initiated with private foreign mining companies and industry-related journals, brochures have been prepared, and complete information is available on properties being offered for international licitation, including preliminary economic analyses and mining law regulations. Unfortunately, the mineral prospects being offered by MINASA are small and do not represent investment opportunities that are attractive to foreign investors. Consequently, the response to the licitation has been poor.

Presently, MINASA finds itself in danger of extinction. MINASA is part of the mixed enterprise conglomerate, CODESA, which is being dismantled. At the time of the evaluation team's visit to Costa Rica, the Minister of Energy and Mines and his staff were battling with the task of saving MINASA.

3. Models for Joint Ventures and Profit-Sharing

The rules for international energy and natural resource financing have changed in recent years. International financiers are more flexible and willing to negotiate now than they were in the past. It is difficult to simultaneously attract investors and not give away national endowment, at least for a while. Key concepts for private investors are profitability based on discounted cash flow calculations, and trade-offs between amount of return on investment and risk. Due to regional uncertainties, private-sector investors in Central America would demand a higher internal rate of return than in stable areas. Some investment configurations that have had success elsewhere are listed below.

First, for the first X years full concession goes to the venture capitalist. After X years, control and proceeds revert to the host country.

Second, at the beginning, 100 percent of all profits go the the investor, and 0 percent to the host country. Every year, X percent of the investor's portion goes to the host country, until a 50-50 arrangement is reached. This arrangement is maintained in perpetuity.

Third, the venture capitalist puts up an initial investment, then receives 100 percent of proceeds until he gets his investment back. From then on, proceeds are shared 50-50 with the host country. Proceeds can be accrued by the host country either in the form of royalties or taxes.

Fourth, the venture capitalist makes an investment and keeps 100 percent of the proceeds until the host country buys him out according to a prearranged schedule.

Fifth, the venture capitalist builds the plant, then becomes part owner of the resulting energy, or energy-based, businesses.

Sixth, holders of foreign debt use the debt to build energy installations. Then they hold equity in those installations and pay off the debt with energy production proceeds.

Seventh, some seed money, soft-term loans and tax concessions are offered by the host country to attract foreign capital.

4. Recommendations

To involve investors in energy development and energy-based industry, the project should help Central American countries to build investment mechanisms and carry out investment campaigns in the public and private investment communities. Energy resources identified by the project must be analyzed and described to meet the requirements of the investment community, as opposed to the research community.

The evaluation team recommends that LANL hire a skilled investment analyst to provide senior-level consulting to LANL's representative in Guatemala from time to time. The latter has a demonstrated background in business management, is fluent in Spanish, and is knowledgeable in Latin American business style. The team, consisting of the part-time consultant and the local representative, could effectively educate Central American decision-makers as to the requirements of the international investment community, and act as facilitator in setting up national bodies who would do the necessary detailed work.

For each energy resource or end-use opportunity, it is necessary to generate economic and business opportunity analyses. The analyses should include discussion of local and international markets, a clear summary of local laws, possible credit support from the government and, for the international investment community, consideration of laws governing the repatriation of profits. Where appropriate, a discussion of government incentives, such as reduced taxes and the availability of grants, loans and other favorable terms, should be enumerated. Such marketing documents should be prepared for each project, at an increasing level of detail as new information develops. These documents should be disseminated to the appropriate clientele, banks and/or private investors. They should show the anticipated profitability of each project after all taxes and expenses (a pro forma cash-flow analysis, preferably on a discounted cash-flow basis). Projects with a high rate-of-return potential might attract significant interest from the financial community. For example, the US$25 million budget for the Ahuachapan geothermal field rehabilitation, which may increase current electrical power production by about US$25 million per year, should attract interest if properly packaged. It is reported that at any one time, somewhere between US50$ million and US$100 million are available in the U.S. investment community for projects that meet proper risk/reward ratios. However, none of that money will be available to international projects where basic terms, such as governing laws, tax rates, repatriation of profit and others, are ill-defined.

Given MINASA's good organization and expertise in project promotion, the evaluation team recommends that an effort be made

to keep it alive and that its responsibilities be expanded beyond the mineral industry so that the functions performed justify its existence. The evaluation team feels that MINASA's approach is precisely what is needed to convert energy and mineral discoveries into sustained economic impact.

On behalf of MINASA, MEM has informally asked the LANL project for analysis and advice in areas touching on its major role, such as attraction of investment, joint-venture models, mine evaluation, mining laws and regulations, concessions for exploration and exploitation, commercialization of minerals, mine management, contracting of drilling, and environmental protection. The evaluation team supports the ministry's request and feels it should be spread beyond the mineral area into the energy area. Project support for MINASA would require that MINASA be attached to an organization other than CODESA, which is being dismantled under pressure from the USAID mission.

VIII. STAFF PERFORMANCE, PROJECT COORDINATION AND MANAGEMENT

The objective of this section is to comply with the following components of the scope of work for this evaluation:

> The evaluation will focus on project coordination and staff performance.
>
> The evaluation team should evaluate project staff performance and their ability to work and interact with national counterpart institutions and bilateral USAID missions. Have communication and responsiveness to counterparts and USAID missions been adequate?
>
> The evaluation team should also review the PASA between AID and Los Alamos . . . to assess congruency in terms of the specific activities which were to be carried out by Los Alamos.

This section includes:

- PASA contract requirements for LANL staff;
- LANL's approach to technical assistance;
- project management, including Los Alamos-based management; and
- recommendations to improve the cost-effectiveness of staff performance.

A. PASA Requirements for LANL Staff

A good starting point for this section is the list of "General Qualifications Required of PASA Staff for the LANL Project" from the official PASA contract (ILA-034-P-ER-5024-00) between AID and LANL. In the following paragraphs, personnel requirements from the PASA document (underlined) are compared to LANL staff qualifications and performance. Note that the PASA agreement is very concerned that there be collaboration with institutions in Central America and connection of energy technology to broader planning and economic concerns. According to LANL, the PASA was negotiated not with LANL, but with the U.S. Department of Energy, and LANL did not receive copies of the PASA until a few months after its signing. The discussion below is based on information gathered by the team during review of

documents and in conversations with project staff, AID personnel, and Central Americans working with the project.

1. Collaboration with Central American Institutions

- Professional stature to command respect and work at peer levels with host-government technical specialists.

Advisors in the engineering and geology areas generally have superb professional credentials, have performed at the highest technical level, and are generally highly respected by host-country technicians. Advisors in the energy situation analysis and energy planning areas generally have less practical and professional experience, although their progress has been good.

Host-country technical experts seem to have been consulted in technical matters, but indicated to the team that they often felt that LANL sets its program objectives without adequately taking into account host government priorities. Memoranda of understanding between LANL and counterpart agencies describing objectives and dividing responsibilities have not always been done and are sometimes weak. Doing a better job with their memoranda might help alleviate some of the negative feelings observed by the evaluation team.

Host-country personnel are exasperated at times by the amount of "hosting" required by large groups of technical experts with little Spanish. Everyone, including LANL, seems to clearly recognize the need for better Spanish speakers and smaller groups.

The geochemical survey geologists from LANL (as opposed to the USGS group) included recent college graduates and, unfortunately, left an impression of cultural insensitivity with a number of people.

- Ability to deal with senior government officials, and with representatives of other sponsoring agencies, on issues of importance to energy and economic development.

An ability to deal with senior government officials effectively depends on speaking excellent Spanish, on having a broad policy approach, and on having worked extensively in Central and Latin America. The only project employees with the appropriate background for dealing with Central American officials in policy matters appear to be the Central American project manager, regional project coordinator, and geothermal programs field coordinator. Thus far, however, it seemed to the team that they have not been given tasks in this area.

- Spanish language at the FSI-2 level will be generally required for in-country work unless waived by the USAID mission. One member of each technical team must have S-3, R-3 in Spanish.

Apparently only three of the LANL team members (the project manager, regional coordinator and geothermal programs field coordinator) speak Spanish with real proficiency. Also, the minimal proficiency requirement (FSI-2) seems to have been waived for short-term consultants. Short-term teams are often accompanied by a LANL interpreter, and Spanish training for long-term staff is supplied under the contract. Neither arrangement is normal for AID contractors. At the technical level, necessity for Spanish is partially obviated by the ability of many Central American technicians to speak English. To operate at the policy level, however, it is the evaluation team's opinion that good Spanish is necessary.

- Collaboration with AID officials.

According to USAID mission staff, collaboration with USAID missions has been weak, and missions have a negative image of the LANL project. Some sources of the negative image are the high frequency, short duration and large size of LANL technical assistance teams; lack of activity design consultation and collaboration with USAID missions; and USAID mission annoyance with regional projects.

USAID missions unanimously perceive the LANL project as being expensive in the extreme, operating independently of some normal AID regulations, and having weak formal relationships with Central American institutions. Some USAID mission staff are concerned that their own hard-earned credibility is being undermined by the LANL project.

2. Economic, Development and Financial Analysis of Energy Programs

- Planning and management of broad programs of economic and social development.

It appears that the PASA requirement for expertise in planning and management of broad programs of economic and social development has not been given adequate attention by LANL. This is an issue in assigning staff to the project with economic, development and planning experience, in carrying out analyses, and in general strategic development planning for the overall project. For example, outside of energy planning teams fielded by LANL, staff tend to be of a purely engineering composition. The need for better financial and economic studies and planning has already been mentioned in several sections of this report.

The evaluation team is aware that this project is LANL's first attempt at work in a developing country. LANL is learning, and it is AID's wish that LANL continue to improve in understanding and performance regarding the broad aspects of development work. However, it does appear to the team that LANL needs to give much more attention to developing skills and improving planning performance in this general area.

- Analysis and proposals addressing economic feasibility, social soundness and energy-related conditions (such as technology transfer).

The teams fielded by LANL are multidisciplinary in that they include a variety of hard scientists, but not in the sense that they include experts in practical economics, social science and technology transfer. Consequently, the PASA requirement for analysis in such areas has received little attention. For example, first, LANL's reports on energy resources meet engineering research requirements, but not the requirements of the investment and development communities. Second, adequate economic analysis and risk analysis have not been performed to test the economic potential of the peat resource. Third, the logging truck component and the geothermal direct heat component have thus far been carried out with little attention to the basic principles of technology transfer.

- Analysis of factors in national energy development and identification of points where national progress has been constrained.

The PASA requirement for expertise in this area has been given inadequate attention by LANL both in making staff assignments and in practice. The vast majority of high-level expertise has been in engineering areas rather than in broad energy and development policy areas. As a consequence, the project has not clearly analyzed major points where energy-based development is constrained, e.g., in relating the project's key activities directly to each country's energy picture and long-term energy and development plans. This issue is addressed in detail in Section III.

- Application of technical knowledge in the energy field to the problems of developing countries.

As mentioned previously, expertise in the role of energy in developing-world economies has not been given adequate attention by LANL in terms of staff assignments or in practice. More expertise is needed in this area. However, in engineering/technical areas, this is less clear. Very good technical work and fieldwork have been done by the staff. How successful LANL will be, or can be, in relating this good technical capability to

developing-country problems is not yet clear to the evaluation team.

B. LANL's Approach to Technical Assistance

It is the understanding of the evaluation team that LANL carried out a very rapid start-up of the project. It is a credit to LANL management that they began and carried out work in such a rapid manner and have attempted to address the problems of Central America. LANL staff have stated that they hope they can provide long-term assistance to development efforts in Central America, and AID has also indicated interest in pursuing this strategy of technical assistance. Since this is a new area of endeavor for LANL, LANL management and staff are in the process of developing different skills and information bases to effectively carry out this new type of work.

What is most different for LANL is the context of the work and the nontechnical issues that are so important to project success. The evaluation team has noted a number of issues that it feels LANL management should be aware of and address. Most of these were pointed out to the team by either AID or local government personnel and were also observed by the team. The evaluation team has approached this subject area cautiously, as there are often several management approaches to achieving results, and these are subjective according to who is doing the managing. If this evaluation can illuminate and bring about discussion of these issues, then it will be successful in helping improve project operations.

Most geological and engineering work is done by teams of experts during short visits to Central America. LANL technical assistance teams consist mainly of highly qualified and specialized technicians who speak little or no Spanish. By AID standards, the teams seem in relation to the scope of work--four- and five-person teams are common, with each member having a narrow technical responsibility.

One result of LANL's approach is a large number of people making numerous trips of short duration to Central America. The evaluation team is concerned with the effect of frequent travel on the continuity of work, relationships with counterparts, and travel costs. The number of LANL staff involved is purported to be 65, although not all travel to Central America. The original PASA agreement and the three amendments budgeted for 228 round-trip tickets to Central America. When the cost of LANL travel is calculated, two days' salary per trip per professional must be included for travel time. This seems to be a high cost that should be examined by LANL in terms of cost-effectiveness.

Two major portions of the large travel itinerary are the geothermal assessment and mineral inventory work in Costa Rica. The hydro-geochemical team often consisted of seven individuals. There is some indication that two to three scientists scheduled for longer periods would have been sufficient to carry out the entire fieldwork program. Also, more effective use of the two highly capable LANL representatives in the region might have saved the project a significant amount of travel.

Energy assessment and planning work has been performed by a combination of short-term and resident advisors. The team feels that the professional background and level of energy planning experience of both short-term and resident advisors have not been at a senior and experienced enough level, and Spanish-language capabilities have been very weak. This is extremely important in the energy planning area, even more so than in other components of the project. The evaluation team questions whether LANL's strategy has resulted in appropriate technology transfer. To address the larger policy and economic analysis issues, the team believes that resident, Spanish-speaking, senior-level personnel are required. The team feels that LANL needs to answer a basic question--what level of expertise and professional experience does LANL feel is necessary to operate at peer levels (as required in the PASA) and provide a product to Central American governments that will solve the problems and meet the objectives of the project?

C. Project Management

1. LANL

It is the evaluation team's impression that the LANL matrix management mode leads to fragmented planning, budgeting and reporting, and an inability to relate costs to project objectives when applied to this type of overseas project. More important, the matrix management mode seems to prevent the formation of a full-time team of people who see their main success as depending on finding solutions to Central American energy and economic problems.

LANL management does a great deal of detailed planning of trip schedules and work. However, it appeared to the team from discussions and document review that very little strategic planning for addressing Central America's energy and economic problems was done. Moreover, currently it seems that reporting is slow and somewhat directed at a research community audience. However, economic development requires quick reporting, designed for the investment community.

LANL management has not been presenting "project-life" budgets. AID should have the total cost of a project activity for reaching economic benefit or self-sufficiency before embarking on the first installment. One example of LANL's approach is the logging truck, for which projected operations and maintenance expenses are very high and were not yet mentioned. Another example is the Guatemala geothermal direct heat demonstration, where maintenance, operations, marketing and training costs were not mentioned.

A positive observation on overall operation in Central America is the unanimous agreement that things improved enormously after the appointment of the Central American project manager. Everyone feels that his ability to speak Spanish and understand Central American problems are essential.

Both the project coordinator and geothermal programs field coordinator in Central America are experienced and competent in overseas management, particularly in dealing with Central American organizations and USAID missions. However, their potential for improving project management is largely lost because they serve mainly as communications links.

2. USAID/ROCAP

USAID/ROCAP project management has been hindered because there are no design and management tools that permit ROCAP to direct the project in a development context and make recommendations and decisions. The evaluation team has made suggestions for improving this situation (see sections IX and X). Also, financial decisions still reside with AID/Washington, which diminishes ROCAP's ability to manage the project.

3. Advisory Committee

The role of the advisory committee should be to bring expert, multidisciplinary review and advice to the LANL project. The committee is multidisciplinary, however, only in the sense that it includes various types of engineers and hard scientists. In fact, the advisory committee is very narrow when compared to problems addressed by the LANL project. The committee includes no Latin Americans, AID personnel, technology transfer experts, industrial development experts, or representatives from the financial community. The advisory committee could have been a mechanism for preparing LANL for its new economic and Central American mission. It has not yet served that purpose.

D. Recommendations

1. Improving Staff Performance

Full-Time, Multidisciplinary Project Team

First, serious consideration should be given to raising the Central America effort to the department level within LANL. Borrowing matrix fashion from other departments for all operations has many weaknesses. The evaluation team is only suggesting here that the management model that has worked well on other LANL programs may not be the best for this one due to the project's subject matter and overseas location.

Second, a full-time Central America task force is needed, and it must be truly multidisciplinary. In addition to this technical area, task force members should have Spanish and management skills, with industrial development and technology transfer as a vocation. In sum, the staffing requirements originally laid out in the PASA contract between AID and LANL should be observed.

Third, the project team should have its own objectives, procedures, success criteria and spirit. Success for the Central American energy task force should include funded development of energy and mineral resources, industrial development, job creation, and balanced payments for Central American countries.

Fourth, decision-making must be near the economic and energy problems of Central America. Decisions must be made by people who understand the field problems thoroughly. This means that the Spanish-speaking staff, at least half of whom should be based in Central America, should decide who visits Central America, when, and with what objectives.

Technical Assistance Teams

To become more cost-effective, LANL should consider having short-term technical assistance teams follow several suggestions. First, they should have longer stays and include fewer travelers, more of whom should speak Spanish. Second, they should take to Central America only those scientists and technologists who must be on site to do their work, leaving in Los Alamos those who can analyze material brought to them from Central America. The evaluation team realizes that LANL management may well have always tried to do this, but suggests that this matter be given a hard look. Third, wherever possible, LANL should use technicians who can handle more than one narrow specialty. Finally, when a translator is needed, one should be hired locally.

Multidisciplinary Advisory Committee

The advisory committee should include not only technical experts, but also technology transfer experts, Central Americans, AID managers, industrial development experts, and representatives from the investment community who might be interested in financing development of the energy and mineral resources found by the project.

2. Planning, Budgeting and Reporting Practices

- Adopt a problem-solving mode rather than a technology-driven mode for generating project activities.

One lesson from the LANL project's energy situation analysis is that energy decisions should be based on analysis of energy and economic problems. Therefore, the LANL project itself should derive project components from the energy situation analysis. The evaluation team is convinced that if careful analysis had preceded the LANL project, the portfolio of components would have been quite different from the current one and considerably more effective.

- Do simple pre-feasibility calculations of the risk analysis type before committing to expensive resource identification and feasibility work.

Expertise in energy and mineral resource identification skills is only really helpful when accompanied by skills at economic analysis. An example is the LANL project's experience with peat in Costa Rica and Panama, where much money was spent, fine work was done, and technology transfer was achieved in an area with questionable economic potential. Put in a nonformal context, Central America (and LANL) must learn not only how to climb hills, but also how to choose which hills to climb.

- Adopt "project-life" rather than "accounting-period" budgets.

To avoid underfunded or incorrect budgets, LANL and ROCAP must adopt a sequence where plans and budgets are derived by working backwards from development objectives. For geothermal assessment, perhaps LANL's most promising activity, the specific planning recommendation is that the project provide a complete road map of activities and associated budgets all the way to on-line power, even if USAID/ROCAP will fund only a portion of these activities. A complete project and budget plan will clearly identify activities critical to power plant financing, thereby

improving scheduling, budgeting, and requests for outside financing.

LANL resource and end-use assessment budgets should be derived by working backwards from invest/discard decision points. First, LANL and ROCAP must agree on invest versus discard decision points toward which each component of resource and end-use assessment is directed. Second, information necessary to make the invest/discard decision must be specified. Third, AID and LANL must agree on the activities and budget necessary for reaching each invest/discard decision. Finally, the amount of time and money necessary to collect, analyze and package the information for consumption by the investment community must be estimated.

- Adopt investment community, rather than research community, reporting requirements.

The most important factor to take into account when building a monitoring and reporting system is the point of view of the system's users which, in this case, are USAID/ROCAP and the development investment community. USAID/ROCAP's interest is in arriving at bankable energy mineral resource end-use projects as quickly and inexpensively as possible. Therefore, reports to AID should include information on which investment decisions are based. Other, separate reports can include technical and scientific information that provides background for investment decisions. Factors on which investment decisions are based are listed in Section X.D.

3. Improving Coordination with Central American Organizations and USAID Missions

First, the LANL project must focus on AID economic objectives for the Central American region. In preparation for clarifying this, a final logical framework for the project should be worked out by LANL and ROCAP. Both financial and program management should be carried out by ROCAP. The current arrangement, where financial decisions are made in Washington, makes this difficult for ROCAP.

Second, all memoranda of understanding between LANL and every counterpart institution should be systematically reviewed, strengthened and clarified. Objectives, responsibilities and contributions should be spelled out clearly. Experience with other AID projects shows that projects without substantial contributions from counterpart organizations rarely work.

Third, project management and SICAPE should be combined in some fashion, so that they share the same communication system and data. Consideration should be given to buying modems so that

electronic mail can connect all energy situation analysis stations and carry out SICAPE and project management communications. The CARINET system now operating throughout Latin America is one possibility.

Fourth, solutions to the future logging-truck coordination problem should be considered. The issues involved are technological sophistication, sharing and management, continued dependence on the United States, and operations and maintenance costs. A partial solution is to make the user pay operations and maintenance fees, including insurance against loss of instrument cables. The fee would be approximately US$50,000 per month and have two beneficial effects in addition to covering operations and maintenance costs. First, the fee would force countries to use the truck while they have it rather than letting it sit. Second, it would make countries give up the truck rather than keep it indefinitely. If agreement to the above arrangement cannot be acquired, then the truck should only be loaned to Central American countries for one year and managed by Los Alamos staff during that year.

4. Change in LANL Project Philosophy

The above recommendations add up to a change in philosophy, not just procedures. The change in philosophy can be described as a change from a "technical excellence" philosophy to include a "cost-effective economic impact" philosophy.

LANL's approach has often been technically excellent. In many cases, especially in the geothermal area, it would not have been possible to purchase higher-quality technical work at any price. However, the approach has not been cost-effective in moving toward economic impact. Technical work serving the purpose of identifying opportunities and attracting investment could have been purchased at a much lower price.

The reasons for LANL's failure to be cost-effective in moving toward AID's economic development objectives are discussed throughout this report. Important among them are the narrow engineering focus of the teams, travel schedules where many people go back and forth many times, failure to establish invest/discard decision points, lack of financial and economic analysis, and failure of the project design to include an investment campaign on behalf of the opportunities developed by the project.

It might be said that LANL has developed a fine model for carrying out resource assessment, especially in the geothermal area. Now is the time for systematically streamlining the ideal model toward cost-effectiveness. LANL should now optimize for energy production per dollar spent, rather than for technical information generated. If LANL wants a place in development

history, then it will attack the cost-effectiveness challenge with the same rigor and intelligence it has traditionally applied to the technical excellence challenge.

IX. LOGICAL FRAMEWORK FOR THE LANL PROJECT

This section meets the following requirement from the evaluation scope of work:

> Review logical framework prepared by LANL and recommend changes, if needed. Particular emphasis should be given to project purpose indicators.

The discussion is divided into the following subsections:

- logical framework from the March 1985 project plan;
- SES Development Corporation's attempt at a logical framework in July 1986;
- objective tree for the project; and
- a tentative new logical framework for the project.

In reading this section, please understand that LANL was not asked for a logical framework until well into the project and that logical frameworks are difficult to prepare. Any criticism implied by this section is of AID management, not of LANL. AID should have included preparation of a logical framework, or other formal project design, from the outset of the LANL project.

A. Logical Framework from March 1985 Project Plan

The logical framework referred to in the scope of work is the product of a contract carried out by SES Development Corporation and delivered to LANL on 1 July 1986. However, a discussion of project design and the logical framework, in particular, must start with the original "Central America Energy Resources Project: Plan for Concurrent Phases I and II," submitted by LANL in March 1985.

In prose, the March 1985 document sets forth a skeleton logical framework, as follows:

- Goal-Level Objectives and Indicators

  --Improve the economic condition of Central America.
  --Create employment.
  --Increased and more efficient use of energy and natural resources.

- Purpose-Level Objectives and Indicators

  --Introduce more efficient technologies into the region.

- Output-Level Objectives

  --Assessment of natural resources, especially nontraditional ones.
  --Analytical framework that compares energy and mineral development options in terms of trade, import substitution, balance of payments, costs and job creation.
  --Technical and managerial skills in the above areas.
  --Involvement of the private sector leading to job-creating, energy-based, commercial and industrial investments.

In the opinion of the evaluation team, this is a reasonable first step toward a solid logical framework and, more importantly, project design. The major weaknesses are the vagueness of the phrases "introduce more efficient technologies" at the purpose level, and "private-sector involvement" and "technical and managerial skill" at the output level. That the March 1985 document is vague in these areas is neither surprising nor serious. However, the fact that thinking, design, documentation and, above all, project operations have not improved on the March 1985 document is important, and may have reduced the project's potential to produce economic benefit in Central America.

The trouble with the phrase "introduce more efficient energy technologies" is that it can mean anything from doing research on Central American soils to leaving behind permanent, operating energy production facilities. Subsequently, in word as well as deed, "introduce" has been taken by LANL to mean something quite close to the former end of the "technology-introduction" continuum.

The problem with "private-sector involvement leading to job creation" at the output level is that what is really needed by the project is public-sector involvement in energy development, which in turn, may lead to job creation by the private-sector. It is not serious that the language is off target, but it is a problem that the attraction of public-sector involvement in energy development is not yet a major part of the LANL project (see Section VII).

Finally, the weakness of "technical and managerial skill" at the output level is that training individuals in various technologies does not necessarily translate into comparable capabilities for their organizations. What is needed is the organizational capacity to perform the skills introduced by LANL,

not just individuals' abilities. The project has not addressed institutional strengthening in either language or action, over and above the training of individuals.

B. SES Attempt at Logical Framework in July 1986

Unfortunately, the 1986 SES Development Corporation's attempt at a logical framework does not improve on the good start made on a framework and project design in LANL's original March 1985 planning document. The SES attempt appears to be an effort made by a group that does not understand how to develop a logical framework or the purposes of this tool. According to LANL, SES was chosen to carry out the work with AID's approval. A detailed criticism of the SES logical framework in this context would not be productive, since there is little to be learned about either the LANL project or developing a useful logical framework.

The logical framework is AID's tool for designing and evaluating projects. One major use of this tool is converting technical activities, such as LANL's efforts, into economic development projects. The logical framework is sophisticated and powerful, and its proper use requires considerable training and experience. A good logical framework should highlight problems or program deficiencies that need to be addressed, suggest solutions and set up project reviews at critical points. These reviews are intended to monitor progress, implement decisions about whether to proceed with the project or search for other alternatives. The SES effort fulfills none of these functions and does not provide a coherent strategy for producing the desired results, such as private-sector involvement, self-sustaining growth or technology transfer.

The process of using a logical framework consists of

- simplifying complex situations,
- quantifying project intentions and objectives, and
- measuring the project's progress against those objectives.

Two important concepts used in a logical framework are reviewed below.

Project purpose refers specifically and unequivocally to the permanent, intermediate development impact of a project--it tells why a project is being carried out, not what it does. For example, a doctor's purpose is to cure patients, not to give them medicine. Project purpose explicitly and absolutely does not refer to tasks carried out during a project.

When properly used, project assumptions refer to factors beyond a project control's that can importantly influence project success and progress. The more assumptions there are, the less feasible a given project is. Thus, careful project design minimizes the number of assumptions by including important factors under the control of the project. In the SES logical framework, the assumptions column was used to list all manner of factors, only some of which were important, both within and outside project control. This did little to help assess project feasibility and the solidity of its design.

C. Objective Tree for the LANL Project

The table on the next page presents an objective tree for the Central America Energy Resources project. The tree is based on LANL project documents, interviews with project participants, and an analysis of the energy and economic situations in Central America. Objective trees are part of the pre-feasibility phase of project design and properly precede risk analysis.

Each entry on the tree represents an objective and each arrow, a cause-effect relationship or hypothesis connecting the objectives. A project plan attempts to assure attainment of the objectives and hypotheses. A monitoring and evaluation system measures achievement of the objectives and, hence, validation of the hypotheses. Causes are located at the bottom of the tree and effects at the top, which mirrors the way AID's logical framework for designing and evaluating projects is organized. The dotted horizontal lines denote boundaries between major levels of the objective tree. Along the left-hand edge, these levels are labeled for later use in developing a logical framework for the project. It should be noted that instead of the usual four-level scheme, this objective tree has five levels. To capture the full sense of this project, a subgoal level between the goal and purpose levels was added.

Of particular importance is the dotted line that ought to separate the purpose and output levels, but does not. As noted in the preceding section, purpose refers to the intermediate development impact that LANL will strive to leave behind after the project is over. Outputs are derived from the project purpose and are deliverables for which LANL has been contracted.*

One could ask, "If the purpose is the desired end, why not contract for it directly?" This cannot be done because the

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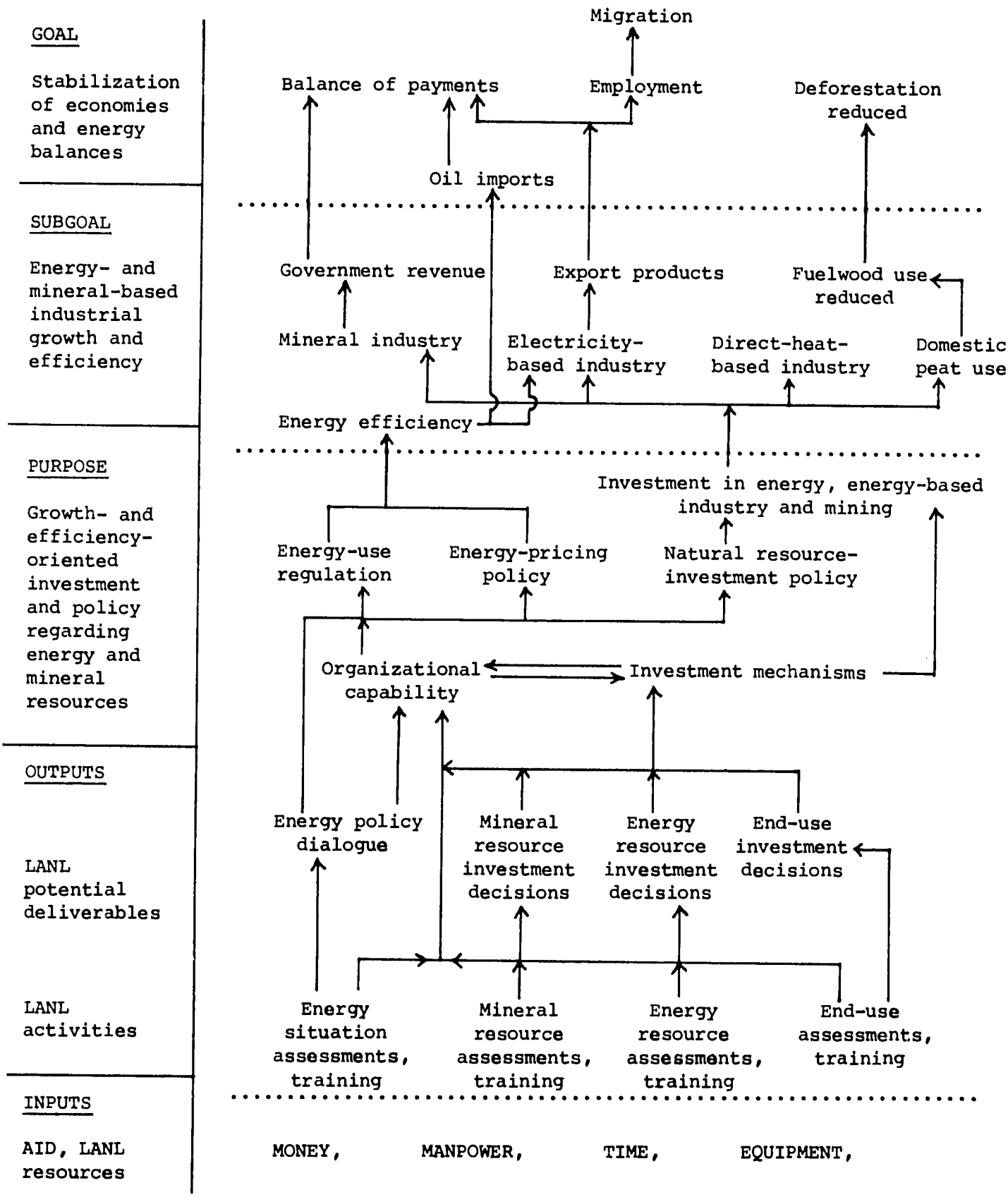
*As matters stand, LANL's contractual obligations are unclear. They seem to require accomplishments at the "assessments" level of the objective tree. They ought to require accomplishments at least at the "investment decisions" level if development objectives higher on the tree are to be met.

Objective Tree for the LANL Project



purpose level is too difficult to achieve. To continue with the same example, the patient wants a cure from the doctor, but no doctor will sign a contract to cure a patient because achievement of a cure (the purpose) cannot be guaranteed. One might then ask, "If the purpose level is too difficult to be contracted for, why should it be included?" First, outputs (or contracts) are derived from a specific definition of project purpose in the same way that medical treatments are derived from a specific definition of an ailment. Second, project success is judged by the achievement of its purpose (development impact), not the completion of outputs (contract deliverables).

The major message of the LANL project's objective tree is the questions raised by the feasibility of scientific activities or projects directed toward clear economic objectives over the medium term. The links necessary to convert the project's scientific and technological activities to economic benefit are numerous and tenuous. They include institutions for investment campaigns, mechanisms and decision-making; energy pricing and conservation; and the management of energy and industrial projects. These links are tenuous because they do not already exist, nor are they being directly created by current project activities. Thus, as things stand now, the project may not be feasible because its justification is couched in terms of economic objectives that cannot be reached given the current set of project activities and its logic.

The missing links just noted are not part of LANL's usual work, nor are they specified clearly in its contract with AID. Thus, it could be argued that they are not LANL's responsibility. Nevertheless, these missing links rob the project of its potential, make its optimal economic impact questionable and may give it a low economic value for AID, compared to other uses for the funds allocated. This set of issues requires further discussion between AID and LANL.

An argument for the project from a research community perspective is that information about the region's potential is worthwhile in and of itself because it may be of practical use sometime in the future. This is correct, of course. However, when investments are made from scarce funds, they cannot be considered just on their own merit, but rather, must be compared. An energy or end-use inventory with immediate, practical economic utility is competitive with other investments, while one that may only be useful at some future time is not.

D. Tentative New Logical Framework for LANL Project

The table on the following pages presents a new logical framework for the Central America Energy Resources project. The evaluation team offers this logical framework only as a suggestion that would require further work and clarification by

Tentative Logical Framework for the LANL Project

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS
Program Goal: Stabilization of Central American economies and energy balances	Measures of Goal Achievement: A. Economies 1. Employment rate returns to 1980 level 2. Balance of payments returns to 1980 level 3. Balance of trade returns to 1980 level 4. Emigration/migration balance B. Energy Balances 1. Stable oil consumption and imports 2. Stable energy cost per calorie 3. Neither energy deficits nor idle capacity 4. Deforestation/reforestation balance
Program Subgoal: Energy- and mineral-based industrial growth and efficiency	Measures of Subgoal Achievement: A. New Energy Plants 1. Electricity generated 2. Direct heat generated 3. Sales, profits, cost coverage 4. Employment generated B. New Energy-Based Industry 1. Value of products 2. Sales, profits 3. Employees C. Mining Industry 1. Value of production 2. Sales, profits 3. Employment 4. Revenues to government D. Energy Efficiency 1. Energy saved 2. Natural resources protected
Project Purpose: Growth- and efficiency-oriented investment and policy regarding energy and mineral resources	Conditions Indicating Purpose Achieved: A. Geothermal Wells 1. Investments 2. Put into production 3. Linked to the economy a. Management b. Pricing B. Peat Mines 1. Investments 2. Put into production 3. Connected to the economy a. Management b. Pricing C. End-Uses 1. Investments 2. Put into production 3. Linked to the economy a. Management b. Marketing D. Government Energy Policy 1. Pricing policy a. Cost-based b. Projection-based c. Environmental costs included 2. Investment policy a. Low-cost alternatives 3. Regulation a. Conservation E. Capable energy organization

NARRATIVE SUMMARY (continued)	OBJECTIVELY VERIFIABLE INDICATORS (continued)
Outputs: A. Invest/discard decisions B. Investment documents C. Investment campaigns D. Investment mechanisms E. Skilled energy professionals	Magnitude of Outputs: A. Invest/discard decisions B. Investment documents 1. Identification of resource, product, market a. Profitability b. Amount c. Time/money needed to complete identification 2. Economics a. Risk analysis b. Cost advantage c. Debt coverage ratio d. Payback period e. Relation to grid, user 3. Investment climate a. Client balance sheet b. Fund repatriation C. Investment campaign 1. Investors contacted 2. Results, why not? D. Investment mechanisms E. Organizational analysis, tailored treatments
Inputs (Budget Categories): A1. Geophysical assessments A2. Economic assessments A3. Financial-climate assessments B. Investment documents C. Investment campaigns D. Training E. Organization building	Level of Effort/Expenditure (Resource Types): Planned (project life) versus actual: Money/person-months/materials/travel

LANL and AID. It is meant as a best approximation of the desired project, but as is always the case with a statement of project design, it must accurately reflect the intent and logic of those implementing the project or it will be useless. This new logical framework serves two functions:

- it corrects project design weaknesses detected through analysis of the objective tree, primarily in refinement of the project purpose and one of its outputs; and

- serves as the basis for a monitoring and evaluation system that will improve project management.

The logical framework suggested here is derived directly from the objective tree discussed in the preceding section, which is the proper way to use the logical framework as a design tool. The levels in the logical framework correspond precisely to those of the objective tree, and indicators in the logical framework parallel entries in the tree, but are more numerous and more precise.

1. Project Purpose

The original purpose of the project was to "introduce more efficient energy technology." This has been replaced with "growth- and efficiency-oriented investment in and policy regarding energy and mineral resources." In the evaluation team's view, this more precise, more ambitious purpose is the permanent, intermediate development impact that the LANL project aspires to achieve without having articulated it. This new purpose is both valuable to AID and attainable by LANL and should become the "criterion for success" to prove that the project is worth the funds invested in it.

2. Private-Sector and Investment Output

One of the four "end-of-project results" proposed for the project is:

> involve the local and U.S. private sectors so that the resource-assessment and development activities lead to job-creating investments in commercial and industrial activities based on energy and other natural resources that will be identified.

The intention clearly is to assure that energy resources, mineral resources and end-use applications identified by the project lead to sustained economic development.

Success in involving the private sector and attracting investment for the purpose of producing sustained economic benefit has been limited. In the judgment of ARD, the lack of success in this crucial area has occurred largely because it has been poorly defined and misunderstood. From ARD's analysis, the lack of understanding of the investment attraction component of the LANL project has three aspects.

First, the language ". . . job-creating investments in commercial and industrial activities based on energy and other natural resources that will be identified" may have focused the project's attention on energy-based industry to the exclusion of investments in development of energy itself. As the objective tree shows, investment in energy development must precede investment in energy-based industry, if the LANL project is to convert its scientific and technical work into economic results.

Second, since energy development is a public-sector activity, especially in Central America, involvement of the public sector, not just the private sector, is crucial to project success. In particular, investment in and the development of geothermal resources are historically the domain of national electric companies and IDB, etc.

Third, "involvement of the private sector" has thus far been limited to attempts at including specific groups in particular projects. Such involvement is fine, but it is not enough. ARD concludes that it makes sense for the LANL project to also help Central American countries build mechanisms for attracting capital from local and international public and private sources. These "mechanisms" could include incentives, investment structures and publicity campaigns for the opportunities offered by Central American energy and mineral resources.

3. Managerial and Technical Skills Output

A concept related to technology transfer and necessary to economic sustainability, but which is missing from the project objectives or tasks, is organizational strengthening. The phrase "build technical and managerial skills so that a self-sustaining economic development process is established" skips over the concept of organizational strengthening. On the one hand, economic sustainability depends on the capacity of organizations to manage technology, investments and projects. On the other, technical and managerial skills are developed at the individual level through experience and workshops and do not necessarily lead to organizational capacity.

4. Bringing Major Assumptions under Management Control

Important factors outside project control that influence a project's success or progress are called project assumptions in logical framework terminology. To date, the Central American Energy Resources project has left major obstacles to energy-based economic development outside its control. One such obstacle is the lack of investment mechanisms for developing energy and mineral resources and end-uses identified by the project, while another is the lack of institutions capable of carrying out the necessary energy policy and energy management tasks.

The tentative logical framework for the LANL project presented here attempts to place both the investment mechanisms and the organizational capacity assumptions under the project's control, thereby improving the project's feasibility, potential and economic value. Of course, the inclusion of such important assumptions under project control can only be partial. This process of bringing appropriate assumptions within management control is the way in which a logical framework is meant to be used as a project design tool. It is the evaluation team's view that the inclusion of the investment mechanisms and organizational capability assumptions within the LANL project's control may make it much more worthwhile.

E. Recommendations

This section has given the LANL project a basis for a new project design and logical framework, aimed at converting technical and scientific activities into economic development results. The next step in the process of refining the LANL project design must be taken by LANL and USAID/ROCAP together, perhaps with the help of a consultant who is skilled in project design and consolidating materials from various perspectives. The process to be followed during refinement of the project design has several steps:

- clarification of and agreement on project logic;
- general definition of project outputs and deliverables;
- quantification of project objectives;
- establishment of a time frame for the achievement of project objectives; and
- definition of project components, responsibilities, resources and budgets.

This process must be initiated immediately and completed within the next three months.

X. MONITORING AND EVALUATION SYSTEM

This section addresses the following requirement from the scope of work for the evaluation:

> Prepare monitoring and evaluation plan which can be used by Los Alamos and ROCAP to monitor project progress with particular attention to tracking goal and purpose achievement.

This section is based on the logical framework analysis presented in Section IX. The topics covered here include:

- the current monitoring and evaluation situation;
- basic principles for building a monitoring and evaluation system;
- evaluation of accomplishments at the goal and purpose levels;
- monitoring progress at the output and input levels; and
- project planning and installation of a project monitoring system.

A. Current Monitoring and Evaluation Situation

Current reporting by LANL tends to focus either on trips taken or on technical details. The reports do not provide a comprehensive view of critical events, nor do they relate technical progress to investment and development decisions. According to personnel in AID/Washington, the nature of LANL reporting has endangered project funding. In addition, "because of LANL fiscal procedures, a direct attribution of financial relationships between dollar inputs and project outputs is not possible" (SES study, July 1986).

Early in the project (November 1985), LANL asked AID for guidance regarding the format and content of progress reports. Part of the problem is the lack of a clear set of progress indicators or an agreed-on set of information to be covered in progress reports. The evaluation team could find no clear guidance from AID to LANL on reporting needs. On the other hand, ROCAP was not in possession of a complete set of technical and managerial reports, and no list or complete repository of project information seems to exist.

B. Building a Monitoring and Evaluation System

Monitoring and evaluation terminology can be defined as follows. Evaluation concentrates on impact measurement, while monitoring focuses on timely, satisfactory completion of the work plan. Evaluation of impact is infrequent, but monitoring of work plan completion is periodic. In the lexicon of AID's logical framework system for designing, monitoring and evaluating projects, the impact levels are called goal and purpose, and work plan levels are labeled outputs and inputs. Ideally, monitoring and evaluation compare planned and actual accomplishment of important objectives. Thus, a general principal is that the basis for sound monitoring and evaluation is a clear plan of accomplishments at both the work plan and impact levels.

The appropriate logical framework unit of analysis for the LANL project may be individual countries rather than the region. Breaking it down further into technical components is easy, but may be counterproductive because insights into the "big picture" are lost.

The most important factor to consider when building a monitoring and evaluation system is the viewpoint of the system's user, which is USAID/ROCAP in this case. USAID/ROCAP is interested in arriving at bankable energy/mineral resource end-use projects as quickly and inexpensively as possible. This corresponds precisely to the interest of people who invest in energy, minerals and their end-uses. Thus, progress reports to AID should also include information that serves as the basis for investment decisions, not just information on the technical and scientific progress which provides a background for those decisions.

The PP presents the project's investment objective as follows:

> Involve the local and U.S. private sector so that resource assessment and development activities lead to job-creating investments in commercial and industrial activities based on the energy and other natural resources that will be identified.

If it is accepted that the project's basic logic is grounded in this investment objective, an important principle which emerges is that project deliverables are not complex technical reports, rather they are invest/discard decisions regarding resource and end-use opportunities, and the technical and economic information supporting those decisions.

C. Logical Framework, and a Monitoring and Evaluation System

In a logical framework, "means of verification" tell where information can be found to measure against the indicators. It should be noted that at the goal and purpose levels, SICAPE (the energy information system for the Central America Energy Resources project) is listed as the data source. At the goal level (economic and energy balance), SICAPE is given as the source for data. At the purpose level (investment and policy), SICAPE is suggested as the data source. However, as stated earlier, SICAPE does not yet collect adequate information to measure and guide the eventual economic impact of the project. It also ought to gather the data needed to assess and guide impacts at the investment and policy level.

The process for transforming SICAPE into an impact evaluation system for the project consists of determining the following for each goal and purpose indicators:

- are the data already included in SICAPE, and if not, could they be;
- if inclusion in SICAPE is not possible, is there a proxy that could be included;
- if the data or a proxy cannot be included, what damage is done by not having the data; and
- if the data cannot be included, but are still necessary, how else can they be collected.

Data that are already in SICAPE or could easily be included are likely to be found at the goal and subgoal levels (economic and energy balance stability, and energy-based growth and efficiency). Data that might be difficult to include are at the purpose level (efficiency- and growth-oriented investments, and policies regarding energy and mineral resources). ARD's view is that investment and policy variables are easy to include in SICAPE and will serve valuable functions far beyond monitoring and evaluation of the project. In particular, tracking the relationship among various energy pricing, regulation and investment policy, and economic variables should yield valuable lessons for energy policymakers.

It should be noted that in this approach, outputs (or deliverables) are not scientific or technical reports, but invest/discard decision information for use by the investment community. They are the investment conclusions drawn on the basis of scientific, technical and economic analysis, but not the full analyses themselves. This decision-point definition of

project outputs has the following advantages to recommend it. First, and most important, ROCAP is given tools it can use to help the project move up the objective tree toward economic impact. Second, a system will be put in place that allows the organization of progress reports to correspond to the logical framework. Finally, the amount of technical and scientific work required of LANL may be reduced, but the amount of economic and financial analysis will increase.

D. Project Planning and Installation of a Project Monitoring System

Project monitoring compares planned versus actual accomplishment of important objectives. Obviously then, a clear plan of accomplishments is the basis for a sound monitoring system. The evaluation team has already suggested that the important objectives accomplished by the project consist of invest/discard decisions regarding energy resource and end-use opportunities and the package of information supporting those decisions. Therefore, installation of a project monitoring system consists primarily of identifying invest/discard decisions being addressed by the project, and the information packages necessary to support them to the investment community's satisfaction.

Improving the project reporting system will require some consolidation work before moving forward. Each project component will need to be described in the investment community's terms. This means that each resource and end-use under study should be described according to the requirements of the financial community. An outline is presented at the end of this section that might be followed for status reports on project components. Directly after the preparation of revised project objectives (perhaps according to the logical framework in Section IX), each project should be analyzed and described according to the outline. The reports should then be updated periodically, perhaps every three months. The first use of the new reporting model will probably require workshops and technical assistance from experts on investment and evaluation systems. Obviously, the outline suggested here will have to be adapted to match the particular aspects of each project component.

E. Recommendations

First, LANL and ROCAP must agree on invest/discard decision-points toward which each component of scientific and technical work is directed. The objective of every technical or scientific effort should be to decide whether or not a resource or end-use is worth a development investment.

Second, LANL must agree on the packet of information supporting each invest/discard decision. The package is made up of the following general elements--specification of the invest/discard decision at issue and the information which must be collected and analyzed to reach that decision, and an estimate of how much money and time must be spent to collect and analyze the information.

Third, plans oriented around invest/discard decision-points must be established for the life of the project, as well as by quarter. Project-life plans refer to progress made in arriving at invest/discard decision-points for opportunities, while quarterly plans give implementation details for making more progress.

Fourth, project-life plans should be presented for the whole project in a single table and for individual countries in separate tables. Quarterly implementation plans should be presented in greater detail by project and perhaps by country.

Fifth, expenditures should be organized by intended accomplishments to permit the detection of funding problems and cost-benefit estimates. After the end of each quarter, LANL should report the original project plan and budget, actual project accomplishments and expenditures. Costs per quarter should be shown and individual task budgets tallied.

Sixth, investors are interested in the investment climate as well as characteristics of the resource or end-use being explored by LANL. Hence, progress reports must include information on available investors, investment mechanisms and creditworthiness of the organization taking on the debt.

Monitoring and Reporting Topics

Progress Toward Decision-Point

1. Statement of the invest/discard decision being addressed by the component of scientific and technical work being reported (e.g., invest in or discard the Platanares geothermal field in Honduras).

2. Statement of information collection and analysis tasks required to reach decision, and time and money necessary to carry out tasks.

3. Statement of information collection and analysis progress made toward decision-point, with estimate of answer.

4. Tentative statement of invest/discard decision to which information seems to be leading.

5. Statement of time and money spent reaching status described in 3, and comparison to planned budget.

6. Estimate of whether funds and time available will be sufficient to reach decision-point.

7. Problems impeding arrival at decision-point and actions required to solve them.

Resource Economics

1. Is there an easily accessible market for the resource? (For example, for geothermal resources, what is the electrical grid system's current and planned relationship to the energy source being studied?)

2. What are the resource's economic characteristics? In particular, what is the debt-coverage ratio? A debt-coverage ratio consists of gross revenues over the amount of the debt--1:5 is considered good.

3. Time until the debt will be paid back--this varies by country, but in Central America, debts generally must be paid back within one to five years, depending on the investment and political climate.

4. Risk analysis--compound probability of technical, financial, commercial, organizational and legal feasibility (e.g., .5 x .5 x .5 = .125 probability of success).

Investment Climate

1. Is the prospective debtor creditworthy? What do the prospective debtor's balance sheet and debt payment record look like?

2. What assures that the debtor will be able to repatriate funds?

3. Investment mechanisms and credit sources.

Investment Campaign

1. List of potential investors.

2. List of contacts made.

3. Results and findings.

XI. SUMMARY OF RECOMMENDATIONS

The following recommendations are taken directly from the text of this report. They are not all-inclusive, but they are the key, most important recommendations from each section. The recommendations are organized under the corresponding report section title. Each recommendation is followed by the page number on which it appears in the report, so that the reader can easily refer to the relevant discussion.

Energy Planning and Situation Analysis

LANL should revise the energy situation report, ENERGY SITUATION IN FIVE CENTRAL AMERICAN COUNTRIES. The report should include the potential long-term impact of lower oil prices on energy policies. In addition to providing a historical and current status of the energy balance in each country, the report should provide critical analysis and recommendations to improve the current energy policy situation under different scenarios and projections. (p. 33)

Energy data and analysis training should be increased. The workshops can be considered a strong aspect of the program. Discussions with participants indicated that this approach should be increased to four or five workshops a year on a regular basis. Additional training programs could be established for counterpart staff in statistics, economics, modeling and policy analysis at an advanced level, at LANL or another appropriate U.S. facility. (pp. 33-34)

Computer resources in Central America should be expanded to permit better availability of information and more effective dissemination. (p. 34)

The project should assist with additional data base design, development and operation. LANL should assist in designing data survey forms to ensure the expansion of energy-balance information. To provide information for economic analysis of energy options, the data base must be expanded to include financial, pricing and social data. (p. 35)

The project should provide more assistance in using energy models as policy analysis tools. LANL energy modeling and analysis projects should be broadened to develop a critical methodology for reviewing alternative energy policy scenarios, and economic, employment and trade factors. The projects should be designed to encourage foreign investment. (p. 36)

The project should support a regional energy data and analysis center in Central America. SIECA might be an

appropriate agency for regional energy/economic analysis. Despite its complexity and the inclusion of conflicting data, policies and problems, a regional model could be initiated by SIECA as a basis for renewed interest within CACM. If SIECA is not acceptable or appropriate, then an alternative regional institution should be found. (p. 36)

The project should support future technical assistance to provide a framework for energy policy analysis at the regional and country levels. (p. 36)

Geothermal Resource and End-Use Identification

Guatemala: Direct-Heat End-Use Activities

A detailed study of commercial-scale, agricultural-processing applications of geothermal direct heat should be conducted. The components of such a study should be the identification and quantification of production methodologies and costs, product markets, marketing mechanisms, transportation and marketing costs, and the competitiveness of product quality and sales prices. (p. 75)

The objective of the Zunil geothermal direct-heat application must be defined before going any further. The lack of clarity concerning objectives and the division of benefits and responsibility is already harming relations with counterpart groups. (p. 75)

Before undertaking the Zunil demonstration, an agreement with INDE, GREMIAL and the Indian Agricultural Cooperative must be written that covers the following areas--tenant rights on INDE land, continuity of the heat supply, conditions under which heat curtailment must occur, price and form (pressurized hot water) of the heat, and responsibility for disposal after the geothermal fluid passes through the pilot plant. (p. 75)

Consideration should be given to charging direct-heat users a price similar to that required under unsubsidized operating conditions. (p. 76)

El Salvador

The proposed revised strategy for the Ahuachapan field consists of several activities:

First, a team made up of a hydrologist and a hydrothermal reservoir engineer would immediately begin evaluation of the massive set of geological, hydrological, and reservoir production

and injection data to determine reservoir flow patterns and recharge zones. (p. 57)

Second, in parallel, a LANL geophysical team should conduct deep DC-resistivity studies southeast of the existing production field to define its extent and assist in locating additional production well sites, and reinterpret existing MT data gathered by Geosystem, Inc., an Italian consulting company. (p. 57)

Third, the logging crew should run its suite of tools independently to determine the extent of individual well damage and collect precise pressure and temperature data, which would assist the hydrologist and reservoir engineer in their interpretation. (p. 57)

In addition, LANL should also provide any of its findings to CEL's chief geologist on a quasi real-time basis because CEL is planning to drill three new wells in the field and LANL's findings may modify the final drilling locations. (p. 58)

A team experienced in geothermal reservoir simulation should be brought in as soon as possible to carry out the simulation. (p. 58)

A detailed analysis should be done to estimate the cost of the additional production wells to bring the field back to its full capacity (plus some reserve) and for drilling all of the injection wells. (p. 58)

A PERT chart should be prepared for all activities to prevent any delay in actual drilling, injection strategy completion and mechanical engineering for the entire system. (p. 58)

Hydrological, reservoir engineering geophysics and well-logging activities should be carried out to provide the necessary data to locate new production and injection wells. (p. 76)

Honduras

The budget for drilling, which is barely sufficient for two holes about 500 meters deep, is considered inadequate. Attempts should be made to double or triple it through budget substitutions, additional ROCAP support, ENEE logistical support (i.e., camp and site preparation which would reduce the drilling contractor's charges for non-drilling activities) or an outright contribution by ENEE. (p. 63)

LANL should carry out an economic pre-feasibility study for combined electrical and direct-heat use of geothermal power at Pavana, near Choluteca. (p. 63)

The geophysical studies at Platanares should be completed. (p. 77)

The Pavana area should be evaluated for direct-heat uses. (p. 77)

Costa Rica

It is recommended that there be no consideration for funding of the geoscientific reconnaissance effort of the Guanacaste Province until:

- a meeting is held with UNDP and ENEL to find out the precise scope of their work; and
- an economic and planning analysis is made of the feasibility of conducting a highly detailed geoscientific set of studies, the results of which may not be put to use in the form of exploration drilling for many years. (pp. 66-67)

Upon analysis of the energy situation in the Central American countries, it is the opinion of the evaluation team that funds allocated for the Costa Rican reconnaissance project would be better utilized in solving the problem of the Ahuachapan reservoir's decline or other valuable projects. (p. 67)

As part of the solution to the scaling issue, the evaluation team recommends that LANL employ a geothermal reservoir chemist to investigate the feasibility of eliminating scaling in boreholes. (p. 67)

The project should log the wells at Miravalles, train a counterpart and prepare a technical report to solve scaling problems. (p. 77)

Guatemala

The project should complete the redesign of the geothermal direct-heat facility with the help of an outside industrial engineer who has food technology experience. A feasibility report should be prepared. (p. 77)

Peat Resource and End-Use Assessment

Costa Rica

More in-depth feasibility, technical and marketing analyses are required and should be carried out by LANL to investigate the cost/benefit justification of a peat program before proceeding any further. (p. 92)

For financial feasibility studies, enough data are available to conduct pre-feasibility analyses for the diverse applications being considered by RECOPE and to determine whether or not to proceed with the project. (p. 93)

Justification from market studies for the selected end-uses is not available at present. Markets for peat-related energy applications, and its use as a domestic cooking fuel, have to be thoroughly investigated and confirmed to complete any cost/benefit analysis of the peat program. (p. 93)

Relative to technical studies, if the pre-feasibility and market studies indicate viable applications, a more exhaustive study of available technologies should be conducted. Only commercially proven technologies should be considered for peat mining and end-use applications. (p. 93)

Panama

Even though the end-use considered for Panama appears to have a certain measure of cost/benefit justification, no further work should be conducted until pre-feasibility, technological and market studies have been completed (similar to those recommended for Costa Rica), and there is a clear indication that peat-based electricity generation is a viable alternative to petroleum products and/or the hydroelectric plant which is presently being considered for northwest Panama. (p. 95)

Costa Rica Mineral Reconnaissance

Future work should depend on the results of preliminary mineral assessments such as that conducted by the USGS in Costa Rica. Additional work should only be considered when the preliminary assessment indicates good potential for economic mineral discoveries. (p. 101)

In terms of cost-effectiveness, more in-depth studies such as geochemical surveys should be justified economically. Incremental expenditures should only be undertaken if they will produce a measurable increase in the probability for mineral

discoveries and recovery of capital investment. When geochemistry is considered, programs must be streamlined to include only analyses for key elements, as indicated from previous experience. (p. 101)

Since the final objective of this type of program is to interest private industry in the development of mineral resources, they should be consulted at an early stage and their recommendations incorporated in program planning. An experienced representative of the mineral industry should be added to LANL's advisory group. AID could also profit from having experienced mineral-industry executives review future mineral-related programs. (p. 101)

Technology Transfer, Private-Sector Involvement and Economic Sustainability

Energy Situation Analysis

Urgent technical transfer needs regarding the energy situation assessment are:

- policy-level seminars conducted by INCAE where policymakers become educated consumers of the information and analysis contained in SICAPE;
- extension of technical assistance beyond data collection and analysis to energy policy formulation on the basis of data;
- self-sufficiency criteria and strategies for each Central American country based on the above description; and
- a phase-out schedule for LANL as Central American self-sufficiency is reached. (p. 112)

Geothermal Program

To maximize the benefit from geothermal resources, the required technology transfer should continue to be included in the development and management of the resources, not only in their discovery and assessment. (p. 112)

Discussions must commence early with potential beneficiaries of the logging equipment to ensure that they are ready to take over the costs of operations and maintenance after the one-year, project-funded logging program is over. It is recommended that the logging truck remain the property of the U.S. government

until such time when the local service organization has met acceptable standards, and a budget for routine maintenance has been established. (pp. 112-113)

If the beneficiary countries do not take over the cost of operation and maintenance after the one-year free service period, the evaluation team recommends that the truck be sent back to the United States rather than being allowed to deteriorate. (p. 113)

Opportunities should be provided for long-term training for professionals in geothermal areas. Two professionals from each country should be provided with the opportunity to complete master's degrees in geophysics in U.S. universities with strong applied geophysics programs and geothermal interests (e.g., University of Utah, San Diego State University, University of California at Riverside). (p. 113)

Peat Assessments

LANL should give RECOPE risk analysis training so that it comes to its own conclusions regarding the economic viability of peat. (p. 113)

Costa Rica Mineral Assessment

It is recommended that satisfactory formal arrangements be made for storing geological and geochemical data in Costa Rica. Possible repositories for the data include UCR and MINASA. Wherever the data are stored, both institutions must have access to the information. (p. 113)

Overall Institutional Strengthening

LANL should assess what is needed to create viable, capable organizations in its technology transfer efforts. Training directed at strengthening organizations must be based on analysis of organizational weaknesses. (p. 113)

Private-Sector Involvement and Economic Sustainability

The evaluation team recommends that LANL hire a highly skilled investment analyst to provide senior-level consulting to LANL's representative in Guatemala from time to time. (p. 118)

For each energy resource or end-use opportunity, it is necessary that the project generate economic and business opportunity analyses. (p. 118)

Given MINASA's good organization and expertise in project promotion, the evaluation team recommends that an effort be made to keep it alive and that its responsibilities be expanded beyond the mineral industry so that the functions performed justify its existence. The evaluation team feels that MINASA's approach is precisely what is needed to convert energy and mineral discoveries into sustained economic impact. (p. 119)

Staff Performance, Project Coordination and Management

Full-Time, Multidisciplinary Project Team

Serious consideration should be given to raising the Central America effort to the department level within LANL. (p. 127)

A full-time Central America task force is needed, and it must be truly multidisciplinary. In addition to this technical area, task force members should have Spanish and management skills, with industrial development and technology transfer as a vocation. In sum, the staffing requirements originally laid out in the PASA contract between AID and LANL should be observed. (p. 127)

The project team should have its own objectives, procedures, success criteria and spirit. (p. 127)

Decision-making must be near the economic and energy problems of Central America. Decisions must be made by people who understand the field problems thoroughly. This means that the Spanish-speaking staff, at least half of whom should be based in Central America, should decide who visits Central America, when, and with what objectives. (p. 127)

Technical Assistance Teams

To become more cost-effective, LANL should consider having short-term technical assistance teams follow several suggestions. First, they should have longer stays and include fewer travelers, more of whom should speak Spanish. Second, they should take to Central America only those scientists and technologists who must be on site to do their work, leaving in Los Alamos those who can analyze material brought to them from Central America. The evaluation team realizes that LANL management may well have always tried to do this, but suggests that this matter be given a hard look. Third, wherever possible, LANL should use technicians who can handle more than one narrow specialty. Finally, when a translator is needed, one should be hired locally. (p. 127)

Multidisciplinary Advisory Committee

The advisory committee should include not only technical experts, but also technology transfer experts, Central Americans, AID managers, industrial development experts, and representatives from the investment community who might be interested in financing development of the energy and mineral resources found by the project. (p. 128)

Planning, Budgeting and Reporting Practices

LANL should adopt a problem-solving mode rather than a technology-driven mode for generating project activities. (p. 128)

It is recommended that LANL do simple pre-feasibility calculations of the risk analysis type before committing to expensive resource identification and feasibility work. (p. 128)

LANL should adopt "project-life" rather than "accounting-period" budgets. (p. 128)

Investment community, rather than research community, reporting requirements should be adopted by LANL. (p. 129)

Improving Coordination with Central American Organizations and USAID Missions

The LANL project must focus on AID economic objectives for the Central American region. In preparation for clarifying this, a final logical framework for the project should be worked out by LANL and ROCAP. Both financial and program management should be carried out by ROCAP. The current arrangement, where financial decisions are made in Washington, makes this difficult for ROCAP. (p. 129)

All memoranda of understanding between LANL and every counterpart institution should be systematically reviewed, strengthened and clarified. Objectives, responsibilities and contributions should be spelled out clearly. Experience with other AID projects shows that projects without substantial contributions from counterpart organizations rarely work. (p. 129)

Project management and SICAPE should be combined in some fashion, so that they share the same communication system and data. Consideration should be given to buying modems so that electronic mail can connect all energy situation analysis stations and carry out SICAPE and project management

communications. The CARINET system now operating throughout Latin America is one possibility. (p. 130)

Logical Framework for the LANL Project

Section IX of this report gives the LANL project a basis for a new project design and logical framework, aimed at converting technical and scientific activities into economic development results. The next step in the process of refining the LANL project design must be taken by LANL and USAID/ROCAP together, perhaps with the help of a consultant who is skilled in project design and consolidating materials from various perspectives. The process to be followed during refinement of the project design has several steps:

- clarification of and agreement on project logic;
- general definition of project outputs and deliverables;
- quantification of project objectives;
- establishment of a time frame for the achievement of project objectives; and
- definition of project components, responsibilities, resources and budgets.

This process must be initiated immediately and completed within the next three months. (p. 142)

Monitoring and Evaluation System

LANL and ROCAP must agree on invest/discard decision points toward which each component of scientific and technical work is directed. The objective of every technical or scientific effort should be to decide whether or not a resource or end-use is worth development investment. (p. 146)

LANL must agree on the packet of information supporting each invest/discard decision. The package is made up of the following general elements--specification of the invest/discard decision at issue and the information which must be collected and analyzed to reach the decision, and an estimate of how much money and time must be spent to collect and analyze the information. (p. 147)

Plans oriented around invest/discard decision-points must be established over the life of the project, as well as by quarter. Project-life plans refer to progress made in arriving at

invest/discard decision-points for opportunities, while quarterly plans give implementation details for making more progress. (p. 147)

Project-life plans should be presented for the whole project in a single table and for individual countries in separate tables. Quarterly implementation plans should be presented in greater detail by project and perhaps by country. (p. 147)

Expenditures should be organized by intended accomplishments to permit the detection of funding problems and cost/benefit estimates. After the end of each quarter, LANL should report the original project plan and budget, actual project accomplishments and expenditures. Costs per quarter should be shown and individual task budgets tallied. (p. 147)

Investors are interested in the investment climate as well as the characteristics of the resource or end-use being explored by LANL. Therefore, progress reports must include information on available investors, investment mechanisms and the credit-worthiness of the organization taking on the debt. (p. 147)

XII. FUTURE PLANS

With regard to future directions for the Central America Energy Resources Project, the evaluation scope of work poses the following questions:

- based on the progress to date, what areas need further assistance;
- what role might regional institutions play in assuring that project activities can be replicated once the project ends;
- what types of further assistance are being requested of Los Alamos by Central American and Panamanian institutions; and
- what are appropriate time frames and funding levels for recommended follow-up activities?

Obviously, this evaluation's major function is to help plan future directions for the project. However, the evaluation team can only suggest such future directions. In particular, the evaluation team cannot estimate funding levels and time frames. Actual planning for the future must be done by LANL and ROCAP, based on the evaluation.

In September 1986, toward the end of this evaluation effort, the team met with key personnel from LANL and ROCAP to begin planning future directions on the basis of the evaluation's results. These discussions were preliminary, and no conclusions were reached in the one day spent considering future plans. Strategic as well as technical areas were discussed. The key strategic areas included:

- a design or logical framework for the project;
- monitoring and evaluation system for the project;
- management structure for the project;
- ways to handle organizational and investment mechanisms that intervene between the scientific work and economic objectives; and
- responses to the oil-price reductions of recent years.

Both the logical framework and monitoring and evaluation system will require setting objectives in terms of the invest/discard decisions at which the technical work is directed, the

information needed to make those decisions, and the activities, time and budget necessary to generate that information.

Specific technical areas for which ROCAP and LANL must establish objectives, activities, budgets and reporting requirements are presented in the following subsections. These areas are derived from the evaluation team's answers to the question, "based on progress to date, what areas require further assistance?"

Energy Analysis and Planning

- Update the December 1985 draft report titled ENERGY SITUATION IN FIVE CENTRAL AMERICAN COUNTRIES to include the current world energy situation and direct linkages to the specific energy problems and programs for each country. This is to be developed by LANL with the active participation of counterpart organizations for each country.

- Expand the SICAPE data base to include better economic and demographic data.

- Improve the validity and accuracy of the SICAPE data base.

- Link SICAPE with the project's monitoring and evaluation system.

- Improve INTEGRA so that it compares the effect of energy projects and policies on such variables as import substitution, job creation and balance of trade.

- Develop seminars to convert energy policy decision-makers into educated consumers and users of LANL energy analysis and planning tools.

- Expand the computer hardware and software available in each country to improve the data collection, evaluation and reporting abilities of counterpart organizations.

Geothermal Resources and End-Uses

- Rehabilitation of the Ahuachapan geothermal resource in El Salvador.

- Drilling exploration at Platanares sufficient to either confirm or disprove the existence of a geothermal reservoir of economic proportions.
- Management of the well-logging truck.
- A detailed study of the economic feasibility of geothermal direct-heat applications.
- Objectives and plans for the Zunil direct-heat applications experiment and its relation to the study of economic feasibility.

Peat Resources and End-Uses

- Pre-feasibility analysis of the economics of mining peat.
- Pre-feasibility analysis of the economics of using peat in five- and 30-MW electricity-generation plants.

Mineral Assessment

- Streamlining the processing of geochemical data.
- Storage of geological and geochemical data in Central America.

Involvement of Investors

- Strategies for and identification of investors, investment mechanisms and expertise.

Technology Transfer

- Analysis of organizational impediments to energy-based economic development.
- Selection of targets of opportunity--a target exists when technological and managerial self-sufficiency in a specific area are feasible, economically worthwhile and have received a commitment from the host-country government and organizations.
- Setting self-sufficiency targets for the project's various technical areas.

- Tailored, focused organizational development approaches and phase-out schedules for targets of opportunity.

Management and Coordination

- Structure and composition of a multidisciplinary technical assistance team.
- Travel policy.
- Composition and function of the advisory committee.
- Roles that regional institutions might play in assuring that project activities can be replicated once the project ends, as well as those that might be taken on by SIECA, ICAITI, INCAE and CABEI.
- Relationships to ROCAP and individual USAID missions.
- Memoranda of understanding with collaborating Central American organizations.

APPENDIX A

Scope of Work

SECTION C - DESCRIPTION/SPECIFICATIONS/WORK STATEMENT

C.1 Statement of Work

I. Objective

The objective of this assignment is to carry out an initial evaluation of AID/ROCAP project CENTRAL AMERICA ENERGY RESOURCES, 596-0134. The evaluation team will be expected to evaluate progress toward achievement of the project purpose and contribution to the project goal, to determine if the project purpose will be accomplished in the time frame established in the Project Paper, whether implementation plans are adequate to achieve the project purpose, and if the work in progress accurately reflects implementation plans. The evaluation team will review the general implementation plan and the quarterly work plans in close consultation with the project team, counterparts in the C.A. region, AID bilateral missions and ROCAP staff. The evaluation will also focus on project coordination, private sector participation and staff performance. Finally, the evaluation will assess the need for and nature of future possible activities. The evaluation team will be expected to produce a final report presenting its findings and recommendations for possible changes in project design and direction.

II. Project Purpose and Goal

Los Alamos National Laboratory through a participating Agency Service Agreement (PASA) is implementing the Central America Energy Resources project. The purpose of the project is to introduce new technologies and assessment technologies into Central America that will allow each of the participating countries to analyze better their current and future energy needs, to develop non-traditional sources of energy such as geothermal and low grade fossil fuel resources found throughout the region, and to more effectively utilize the energy and mineral resources found in the region. The project will help the participating countries in becoming self-sufficient in those areas over the long term. The goal of the project is to improve the economic situation in Central America and help create employment through increased and more efficient utilization of the region's energy and natural resources endowment.

The project comprises two phases. The first phase has two major components: 1) a regional energy situation analysis that will involve the collection and analysis of regional energy and resource data, construction of a standardized regional data base, and the development of long term planning

methodologies to assist in the formulation of energy and resource policy; 2) an alternative energy resource development component which will: a) provide assistance in the identification and use of geothermal resources to generate electricity; b) assess potential industrial and domestic uses for peat and low grade coal; and c) assess the feasibility of and demonstrate the use of geothermal heat for commercial and agro-industrial uses. Both components will involve the training of local economists, technicians and scientists and the purchase of equipment which will make the participant countries self-sufficient in the areas mentioned above over the long term.

Activities in phase II of the project derive primarily from the results of activities begun in phase I. In general, phase II was to consist of the expansion of geothermal and peat development activities, conducting country specific mineral resources assessments, providing mineral sector profiles, and funding a study of energy conservation potential in the transportation sector in Central America.

Although no formal end-of-project conditions were identified as such in the project paper, the following represent a sense of where the project would be at the time of its completion:

1. Identify, quantify and assess the natural resource endowment possessed by the countries of the region. This includes energy resources that can be used to substitute for presently imported energy sources, predominantly petroleum, as well as energy and other resources that could be used to decrease import of non-energy raw materials and increase revenues earned from export of both energy and non-energy materials.

2. Create an analytical framework that allows rapid comparisons of energy and mineral development options in terms of balance of trade, import substitution, direct cost, job creation, etc.

3. Through the activities identified in Objectives 1 and 2, build technical and managerial skills so that a self-sustaining economic development process is established. This objective will be achieved predominantly by on-the-job training associated with the project components, training workshops, sponsored graduate student participation and visits by regional technicians to Los Alamos.

4. Involve the local and US private sector so that the resource assessment and development activities lead to job creating investments in commercial and industrial activities based on the energy and other natural resources that will be identified.

III. Project Components

The evaluation report should assess actual progress in each of the following areas as delineated in the Project Paper for the project authorized in March 1985. Since changes may have occurred in some of the activities, the evaluation team should also review the PASA between AID and Los Alamos as well as quarterly work plans to assess congruency between these documents and the Project Paper in terms of the specific activities which were to be carried out by Los Alamos. In addition, a comprehensive logical framework, incorporating the various modifications to project activities, is in the process of being prepared and will also be available to the evaluation team. The logical framework should be reviewed thoroughly for completeness and specificity and suggestions for improvement should be made if required. In addition, a monitoring and evaluation plan should be prepared along the lines of the model included as Annex A. The evaluation should assess the appropriateness of project activities and results in the context of the region's current and near-term energy sector and mineral priorities.

A) Phase I

1. Energy Situation and Analysis: projected status by end of Phase I

   - Update of MITRE study completed and report published.
   - Workshop held to disseminate results of the Energy Situation Update and to discuss energy problems and data needs.
   - Regional counterparts and training needs identified.
   - Computerization of readily available data completed in a framework compatible with one in use in Costa Rica.
   - Basic energy data requirements identified and surveys designed to collect missing data or to update old data.
   - Maps for resource and infrastructure atlas completed in preliminary form.

2. Analysis and Assessment of Non-Traditional Energy Resources

   a. Regional Geothermal Energy Resources

      (1) Honduras Geothermal Reconnaissance: projected status by end of Phase I:

      A detailed compilation and evaluation of prior work in Honduras completed and published as a technical report. Pertinent data from existing oil wells included, as appropriate, for comparison with prior geological findings.

- A reconnaissance scale field investigation completed with emphasis concentrated in identified areas of potential geothermal interest. A technical report published that includes updated geologic maps, details of the lavas and pyroclastic rocks for identifying the nature of the heat sources, radiometric rock age dating results, and geologic cross-sections for the most promising geothermal areas.

- A comprehensive field sampling effort of the hot and cold springs and active fumaroles completed. A technical report published that includes major/trace element chemistry, stable isotope data, tritium concentrations, gas compositions, CO_2 isotope data, geothermometer temperature data, localized structure/alteration maps, and hydrologic models of potential geothermal systems including estimated age and recharge characteristics of the system.

- Based on detailed interpretations of the field and laboratory data, two or three areas in Honduras identified as the most promising sites for future geothermal developments.

- Shallow temperature gradient wells drilled at the most promising sites to obtain lithologic and geothermal gradient data.

- A geophysical testing program including audiomagnetotelluric (AMT) soundings and deep dc resistivity measurements initiated at the most promising geothermal development sites. A preliminary technical report published on initial geophysical results.

- Trained professionals from ENEE and DGMH will have participated in all field investigations and data interpretation activities. Periodic seminars presented at both organizations to describe the techniques, equipment, and evaluation procedures being implemented by the Los Alamos-Honduran team.

- Hondurans hired for field support activities throughout the duration of this project component.

- A report published that includes specific recommendations for completing the prefeasibility study of geothermal resources in Honduras.

167

- Professionals from ENEE and DGMH will have received intensive field training in the latest volcanology, geology, geochemical and geophysical exploration techniques.

(2) Miravalles Geothermal Development: project status by end of Phase I.

- A surplus well logging rig overhauled, equipped with high-temperature armored 7-conductor geothermal logging cable suitable for use in the Miravalles wells, tested in a U.S. geothermal well, and shipped to the Miravalles field in Costa Rica.

- Working with ICE scientists and engineers, a Miravalles well logging program developed.

- A selection of high-temperature geothermal well logging tools, consistent with the requirements of the Miravalles well logging program, tested and shipped to the Miravalles field in Costa Rica.

- Working with ICE and University of Costa Rica scientists and engineers, a data acquisition system fabricated and installed in a facility at the Miravalles geothermal field.

- A well logging program conducted in the Miravalles geothermal wells. (It was anticipated that 3-4 wells would be logged and that a minimum of 6-8 different logs obtained for each well).

- ICE personnel trained in the operation of the logging rig, the operation of the downhole logging tools, and the interpretation of the data from the tools.

- The proposed well designs, casing schedules, completion techniques, and drilling fluid programs for future wells at Miravalles evaluated on the basis of the logging data obtained from the existing production wells.

(3) Costa Rica Reconnaissance: projected status at end of Phase I

- A compilation and evaluation of prior work in Costa Rica completed and published as a technical report.

168

- A limited reconnaissance scale field investigation completed with emphasis concentrated within the Cordillera de Guanacaste. A technical report published that includes map improvements based on stratigraphic analysis, characteristics of pyroclastic rocks associated with young volcanic fields, radiometric rock age dating results, and preliminary geologic cross-sections for the most promising geothermal areas.

- A limited field sampling effort of the hot and cold springs and active fumaroles completed. A technical report published that includes major trace element chemistry, stable isotope data, tritium concentrations, gas compositions, CO_2 isotope data, geothermometer temperature data, and preliminary hydrologic models of potential geothermal systems including estimated age and recharge characteristics of the system. Results primarily limited to areas within the Cordillera de Guanacaste.

- Trained professionals from ICE will have participated in joint Los Alamos/ICE field investigations and in the data interpretation activities. Periodic seminars presented by professionals of both organizations at ICE to describe the techniques and evaluation procedures being implemented.

- As a training vehicle, Costa Ricans will have been involved in field support activities throughout the duration of this project component.

- An informal report drafted that includes recommendations for completing the reconnaissance and initiating the prefeasibility study of geothermal resources in Costa Rica.

(4) Support Equipment for Central America: Status at End of Phase I.

- Technical specifications for a state-of-the-art geothermal logging truck developed, procurement contracts awarded, and the basic logging truck fabricated and delivered to Los Alamos.

- Required data acquisition equipment ordered, delivered to Los Alamos, and installed in the logging truck.

- The high-temperature 7-conductor logging cable ordered, delivered to Los Alamos, fitted with a high-temperature cable head, and installed on the logging truck cable drum.

- Los Alamos engineers will have performed a thorough check-out of all logging truck systems, electronic components, and the high-temperature cable using a local geothermal well. Any noted deficiencies corrected and the required logging accessories, miscellaneous equipment, and spare parts packed in the logging truck.

- A detailed operating handbook prepared for the operation and scheduled maintenance of the logging truck.

- The logging truck and associated equipment shipped to Central America.

- Technical specifications for the downhole logging tools developed, procurement contracts awarded, and the tools fabricated and delivered to Los Alamos.

- Los Alamos engineers will have performed a thorough check-out of all downhole tools, correct any noted deficiencies, prepare operating instructions for their use, and ship the tools and spare components to Central America.

- Technical specifications for the dc resistivity system developed, procurement contracts awarded, and the system fabricated and delivered to Los Alamos.

- Los Alamos geophysicists and engineers will have performed a thorough check-out of system performance, corrected any noted deficiencies, prepared an operating handbook for its use, and shipped the system to Central America.

- Technical specifications for the audiomagnetotelluric (AMT) system developed, procurement contracts awarded, and the system fabricated and delivered to Los Alamos.

- Management arrangements for the dedicated truck system are finalized.

170

(5) Direct Heat Applications in Central America: Status at end of Phase I.

- Survey of direct heat requirements completed.
- Counterparts established and trained in the appropriate methodologies.
- Direct heat applications surveyed and most promising selected.
- Technical exchange meeting held to disseminate information about direct heat applications and to solicit comments from the private sector.
- Two most promising applications selected and feasibility studies completed.

b. Costa Rican Peat End Use Assessment: Status at End of Phase I

- Potential end uses analyzed with regard to Costa Rican market conditions and regional characteristics including literature review of world-wide peat use and associated costs.
- Technical exchange meeting held to educate private sector members in peat end uses and to solicit their input.
- Physical characterization of peat completed and results incorporated in selection of most promising end uses.
- Costa Rican engineers or economists trained in technology comparisons and feasibility methodology. Geologists trained in peat sampling and analysis.
- Report completed with cost/benefit analysis of up to three of the most promising end uses, including preliminary design, site selection, and environmental analysis.

B) <u>Phase II</u>

1. Costa Rica Mineral Reconnaissance Component: Expected Accomplishments

- Collection of reconnaissance-scale stream-sediment samples for all of the Provincia de San José and a portion of the Talamanca 1:200 000-scale quadrangles.
- Analysis of all geochemical survey samples for up to 45 elements.

171

- Evaluation of the data and publication of the results in a brief report and map folio. The report will describe procedures utilized and identify regions most promising for follow-up investigations of selected commodities. The map folio will contain color plates highlighting results of the integrated data analysis for the two study areas, published at 1:2000 scale.

- After joint evaluation by Los Alamos, DGMH, UCR and USGS personnel, the stream-sediment analytical data for the two study areas will be reformatted so that it can be used at DGMH and UCR facilities.

- As part of on-the-job training, DGMH and UCR personnel will be involved in field sampling and field support activities. Visits to Los Alamos by personnel of the DGMH and UCR during the planning, analysis, and interpretation stages will insure transfer of exploration expertise (from Los Alamos) and utilization of in country geological expertise (from Costa Rica)

- Creation of a trained manpower source that can be used in future programs by inclusion of UCR students in the program.

- Enhancement of UCR facilities through library purchases and equipment upgrades.

- Initial creation of a San Jose and Talamanca data base. This data base can be used for resource assessment, mineral exploration, land use, agriculture, health, and environmental monitoring programs.

- Presentation of results to the DGMH and UCR in a seminar.

The U.S. Geological Service under a separate agreement with Los Alamos agreed to carry out the following activities:

a. <u>RMRA Subproject (scale 1:500,000)</u>

(1) Compiled geologic map, initiate compilation May 1, 1985; complete preliminary map by January 15, 1986.

(2) Compiled geophysical (gravity and aeromagnetic) map, initiate compilation May 1, 1985; complete preliminary map by February 15, 1986.

(3) Compiled mineral occurrence map (spot map), initiate compilation May 1, 1985; complete preliminary map by October 31,. 1985.

(4) Compiled terrane map, initiate compilation May 1, 1985; complete preliminary map by January 1, 1986.

(5) PMRA (1:500,000) final report (including compiled geologic, geophysics, mineral occurrence, and terrane maps), initiate writing by August 1, 1985, complete by June 30, 1986.

(6) Mineral Deposit Models Course, initiate course preparation May 1, 1985; present course in support of PMRA subproject, September 30 - October 22, 1985.

(7) Review and edit, submit final PMRA manuscript (maps and extended explanation texts) to USGS editorial group for review July 15, 1986; submit material available to DGMH and UCR for review and editing; complete USGS, DGMH, USGS editing by September 30, 1986.

(8) Printing, present final manuscript materials for PMRA Folio to Los Alamos for final review October 1, 1986.

b. <u>GDS (Scale 1:200,000)</u>

(1) Geologic map, initiate geologic mapping of the district October 1, 1985; complete geologic mapping by November 30, 1985.

(2) Exploration targets map, initiate work in conjunction with Los Alamos by March 1, 1986; complete interpretation by April 1, 1986.

(3) Final Report, GDS, initiate with Los Alamos components (geochemical map, interpretative map, others) by May 31, 1986; complete by October 1, 1986.

(4) Mineral Resource Assessment Course, initiate preparation by May 1, 1985; complete preparation by May 1, 1986.

(5) Mineral Reseources Assessment Course, present course, begin May 26, 1986; complete course by June 6, 1986.

Activities to be accomplished under the components listed below remain to be spelled out. The evaluation team should assess whatever documentation is available at the time of their field work to determine whether this documentation is adequate in terms of clarifying whether the projected activities will contribute to the project purpose.

1. Mineral Sector Profiles Component
2. Coal, Lignite and Peat Component
3. Equipment Maintenance Expenditures Components
4. Database Maintenance Component
5. Geothermal Support to El Salvador, Panama and Guatemala Component
6. Conservation and Fuel Substitution in the Transport Sector Component
7. Wind Energy Component
8. Bi Phase Energy System Geothermal Well Prover in Guatemala

175

IV. Institutional Strengthening and Analysis of Broad Project Impact

A) Review logical framework prepared by Los Alamos and recommend changes if needed. Particular emphasis should be given to project purpose indicators. Prepare monitoring and evaluation plan which can be used by Los Alamos and ROCAP to monitor progress of project with particular attention to tracking goal and purpose achievement. Annex A is an illustrative monitoring and evaluation plan.

B) Assess the degree to which the project has been able to generate interest and cooperation in national institutions, its ability to provide the necessary technical assistance, transfer generated information and strengthen these national organizations. Assess plans to continue with this transfer/strengthening activity and make recommendations to improve it, if necessary.

C) Evaluate the project's coordination and cooperation with other regional entities, i.e. ICAITI, INCAE, Central American School of Geology, CABEI, etc. Has the project capitalized on opportunities to collaborate with other projects, lever new funds or promote cofinancing?

D) Assess the application and utility of the Energy Situation Analysis report, its computerization and the ability of counterpart institutions to manage, manipulate and make better planning decisions with this information.

E) Evaluate project's results to date, i.e. recommendations generated by the Energy Situation Analysis, and recommend a prioritization of potential follow-on activities.

F) Assess project's strategy to develop sustainable programs beyond project completion date and make recommendations to improve prospects for continuation, if required.

G) Evaluate the appropriateness of the project's training program in terms of quality, content and overall relevance to energy needs in the CA/P countries. Assess whether number and quality ofparticipants will permit activities to continue in each country after project termination.

H) Evaluate project staff performance and their ability to work and interact with national counterpart institutions and bilateral USAIDs.
Has communication and responsiveness to counterparts and USAIDs been adequate?

114

V. Future Activities

The evaluation team should provide responses to the following questions and assess the Project Paper amendment to be submited by Los Alamos in light of these questions:

A. Based on progress to date, what areas need further assistance?

B. What role regional institutions might play in assuring that project activities can be replicated once project ends?

C. What types of further assistance are being requested of Los Alamos by CA/P institutions?

D. What are appropriate time frames and funding levels for recommended follow-up on activities?

V. Timing

The evaluation will require the services of the team members over a period of up to 8 weeks beginning NLT June 27. Team members will visit Los Alamos headquarters for three days and also meet with the Technical Advisory committee for two days. They will then proceed to the participating countries in the CA/P region to consult with national institutions, and observe project activities. They should spend 4 days in El Salvador, 5 days in Honduras, 10 days in Guatemala (including ROCAP), 5 days in Costa Rica and 4 days in Panama. The team may modify this schedule if circumstances require. Meetings with bilateral USAID Missions will be scheduled in conjunction with country visits. Before the initiation of the evaluation, the team will meet with ROCAP staff to be briefed on ROCAP's needs and expectations of the evaluation. Prior to departure, the team will discuss its findings and recommendations with ROCAP officials in Guatemala. One additional week of the team leader's service are projected to allow for initial orientation, production of the report and debriefing with ROCAP/Guatemala.

VI. Report requirements

Within five working days of arrival of the team leader, he/she will submit to ROCAP a detailed work plan for the team. Theteam leader will submit a draft final report in English to ROCAP prior to his/her departure. ROCAP will gather all bilateral AID comments and send written comments on the draft report to the contractor within fifteen working days following receipt by ROCAP and USAIDs of the draft final report. The contractor will submit twenty (20) copies in English of the final evaluation report to ROCAP within fifteen working days of the receipt of ROCAP's comments. Word processing facilities and secretarial assistance will be provided by

175

ROCAP while the team is in Guatemala. Funds for secretarial assistance in the U.S. are provided in the budget.

The contractor evaluation report will include the following:

1. An executive summary, including purpose of the evaluation, methodology used, findings, conclusions and recommendations. It will also include comments on development impact and lessons learned. It should be complete enough so that the reader can understand the evaluation without having to read the entire document, i.e. the summary should be a self-contained document.

2. A copy of the scope of work under which the evaluation was carried out. The methodology used by the evaluators will be explicitly outlined. Any deviation from the scope will be explained.

3. A listing of the evaluation team, including host country personnel, their field of expertise and the role they played on the team.

4. A clear presentation of the evaluation recommendations, in a separate section of the report if convenient, so that the reader can easily locate them.

5. A separate section on development impact of the project. This section should clearly present the development benefits resulting from the project.

6. A paginated table of contents.

APPENDIX B

LANL Overview Budget as of 31 May 1986

CENTRAL AMERICA ENERGY RESOURCES PROJECT
PROJECT COMPONENTS AND BUDGETS
$K

	INITIAL APPROVAL WITH PROJECT PAPER	ADDENDUM I	ADDENDUM II	TOTAL
RESOURCE ASSESSMENTS				
Honduras Geothermal Assessment	1,400		340	1,740
Costa Rica Geothermal Assessment	200		10	210
Costa Rica Mineral Assessment		2,500		2,500
GEOTHERMAL DEVELOPMENT ACTIVITIES				
Miravalles Geothermal Development	400		45	445
Geothermal Support Equipment	700		95	795
Geothermal Support to Panama & El Salvador			300	300
INDUSTRIALIZATION				
Direct Heat Application in Guatemala	400		170	570
Costa Rica Peat End Use Assessment	500		170	670
Panama Peat to Electric Power Assessment			430	430
ENERGY PLANNING ASSISTANCE	1,100		440	1,540
MANAGEMENT AND CONTINGENCY	500		500	1,000
TOTAL	5,200	2,500	2,500	10,200

178

CENTRAL AMERICAN ENERGY RESOURCES PROJECT
BUDGET SUMMARY, $K
May 31, 1986

	Energy Planning Assistance	Honduras Geothermal Reconnaissance	Costa Rica Geothermal Reconnaissance	Miravalles Geothermal Development	Geothermal Support Equipment
Costs					
Personnel	808.2	715.8	113.1	208.1	296.8
Travel	60.4	143.8	26.9	33.1	7.1
Material & Equipment	71.8	39.6	.8	34.7	48.7
Consultants	62.2	124.4	5.7	24.8	20.2
Contracts	192.7	96.1	0	48.4	96.6
Other	55.3	47.5	.2	3.2	9.1
Expended	1,250.6	1,167.2	146.7	352.3	478.5
Outstanding Committments	22.5	352.6	50.0	0	253.6
Estimate to Complete	262.7	220.2	25.0	106.5	22.0
Estimated Total	1,535.8	1,740.0	221.7	458.8	754.1
Allocation	1,540.0	1,740.0	210.0	445.0	795.0
Difference	4.2	0	(11.7)	(13.8)	40.9

CENTRAL AMERICAN ENERGY RESOURCES PROJECT
BUDGET SUMMARY, $K
May 31, 1986

	Geothermal Support to El Salvador and Panama	Geothermal Direct Heat	Costa Rica Mineral Assessment	Peat Resource and End-Use Studies	Management and Contingency
Costs					
Personnel	33.9	253.9	514.7	507.8	239.1
Travel	5.1	38.3	109.6	74.7	70.0
Material & Equipment	0	2.5	230.6	42.9	7.0
Consultants	1.2	25.0	161.3	32.9	252.4
Contracts	0	43.5	70.7	49.3	52.5
Other	0	6.4	3.1	6.3	10.4
Expended	40.2	369.6	1,090.0	713.9	631.4
Outstanding Commitments	0	13.0	1,006.8	83.2	103.0
Estimate to Complete	251.4	198.1	404.0	354.0	265.6
Estimated Total	291.6	580.7	2,500.8	1,151.1	1,000.0
Allocation	300.0	570.0	2,500.0	1,100.0	1,000.0
Difference	8.4	(10.7)	(.8)	(51.1)	0

CENTRAL AMERICAN ENERGY RESOURCES PROJECT
PROJECT TOTALS, $K
May 31, 1986

Costs	
Personnel	3,691.3
Travel	569.0
Material & Equipment	478.5
Consultants	711.1
Contracts	649.1
Other	141.4
Expended	6,240.4
Outstanding Commitments	1,884.7
Estimate to Complete	2,109.5
Estimated Total	10,234.6
Allocation	10,200.0
Difference	(34.6)

181

APPENDIX C

Individuals Contacted

Los Alamos National Laboratory

Jim Aldrich
John Altseimer
Steve Bolivar
David Chavez
Art Cohen
Gustavo Cuellar
Ron DiPippo
Joe Frank
Fraser Goff
Bob Hanold
Grant Heiken
Bill Laughlin
Ron Lohrding
Verne Loose
Sam Ratick
Gary Thayer
Linda Trocki
Ken Williamson
Hatten Yoder

U.S. Geological Survey

Norman Page, Program Director, Menlo Park

Central American Region

Gabriel Dengo, consultant to USAID/ROCAP
Ellis Hill, ICAITI
Ludwig Ingram, ICAITI
Julio Obiols, SIECA
Carlos Sarti, SIECA
Guillermo Selva, INCAE
Raul Valdez, SIECA

Belize

Peter Lapera, USAID Mission Energy Officer

Costa Rica

Hannia Azuola, MINASA
Steven Booth, LANL/MIEM
Rolando Castillo, UCR
Jose Francisco Castro, DGMH/MIEM
Manual Corrales, ICE
Jorge Dengo, First Vice-President of Costa Rica
Milton Fonseca, LANL
John MacMann, ROCAP
Luis Malavassi, RECOPE
Alfredo Mainierri, ICE
Alfonso Monge, MINASA
Jorge Monge, MIEM
Juan Obando, MINASA
Sergio Paniagua, UCR
Guillermo Porras, INC
Lourdes Quesada, RECOPE
Oldemar Ramirez, RECOPE
Heriberto Rodriguez, USAID Mission Energy Officer
Minor Sagot, Economic Officer, U.S. Embassy
Alvaro Umana, Minister, MIEM

El Salvador

Jaime Acosta, CEL
Andy Anderson, Economic Officer, U.S. Embassy
Peter Deinken, General Development Officer, USAID Mission Energy Officer
Oscar Melgar, CEL
Victor Valle, CEL

Guatemala

Klaus Allmayer, GREMIAL de Exportadores
Carlos Avalos, MEM
Lucrecia Arriola, GREMIAL de Exportadores
Felix Bethancourt, UNDP/MEM
Hugo Rolando Bethancourt, INDE
Andres Caicedo, INDE
Telmo Cojulun, GREMIAL de Exportadores
Earnest L. Cooper, LANL consultant
Carl Duisberg, Energy Officer, USAID/ROCAP
Mario Estrada, Manager, GREMIAL de Exportadores
Gerardo Feterman, GREMIAL de Exportadores
Carlos E. Figueroa, MEM
Mario Funes, MEM
Juan Dimas Garcia, GREMIAL de Exportadores
Tom Ivers, USAID, GREMIAL de Exportadores
Michael Charles Kines, USAID/CLUSA

Gerardo Lozano, GREMIAL de Exportadores
Mario Arturo Morales, GREMIAL de Exportadores
Larry Odele, Engineer, USAID Mission Energy Officer
Mary Ott, USAID
Luis Paz, MEM
Flavio Pereira, GREMIAL de Exportadores
Max Salan, BCIE
John Sandbach, USAID consultant, GREMIAL de Exportadores
Ewald Scheel, GREMIAL de Exportadores
Bob Tansey, Economic Officer, U.S. Embassy
Edgar Tobias, INDE
Mario Fidel Torres, INDE supervisor
Rolando Yon-Siu, MEM

Honduras

Wilmer Flores, EENE
Walter Gomez, USAID
Salomon Mendez, CONSUPLANE
Rafael Ochoa, CONSUPLANE
Raul Raudales, CONSUPLANE
Lynn Sheldon, USAID Mission Energy Officer

Panama

Ramon Argote, CONADE
Daniel Esquivel, CONADE
Arturo Ramirez, IRHE
Vicente Rios, IRHE
Jose Sanchez, USAID Mission Energy Officer
Paul Trivelli, Economic Officer, U.S. Embassy

APPENDIX D

Participating Agency Service Agreement

1. Proposed Starting Date (Mo., Day, Yr.) January 15, 1985	**PASA** PARTICIPATING AGENCY SERVICE AGREEMENT BETWEEN THE AGENCY FOR INTERNATIONAL DEVELOPMENT AND DEPARTMENT OF ENERGY Los Alamos National Laboratory	6. [X] PASA ORIGINAL [ ] PASA AMENDMENT
2. Projected Completion Date (Mo., Day, Yr.) December 31, 1986		7. PASA Number ILA-0134-P-ER-5042-00
3. Category [X] TDY [X] ASSIGNED		8. Country/AID/W Office Central America Regiona
4. Duration of Funding [X] CURRENT YEAR [X] FORWARD FUNDING	5. Project Number and Title 596-0134 Central America Energy Resources	9. Type [X] GRANT [ ] LOAN [ ] COUNTRY FINANCED; 10. Year FY 19 85/86

11. FUNDING

A. CITATIONS	(1) Appropriation Number 72- See Below	(2) Allotment Number See Below	(3) PIO/T/Obligation Number 596-0134-2-5659524
B. FOR PARTICIPATING AGENCY	(1) Initial or Current $3,732,400	(2) Change (+ or –) -	(3) New Total $3,732,400
C. RETAINED FOR AID DIRECT DISBURSEMENT	(1) Initial or Current $6,467,600	(2) Change (+ or –) -	(3) New Total $6,467,600
D. TOTAL AMOUNT OBLIGATED (Blocks B + C)	(1) Initial or Current $10,200,000	(2) Change (+ or –) -	(3) New Total $10,200,000

E. PRINCIPAL COST COMPONENTS OF (Block B)	(1) Salaries, Differential and Benefits $898.7	(2) Transportation Including Per Diem $228.0	(3) Miscellaneous $1,927.0	(4) Overhead $678.7

12. Statement of Purpose

o/c 2580

I. SUMMARY

The purpose of this agreement between A.I.D. and the Department of Energy, Los Alamos National Laboratory, is to provide funding for technical services to perform specific tasks in support of energy and natural resource development in Central America and Panama under the Central America Energy Resources Project (596-0134). The project will contribute to the larger goal of promoting the economic growth and social progress of Central America and Panama by fostering the availability of energy needed for funding achievement of development goals. Funding herein is in support of services to be provided during the period January 15, 1985 through December 31, 1986.

	Appropriation Symbol	Allotment Symbol and Charge
1984	72-114/51037	LES 485-35596-KG13 (470-65-596-00-69-51)
1985	72-1151037	LES 85-35596-KG13 (537-65-596-00-69-51)

13. GOVERNING PROVISIONS: Pursuant to the General Agreement dated September 21, 1977 between AID and the Department of Energy, the Agency named above agrees to provide the services outlined in Block 12 amplified as needed by Appendix A, unless otherwise authorized by AID, all services shall be of U.S. origin. Any appendices attached hereto are considered part of this PASA.

14. Signatures

NAME	NAME
TITLE/OFFICE DEPUTY SECRETARY, DOE	TITLE/OFFICE ADMINISTRATOR, AID
DATE March 29, 1985	DATE 3/29/85 /WITNESS:

15. Appendices

- [X] APPENDIX A - SCOPE OF WORK
- [X] APPENDIX B - BUDGET PLAN
- [X] APPENDIX C - USE OF AID PERSONNEL/FACILITIES

16. Negotiating Officers

AID: CM/SOD/IIA – J. Auer/E.R. Wills

II. SCOPE OF WORK

Specialists provided by LANL will undertake project tasks necessary to carry out the purposes of the project as described in the Project Paper (submitted to Los Alamos under separate cover). The major responsibilities of LANL fall into the following general categories: 1) data collection and analysis; 2) overseas technical assistance; and 3) information dissemination and training. The specific tasks LANL will undertake are described in detail in the Project Paper (Statement of Work). Below is a general description of the types of tasks to be undertaken:

A. Data Collection and Analysis

1. Develop regional energy data base and related data in order to perform analyses and projections of energy and economic supply and demand for regional and country entities, AID missions, multilateral development banks.

2. Undertake specialized research and analysis on energy-related issues and problems in Central America and Panama as specifically requested by LAC Bureau, ROCAP or USAID Missions.

B. Overseas Technical Assistance

Provide technical assistance to the host governments on either short-term or long-term assignment on a variety of specific tasks within the general framework of energy and natural resource assessment and utilization. Specific project activities are described in the Project Paper and in task orders from AID that modify, delete or add to the Project Paper activities.

C. Information Dissemination and Outreach

1. Write, publish, and/or disseminate reports and other literature on the project activities executed under the project and other related subjects as approved by AID.

2. Organize and manage seminars, training courses, workshops and/or conferences on topics related to energy and natural resource development, and on request attend conferences or workshops and/or arrange for persons from AID-assisted developing countries to attend conferences on appropriate topics.

III. MECHANISMS FOR SUPPORTING SERVICES

A. The Director of Technical Services (LAC/DP) and the Energy Officer (LAC/DR) (or the LAC/DP designee) will identify project activities and needs for technical assistance through contact with USAID Missions and host country governments with the participation of the LANL Project Officer who will contribute to program conceptualization and implementation planning. The Project Officer will be responsible for establishing program priorities and schedules with the clearance of appropriate USAID Missions and the LAC Bureau.

B. To undertake project activities, LANL will make technical specialists available from its own staff, as resources permit. If suitable persons are not readily available at LANL to carry out these activities, LANL may be authorized to contract for the needed work, subject to the approval of the LAC/DR Director of Technical Services and the AID Agreements Officer in the Office of Contracts Management before entering into contracts for the work.

C. More specifically, LANL will provide the personnel to execute the project activities through:

1. Assignment of LANL staff as needed on a part-time or temporary basis for project work at LANL, in Washington, in a USAID field mission or in a host country government agency or other entity.

2. Hiring of technical advisers from other national laboratories, universities or the private sector under LANL contracts as needed for project work in a USAID Mission, a host government agency or other entity, or in Washington.

D. Quarterly meetings will be held between LAC/DR and/or ROCAP and LANL to review project implementation and quarterly status reports prepared by LANL.

E. Specific in-country assignments will be developed collaboratively by the LAC Energy Officer and LANL Project Director, with appropriate consultation and clearance of mission personnel. The tasks to be undertaken are spelled out in detail in the Project Paper and are summarized below. Modifications to the task statement must be reviewed and approved by the LAC Director of Technical Services (or his designee) and the AID Agreements Officer.

1. Geothermal Resource Assistance.
   --Resource reconnaissance work
   --Well measurement work in existing geothermal fields
   --Provision of appropriate technical equipment
   --Identification of low-temperature opportunities and feasibility demonstration

2. Other energy resource and conservation assessment and feasibility work.

3. Regional energy/economic data collection and analysis.

4. Mineral resource assessment work.

IV. GENERAL QUALIFICATIONS REQUIRED OF PASA STAFF

The LANL PASA staff or consultants should possess a broad range of the following attributes, qualifications, or experiences:

A. Professional stature to command respect and to work at peer levels with host government and AID officials and technical specialists in relevant areas of responsibility;

B. Experience as project, program or staff specialists serving in organizations responsible for planning and managing broad programs of economic and social development, preferably with an energy emphasis;

C. Experience in applying technical knowledge in the energy field to the problems of developing countries as a means of fostering sustained economic growth

D. Demonstrated ability to assess the social soundness and economic feasibility of proposals for economic advancement in relation to energy-related conditions existing in developing countries particularly in Central America.

E. Knowledge of the relationships of economic, social, and technological factors in national energy development, and the ability to identify points where progress has been constrained; and

F. Ability to deal successfully with senior government officials of AID-recipient countries, as well as with representatives of other sponsoring agencies, on technical and analytical issues of importance to energy and economic development.

V. INTERNATIONAL TRAVEL

No international travel orginating in the U.S. will be undertaken unless prior approval has been obtained from the LAC Chief Energy Officer, the USAID Mission, and/or SER/CM/SOD/IIA.

All travel arrangements (including tickets and/or advances) shall be arranged by the Participating Agency.

VI. LOGISTIC SUPPORT

A. In order to ensure responsive and smoothly functioning project staff, the PASA technicians will have available a full complement of support services by LANL, such as access to periodical subscriptions, technical books, through its library facilities, access to existing computer data services, publication search services and on-line data bases.

B. DOE/LANL shall make all arrangements for in-country use of temporary office space/equipment, housing, furniture, household equipment; interpreter/secretarial services, medical facilities and use of official vehicles. When possible, USAIDs will assist in either the provision or obtaining of office space/equipment and in-country transportation.

VII. Special Provisions

A. Authority - The Central American Energy Resources Project (596-0134) will be performed by the Los Alamos National Laboratory (LANL) under the authority of the Economy Act of 1932 (31 U.S.C. 1535-36), as amended, and in accordance with the provisions of DOE's prime contract with the University of California (UC), which operates the Government-owned Los Alamos National Laboratory for the Department of Energy under Contract Number W-7405-ENG-36. The tasks described in the Project Paper are to be performed on a non-interference basis and will not commit DOE facilities and personnel to the detriment of DOE's program activities. In compliance with the Economy Act and DOE's policy of not competing with private industry, the Agency for International Development (AID) certifies that any work requested from DOE cannot be as conveniently or more cheaply performed by private agencies and that the DOE capability is unique in the United States.

B. All commodities procured under this agreement, except those donated to host country entities, will be retained by AID at the conclusion of the agreement.

C. Total funding provided herein is for projected costs as submitted by DOE/Los Alamos in support of the objectives of this PASA. Funds shown on the face sheet of this document under item 11c (1), Retained for AID Direct Disbursement, represent costs requiring additional supporting information or justification from DOE/Los Alamos. Upon receipt of such documentation the agreement will be amended as appropriate.

D. In accordance with AID Handbook 18, the Office of Information Resources Management (M/SER/IRM) must review computer system designs prior to procurement.

E. Spanish language at the FS-2 level will generally be required for in-country work unless waived by the USAID mission. One member of each technical team must have S-3, R-3 in Spanish.

F. Access to classified information will not be required by specialists.

G. Duty Post: Los Alamos, New Mexico with TDYs in Washington, D.C., and the Central American countries excluding Nicaragua.

H. All participant training under this agreement shall be performed in accordance with provisions of AID Handbook 10.

I. All procurements shall be made in accordance with U.S. Government procurement regulations.

VIII. REQUIRED REPORTS

A. Los Alamos will prepare quarterly work plans which outline the intended project activities for each three month period of the project. These plans will include all relevant activities including trips to the field, participating personnel, and expected outputs. Quarterly work plans will be submitted to the A.I.D. Project Manager.

B. At the end of each quarter, Los Alamos will submit to the A.I.D. Project Manager a quarterly report which summarises the activities completed during the period and a comparison of actual accomplishments compared to earlier projections. Any need for remedial action will be carefully outlined. These reports should allow AID to monitor the progress of the project and to assess its conformity to the Statement of Work.

C. Prior to each field trip, Los Alamos will submit a detailed work plan to the appropriate U.S.A.I.D. Mission and to A.I.D./Washington. This work plan will describe the nature of the work to be undertaken and the personnel and host country participating agencies that will be involved. Any needs for special logistical or other support from the Mission should be carefully described in this document. Prior to going to the field, the Mission and A.I.D./Washington must concur with the work plan.

IX. GUIDANCE AND LIAISON

A. Relationships and Responsibilities

The Participating Agency will perform tasks as outlined in the Statement of Work of the Project Paper. The responsible officer at Los Alamos will be the Director for Industrial and International Initiatives. A.I.D. will employ a tripartite management structure with a Project Manager in Washington (LAC/DR/EST) and a project person in ROCAP and in each of the participating bilateral missions. Quarterly general work plans will be prepared by Los Alamos and all TDYs to the field will be preceded by a detailed work plan approved by both the Bureau the the appropriate mission. When in a particular country, the Participating Agency will coordinate its activities with the mission.

The Cooperating Country Liaison Official will differ depending on the country, the agency, and the specific project component.

B. AID Liaison Officials

Mission Director and/or Mission Energy Officer
LAC/DR/EST, Al Bisset, or Designee
ROCAP Director or Designee

X. SUBCONTRACTING

In fulfilling the requirements of this agreement, DOE/LANL is hereby authorized to enter into non-personal services contracts under its own contracting authority and in accordance with AID Handbook 12, pages 1-21 and 1-21a.

190

APPENDIX E

PCI 72-6

LOGICAL FRAMEWORK FOR SUMMARIZING PROJECT DESIGN

Est. Project Completion Date _____

Date of this Summary _____

Project Title: _____

	NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
If Purpose, Then Goal	Program Goal: The broader objective to which this project contributes:	Measures of Goal Achievement:		Concerning long term value of program/project:
If Outputs, Then Purpose	Project Purpose:	Conditions that will indicate purpose has been achieved: End of project status.		Affecting purpose-to-goal link:
If Inputs, Then Outputs	Outputs:	Magnitude of Outputs necessary and sufficient to achieve purpose.		Affecting output-to-purpose link:
	Inputs: Activities and Types of Resources	Level of Effort/Expenditure for each activity.		Affecting input-to-output link:

DEVELOPMENT HYPOTHESES

MANAGEABLE INTEREST

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